rowave power sources, and output power levels of 1.4 kW or 5 kW at 2,450 MHz and 30 kW at 915 MHz are typical. Examples of low power applications include a moisture meter, intrusion alarms, and automatic door sensors, which operate in the X-band. Biomedical applications include microwave heating for arthritis and rheumatism, the joint use of microwave power and X-rays in the treatment of malignant tumors, and microwave-induced enzyme inactivation in the brains of small animals.

5948 STUDY OF ELECTROKINETIC PROPERTIES OF BLOOD FORMED ELEMENTS UNDER THE ACTION OF ELECTROMAGNETIC FACTORS. *(Rus.)* Arsent'ev, Iu. V. (Dept. Normal Physiology, Chita Medical Inst., Chita, USSR); Arsent'eva, T. V. *Probl Gematol Pereliv Krovi* 23(8): 25-28; 1978. (12 refs)

The effects of electromagnetic fields of different frequency and intensity on the electrophoretic mobility (EPM) of erythrocytes and thrombocytes of dogs and human donors were studied in vitro, using cell suspensions in physiologic saline solution (about 100 cells/mm^3). Exposure to electromagnetic fields with 10-200 Hz frequency and 200 Oe field intensity for 5-60 min caused no significant changes in the EPM of the erythrocytes and thrombocytes of dogs. Human thrombocytes were exposed to electromagnetic fields with a radiation energy of 20-150 W and a frequency of 2,375 MHz for 45 sec. The exposure caused energy-dependent decrease in the EPM of the thrombocytes: the EPM was 1,100 μ/sec/W/cm following exposure to a 20-W field, 1,074 μ/sec/W/cm following exposure to a 75-W field, and 1,021 μ/sec/W/cm following exposure to the 150-W field, versus 1,140 μ/sec/W/cm in the non-irradiated control. The difference from the control became statistically significant at the $p<0.01$ level at a radiation energy of 75 W. The results are interpreted as a global effect determined by the competition between the structural reconstruction of the membranes and sorption of blood plasma proteins on their surface.

5949 DIFFERENTIATION OF BONE MARROW LEUKOCYTES OF ALBINO RATS UNDER THE EFFECT OF SUPER-HIGH-FREQUENCY ELECTROMAGNETIC FIELD. *(Rus.)* Obukhan, E. I. (Biology and Hygiene Res. Lab., A. N. Marzeev Scientific Res. Inst. General and Communal Hygiene, Kiev, USSR); Belokrinitskii, V. S. *Vrach Delo* (6): 120-124; 1978. (9 refs)

The effect of whole-body exposure to electromagnetic field (2,375 MHz) on the differentiation of bone marrow leukocytes was studied in 40 male and female adult albino rats; 14 others served as nonirradiated controls. One group was exposed to an electromagnetic field with 500-μW/cm^2 intensity for 6 hr; the second group was exposed to a 50-μW/cm^2 field 6 hr/day for 10 consecutive days. Destruction of the majority of the cells of the granulopoietic series (pyknosis, chromatinolysis, nucleolysis, and cytolysis), vacuolization, hemorrhages in the bone marrow, marked hypoplasia and predominance of erythrocytes over myelokaryocytes, significant increase in the eosinophil count among the myelocytes, and less frequently, among the metamyelocytes, increased functional activity of granulocytes, hypersegmentation of the nuclei of the neutrophil granulocytes, dissociation in the rates of maturation of the nucleus and cytoplasm, and "young" myelocytes were seen 16-72 hr after the single-time exposure. Similar but less intense changes were seen in the hemorrhagic regions of the bone marrow of the rats exposed to the 50-μW/cm^2 field 10 times. In the nonhemorrhagic zones, there were only few deformed cells and numerous hypertrophied, slightly differentiated, granulocytes. The findings indicate the adaptation and regeneration of the leukocytes during fractionated exposure.

5950 INDUCTION OF CHROMOSOME ABERRATIONS IN PLANTS IN A CONSTANT MAGNETIC FIELD. *(Rus.)* Shevchenko, V. V. (N. K. Kol'tsov Inst. Developmental Biology, USSR Acad. Sciences, Moscow, USSR); Grinikh, L. I.; Strekova, V. Yu. *Genetika* 14(6): 1101-1103; 1978. (3 refs)

The cytogenetic effect of a constant electromagnetic field (9 or 12 kOe, gradient 200-400 Oe) on germinating seeds of *Crepis capillaris* was studied. In the first experiment, the seeds were germinated for 2 days in a colchicine solution (0.01%) while being exposed to the electromagnetic field. In the second experiment, air-dried seeds were exposed to the magnetic field for 2 mo before germination in colchicine solution (0.01%). The magnetic field induced no chromosome aberrations in the root tip meristem cells in either experiment.

5951 THE NUMBER OF MICROWAVE RADIATION SOURCES INCREASES BY 15% ANNUALLY. IS MICROWAVE RADIATION AN INVISIBLE HAZARD? *(Dut.)* Anonymous *PT (Procestechniek) Aktueel* (31/32): 7; 1978. (0 refs)

The general problems of the health hazards of microwave radiation are discussed in light of the increasing use of microwave ovens. Aside from the direct or thermal effects, microwave radiations, especially small doses, are claimed to modify human behavior by causing asthenia syndrome (apathy, laxity, inability to concentrate, sleeplessness). The biologic effect of microwave radiation is dependent on the energy, frequency, and duration of exposure.

5952 MAGNETIC PROPERTIES OF BIOLOGICAL MEMBRANES. *(Ukr.)* Kadnikov, O. G. (Kharkov State Univ., Kharkov, USSR); Zallubovs'kii, I. I.; Iakovlev, O. V. *Dopov Akad Nauk Ukr* 13(6): 550-554; 1978. (13 refs)

Studies on the magnetic properties of biologic membranes and on the effects of magnetic fields on such membranes are reviewed. It has been demonstrated that the free radical peroxidation of membrane lipids is one of the processes that determines the magnetic properties of biologic membranes. In one experiment, the white substance of the brain

of bulls was exposed in vitro to a magnetic field (9 kOe) for 2 hr. The spectrophotometric study of the lipid membranes in the wavelength range of 3,200-3,500 cm^{-1} demonstrated an increase in the absorption of the exposed specimens compared with the nonirradiated controls before the increase in the total hydroperoxide concentration. The investigation of the individual fractions (cardiolipin, sphyngomyelin, lecithin, and phosphatidylethanolamine) revealed that the change in the concentration was caused mainly by lecithin.

5953 TEMPERATURE REACTIONS AND SURVIVAL OF EXPERIMENTAL ANIMALS AFTER EXPOSURE TO MICROWAVES OF VARIOUS INTENSITY. *(Rus.)* Matrenina, V. L. (Scientific Res. Inst. Medical Radiology, Obninsk, USSR); Posadskaia, V. M.; Rudakov, I. A. *Biull Eksp Biol Med* 86(9): 282-285; 1978. (6 refs)

The effect of whole-body exposure to microwave radiation (2,375 MHz, energy density 10, 40, and 60 mW/cm^2, length of exposure 10, 30, 45, and 60 min) on the rectal temperature and survival of 48 adult CBA mice and of 26 Wistar rats was studied. Irradiation at 40 mW/cm^2 caused restlessness, then asthenia, hyperemia of the ears, tail, paws, and nasal discharge in the rats. Compared with the initial values, the rectal temperature in the rats rose by 2.1 C during the irradiation, but it was reduced by 0.5-1.3 C between 3 hr and 5 days after exposure. Irradiation of the mice at 40 mW/cm^2 caused only insignificant hyperthermia during exposure, but the rectal temperature dropped subsequently to 29.2-35.4 C. Exposure to 10 and 40 mW/cm^2 for 10 min caused no deaths among the mice, but 8 of the 24 mice irradiated at 40 mW/cm^2 for 30 min died: 2 died during the irradiation, 3 on day one, 2 on day two, and one on day 19 after exposure. Exposure to 40 mW/cm^2 for 30 min caused the death of 2/8 rats on days 19 and 23, respectively. Exposure to 40 mW/cm^2 for 60 min caused the death of 9/10 rats: 4 died during the irradiation, 2 on day one, and one each on days 21, 25, and 30 after exposure, respectively. Irradiation at 10 mW/cm^2 caused no significant change in the rectal temperature or the mortality of the animals. Further studies will be necessary to elucidate the causes of the late death of the animals.

5954 HIGH TENSION (LETTER TO EDITOR). *(Eng.)* Miller, M. W. (The Univ. Rochester, Rochester, NY); Kaufman, G. E.; Carstensen, E. L.; Becker, R. O.; Marino, A. A. *Sciences* 18(8): 2-3, 27; 1978. (3 refs)

Opposing views concerning the hazards of extremely low frequency radiation generated by high tension power transmission lines are presented. On the one hand, claims that the electric and magnetic fields from high tension lines cause biologic effects appear to be without basis and that no one has identified a single effect that will occur from direct exposure to a transmission line's electric or magnetic field. The general conclusion from investigations on the growth and development of plants and animals, on the cellular and molecular aspects of metabolism, on cell physiology, on whether or not there are alterations in behavior, on the health of people living near transmission lines, and on the health of utility linemen working for a period of 9 yr on energized 345,000- and 765,000-V transmission lines is that there is an absence of biologic effects from field levels comparable to those experienced by persons or other living objects underneath an operational 765,000-V transmission line. On the other hand, it is claimed that such electrical environments have been shown to cause biologic effects in test animals, including human beings, in more than 70 independent investigations conducted throughout the West. Numerous additional studies within the Soviet Union have also demonstrated that transmission line fields cause adverse biologic effects in humans and animals. It is claimed that living or working near high-voltage transmission lines constitutes human experimentation because many independent studies indicate that there is a risk, even though the specific effects of the exposure cannot be pinpointed. Examples are cited of the effects of electric and magnetic fields on human serum triglyceride levels, the appearance of bone tumors in rats, the growth pattern of flatworms, human reaction time, human biorhythms, and growth stunting in mice.

5955 VISUAL DISPLAY UNITS—ARE THEY SAFE? *(Eng.)* Gilbert, P. (Post Office Telecommunications, Occupational Health Service, London, England). *Occup Health* 30(8): 357-362; 1978. (8 refs)

Potential health hazards of visual display units (VDU) are discussed. Large numbers of VDUs have been monitored for both ionizing and nonionizing radiation with no detectable results for each category. Since the refresh rate of the modern VDU screen is at least 50 Hz, as opposed to approximately 25 Hz for domestic television sets, the likelihood of flicker-induced photic fits in susceptible subjects is extremely remote. Although a wide range of subjective or psychologic symptoms have been reported in association with viewing VDU screens (tiredness, headaches, giddiness, nausea, irritability, anxiety, and depression), there is no evidence to link the incidence of these symptoms directly with viewing the VDU screen. It is concluded that at present there is no objective evidence that working with VDUs constitutes a health hazard, although the ergonomic factors of the total work situation merit continuing attention.

5956 MICROWAVE-INDUCED HYPERTHERMIA DOSE DEFINITION. *(Eng.)* Atkinson, E. R. (Div. Cancer Treatment, Natl. Cancer Inst., Bethesda, MD 20014). *IEEE Trans Microwave Theory Tech* 26(8): 595-598; 1978. (17 refs)

A hyperthermal dose-unit definition is proposed. It is suggested that the simple short-term reaction kinetics of cell viability as a function of time and temperature be employed to quantitate hyper-

thermal dosage. In order to arrive at a dosage figure by this means, it is merely necessary to interpret the time and temperature measurements which are already ordinarily monitored in clinical hyperthermia in terms of the nonlinear reaction kinetics of tissue viability. The hyperthermal dose-unit definition amounts simply to incorporating a nonlinear weighting factor in the procedure already in use for computing hyperthermal exposure in degree hours above an arbitrary temperature. It may be loosely interpreted as the percentage of cells killed by such a treatment applied to in vitro tissue culture. The dose defined will not in general be linearly cumulative over times comparable to cell cycle duration and will be strictly interpretable as a surviving fraction only for the cell subpopulation and under the growth conditions for which the numeric values of cytotoxicity are determined. As an example of the clinical applicability of the hyperthermal dose definition, the rectal temperature profile of two patients receiving whole body hyperthermia may be taken as equivalent to a hyperthermal exposure to 42.0 C for 30 min or to 41.8 C for 50 min, since both of these conditions produce a dose of about 20 units.

5957 EFFECT OF ELECTROMAGNETIC WAVES IN THE MILLIMETER RANGE (8.2 MM) ON THE VIABILITY OF BAKER'S YEAST. *(Rus.)* Abramova, N. V. (Kishinev, USSR); Makeev, Iu. V.; Tenn, F. A. *Elektron Obrab Mater* (2): 74-75; 1978. (7 refs)

The effect of exposure to electromagnetic field (wavelength 8.2 mm, intensity 1 mW/cm^2, length of exposure 10, 20, or 30 min) on the viability of *Saccharomyces cerevisiae* strain 14 in beer-wort was studied at 29 C. The viability was determined from the number of colonies growing in wort agar after irradiation. Compared with the untreated control, exposure caused a 20% decrease in the viability (number of colonies). There was no significant difference in the reduction as a function of the length of exposure.

5958 ENHANCED EFFECT OF RADIOTHERAPY FOR MALIGNANT TUMORS BY SUPER-HIGH-FREQUENCY HYPERTHERMIA. *(Rus.)* Aleksandrov, N. N. (Scientific Res. Inst. Oncology and Medical Radiology, Belorussian SSR Ministry of Health, Minsk, USSR); Fradkin, S. Z.; Zhavrid, E. A.; Muravskaia, G. V.; Malinovskii, G. V.; *et al.* *Vopr Onkol* 24(8): 14-19; 1978. (8 refs)

The enhancement of the effect of radiotherapy by means of local super-high-frequency (SHF) hyperthermia was studied in 105 mice with solid Ehrlich's tumor, 500 rats with sarcoma-45, and 145 patients (31 men, 114 women, aged 10-70+ yr) with malignant tumors (skin melanoma, synovioma, angiosarcoma, fibrosarcoma, breast cancer, and other tumors). The animals received telecobalt treatment (dose rate 125 R/min) 5 min to 72 hr after local hyperthermia (41.5 C, wavelength 12.6 cm, duration 30-60 min). The inhibition of tumor growth was about 150% greater than in animals receiving ionizing radiation only. The mean survival time was 50.6 ± 2.9 days after hyperthermia and radiotherapy, 42.8 ± 2.6 days after ionizing irradiation, and 38.6 ± 2 days after exclusive hyperthermia. The enhancing effect of hyperthermia was strongest when it was followed immediately by radiotherapy. In the human patients, hyperthermia (42 C) was generated by electromagnetic field (wavelength 2,450 ± 49 MHz for superficial tumors, 460 MHz for deep tumors; duration 60-120 min), and it was followed immediately by radiotherapy. Twelve patients received hyperthermic treatment alone before surgery; six of these achieved complete remission, four others 25-30% remission. Hyperthermia was combined with radiotherapy in 133 patients. Complete disappearance of tumor cells, and necrosis was seen in 36 patients, marked destructive changes and subtotal necrosis in 75, but there were no marked changes in 22. The findings indicate the marked radiosensitizing effect of SHF hyperthermia in cancer therapy.

5959 BILATERAL TESTICULAR ATROPHY FOLLOWING ACCIDENTAL DIRECT RADAR BEAM EXPOSURE. *(Ger.)* Ikinger, U. (Urologische Abteilung des Chirurgischen Zentrums, Universitat Heidelberg, Neuenheimer Feld, D-6900 Heidelberg 1, W. Germany); Palmtag, H.; Mohring, K.; Wurster, K. *Aktuel Urol* 9(4): 221-224; 1978. (7 refs)

A 36-yr-old man developed marked bilateral testicular atrophy 1-2 yr after accidental exposure of the genitals to radar waves (300 W, pulse power 10 kW). During a 15-min repair of radar equipment, the patient's genitals were at the height of and a few centimeters from the emitter, which he thought was turned off. Fourteen days after exposure, the patient developed painful reddening of the scrotal skin; however, symptoms disappeared within days. One year after exposure, he noticed a lessening in volume of the right testicle and the following year a decrease in the left testicle. Three yrs after exposure, the patient underwent testosterone therapy (280 mg/mo). Nine yr postexposure, investigations of biopsy specimens showed shrinkage of the seminiferous tubules with broadening of the lamina propria, marked hyperplasia of the elastic fibers, thickening and hyalinization of the basal membranes, the absence of mature sperm, foci of Leydig's cell hyperplasia, intimal fibrosis, and hyalinosis of the small vessels. It was concluded that the histology of the testicular material demonstrated the same damage after radar exposure as that seen after therapeutic x-irradiation.

5960 RESPONSE OF INSULATED ELECTRIC FIELD PROBES IN FINITE HETEROGENEOUS BIOLOGICAL BODIES. *(Eng.)* Mousavinezhad, S. H. (Sch. Engineering, Ferdowsi Univ., Mashhad, Iran); Chen, K.-M.; Nyquist, D. P. *IEEE Trans Microwave Theory Tech* 26(8): 599-607; 1978. (16 refs)

An idealized spherical metallic probe insulated by a dielectric layer and immersed in a finite lossy-dielectric biologic body was studied to demonstrate

that location-dependent probe parameter variations can be reduced by insulating the metallic probe with a thick coating of low-permittivity dielectric. This type of probe was demonstrated both analytically and experimentally to have a relatively constant calibration factor. The effective diameter and equivalent impedance of the spherical probe become relatively independent of finite size and electrical parameters of the body in which it is immersed when the insulation-to-probe diameter ratio exceeds 1.5 with an insulation having a dielectric constant of about 2.0. Agreement of actual measurements for the field distribution in a simulated finite biologic body, obtained using such an insulated probe, with theoretic predictions confirmed this conclusion. Since the main findings of this study were rather geometry independent, it appears that the results of the present study can be applied to systems without spherical symmetry; this point was verified experimentally. The main advantages of using an implantable electric field probe over a temperature probe are its capability of measuring a low induced field and its ability of measuring each component of the induced electric field separately. However, it also had disadvantages, such as, the limitation of using it in regions with low dielectric constants and the difficulty of designing an interference-free lead wire system for the probe.

5961 COHERENT ELECTRIC VIBRATIONS IN BIOLOGICAL SYSTEMS AND THE CANCER PROBLEM. *(Eng.)* Froehlich, H. (Dept. Physics, Oliver Lodge Lab., The Univ., P.O. Box 147, Liverpool L69 3BX, England). *IEEE Trans Microwave Theory Tech* 26(8): 613-617; 1978. (18 refs)

Theoretic and experimental evidence for the existence of coherent electric vibrations in biologic systems is reviewed in relation to the control of cancer. Evidence for the biologic importance of vibrations in the region of 5×10^{10} Hz has been obtained from experiments with coherent millimeter waves. For example, in one experiment yeast was suspended in a stirred aqueous nutrient medium and exposed to a frequency range of between 4.14 and 4.19×10^{10} Hz. The results showed five minima with growth rates between 70 and 85% of controls within 4.65 and 4.79×10^{10} Hz, separated by maxima of rates between 100 and 115% of controls, and no noticeable effect outside this range. Thus, the effect was largely negative and exhibited extremely sharp biologic frequency resonances. These findings strongly support the conjecture that coherent electric vibrations play an important role in biologic activities. The strongest evidence for the biologic importance of vibrations obtained from Raman effect experiments with bacterial cells has been observed at a frequency of about 3×10^{12} Hz, although the effect may extend to lower frequencies, possibly to about 10^{11} Hz. A model calculation is presented to support the proposal of coherent excitation of electric vibrations (polarization waves) through supply of metabolic energy. With regard to the control of cell division in normal tissue, which is absent in cancer, it is shown that in principle this control could rest on the coherent electric vibrations discussed above. If the range of millimeter waves is relevant to the control of tissue growth and if this relevance shows resonant effects similar to those discussed above, then important nonthermal effects of millimeter waves of correct frequencies on cancer tissues should be expected. Recently the existence of several Raman lines in the region of 50-200 cm^{-1} has been demonstrated, and these were found to be broadened and split in the case of mammary carcinoma. If confirmed and if strong anti-Stokes lines also exist, then this finding is in accordance with the suggestion that cancer cells contain unattached electrons such that their plasma frequency is close to the frequency of the coherent vibrations discussed above.

5962 THE EFFECTS OF MICROWAVE RADIATION, HYPERTHERMIA, AND L-ASCORBIC ACID ON EHRLICH ASCITES CARCINOMA CELL METABOLISM. *(Eng.)* Piontek, G. E. (Radiation Oncology Training Program, Univ. Illinois, Urbana, IL); Cain, C. A.; Milner, J. A. *IEEE Trans Microwave Theory Tech* 26(8): 535-540; 1978. (41 refs)

The effects of 2.45-GHz microwave radiation, hyperthermia, and L-ascorbic acid on glucose and citrate metabolism in Ehrlich ascites tumor cells in vitro are studied, and these data were compared to glucose metabolism in rat kidney slices. Microwave-irradiated and nonirradiated water bath cells were maintained at 37.5 C and 42.5 C in the presence or absence of L-ascorbic acid. The metabolic responses of Ehrlich ascites tumor cells and rat kidney slices were not different between irradiated and nonirradiated samples. Ascorbic acid increased the rate of glucose and citrate metabolism, and this effect was found at 37.5 and 42.5 C in both irradiated and nonirradiated cells. No significant differences in glucose or citrate metabolism were found between irradiated and nonirradiated cells at the same temperature and ascorbic acid concentration. Hyperthermic treatment alone for 1 hr did not significantly affect tumor cell metabolism; however, hyperthermia in the presence of ascorbic acid significantly increased tumor cell citrate metabolism but not glucose metabolism. This result held for both irradiated and nonirradiated cells. When glucose metabolism in normal kidney tissue slices from rats was studied, there was no significant changes with or without ascorbic acid. In addition, there were no significant metabolic changes resulting from incubation at 42.5 C versus 37.5 C.

5963 A SYSTEM FOR DEVELOPING MICROWAVE-INDUCED HYPERTHERMIA IN SMALL ANIMALS. *(Eng.)* Baker, R. J. (Radiation Oncology Center, Parkview Memorial Hosp., Fort Wayne, IN 46805); Smith, V.; Phillips, T. L.; Kane, L. J.; Kobe, L. H. *IEEE Trans Microwave Theory Tech* 26(8): 541-545; 1978. (19 refs)

A system for producing microwave-induced hyperthermia in small laboratory animals by irradiating

an entire transverse section of the animal is described. The applicator consists of a conventional WR-650 coax-to-waveguide adapter followed by an electrically compensated transition section (tapered in the height dimension only) to adapt the larger component to the reduced height waveguide test section. The relatively large WR-650 waveguide allows the use of a low frequency to ensure good depth of penetration but of reduced height to limit the region of heating. The frequency of the system is 1,210 MHz; this was chosen based on measurements that indicated maximum energy absorption in the test animal at this frequency. In an initial trial, anesthetized mice were heated to 41.2 C for 25 min or to 44.8 C for 15 min at this frequency using a 1.91-cm high microwave section. Long-term survival was not obtained in this trial. Uniform heating (within 0.25 C) resulted when a test tube containing the mouse was rotated 180 degrees at four times/min during the heating period. Of 17 animals heated to 44.8 C for 5 or 10 min, throughout the entire abdominal region, 7 survived for 7 days postheating. Histologic data obtained after 3 days from animals heated to 44.8 C for 15 min indicated damage of the crypt cells and villi of the jejunum only. The kidney, lung, liver, and spleen were all normal. Based on these preliminary studies, it appears possible to assess cellular and tissue damage in tumor and normal tissue of animals exposed to microwave hyperthermia.

5964 BIOLOGICAL EFFECT OF 27.12-MHZ SHORT-WAVE DIATHERMIC HEATING IN EXPERIMENTAL TUMORS. *(Eng.)* Overgaard, J. (Inst. Cancer Res. and the Radium Center, Aarhus Municipal Hosp., DK-8000 Aarhus C, Denmark). *IEEE Trans Microwave Theory Tech* 26(8): 523-529; 1978. (24 refs)

Short-wave diathermy (27.12 MHz) in the temperature range of 41-43 C was used to treat 12 isologous transplantable mouse tumors of different origin, histology, and degree of differentiation. Local tumor control was obtained after a minimum threshold heat dose (combination of temperature and treatment time), but curability varied from 9-25% in different tumors. The cures were obtained without evidence of damage to normal tissue, therefore, tumor destruction seemed to be a selective process. Curative results did not improve when the heat dose was increased beyond the threshold dose by a factor of up to four. The initial clinical response was the same in all tumors treated with a curative heat dose. The tumor shrank, became increasingly firm, and gradually disappeared; however, in about 80% of the cases, recurrent growth appeared within 1-2 wk. This recurrence was always found in the periphery of the treated tumors. Histopathologic examination of recurrent tumors demonstrated that in many cases a small marginal spot of viable tumor cells causing the regrowth could be observed. This was especially found as small tumor islands situated in the surrounding fatty or connective tissue. Although a general threshold dose seemed to be required to obtain a curative effect in the tumors, the curative yield following the actual threshold dose was not the same in all tumors, showing variations ranging from a few to about 25%. The degree of peripheral infiltrative growth was the only parameter that correlated with the cure rate: tumors with a narrow corona had a higher number of cures than tumors with more infiltrative growth. It seems that a heterogeneous and insufficient physical destruction by the heat applied by the present diathermy technique is the most likely explanation for tumor regrowth. Therefore, the usefulness of low-frequency diathermy in tumor control is limited by the application technique and by the tissue heterogeneity.

5965 DEVELOPMENT OF A 915-MHZ DIRECT-CONTACT APPLICATOR FOR THERAPEUTIC HEATING OF TISSUES. *(Eng.)* Guy, A. W. (Dept. Rehabilitation Medicine RJ-30, Univ. Washington Sch. Medicine, Seattle, WA 98195); Lehmann, J. F.; Stonebridge, J. B.; Sorensen, C. C. *IEEE Trans Microwave Theory Tech* 26(8): 550-556; 1978. (12 refs)

A 915-MHz diathermy dielectrically-loaded applicator with a TE_{10}-mode aperture field distribution is described. The applicator consists of a transition from a coaxial connector to a stripline power splitter that supplies power to two independent waveguides by excitation loops. A porous foam dielectric (dielectric constant of 4) is used that allows cooling air to be blown through the applicator and onto the surface of tissue being treated. When the applicator was oriented with the electric field perpendicular to the femur of human volunteers, it was reasonably matched for this position from direct contact with the tissue to a distance of 3 cm from the tissue. When the applicator was turned 90 degrees so that the electric field was parallel to the femur, the applicator was still reasonably matched at distances of 0-2 cm from the tissue surface. The applicator was tested continuously under high power conditions up to 600 W, and it performed satisfactorily with negligible heating of the dielectric material and the metal hardware. Bandwidth evaluations of the applicator indicated that it is matched over the frequency range of 880-940 MHz, which is more than adequate for covering the 915 ± 13-MHz band. Previous results indicate that with 1 W of input power, the applicator can produce a maximum specific absorption rate of 3.25 W/kg in muscle. Therefore, an input power of 50 W is sufficient to produce a specific absorption rate of 150 W/kg in muscle, which is more than adequate for typical clinical use.

5966 VDUs—AN OPERATOR'S VIEW. *(Eng.)* Timbs, O. (No affiliation given). *Occup Health* 30(8): 363; 1978. (0 refs)

Problems associated with working with visual display units (VDU) are discussed from an operator's viewpoint. Although the operator was prepared to accept the evidence that working with VDUs is 100% medically safe, long periods of VDU operation were nevertheless irritating. The main problem that the operator experienced was flashing messages

that appeared across the VDU screen. Since the "refresh rate" of the modern VDU screen is at least 50 Hz, in contrast to the 25 Hz for domestic television sets, flickering should not be very much of a problem. However, the software that this particular operator deals with is very delicate, and while working on a program, the operator could easily make an error with the result that messages of warning flash across the screen until the mistake is rectified. These incessant flashes, apparently, are most exhausting. The operator feels that only in exceptional circumstances should an operator work on a VDU for more than 2 hr without a break. This view is supported by industrial committee guidelines for VDU operators, which recommend at least a 30-min break from the screen after every 2-hr work period at the VDU.

5967 PULSED MICROWAVE-DIATHERMY. *(Eng.)* Wildervanck, A. (Jousterweg 4, HASKERHORNE [Fr], 9350, Netherlands). *Biomed Tech (Berlin)* 23(7/8): 158-165; 1978. (16 refs)

Continuing studies of heating pattern, temperature elevation, and pearl chain formation were conducted with a pulsed microwave applicator (Diatron-1500) operating at a frequency of 2,450 MHz. The applicator delivers both continuous microwave radiation and pulsed microwave radiation with a pulse duration of 60 μsec. The energy dosage is regulated by varying the number of pulses over eight dial settings from 100-900 pulses/sec; the first four settings are denoted as diatronic athermic therapy and the latter four as diatronic thermic therapy. Heating pattern studies using the egg white coagulation method revealed that none of the pulse rate settings resulted in any visible sign of coagulation; whereas, the first sign of coagulation occurred within 10 min after switching the applicator on the continuous microwave setting. In the gluteal muscle of rabbits, there was no observable temperature rise after exposure to pulsed microwaves (any pulse rate setting) for 20 min. In contrast, a definite rise in temperature was recorded from the beginning of radiation when continuous microwaves were used. Similar negative results were obtained in dog muscle for the first four pulse rate settings (diatronic athermic therapy); however, a slight and slow temperature rise (about 1 C) occurred during 20 min of irradiation for the four diatronic thermic therapy settings. Continuous microwave irradiation resulted in a strong temperature rise of nearly 3 C within 20 min of exposure for dog muscle. Pearl chain formation with diluted milk and with blood was easily demonstrated with pulsed microwave radiation at the lowest diatronic athermic settings.

5968 HEAT POTENTIAL DISTRIBUTION IN AN INHOMOGENEOUS SPHERICAL MODEL OF A CRANIAL STRUCTURE EXPOSED TO MICROWAVES DUE TO LOOP OR DIPOLE ANTENNAS. *(Eng.)* Hizal, A. (Electrical Engineering Dept., Middle East Technical Univ., Ankara, Turkey); Baykal, Y. K. *IEEE Trans Microwave Theory Tech* 26(8): 607-612; 1978. (8 refs)

Heat potential distribution is calculated for a multilayered inhomogeneous spherical model of a cranial structure situated symmetrically in the near zone of either a small loop antenna or an electrical dipole antenna radiating at a frequency of 3 GHz. The idealized model chosen was a six-layered spherical model with a maximum radius of 3.3 cm, which might correspond to a monkey's or an infant's head. At 3 GHz frequency, the peak internal heat potential makes a maximum for the plane-wave excitation. The permittivity and the conductivity of the layers were taken at this specific frequency with sharp sinusoidal transitions between the layers. For the dipole excitation, a rather uniform heat potential distribution was found to occur, with no considerable hot spots. For the loop excitation, a significant hot spot occurred near the center of the structure. When compared with the plane-wave excitation, it was seen that the exact center of the head could best be heated by the plane-wave incidence. Also, for all excitations, a concentration of heat at this frequency and cranial size could be observed at the skin because of the high conductivity of this outermost layer.

5969 SOME BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS BELOW 300 MHz (PREGNANCY, LITTER SIZE AND GONADOTROPIC ACTIVITY OF THE ANTERIOR LOBE OF THE PITUITARY GLAND). *(Pol.)* Mikolajczyk, H. (Instytut Medycyny Pracy, ul. Teresy 8, 90-950 Lodz, Poland). *Med Pr* 29(2): 111-120; 1978. (9 refs)

The fecundity and litter size were investigated in three successive generations of 31 control and 21 experimental female rats irradiated before and/or during pregnancy in electromagnetic fields of 30, 70, or 210 MHz at 200 V/m intensity for 2 hr/day. While all experimental rats became pregnant, the litter size of the rats irradiated at 70 MHz was 70% that of the controls. The male-to-female ratios in the litters were 29:29 after irradiation at 70 MHz, 63:55 after irradiation at 30 MHz, and 22:26 after irradiation at 210 MHz. The follicle-stimulating hormone (FSH), luteinizing hormone (LH), and growth hormone (GH) levels of the anterior lobe of the pituitary gland were determined in 35 male and 21 female sexually immature rats irradiated once (100 MHz, 2-0 V/m, 2 hr) or repeatedly (227 KHz or 210 MHz, 200 V/m, 40 x 2 hr). Thirty-five males and 21 females served as intact controls. Single-time irradiation of males caused a significant increase in the LH and GH levels; irradiation with 210 MHz caused significant or nearly significant decreases in the FSH, LH, and GH levels. Irradiation with 227 KHz caused significant decrease in the LH and GH levels.

5970 INFLUENCE OF A CONSTANT MAGNETIC FIELD ON NERVOUS TISSUES: I. NERVE CONDUCTION VELOCITY STUDIES. *(Eng.)* Schwartz, J.-L. (Laboratoire de Physiologie Animale, Universite de Poitiers, Poitiers, France). *IEEE Trans Biomed Eng* 25(5): 467-473; 1978. (25 refs)

The effects of a constant magnetic field (1.2 tesla) on the propagation velocity of nerve impulses along the circumesophageal nerve of the lobster *(Homarus Americanus)* were investigated. Nerve chambers with either straight or V-shaped electrodes were constructed from acrylic plastic with one section at 90 degrees to the other in such a way that the nerve would be held in an L-shaped groove, with the long side of it perpendicular to the magnetic field and the short side parallel to the field. The nerve was first stimulated for a 5-10-min period to check for healthy condition and stability. The magnet was then energized to establish the magnetic field in the air gap where the experimental chamber was located. The exposure period lasted usually 20-30 min after which the magnetic field was brought back to zero. The electrical response of the nerve was then monitored during another period of 20 min. During the exposure and postexposure periods, the stimulation was kept supramaximal and at a frequency of 0.1 Hz. Each nerve thus served as its own control. The results indicated that the magnetic field had no significant influence on the propagation velocity of the impulse along the circumesophageal nerve of the lobster in either parallel or perpendicular configuration with respect to the magnetic field vector direction.

5971 PRELIMINARY OBSERVATIONS WITH AN ELECTROMAGNETIC METHOD FOR THE NONINVASIVE ANALYSIS OF CELL SUSPENSION PHYSIOLOGY AND INDUCED PATHOPHYSIOLOGY. *(Eng.)* Larsen, L. E. (Walter Reed Army Inst. Res., Dept. Microwave Res., Washington, DC); Jacobi, J. H.; Krey, A. K. *IEEE Trans Microwave Theory Tech* 26(8): 581-595; 1978. (40 refs)

A method for the high-speed noninvasive electromagnetic analysis of cell suspension physiology and induced pathophysiology is presented. The method is especially suitable for pathophysiologic applications where a high rate of data acquisition is necessary. This requirement is met by the technique of automatic network analysis and off-line processing to derive complex permittivity from the error-corrected complex reflection coefficient. The present system offers some freedom from the interfacial effects that plague all permittivity measurements in electrolytes insofar as platinum/platinum black is used only in a calibration step. Experimental results demonstrate that changes in high frequency band permittivity dispersion may be related to physiologic and drug-induced pathophysiologic states of the cell membrane. The effect of species, suspending medium, and temperature are systematically analyzed in erythrocyte suspensions to aid a comparison between published studies of red blood cell preparations. Absolute measurements, subject to limitations involving the frequency range and dielectric constant, appear to be within the range of variation in the published literature once all contributing factors are considered. The method appears to have useful sensitivity to small movements of water and electrolytes. A system for the interpretation of cell suspension dispersion is presented along with experimental evidence to support the interpretive scheme. The method offers the potential for noninvasive measurement whereby the contribution of intracellular and extracellular spaces may be separately analyzed. It is asserted that the physiologic foundation for the observed dispersion is the cell membrane and that its activity may be inferred without the need for membrane disruption.

5972 THE ELECTROMECHANICAL EFFECT IN BONE. *(Eng.)* Johnson, M. W. (Ph.D. dissertation, Univ. Illinois at Urbana-Champaign, 1977); 135 pp. [available through National Technical Information Service, Springfield VA 22161, Document No. COO-1198-1183]. (58 refs)

The physics of piezoelectricity in bone is examined, with particular reference to the applicability of the stress gradient theory to both dry and wet bone. Experiments with dry bond from bovine tibia led to the conclusion that the otherwise anomalous electromechanical effect in bent dry bone is due to spatial variations in the piezoelectric moduli. This result unified the electromechanical phenomena for dry bone under one effect, the piezoelectric effect. A model for the piezoelectric behavior of an osteon in which an osteon resembles a radially-poled cylinder is also presented. There is some evidence that this model is applicable to an osteon, but further experimental work on the microscopic piezoelectric behavior of bone is needed to test this model. The possibility that trapped charge may contribute to the electromechanical effect in bone through the electrostriction effect was considered, and it was concluded that although this theory may be applicable to some polymers, it is not applicable to bone. It is suggested that the electromechanical effect in poled polyvinylidene fluoride in cantilever bending may be due to spatial variation in the piezoelectric moduli. Measurements on wet bone showed that the electromechanical effect in bent wet bone exhibits the same z-dependence and symmetry properties that are characteristic of dry bone and that the magnitude of the effect in wet bone is of the order expected if the signals had the same origin. It is concluded that the effect in bent wet bone is due to variations in the piezoelectric moduli. However, the sign of the signal observed in wet bone is always positive, even for samples that have a negative signal when dry. It is tentatively concluded that there is more than one effect contributing to the signal in wet bone and that part of that signal is due to a variation in the piezoelectric moduli.

5973 SURVEYS OF ELECTROMAGNETIC FIELD INTENSITIES NEAR REPRESENTATIVE HIGHER-POWER FAA TRANSMITTING ANTENNAS. *(Eng.)* Larsen, E. B.; Shafer, J. F. (Electromagnetics Div., Inst. for Basic Standards, Natl. Bureau Standards, Boulder, CO 80302). 115 pp.; 1977. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD A051717]. (17 refs)

Data from an NBS survey of electromagnetic field intensities near the antennas of typical higher power Federal Aviation Administration transmitting systems are presented. These systems include ground surveillance radars, airborne weather radars, instrument landing systems, and various navigation and communication radiators, or any system likely to produce an equivalent free space power density exceeding 0.1 mW/cm^2 or an electric field magnitude above 20 V/m. Commercial monitors with thermocouple sensors were used to measure electric fields between 0.5 and 24 GHz and magnetic fields between 10 and 300 MHz. Probes designed at NBS with diode detectors were used for electric fields between 100 kHz and 10 GHz. The intensity in the direct beam of air route surveillance radars was greater than 10 mW/cm^2 at distances within about about 14 m from the antennas. The intensity of airport surveillance radars was above 10 mW/cm^2 at distances within 15 m, except for a newer airport surveillance radar model (ASR-8). For all aircraft radars checked, no intensity exceeding 10 mW/cm^2 was found at a distance beyond 6 m. Taking the time-averaging effect for antenna scanning into consideration, these field values would be greatly reduced. Also, the near-zone beams of such antennas are not normally accessible to personnel. In accessible areas the measured fields were generally less than 1 mW/cm^2.

5974 A MAGNETIC COMPASS RESPONSE OF AN ORGANISM. *(Eng.)* Brown, F. A.; Bennett, M. F.; Webb, H. M. (Dept. Biological Sciences, Northwestern Univ., Evanston, IL). 10 pp.; 1960. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD 247 747]. (3 refs)

Snails *(Nassarius obsoleta)* were placed in magnetic fields at right angles to one another to determine whether the animals possess a capacity to differentially respond to such fields. The experiments comprised permitting snails to emerge from a magnetic-south-directed, straight, narrow corridor into a constant, symmetrical field provided with a grid such that the mean amount of right or left turning during the initial 3 cm of free movement could be assayed. Each experimental series consisted of two samples of 10 passages in the earth's field, two samples of 10 passages in an experimentally increased field oriented as the earth's field, and two samples of 10 passages in an increased field rotated 90 degrees clockwise from the natural field. A total of 564 series of 60 snail runs was obtained between the hours of 5 AM and 9 PM. The results indicated that the snail is able to differentiate between two weak magnetic fields, one oriented at right angles to the other. The relative influences of experimental north-south and east-west oriented magnetic fields in producing dispersion of snail pathways, or effecting a magnetoklinokinesis, displayed both solar- and lunar-day rhythms. The relative influences of experimental north-south and east-west fields in effecting a predominantly counterclockwise snail-turning exhibited solar daily, lunar daily, and semi-monthly rhythms. The solar and lunar clock-regulated discriminatory responses for magnetic fields indicate that the snail is significantly oriented as if by internal magnetic compass needles, which in turn are hands of horizontal solar- and lunar-day clocks.

5975 QUANTITATION OF MICROWAVE RADIATION EFFECTS ON THE HEAD AND EYES OF RABBITS, PRIMATES AND MAN. *(Eng.)* Kramer, P. O. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, BB 919 Health Sciences, Univ. Washington, Seattle, WA 98195). 11 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD A054421]. (8 refs)

The right five eyes of five adult albino rabbits were exposed for 5-min periods either every other day or every third day to a subthreshold apparent power density level of 300 mW/cm^2 from a 2,450-MHz microwave C director to determine the effect of such exposures on cataract formation. The left eyes of these same rabbits served as controls. Cataract formation was observed in three out of three rabbits exposed to microwave radiation every other day; whereas, no cataracts were observed in two rabbits exposed every third day to microwaves. Therefore, it appears that 2 days are required between exposures to allow the lens to recover. *Post-irradiation retrolental temperatures of* between 42 and 46 C were recorded in all cases. When circulating hot water was used to elevate the retrolental temperature of rabbits to 43 or 45 C, lens changes similar to those following acute microwave irradiation were observed. These findings combined with the lack of detectable lens changes following chronic low level irradiation suggest that the presence of a specific nonthermal microwave factor is unlikely in cataractogenesis.

5976 HAZARDS DUE TO TOTAL BODY IRRADIATION BY RADAR. *(Eng.)* Schwan, H. P.; Li, K. (Moore Sch. Elec. Engrg., Univ. Pennsylvania, Philadelphia, PA). 10 pp.; 1956. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD 122467]. (18 refs)

Hazards due to total body irradiation by radar are theoretically analyzed in terms of the percentage of airborne electromagnetic energy absorbed by the human body and the distribution of heat sources in the various tissues of the body. It is assumed that plane electromagnetic radiation is propagating perpendicular to the surface of the body. This case will be approximated roughly by the trunk of a person facing the source of radiation. Taking 0.01 W/cm^2 for long time exposure and 0.01 $W/hr/cm^2$ for short exposures as tolerance figures, both not to be exceeded in the case of total body irradiation, the following conclusions seem justified. Frequencies substantially below 1,000 MHz (500 MHz and lower) are associated with true deep heating. The coefficient of absorption is about 30-40%. This means that incident energy

flux figures of less than 0.03 W/cm^2 can be tolerated. Frequencies ranging from 1,000-3,000 MHz may be absorbed completely. Skin, subcutaneous fat, and deep tissues participate in this absorption, and conversion into heat occurs in a complex manner. Here the percentage of airborne energy that is absorbed by the body may vary between 20 and 100%, depending on the thickness of the skin and subcutaneous fat. Hence, 0.01 W/cm^2 is considered as a recommendable tolerance statement. Frequencies in excess of 3,000 MHz are absorbed in the surface of the body, and heat dissipation to the outside is excellent. The coefficient of airborne energy that is absorbed is 40-50%. Hence, more than 0.02 W/cm^2 is tolerated by the body.

5977 THE EFFECT OF LOW FREQUENCY RADIO WAVES ON BIOLOGICAL MATERIALS. *(Eng.)* Ginsburg, N.; Cholet, P. (No affiliation given). 20 pp.; 1954. [available through Armed Services Technical Information Agency, Dayton, OH, Document No. AD 24365]. (2 refs)

The effect of low frequency radiowaves on the viability of two varieties of *Zea maize* seeds (Golden Bantam and Ear-Bred varieties) is investigated. Lethal effects were produced when the seeds were exposed to a frequency of 20 MHz at 800 V root mean square for periods of 4.5 hr. The heating effect under these conditions was pronounced. Measurements of dissipation factor versus frequency as a function of temperature were extended to the 10 MHz frequency range, and the two varieties of corn compared with sunflower seeds. Measurements were also made to compare dehydrated seeds with frozen seeds. Freezing and dehydration had similar effects on the dissipation factor. Graphs showing the variation of equivalent parallel resistance with frequency were constructed from quantities measured in the present experiments and in past experiments. There was a close similarity between these curves for various conditions. It is suggested that the lethal effects observed after 20-MHz irradiation are probably due only to heating. At the low frequency end of the measurements, the greatest probability is that the observed effects are nearly all due to ionic conduction within the seeds. It is assumed that the conduction mechanism is very sensitive to small amounts of water as indicated by large changes in the dissipation factor produced by freezing and the nearly identical changes produced by dehydration. No definite statement may be made on the changes in conduction mechanism produced by heating. The large increases in dissipation factor and the increase in the dielectric constant at low frequency are not due to molecular reorientation but to ionic polarization effects.

5978 AN ANALYSIS OF RADIOFREQUENCY AND MICROWAVE ABSORPTION DATA WITH CONSIDERATION OF THERMAL SAFETY STANDARDS. *(Eng.)* Tell, R. A. (Environmental Protection Agency, Office Radiation Programs, Electromagnetic Radiation Analysis Branch, P.O. Box 15027, Las Vegas, NV 89114). 56 pp.; 1978. [available through National Technical Information Service, Springfield, VA. Document No. EPA Technical Note, ORP/EAD 78-2]. (103 refs)

An analysis of the existing radio frequency (RF) and microwave (MW) absorption data for man in relation to electromagnetic power deposition in tissues of the body leading to various levels of thermal loading is presented. The results illustrate the strong frequency-dependent nature of electromagnetic energy absorption in man and the existence of resonance frequencies for the body as a whole and the anatomic substructures. The analysis reveals a particularly important resonance frequency range, 10 MHz to 1,000 MHz, in which RF and MW absorption may lead to whole body thermal loads several times the whole body basal metabolic rate for exposures equal to the present safety standard in use in the United States. For the human adult, at a resonance frequency of about 70 MHz, a free space exposure field of 140 nJ/m^3 electromagnetic field energy density (a far-field equivalent of 4.2 mW/cm^2 power density) will induce a doubling of the heat load due to the basal metabolic rate. This would probably be detectable as a rise in body temperature by most individuals at rest. While the whole body heat loading is only doubled, the nonuniform nature of the absorption process could potentially lead to localized absorption rates as high as 30 W/kg. Such a high local absorption rate is probably not advisable for the general population. The results reveal serious reservations for applying the currently used American National Standards Institute standard to the population as a whole in that localized power deposition could, under proper conditions of exposure, apparently lead to substantial thermal burdens in various parts of the body. The adoption of more conservative limits would not appear in general to impose undue hardships on existing facilities inasmuch as environmentally encountered RF and MW intensities are rarely above 4 nJ/m^3.

5979 EFFECT OF COBALT-60 RADIATION, MICROWAVE HYPERTHERMIA AND PARA-FLUOROPHENYLALANINE ON HAMSTER MELANOMA. *(Eng.)* Traub, R. J. (Ph.D. dissertation, Purdue Univ., 1977); 131 pp. (available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 78-13,131). (31 refs)

The effects of cobalt-60 radiation (500 rad per treatment) alone and in combination with 2.45-GHz microwave hyperthermia (43 C for 15 min) and p-fluorophenylalanine (100 or 200 mg/kg per treatment) on a slightly pigmented and a nonpigmented melanoma syngenic to golden Syrian hamsters was investigated to determine if hyperthermia or the drug could enhance radiosensitivity or if the drug could enhance the thermosensitivity of these tumors. The animals were exposed to radiation and hyperthermia every other day for five treatments. Hyperthermia preceded cobalt-60 radiation by approximately 5-10 min. p-Fluorophenylalanine was administered intraperitoneally for 10 daily treatments. Cobalt-60 radiation significantly

decreased tumor growth in both tumor types studied (at day 15, 36% of control for low passage and 16% of control for high passage derived tumors), and this resulted in an increased survival time after the initial treatment. Microwave hyperthermia had a significant effect on reducing tumor growth on day 5, 10, and 15. However, the influence on tumor growth did not result in a significant effect on the survival of tumor-bearing animals. p-Fluorophenylalanine had a significant influence on tumor growth for all days studied. The decreased tumor growth did not result in an increased survival time after the initial treatment. Although there was a significant decrease in tumor growth for high passage derived tumors compared to low passage derived tumors as a result of cobalt-60 radiation, there were no consistent differences between the two tumor types with respect to their response to microwave hyperthermia or p-fluorophenylalanine. The combination of cobalt-60 radiation with microwave hyperthermia and/or p-fluorophenylalanine showed no significant synergism. The combined treatment effects could be predicted by assuming independent additivity of the main treatment effects.

5980 BIOMAGNETISM: A REVIEW. *(Eng.)* St. Lorant, S. J. (Stanford Linear Accelerator Center, Stanford Univ., Stanford, CA 94305). 9 pp.; 1977. [available through National Technical Information Service, Springfield, VA 22161 Document No. CON-770842-18]. (89 refs)

A literature review of the biologic effects of static and slowly varying magnetic fields is presented. In general, magnetic effects appear to be fully reversible once the organism is permitted to return to its original environment. No experimental evidence exists that would indicate a cumulative effect caused by repeated exposures without adequate recovery times between exposures. A survey of hundreds of experiments performed in the last 20 yr in which mice, plants, insects, lower organisms, primates, and humans were subjected to magnetic fields of varying degrees shows that magnetic fields provoke biologic responses, which may be placed into four classes according to the mechanism or reaction that produces them. The first class consists of effects that seem to originate in some kind of sensory apparatus through which the organism can detect magnetic fields of the order of the geomagnetic field. The second class encompasses physiologic stress effects, which result from the many physical processes that occur in an organism subjected to a magnetic field. The third class encompasses all possible mutagenic effects of magnetic fields. The evidence for these is rather mixed, and the question of possible genetic effects is still open. The fourth class comprises magnetic effects that appear only in the presence of other physical parameters, such as, ionizing radiation, temperature, and oxygen tension. Even though knowledge on the biologic effects of magnetic fields seems to be inconclusive, a set of safety guidelines was recommended by the Stanford Linear Accelerator Center in 1970. For extended periods (hours), maximum exposures of 0.02 tesla for the whole body or head and 0.2 tesla for the arms and hands are recommended. For short exposure periods (minutes), a maximum exposure of 0.2 tesla for the whole body or head and 2 tesla for the arms and hands are recommended. These recommendations, which have found their way into the safety codes of many laboratories in the West, reflect the results of a survey of biomagnetic literature up to 1970. As no significant developments in the field have taken place since that time, the standards have remained unchanged.

5981 PAVLOVIAN CONDITIONING OF MICROWAVE-INDUCED HYPERTHERMIA IN THE RAT. *(Eng.)* Bermant, R. I. (Ph.D. dissertation, Univ. Kansas, 1977); 159 pp. (available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 78-12,023). (340 refs)

Experiments on Pavlovian conditioning of microwave-induced hyperthermia were performed to determine if a rise in core temperature is amenable to classical conditioning in a small mammal. A relatively pure hyperthermal response, presumably uncontaminated by a major emotional component, was produced by using microwave radiation (2,450 MHz) as an unconditional stimulus. A group of rats exposed to a noxious electric shock was also used so that comparisons could be made between the hyperthermia secondary to emotional arousal induced by an electric shock and the primary (non-emotional) hyperthermia induced by exposure to microwave radiation. Control animals were presented only with the conditional stimulus (30 sec of tone), thus providing a baseline against which the hyperthermal reactions of the experimental animals could be evaluated. An analysis of the data obtained from these experiments revealed that animals exposed to either microwave radiation or to the electrical shock developed generalized hyperthermal reactions that were triggered by the conditioning milieu. In contrast, control animals placed in the same environment, but in the absence of an unconditional stimulus, exhibited statistically reliable declines of colonic temperature. The conditional hyperthermia of the experimental animals proved highly resistant to extinction and persisted after 100 unreinforced presentations of the conditional stimulus. Taken as a whole, the data indicate that hyperthermia induced either by electrical shock or by exposure to microwave radiation is highly general and is highly resistant to extinction.

5982 ELF ELECTRIC AND MAGNETIC FIELD SIMULATION FOR A LABORATORY BIOLOGICAL EXPERIMENT. *(Eng.)* Gauger, J. R. (IIT Res. Inst., 10 West 35th St., Chicago, IL 60616). 59 pp.; 1978. [available through National Technical Information Service, Springfield, VA, Technical Report E6357-10]. (0 refs)

An extremely low frequency (ELF) electromagnetic field simulator, which operates at a center frequency of 76 Hz, is described. The simulator was designed and built in support of biologic tissue culture experiments performed at the Naval Medical Research Institute in Bethesda, Maryland. The simulator generates uniform electric and magnetic fields having the same characteristics as those produced by the Navy's proposed ELF communications system.

5983 CHARACTERIZATION OF A SMALL CHAMBER USED FOR EXPOSURE TO MICROWAVE RADIATION OF SMALL ANIMALS. *(Eng.)* Yeandle, S. S.; Bassen, H.; Thomas, J. R. (Naval Medical Res. Inst., Bethesda, MD 20014); 13 pp.; 1978. [available through National Technical Information Service, Springfield, VA, Report No. NMRI 78-17]. (5 refs)

A chamber for exposing rats to 2,450 MHz radiation in studies of microwave-induced behavioral effects is described. The irradiation chamber consists of a wooden frame upon which rectangular blocks of microwave absorber are placed. Reflection of 2,450 MHz radiation from the absorber is rated at 20 dB. For exposure to radiation the rat is placed in a sleeve of fine plastic netting, the ends of which are tied with string so that the rat can not move. The harness is hung from a wooden frame, and the frame is placed in the chamber so that the rat's head is lying along the boresight (axis of propagation) of a horn antenna placed at the mouth of the chamber. The horn is a standard gain type designed to be operated in the range of 2.6-3.95 GHz and is thus slightly mismatched to the 2.45 GHz radiation used in the behavior studies. The horn is fed by a pulsed microwave generator. Pulses of microwaves of variable repetition rate and pulse duration can be produced by switching on and off the supply voltage to a resonant cavity oscillator. The variation in the field in the absence of the rat over the space occupied by the rat's head is not very great (about 10%) even though the field over the entire rat's body varies greatly (as much as 50%). In the absence of the rat, standing waves, although noticeable, are not large. When the rat is present, because it is a conducting body of complicated shape, the field is distorted and large standing waves are set up in front of the rat.

5984 COMPILATION AND ASSESSMENT OF MICROWAVE BIOEFFECTS: A SELECTIVE REVIEW OF THE LITERATURE ON BIOLOGICAL EFFECTS OF MICROWAVES IN RELATION TO THE SATELLITE POWER SYSTEM. *(Eng.)* Justesen, D. R.; Ragan, H. A.; Rogers, L. E.; Guy, A. W.; Hjeresen, D. L.; Hinds, W. T. (Battelle Memorial Inst., Pacific Northwest Lab., Richland, WA 99352). 86 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. PNL-2634/UC-41]. (138 refs)

A review of the literature on the biologic effects of microwaves in relation to the proposed microwave satellite power system is presented. Experimental and epidemiological findings indicate that thresholds of relatively short-term radiation for morbid biologic effects (e.g., cataracts, heart disease, hematologic effects, immunologic disturbances, and genetic and developmental defects) are well above the maximal power density (1 mW/cm^2) that is tentatively projected at and beyond the area of exclusion of the receiving antenna for the 2,450-MHz continuous wave microwave satellite power system. However, no experimental study has ever been performed that even remotely approaches the 30 yr or more that the satellite power system would be operative. In addition, no data are available with respect to consequences for airborne species that may fly over the receiving antenna or for terrestrial or airborne species that may ascend or descend to the surface of the antenna, thereby incurring radiation at power densities that could exceed 20 mW/cm^2. Only intensive experimental study can reveal whether the satellite power system concept can be safely implemented.

5985 ELF ELECTRIC FIELD ANALYSIS FOR A LABORATORY BIOLOGICAL EXPERIMENT. *(Eng.)* Shiau, Y. (IIT Res. Inst., 10 West 35th St., Chicago, IL 60616). 71 pp.; 1978. [available through National Technical Information Service, Springfield, VA, Technical Rpt. E6357-9]. (8 refs)

An analysis of the electric field levels induced in individual tissue culture samples when exposed to uniform electric and magnetic fields in a laboratory simulator operating at a frequency of 76 Hz is presented in connection with the Navy's proposed Seafarer extremely low frequency (ELF) communications system. The following observations and conclusions are drawn from the study. The ELF magnetic field will penetrate the tissue cultures without change. As anticipated, the induced electric field internal to the biologic tissue in the tissue culture tray decreases as the permittivities of the tissue and its surrounding medium increases. The ELF electric field internal to the tissue sample will be much less than the applied field. For a single layer of trays, the reduction factor is about 6×10^7. The electric field coupling to the tissue also depends on the separation between the tissue culture tray and the upper and lower plates of the simulator. Maximum internal field strength is achieved when the parallel plates are placed right on and beneath the culture tray. Like the ELF electric field coupling to a single isolated biologic object, the coupling is stronger for objects having a more elongated geometric shape. The coupling is strong when the object exhibits a geometric shape somewhat like a long and thin circular cylinder. On the other hand, the coupling is small for a geometric shape. From the limited numeric results obtained in this study, it appears that the array spacing and the object size also affect the electric field coupling. However, the effect, which primarily arises from the variation in the effective permittivity of the tissue culture tray for different array spacing and object

size, is not significant at extremely low frequencies. Although sophisticated field theory was required to analyze the complex geometry used in this experiment, an adequate estimate of the field coupling can be obtained using a simple circuit model. This model also aids in the understanding of the coupling mechanism.

5986 REVIEW OF OCCUPATIONAL SAFETY AND HEALTH ASPECTS OF ELECTROMAGNETIC PULSE EXPOSURE. *(Eng.)* Bruner, A. (Lovelace Biomedical and Environmental Res. Inst., P.O. Box 5890, Albuquerque, NM 87115). 24 pp; 1977. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD A053394]. (17 refs)

Observations on the occupational safety and health aspects of exposure to electromagnetic pulse (EMP) simulators are reported. These simulators have been in operation in the United States since the early 1960's. Their mission involves the study of electromagnetic fields designed to simulate the intense electromagnetic transient that accompanies a nuclear explosion, which may involve field densities on the order of 10^5 V/m with nanosecond rise and fall times. Experience with EMP worker exposures has accumulated now for more than 20 pulser projects, some of which have been in operation for over 10 yr. To date, no adverse health effects of such exposure have been determined from either repeated physical examinations of personal observations of nearly 600 individuals exposed to EMP. Further, no reports by exposed employees of motivational-emotional changes (e.g., asthenic syndrome) have been ascribed to the EMP exposure environment per se, unlike the psychic complaints of microwave-exposed subjects often mentioned in the Soviet literature. Therefore, sufficient no-effect findings from both human and animal experiences seem to exist to allay fears of an EMP worker hazard, at least for within a 10-yr observational time frame.

5987 INTERACTION BETWEEN MICROWAVE AND NEUROACTIVE COMPOUNDS. *(Eng.)* Galloway, W. D.; Waxler, M. (Div. Biological Effects, Bureau Radiological Health, Rockville, MD). 8 pp.; 1977. [available through National Technical Information Service, Springfield, VA 22161, Document No. PB-272 906]. (19 refs)

Rhesus monkeys were exposed to microwaves and/or the serotonin depleter fenfluramine to determine if there is a neurotransmitter-linked mechanism of microwave action. The subjects had been exposed to various drug and microwave radiation regimes while performing a match-to-sample task prior to the onset of the described experiment. The experimental apparatus contained three acrylic plastic stimulus panels, which could be lighted either red or green. Below each stimulus panel was a response lever. For each trial, the center panel was lighted red or green, and a single response on the center lever turned off the center panel and simultaneously lighted the side panels, one red and one green. Correct matches on the side levers were reinforced on the average of once a minute. Each subject was exposed to continuous wave, 2,450-MHz microwave radiation at dose rates of 1, 3, 5, 10, and 15 W. Each subject was also injected intramuscularly with various doses of fenfluramine. For each subject, the highest dose of fenfluramine that did not produce a change from non-drug baseline behavior was administered in combination with an integral microwave dose rate of 15 W. For each session, eight behavioral measures were calculated: percent correct red and green matches, percent responses on the red choice key, percent responses on the right-side key, and response rates of correct and incorrect red and green key responses. A dose of fenfluramine was found for each subject that resulted in a decrease in response accuracy and in decreased response rates. The minimum effective dose ranged from 0.2-4.0 mg/kg. Integral dose rates of 1-15 W of microwave radiation produced no change in the behavior of any subject. The combination of fenfluramine and an integral dose rate of 15 W, however, produced a severe disruption in the behavior of three of four subjects. Despite the fact that no microwave threshold dose was found, the combination of microwaves and fenfluramine resulted in a substantial behavioral deficit. These findings suggest that microwaves interact with monaminergic processes in the brain.

5988 EFFORTS BY THE ENVIRONMENTAL PROTECTION AGENCY TO PROTECT THE PUBLIC FROM ENVIRONMENTAL NONIONIZING RADIATION EXPOSURES. *(Eng.)* United States General Accounting Office (Washington, DC). 15 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. PB-279 483]. (1 ref)

Efforts by the EPA to protect the public from nonionizing radiation exposures are reviewed. Currently, there is no official public health standard for exposure to environmental nonionizing radiation sources. According to the EPA, research programs to detect and evaluate biologic effects of nonionizing radiation have not yet generated a sufficient data base on which quantitatively and scientifically sound radiation protection standards can be established for microwaves and other nonionizing frequencies. The EPA plans to decide on the need for protection standards in March 1978, developing Federal guidance by April 1979, if determined necessary. The EPA is currently obtaining data on environmental levels of radio frequency and microwave radiation in urban areas. As of February 1978, EPA had collected measurements in 11 metropolitan areas and will continue similar studies in Denver, Los Angeles, San Francisco, and Seattle during the next 18 mo. The highest levels measured were about 150 $\mu W/cm^2$. According to EPA officials, the overall median exposure levels measured in urban areas were quite low (less than 1 $\mu W/cm^2$). About 98-99% of the population would appear to be exposed to levels meeting even the very strict Soviet standard. However, 1 or 2% of the general population may be exposed to

higher levels. For example, EPA measurements approached 2,000 $\mu W/cm^2$ at the base of a frequency-modulated (FM) radio station antenna on Mount Wilson, California. Measurements in excess of 180,000 $\mu W/cm^2$ were found on the FM tower itself, thus creating concern for workers who need to climb such towers. In addition to its measurement program, EPA research facilities at Research Triangle Park are developing health effects data to investigate the possible low-level effects findings of the Soviet Union. Preliminary results indicate that such exposures may affect the immune system, create anomalies in mouse litters, and produce a trend toward lowered behavioral performance.

5989 DEWAR CALORIMETRY TECHNIQUE FOR DETERMINING SPECIFIC ABSORBED POWER OF RODENTS IN RADIOFREQUENCY FIELDS. *(Eng.)* Hurt, W. D. (USAF Sch. Aerospace Medicine, Aerospace Medical Div., Brooks Air Force Base, TX 78235). 15 pp.; 1977. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD A054155]. (2 refs)

A Dewar calorimetric technique for determining specific absorbed power in rodents exposed to radio frequency (RF) fields is described. The main component of the Dewar calorimeter is a vacuum flask containing a measured amount of water. A simple mathematic relationship is used to calculate the thermal dose from the RF exposure using the initial and final average temperature of the irradiated sample. The average energy absorbed by the sample is computed from the average temperature of the sample immediately before and after the exposure and from the composite specific heat and the mass of the sample. The average rate of energy absorption can be calculated from the average energy absorbed by the sample by dividing the latter value by the exposure duration as long as the temperature change is linearly proportional to the exposure time. Up to three specific absorbed power determinations were made for each of 18 positions used in a study of mice exposed to 2.6 GHz radiation. The results of free field measurements indicated that the mice absorbed 1.15 W/kg per 1 mW/cm^2. This factor, when applied to the specific absorbed power data, allowed a comparison of free field measurements with effective power density values. The average of seven inner readings for the free field was only 5% higher than the average of 11 periphery readings. However, for the specific absorbed power measurements, the seven inner readings were 12% higher than those on the periphery, probably as a result of the increase in field resulting from more predominant scatter toward the center than on the edges. These measurements demonstrate the usefulness of the Dewar calorimetry technique in determining absorbed power from microwave fields. The basic system provides a relatively inexpensive method for determining absorbed power in rodents.

5990 THE BIOLOGICAL ACTIVITY OF THE DISTURBED GEOMAGNETIC FIELD. *(Eng.)* Muzalevskaya, N. I. *In: Effects of Solar Activity on the Earth's Atmosphere and Biosphere.* Hardin, H., ed. (Jerusalem: Keter Publishing House Jerusalem Ltd.). Ltd.): pp. 128-137; 1977. (17 refs)

A theoretic analysis of the biologic activity of disturbed geomagnetic fields is presented. It is shown that the energy density and the power flux density of the geomagnetic field (GMF) at the time of a disturbance generally exceeds the sensitivity threshold of the human organism, expressed in the corresponding units. On the basis of a comparison of the parameters of the threshold sensitivity and the disturbed GMF, and proceeding from the general principles of reception, it is shown in principle that an interaction between the human organism and the magnetic field of the earth is possible. The position of the GMF was determined on a common scale of the energy parameters of the ecologic factors, and the character of the reaction and the interaction of the GMF with the organism were investigated at the structural level from the standpoint of theoretic biology. It was demonstrated that the first half of the phase of excitation of biologic structures corresponds, on the indicated energy scale, to the position of the parameters of the disturbed GMF. Special features of the GMF that were noted in terms of possibly strengthening the biologic effect included a power flux exceeding the level corresponding to the threshold sensitivity for a long time and abrupt jumps of energy and flux in the case of storms with sudden onsets.

5991 SOLAR ACTIVITY AND CARDIOVASCULAR DISEASES. *(Eng.)* Novikova, K. F. (Sverdlovsk Medical Inst., Sverdlovsk, USSR); Ryvkin, B. A. *In: Effects of Solar Activity on the Earth's Atmosphere and Biosphere.* Hardin, H., ed. (Jerusalem: Keter Publishing House Jerusalem Ltd.): pp. 184-200; 1977. (34 refs)

A comparison of the frequency of cardiovascular disorders with some elements of solar activity and magnetospheric processes was conducted for several Soviet cities that are geographically far apart. The studies showed that there is an influence of heliogeophysical factors on the origin, course, and outcome of cardiovascular diseases. The percentage of myocardial infarction, morbidity and mortality, the frequency of hypertonic crises, attacks of stenocardia, cerebral insults, and mortality due to them were significantly higher on magnetically active days than on magnetically quiet days. With an increasing intensity of geomagnetic disturbances, the frequency of various cardiovascular disorders increased. The rates of incidence and mortality of cardiovascular diseases increased on days of magnetic storms and on the next 2 days thereafter, with a maximum occurring in the first 24 hr after the onset of

the magnetic storm. There was a tendency for cardiovascular disorders to arise on certain days of the 27-day calendar, which may indicate a solar origin of such a recurrence. The dynamics of cardiovascular disorders shows an 11-yr cycle, although to some extent this is concealed by the efficacy of modern treatment. In studying the influence of solar activity on the appearance of pathologic reactions in cardiovascular diseases, it is suggested that the gradient and tempo of variation in solar activity must be considered in addition to deviations from average values.

5992 SUDDEN DEATH FROM CARDIOVASCULAR DISEASES AND SOLAR ACTIVITY. *(Eng.)* Gnevyshev, M. N.; Novikova, K. F.; Ol', A. I.; Tokareva, N. V. (Main Astronomical Observatory, USSR Acad. Science, Moscow, USSR). *In: Effects of Solar Activity on the Earth's Atmosphere and Biosphere.* Hardin, H., ed. (Jerusalem: Keter Publishing House Jerusalem Ltd.): pp. 201-210; 1977. (21 refs)

Data are presented correlating sudden death from cardiovascular diseases with solar activity and geomagnetic disturbances. An analysis of deaths from cardiovascular diseases in the city of Sverdlovsk during two 11-yr solar cycles (1944-1967) reveals a positive correlation between the frequency of such deaths and increased solar activity. Moreover, during the years 1961-1963, a marked peak in the curve for geoeffectiveness index was observed; this period was also marked by increased mortality due to cerebral insults (hemorrhages, thromboses), indicating the possibility of a joint action of some solar agent on both cardiac and cerebral deaths. The frequency of sudden deaths from cardiovascular diseases in Sverdlovsk was also correlated with geomagnetic disturbances for magnetic storms with gradual onset during the period 1955-1965. A correlation was also found between the dynamics of sudden cardiac death in Sverdlovsk and the total duration of bead type geomagnetic field oscillations. Active longitudes, where both the indexes of geomagnetic disturbance level and the number of sudden cardiac deaths were high, were observed along with a relationship between these phenomena. An analysis of clinical observations indicated that in periods of intensified geomagnetic activity, cases of sudden death were 2.7 times more frequent than in magnetically quiet periods. The largest number of sudden deaths occurred within the first 24 hr after the onset of a magnetic storm; however, the number of sudden deaths was also increased on the day when the storm was building up.

5993 TREATMENT OF SOME DISEASES WITH WEAK MAGNETIC FIELDS. *(Eng.)* Novak, J. (First Dermatology Clinic, Charles Univ., Prague, Czechoslovakia). *In: Effects of Solar Activity on the Earth's Atmosphere and Biosphere.* Hardin, H., ed. (Jerusalem: Keter Publishing House Jerusalem Ltd.): pp. 229-231; 1977. (1 ref)

The effect of weak electromagnetic fields on humans is investigated to determine whether such fields can be utilized for treating various diseases associated with nervous disorders. In some experiments a sheet metal cubicle (modified Faraday cell) with a 34-coil solenoid mounted inside it was used. The intensity of the direct current was 1-2 mA, which created a magnetic field of 40-80 gammas. In other experiments, a steel mesh helmet with a five-coil solenoid inside it was used. A current intensity of 1 mA was generated, which created a magnetic field of 280-480 gammas. The treatment consisted of leaving the patient in the cubicle for 90 min once a day for 10 days. An effect was already apparent after 5 days, and maximum results were obtained 2 wk after the end of treatment. The effect of the treatment usually lasted for 3-6 mo, and in a number of cases longer. If a relapse occurred, the treatment was repeated. In controlled experiments involving a total of 141 patients with diagnoses of urticarial fever, other allergic dermatoses, skin edema, photodermatoses, bronchial asthma, neuralgia, epilepsy, and stenocardia, cures were obtained in 41 patients, considerable improvement in 50 patients, improvement in 27 patients, and no change in 23 patients. The experiments show that weak magnetic fields of the same magnitude as those naturally occurring on the earth under the influence of solar corpuscles probably have an effect on meteolabile persons.

5994 THE MECHANISM OF THE INFLUENCE OF SOLAR-ACTIVITY OSCILLATIONS ON THE HUMAN ORGANISM. *(Eng.)* Osipov, A. I.; Desyatov, V. P. (Tomsk Medical Inst., Tomsk, USSR). *In: Effects of Solar Activity on the Earth's Atmosphere and Biosphere.* Hardin, H., ed. (Jerusalem: Keter Publishing House Jerusalem Ltd.): pp. 232-237; 1977. (5 refs)

Studies on the influence of solar activity and magnetic fields on the human organism are reviewed. At the Institute of Higher Nervous Activity and Neurophysiology of the USSR Academy of Sciences, it was demonstrated that magnetic fields can inhibit the formation of conditioned reflexes. All divisions of the brain react to artificial magnetic fields, but the cortex and hypothalamus are the most responsive. A comparison of cases of sudden death from cardiovascular diseases with sharp oscillations of the geomagnetic field (magnetic storms) over the period July 1958 to 1966 revealed that on the average there were 0.33 cases of death on the day of a magnetic storm and on the first day after, while there were only 0.22 cases of sudden death on magnetically quiet days. When the influence of domestic factors on the results was eliminated, the average mortality on days with magnetic storms was almost twice as high as on quiet days; the statistical difference was significant at the 0.1% level. Studies on automobile accidents between the years 1958 and 1964 indicated that the number of such accidents was almost four times as high on the first day after a solar flare as on quiet days. This difference was statistically significant on the day of the flare (0.1% level) and on the two following days (0.1% and 5% levels, respectively).

5995 SOLAR ACTIVITY AS A WEIGHTY FACTOR IN ROAD ACCIDENTS. *(Eng.)* Masamura, S. (Div. Culture and National Education, Nagoya, Japan). *In: Effects of Solar Activity on the Earth's Atmosphere and Biosphere.* Hardin, H., ed. (Jerusalem: Keter Publishing House Jerusalem Ltd.): pp. 238-240; 1977. (0 refs)

The incidence of road accidents in Japanese cities is compared with solar activity over various time spans to determine if there is a correlation. When the number of road accidents in Tokyo and in Japan as a whole from 1943 to 1965 was compared with the Wolf number variation in solar activity during the same years, good agreement was seen between the curves for these parameters. When the number of road accidents in 10 Japanese cities between July 1 to July 15, 1966 was examined (a solar flare was observed on July 7), it was found that there was a substantial increase in road accidents during this period. The number of accidents rose immediately after the flare and also coincided with an increase in the sunspot area, both in the central zone and on the entire disk. An examination of individual cases of increases in the number of road accidents shows that they often coincide with magnetic storms, another manifestation of solar activity. It is suggested that the correlation between solar activity and road accident frequency derives from the influence of oscillations of the geomagnetic field on the human nervous system.

5996 THE DISTURBANCE LEVEL OF THE GEOMAGNETIC FIELD AND THE MOTOR ACTIVITY OF INSECTS. *(Eng.)* Chernyshev, V. B. (Dept. Entomology, Moscow State Univ., Moscow, USSR). *In: Effects of Solar Activity on the Earth's Atmosphere and Biosphere.* Hardin, H., ed. (Jerusalem: Keter Publishing House Jerusalem Ltd.): pp. 247-258; 1977. (12 refs)

Observations of the flight of different insects toward light and multidiurnal recordings of the motor activity of one species of beetle in the laboratory are analyzed to determine if a correlation exists between solar activity and insect behavior. An analysis of the correlation between the number of insects caught in a light trap during a given night and the characteristics of the magnetic activity for that day was performed for five randomly chosen geographic locations. A correlation between the number of insects caught in one night and the diurnal characteristics of geomagnetic activity was detected for all but one of the locations. The significance of the correlation always increased when meteorologic factors were also taken into account. In no case was there a correlation with magnetic disturbance level in the course of the collection night alone; rather, nocturnal flight was always affected by disturbances of the geomagnetic field occurring earlier in the day. Multidiurnal recordings of the motor activity of the Khapra beetle, *Trogoderma glabrum herbst*, were made in the laboratory to study the correlation of rhythmic indexes with five-point magnetic characteristics of certain days and with ten-point relative magnetic characteristics for the periods 18:00-21:00 hr, 21:00-24:00 hr, and 00:00-03:00 hr, Moscow time. The laboratory observations confirmed the correlation observed between insect motor activity and disturbance levels in the geomagnetic field.

5997 AN EXPERIMENTAL STUDY OF THE EFFECT OF ULTRALOW-FREQUENCY ELECTROMAGNETIC FIELDS ON WARMBLOODED ANIMALS AND MICROORGANISMS. *(Eng.)* Vladimirskii, B. M.; Volynskii, A. M.; Vinogradov, S. A.; Brodovskaya, Z. I.; Temur'yants, N. A.; Achkasova, Y. N.; *et al. In: Effects of Solar Activity on the Earth's Atmosphere and Biosphere.* Hardin, H., ed. (Jerusalem: Keter Publishing House Jerusalem Ltd.): pp. 259-269; 1977. (13 refs)

The effect of ultra-low-frequency electromagnetic fields on rabbits and dogs as well as on various types of microorganisms was studied. Alternating electromagnetic fields (AEF) in the frequency range from 0.1-8 Hz at low field strengths proved to be biologically active. In all of the animals investigated, there was a change in the systolic rhythm as well as in bioelectric phenomena in the heart characterizing changes in the system producing excitation in the heart. Dynamic changes occurred in the electrical activity of the cortex, and distinctive dynamic changes occurred in the blood. Under the influence of AEF, peroxidase was found to be inactivated, with the degree of enzyme inactivation depending on the field strength. The effect of inactivation was observed at field strengths close to those under natural conditions during violent magnetic storms. Anatomopathologic examinations revealed some destructive changes in the heart and lung tissues. Microorganisms were found to react to AEF by more intensive multiplication and by nonhereditary changes of morphological and cultural properties. The above results may be considered as experimental confirmation of the hypothesis concerning the ecologic role of natural AEF controlled by solar activity.

5998 SURVEY OF MICROWAVE AND RADIOFREQUENCY BIOLOGICAL EFFECTS AND MECHANISMS. *(Eng.)* Cleary, S. F. *In: The Physical Basis of Electromagnetic Interactions with Biological Systems: Proceedings of a Workshop held at Univ. Maryland, College Park, MD, June 15-17, 1977.* Sponsored by Office of Naval Res., Naval Medical Res. & Development Command, BRH, FDA (available through NTIS, Springfield, VA 22161, Document No. AD A051218): pp. 1-33, 1978. (72 refs)

Selected literature on the neuroendocrinologic, hematopoletic, and neural effects of microwave radiation is reviewed, with special emphasis on effects reported at intensities of 10 mW/cm^2 or less. The weight of scientific evidence that has accumulated during the past few years lends credence to the hypothesis that low intensity microwave and radio frequency fields can in some cases result in physiologic and psychologic al-