0532 MECHANISMS OF ELECTROCHEMICAL TRANSDUCTION AT CELL MEMBRANE SURFACES. Adey, W. R.; Sheppard, A. R.; Sagan, P. M.; LinLiu, S. (Dept. Medicine and Surgery, U.S. VA, 11201 Benton St., Loma Linda, CA 92357).

The nature of low frequency nonionizing radiation interactions with cell surface membranes will be investigated. The research program will include the study of 1) the molecular biology of cell membrane surfaces and macromolecular mechanisms in weak electric field transduction; 2) the microphysiology of cell responses to nonionizing electromagnetic (EM) field exposure, performed with special tissue preparations (avian cerebral hemisphere, hippocampal slices, and invertebrate ganglion cells); 3) the biochemistry of low frequency field interactions with cultured osteoblast and osteoclast cell lines; 4) the effects of radio frequency (RF) fields modulated at low frequencies on calcium uptake by red blood cells in stored human blood; 5) the effects of modulated RF and microwave fields on behavior and biochemistry in chicks, rats, and monkeys, with observations on free behavior, learned behavior, and on diurnal biologic rhythms; and 6) the development and testing of quantum mechanical models of long-range interactions between charge sites on tissue macromolecules suspected of participation in transductive coupling of weak EM fields. Previous studies have shown the "cooperative" nature of these interactions, based on nonequilibrium processes with resonant molecular interactions at cell membrane surfaces. These studies suggest an unknown means of cell-to-cell communication in brain tissue. There is also strong evidence that these long-range macromolecular interactions occur in immunologic and endocrinologic events at cell membrane surfaces. Radio frequency EM fields within carefully defined "windows" of incident energy and modulation frequencies, which may optimize therapeutic applications (including bone regeneration, immunotherapy, and tumor therapy), will be imposed. (funding period n/a)

Supporting Agency:U.S. VA, Dept. Medicine & Surgery

0533 SUBMINIATURE IMPLANTABLE ELECTRIC FIELD PROBES FOR MICROWAVE DOSIMETRY IN BIOLOGICAL SYSTEMS. Batchman, T. E.; Mattauch, R. J. (Dept. Electrical Engineering, Sch. Engineering & Applied Science, Univ. Virginia, Charlottesville, VA 22903).

The University of Virginia, the Georgia Institute of Technology, and the BRH are cooperating in a program to produce in vivo electric field measurements from continuous wave and low frequency modulated electromagnetic radiation at frequencies of 100 MHz to 3 GHz. An analysis of insulated subminiature dipole probes is being conducted at Georgia Institute of Technology, using dipole probes designed by the University of Virginia Semiconductor Devices Laboratory and the BRH and calibrated and evaluated at the BRH. The probes will then be used for in vivo measurements by research groups working on the electromagnetic field biologic effects with the BRH. Research into the problems associated with the use of a smaller field probe than that which is currently available is being performed to measure the in vivo electric field produced by microwave radiation. This involves the optimization of the probe, the diode parameters, and the microtechnology needed to produce a single axis probe. (funding period 2/79-7/81).

Supporting Agency:NSF, Div. Engineering

0534 ELECTROMAGNETIC STIMULATION OF BONE GRAFTS. Enneking, W. F.; Miller, G. J.; Burchardt, H. (Dept. Orthopedics, Sch. Medicine, Univ. Florida, 1600 Archer Rd., Gainesville, FL 32610).

The effects of electromagnetic (EM) stimulation on experimental autogenous bone grafting will be evaluated using a canine fibular segment cortical bone graft model. The stimulation will be applied for either 2 or 6 mo to determine if stimulation can reduce the time for initial graft stabilization and/or enhance the subsequent remodeling and consolidation of autograft material. The use of homotypic (right-left) fibulae will provide an experimental graft and internal control graft within the same animal. Quantitative information will be obtained using previously developed histologic and biomechanical techniques. This information, coupled with biweekly roentgenography, will allow for statistical comparisons and evaluation of the efficacy of electromagnetic stimulation for enhancement of autogenous bone graft incorporation. (funding period 4/79-3/80)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Arthritis, Metabolism, & Digestive Diseases

0535 NONTHERMAL EFFECTS OF MICROWAVES ON LIVING TISSUE. Ghandhi, O. P.; Hill, D. W.; Partlow, L. M.; Stensaas, L. J.; Hagmann, M. J. (Dept. Electrical Engineering, Sch. Engineering, Univ. Utah, 1400 E. 2nd St., Salt Lake City, UT 84112).

Experiments are in progress to determine if microwave spectroscopy can be used as a diagnostic tool in cancer screening. Previous studies have suggested that significant differences may exist in the microwave absorption spectra of normal and malignant cells. In addition, other evidence indicates that microwave resonance radiation may be useful in cancer therapy. Presently, the absorption spectra in the 26.5-90 GHz range are being determined for biologic compounds (e.g., water, proteins, DNA, RNA, etc.), biologic solutions (e.g., *minimum* essential media, saline, Luria broth, etc.), and cell suspensions (e.g., red blood cells, bacteria, yeast, fungi, viral suspensions, normal and transformed mammalian cells, etc.). The mammalian cell studies

include: (a) B16 murine melanoma and transformed BHK 21/C13 cells, (b) two lines of normal and transformed cells bearing temperature-sensitive viruses, and (c) three different systems in which normal cells can be compared with virus-transformed cells, isolated spontaneous transformants, and drug-induced transformants. Experiments are also being conducted to determine whether significant differences in sensitivity to microwave irradiation exist between normal and transformed cells. These studies are being carried out using a recently developed procedure that allows the direct irradiation of cells in culture without local heating. In this experiment, the effect of microwave irradiation will be studied on cell growth and on the morphology of several cloned cell lines and primary cell cultures (using both light and electron microscopy). In addition, biochemical parameters, such as RNA and protein synthesis, will be analyzed. The results will indicate the extent to which frequency-specific athermal microwave irradiation can be used as a possible form of cancer therapy. (funding period 9/77-8/79)

Supporting Agency:HEW, PHS, NIH, Natl. Cancer Inst.

0536 HYPERTHERMIA--A DIFFERENTIAL RADIOSENSITIZER IN VIVO. Gibbs, F. A.; Dethlefsen, L. A.; Durney, C. H.; Henle, K. (Dept. Radiology, Sch. Medicine, Univ. Utah, 1400 E. 2nd St., Salt Lake City, UT 84112).

A murine model is being used to study the effect of heat in conjunction with x-ray on the jejunum (crypt colony assay and $LD_{50}/6$), on spinal cord myelitis, and on two transplantable mammary tumors. Microwave heating is being used where feasible. The standard treatment for all assays consists of 15-min of heating at 44 C followed in 5 min by x-ray irradiation. Thermal enhancement ratios will be determined and therapeutic gain factors will be calculated. (funding period 5/77-4/80).

Supporting Agency:HEW, PHS, NIH, Natl. Cancer Inst.

0537 MICROWAVE HYPERTHERMIA SYSTEMS FOR CANCER TREATMENT. Cheung, A. Y.; Taylor, L. S.; Scott, R.; Robinson, J. E.; Harrison, G. H. (Div. Radiation Therapy, Sch. Medicine, Baltimore Professional Sch., Univ. Maryland, 1420 N. Charles St., Baltimore, MD 21201).

See Current Research 0513 for description of this research. (funding period 9/78-7/80)

Supporting Agency:HEW, PHS, NIH, Natl. Cancer Inst.

0538 HYPERTHERMIA PRODUCTION AND MEASUREMENT. Christensen, D. A.; Durney, C. H.; Iskander, M. F.; Plenk, H. P.; Gibbs, F.; Gehmlich, D. K. (Dept. Electrical Engineering, Sch. Engineering, Univ. Utah, 1400 E. 2nd St., Salt Lake City, UT 84112).

See Current Research 0454 for description of this research. (funding period 9/78-8/80)

Supporting Agency:HEW, PHS, NIH, Natl. Cancer Inst.

0539 X-RAY AND MICROWAVE HYPERTHERMIA FOR CANCER TREATMENT. Robinson, J. E.; Cheung, A. Y.; Samaras, G. M.; Harrison, G. H.; Sjodin, R. S. (Dept. Radiology, Sch. Medicine, Baltimore Professional Sch., Univ. Maryland, 1420 N. Charles St., Baltimore, MD 21201).

See Current Research 0459 for description of this research. (funding period 9/78-8/80)

Supporting Agency:HEW, PHS, NIH, Natl. Cancer Inst.

0540 DETECTION AND DELINEATION OF SOFT-TISSUE TUMORS. Gregg, E. C. (Dept. Radiology, Sch. Medicine, Case Western Reserve Univ., 2109 Adelbert Rd., Cleveland, OH 44106).

The potential of 10 GHz microwave beams to detect and delineate soft tissue tumors will be investigated. Since microwave absorption in muscle tissue is 10 times greater than that in fat, a tomographic image, computed from the transmission of a beam of microwaves scanned in a planar EMI-type raster through a body section, may be able to easily distinguish fatty tissue from muscle with resolutions on the order of 1.0 cm. This approach will be particularly useful for detecting breast tumors, which are primarily muscle-like tissues in a fatty parenchyma. Tumors in other organs may also be more easily detected by microwaves than by the current techniques. The dielectric constants and attenuation coefficients of several tissue and tissue-like materials, as well as the coefficients at some air-tissue interface, have already been measured. For this project, the microwave absorption of a variety of normal and abnormal tissues will be measured, a simple laboratory microwave computed tomographic scanner will be designed and constructed, and the feasibility of the system will be established by evaluating images of planar sections of the breast (in vivo) and other organs. (funding period 1/76-6/80)

Supporting Agency:American Cancer Society, Inc.

0541 EFFECTS OF MICROWAVE EXPOSURE ON IMMUNE DEFENSE MECHANISMS. Liddle, C. G. (Developmental Biology Branch, Experimental Biology Div., EPA, Durham, NC 27111).

The effects of low-level microwave exposure on immunologic responses in laboratory animals will be examined in mice that have been immunized against Type III *Streptococcus pneumoniae* and then exposed to 9 GHz pulsed microwaves for 2 hr/day for 5 days. Three groups of approximately 24 mice with appropriate controls have been irradiated at an incident power density of 10 mW/cm^2. The circulating antibody response was measured the day after the last exposure. All three groups showed an

increased antibody response among the irradiated animals. Composite results showed an average titer of 7.89 ± 1.39 for the irradiates versus 7.47 ± 1.31 for the controls ($p<0.05$). Titers are exposed as the reciprocal power to the base 2, i.e., 1 over 2x. Hematology results are presently being analyzed. The results should give an indication as to whether low-level microwaves alter the immunologic competence of laboratory animals as suggested by Eastern European and Soviet research. If an alteration is found, further investigation will be conducted to try and determine the lowest exposure level that produces an effect. (funding period n/a)

Supporting Agency:EPA, Office Res. & Development, Health Effects Res. Lab.

0542 MICROWAVE-INDUCED DAMAGE IN THE MAMMALIAN BRAIN. Catravas, G. N.; Takenaga, J. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, U.S. Dept. Defense, Bethesda, MD 20014).

See Current Research 0487 for description of this research. (funding period 10/76-9/80)

Supporting Agency:U.S. Dept. Defense, Defense Nuclear Agency, Armed Forces Radiobiology Res. Inst.

0543 ELECTROMAGNETIC RADIATION EFFECTS ON BRAIN TISSUE PERMEABILITY. Oscar, K. (Mobility Equipment Res. & Development Command, U.S. Dept. Defense, Army, Fort Belvoir, VA 22060).

See Current Research 0336 for description of this research. (funding period n/a)

Supporting Agency:U.S. Dept. Defense: Army, Mobility Equipment Res. & Development Command

0544 MICROWAVE INDUCED RESTING POTENTIAL SHIFTS IN CHARA. Pickard, W. F.; Rosenbaum, F. J. (Dept. Electrical Engineering, Sch. Engineering & Applied Science, Washington Univ., 4559 Scott Ave., Saint Louis, MO 63130).

This research is being conducted to determine if an immediate nonthermal consequence of electromagnetic irradiation of a cell is a shift of its resting potential. Specifically, the response of the vacuolar resting potential of *Chara braunii* to rectangular pulses of irradiation with carrier frequencies in the range of 0.2 MHz to 8.2 GHz will be examined using standard micropipette techniques. Shifts of less than 1 μV will be identified with the aid of digital signal averaging. Since the thermal time constants of a practical apparatus are much longer than the anticipated electrical time constants of the cell, the thermal effects will be separated from the nonthermal effects on the basis of the response time of the cell to the pulse of irradiation. (funding period 11/78-4/81)

Supporting Agency:NSF, Div. Engineering

0545 RADIATION THERAPY ONCOLOGY GROUP. Plenk, H. P. (Radiation Center, Latter Day Saints Hosp., 325 8th Ave., Salt Lake City, UT 84103).

A variety of radiation therapy oncology group protocols will be used to develop improved radiation therapy techniques for different types of cancer. A new endometrial carcinoma protocol is proposed. Instrumentation to improve heating by microwaves is being developed, and thermometry of hyperthermia and radiation will be combined to improve the results of radiation therapy in advanced lesions. Specifically, the equipment and measurements with a 434-MHz applicator will be developed. Newly developed solid state probes to measure heat in depth within microwave fields will also be tested. (funding period 4/78-3/80)

Supporting Agency:HEW, PHS, NIH, Natl. Cancer Inst.

0546 PROBES OF EM/RADIATION HAZARD MEASUREMENT. Ries, F. X. (NBS, Dept. Commerce, 325 S. Broadway, Boulder, CO 80302).

The required standards, instrumentation, and measurement techniques to reliably probe the electromagnetic (EM) environment will be developed. Probes sensitive to selected frequencies and to total energy of environment, responsive to simple and complicated waveforms, and having isotropic and directional properties will be developed. The probes are limited by design constraints so that optimizing their function for one application limits their use in another. Therefore, a number of optimum designs will be developed for selected applications. Methods for evaluating probe designs will be established. Accomplishments to date include the adaptation of the loaded dipole technique to the TEM horn and the modification of the E-field resistive loaded dipole to make frequency selective E-field measurements from 10 MHz to 1 GHz. (funding period n/a)

Supporting Agency:U.S. Dept. Commerce, NBS

0547 INTENSIVE TREATMENT OF RETINOBLASTOMA. Schipper, J.; Lagendijk, J. J.; Tan, K. E.; Rutgers, D. H. (Dept. Radiotherapy, Academic Hosp., Catharijnesingel 101, Utrecht, Netherlands).

This project is devoted to improving the results of the conservative treatment of retinoblastoma by optimization and improvement of the irradiation techniques used with radiotherapy. An accurate megavoltage irradiation technique for retinoblastoma has been developed. The results obtained with conservative treatment of retinoblastoma by this technique in combination (if necessary) with light coagulation

or cryotherapy are being evaluated. An accurate irradiation technique for local treatment of retinoblastoma, using 10 meV electrons, will be developed. The treatment of retinoblastoma with radiotherapy combined with hyperthermia will involve 1) the development of a heating technique with microwaves for local hyperthermia of the posterior half of the affected eye, 2) the development of a technique to determine the temperatures in and around the eye without disturbing the microwave field and the heat distribution, 3) the measurement of temperature distributions in the rabbit eye with or without microwave heating and the correlation of the results with a mathematical model of the heat distribution, 4) the study of the damage in the rabbit eye after radiotherapy combined with (or without) microwave hyperthermia, 5) the study of the effect of radiotherapy combined with or without microwave hyperthermia on retinoblastoma implanted in the anterior chamber of the eye of nude mice, and 6) the study of the effect of radiotherapy combined with hyperthermia on the cell kinetics of the retinoblastoma model, with help of flow cytofluorometry. (funding period 0/79-1/82)

Supporting Agency:Koningin Wilhelmina Fonds

0548 RELATIONSHIP OF EXPOSURE TO RADIOFREQUENCY ENERGY AND SELECTED REPRODUCTIVE AND HEALTH FACTORS. Stellman, J. (Occupational Health & Toxicology Div., American Health Foundation, Inc., 1370 Avenue of the Americas, New York, NY 10019).

The association between low level exposure of fathers to radio frequency energy and the incidence of birth defects, particularly clubfoot, among their offspring will be investigated. In addition, the relationship of such exposure to fertility, pregnancy outcome among their wives, and the incidence of illnesses and symptoms will be assessed. The mailing list of the American Physical Therapy Association has been obtained and the survey questionnaire and study protocol have been finalized. The pretest was conducted in February 1978. The retrospective mail survey of 5,200 male physical therapists, with and without (controls) occupational exposure to radio waves, is being conducted. Data on exposure, work history, family, and reproductive and medical histories will be collected. (funding period n/a)

Supporting Agency:HEW, PHS, FDA, BRH

0549 ENGINEERING STUDY OF ELECTROMAGNETIC FIELD DISTRIBUTIONS IN LARGE ORGANS. Toler, J. C. (Engineering Experiment Station, Georgia Inst. Technology, 225 North Ave., N.W., Atlanta, GA 30332).

Engineering methods and data necessary to understand the basic interaction that exists when arbitrarily-shaped organs of heterogeneous composition are exposed to electromagnetic (EM) waves will be developed. Fourteen separate but inter-related tasks providing methods and data will be studied. The research is focused on the influence of optimum frequency assignment, dosimetry, and accurate temperature and phase states. The results will be applied to develop a generalized set of definitions and mathematic models of the internal EM wave distributions during exposure of large organs to EM fields. This knowledge may be useful for thawing and for application to other large organs. (funding period 9/76-8/81)

Supporting Agency:NSF, Div. Engineering

0550 CANCER THERAPY WITH LOCAL MICROWAVE-INDUCED HYPERTHERMIA. Anonymous. (Sch. Medicine, Dartmouth Coll., P.O. Box 833, Hanover, NH 03755).

No descriptive information is available. (funding period 0/78-n/a)

Supporting Agency:Whitaker Foundation

0551 STUDY OF BIOLOGICAL AND ECOLOGICAL EFFECTS OF ENERGY TRANSMISSION BY MICROWAVES ON INSECT BEHAVIOR. Gary, N. E. (Sch. Agriculture, Environmental Science, and Etomology, Univ. California, Davis, CA 95616).

No descriptive information is available. (funding period n/a)

Supporting Agency:U.S. Natl. Aeronautics & Space Admin., Office Organization & Management, Office University Affairs

0552 R.F. THERAPY FOR MALIGNANT TUMORS. LeVeen, H. H. (Surgical Service, Dept. Medicine and Surgery, U.S. VA, 800 Poly Place, Brooklyn, NY 11209).

No descriptive information is available. (funding period 3/79-n/a)

Supporting Agency:U.S. VA, Dept. Medicine & Surgery

6278 FROM ACADEMY REPORTS: PAVE PAWS RADAR FIELDS AND EXPOSURES. *(Eng.)* Anonymous. (No affiliation given). *Natl Acad Sci News Rep* 29(7): 8-9; 1979. (2 refs)

Potential exposures and biologic effects resulting from a phased-array radar warning system (PAWS) being developed by the United States Air Force (PAVE unit) are discussed. The PAWS radar may be anticipated to expose a limited number of members of the general public intermittently to low intensities of pulse-modulated microwave fields with maximal instantaneous intensities of 100 $\mu W/cm^2$ or less and time-averaged intensities lower by two orders of magnitude. There are no known irreversible effects of such exposure on either morbidity or mortality in humans or other species. Thus, it is improbable that exposure will present any hazard to the public. In view of the known sensitivity of the mammalian central nervous system to electromagnetic fields, especially those modulated at brainwave frequencies, the possibility cannot be ruled out that exposure to PAWS radiation may have some effects on people. However, because these effects are still hypothetical, it is not feasible to assess their health implications. There should not be any important deleterious consequences due to exposure of persons with surgical implants or other prosthetic devices. However, special attention should be given to evaluating the effects of PAWS radiation on electronic devices used for medical monitoring or health evaluation because there is evidence that such devices may be sensitive to such exposure.

6279 EFFECT OF STATIONARY MAGNETIC FIELD (SMF) ON THE GROWTH AND DEVELOPMENT OF *ARABIDOPSIS THALIANA*. *(Rus.)* Novitskii, Iu. I. (No affiliation given); Strekova, V. Iu.; Tarakanova, G. A. *Elektron Obrab Mater* (5): 71-74; 1978. (8 refs)

The effect of stationary magnetic field (SMF) generated by permanent magnets (field intensity 3,011-8,300 Oe, gradient 300-3,300 Oe/cm, gradient on the face of the magnets approximately 1,500 Oe/cm) on the growth and development of *Arabidopsis thaliana* was studied. Regardless of the physical parameters, the exposure had no significant effect on the rate of growth and development of the plant, nor did it cause any significant increase in the frequency of mutations compared with the controls. The irradiation caused an increase in the number of seeds per pod from 1 to 20%; the difference was significant only in experiments where higher field intensities were used.

6280 GAMMA RAYS AND MAGNETIC FIELDS--INDUCED VIVIPARY IN *CUCUMIS PUBESCENS* WILLD. (LETTER TO EDITOR). *(Eng.)* Rao, M. B. (Cytogenetics Lab., Dept. Botany, Osmania Univ., Hyderabad 500 007, India); Bhalla, J. K. *Curr Sci* 48(7): 308; 1979. (6 refs)

The induction of vivipary in *Cucumis pubescens* by gamma rays and magnetic fields is reported. Dry seeds of *C. pubescens* were treated separately with 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 5.0, 10, 15, and 20 KR of gamma rays and with magnetic fields of 1,000, 2,000, 3,000, and 5,000 G. The fruits were harvested after ripening. After 6 days of harvesting, one fruit treated with 2.0 KR of gamma rays exhibited germinated seeds in situ. Out of 200 seeds in the fruit, 20 seeds had germinated. They were transferred into petri dishes and were found to exhibit normal growth. Similarly, after a 2,000-G magnetic field treatment, one plant exhibited vivipary in one fruit, but the number of seeds germinated was less than that in the fruit harvested after gamma ray treatment. This type of abnormality was not observed in controls. Magnetic field treatment may have altered the normal course of development, resulting in the observed vivipary.

6281 AN EVALUATION OF THE INCIDENCE OF METASTASES FOLLOWING LOCAL MICROWAVE THERAPY, CO-60 RADIATION THERAPY AND COMBINED MICROWAVE-CO-60 THERAPY ON THE F1 and F10 LINES OF THE B16 MOUSE MELANOMA AND AN AMELANOTIC HAMSTER MELANOMA (ABSTRACT). *(Eng.)* Murphy, D .W. (Ph.D. dissertation, Purdue Univ., 1978); 68 pp. [available through *Diss Abstr Int B*, Order No. 7914939]. (0 refs)

The effect of local 2,450-MHz microwave therapy and/or cobalt-60 radiotherapy in the F1 and F10 lines of B16 mouse melanoma and in an amelanotic hamster melanoma was investigated to determine if the use of microwaves to induce primary tumor hyperthermia has any effect on incidence of metastases. Microwave hyperthermia was maintained at 43 C for 15 min in experiments with hamsters and at 42 C for 15 min in experiments with mice. Cobalt-60 radiation was given at a dose of 701 R/treatment for the hamster melanoma and at a dose of 618 R/treatment for the murine melanoma. The animals were treated daily for 5 consecutive days. The results indicate that microwave therapy does not enhance the appearance of metastatic disease and may in some cases decrease the incidence of metastases. There appeared to be no difference between the results obtained in the radiotherapy groups and in the combined microwave-radiotherapy groups for the three cell lines studied.

6282 ANIMALS FIND THEIR WAY. *(Eng.)* Emlen, S. T. (No affiliation given). *Mosaic* 10(3): 25-32; 1979. (0 refs)

The sensitivity of various animals and certain types of bacteria to magnetic fields is discussed. Experiments using bar magnets or Helmholtz coils mounted on homing pigeons have shown that pigeons given spurious magnetic information are often disoriented under overcast skies and that even under sunshine the orientation is poorer than normal. Errors in daily flight direction of homing pigeons have also been shown to correspond with changes in the earth's magnetic field arising from such

events as magnetic storms on the sun. Migrating birds give evidence that they respond to magnetic north and that they may use magnetism in a hierarchy of cues by which they guide themselves. Some bacteria have been discovered that possess magnetic crystals and that orient themselves to magnetic fields. The bacteria are of a hitherto unknown type, called magnetic spirillum one (MS-1); these organisms do not fit into any of the currently recognized spirillum groups. Bees also possess a magnetic sensitivity, but it is unclear how they use it. When a beehive is set on its side so that there is no vertical surface to dance upon (and no light or artificial cue), the bee dances go random. Then, after 2 wk, some orientation reappears as the bees dance to the eight cardinal points of the compass. There is also evidence that bees build the combs of a new hive in the same magnetic orientation as the combs in the old hive.

6283 EFFECTS OF MICROWAVE ENERGY ON *ACACIA LONGIFOLIA*. *(Eng.)* Tran, V. N. (Sch. Engineering and Architecture, Deakin Univ., Belmont 3216, Victoria, Australia); Cavanagh, A. K. *J Microwave Power* 14(1): 21-27; 1979. (15 refs)

The exposure of *Acacia longifolia* seeds to 2,450 MHz microwave energy for periods ranging from 60-240 sec resulted in enhanced germination of the seeds. The extent of germination depended on the surface temperature reached during microwave treatment. Seeds treated for more than 80 sec developed a fine network of cracks on the seed coat. Although these cracks may play only a minor role in water uptake, they may serve as a guide for appropriate microwave dosage. Along with the appearance of cracks on the seed coat, the whole strophiolar region looked golden, raised, and well defined under a microscope. Microwave-treated seeds germinated satisfactorily after 4 wk of storage in paper envelopes under ambient conditions with no apparent loss of viability. Thus, the use of microwaves to enhance *A. longifolia* seed germination offers advantages for use with direct seeding techniques.

6284 CLINICAL INSTRUMENTATION REQUIREMENTS WITH A REVIEW OF THE PERTH HYPERTHERMIA EXPERIENCE. *(Eng.)* Caldwell, W. L. (Div. Radiation Oncology, Dept. Human Oncology, Univ. Wisconsin Center for Health Sciences, 600 Highland Ave., Madison, WI 53792). *Cancer Res* 39(6, Part 2): 2332-2335; 1979. (12 refs)

The use of external electromagnetic heating methods in cancer therapy is discussed with particular reference to clinical experience with microwave hyperthermia in combination with ionizing radiation therapy. With external heating methods, tumors with sluggish blood flow can be heated to a greater degree than normal tissues. While this should be particularly true for hypoxic foci that are at some distance from cooling capillaries, it seems unlikely that practical detectors can be designed to measure the temperatures in these crucial microenvironments. A review of clinical experience with 52 patients with head and neck cancer who were treated with 434-MHz microwave radiation (probable tumor temperature, 39.5 ± 1 C) for 20-30 min prior to treatment with megavoltage x-rays reveals that patients with early stage disease had a 2-yr survival rate of 100% and that patients with advanced disease had a 2-yr survival rate of 49%. These results are particularly encouraging since they were obtained with lower than conventional doses of ionizing radiation and normal tissue tolerance was excellent.

6285 TEMPERATURE DISTRIBUTIONS IN NORMAL AND NEOPLASTIC TISSUES DURING HYPERTHERMIA: LUMPED PARAMETER ANALYSIS. *(Eng.)* Sien, H. P. (Suntech Group, Marcus Hook, PA 19061); Jain, R. K. *J Therm Biol* 4(2): 157-164; 1979. (68 refs)

A lumped parameter model was developed to simulate the thermal interaction between a solid tumor (Walker Carcinoma 256) and its host body (Sprague-Dawley rat) during normal temperature conditions and during various modes of hyperthermia. The model adequately described the temperature distribution data in a tumor-bearing rat under normal conditions and during whole-body hyperthermia. Numerical simulations were performed to compare whole-body and localized hyperthermia induced by microwave diathermy with hyperthermia due to regional perfusion with preheated blood. These data indicate that regional perfusion is the most effective of these three modes of hyperthermia because of its ability to instantaneously increase the temperature of the tumor above 40 C while keeping the temperature of normal tissues below 42 C at steady state.

6286 MAGNETIC FIELD-INDUCED INCREASE OF THE YIELD OF (BACTERIO)CHLOROPHYLL EMISSION OF SOME PHOTOSYNTHETIC BACTERIA AND OF *CHLORELLA VULGARIS*. *(Eng.)* Rademaker, H. (Dept. Biophysics, Huygens Lab. State Univ., P.O. Box 9504, Wassenaarseweg 78, 2300 RA Leiden, Netherlands); Hoff, A. J.; Duysens, L. N. *Biochim Biophys Acta* 546(2): 248-255; 1979. (20 refs)

The effect of a static magnetic field on the emission yield of bacteriochlorophyll of whole cells and chromatophores of the photosynthetic bacteria *Rhodopseudomonas sphaeroides* (strain 2.4.1 and its carotenoidless mutant R-26) and *Rhodospirillum rubrum* (strain S1) was investigated. In state PIX^-, the emission yield was an increasing function of the strength of the magnetic field and was correlated with a decreasing yield of triplet formation. The results support the hypothesis that charge recombination predominantly generates the excited singlet state P^*I. In *Chlorella vulgaris* and spinach chloroplasts at a temperature of 120 Kelvin, the curve of the yield of the fluorescence versus the field strength, measured at 685 or 695 nm, was similar to that found for bacteria. It is suggested that in Photosystem II, an intermediary electron acceptor is present between P-680 and Q.

6287 AN EM RADIATION SAFETY CONTROLLER. *(Eng.)* Bassen, H. (BRH, FDA, Rockville, MD 20857); Bing, J. *J Microwave Power* 14(1): 45-48; 1979. (0 refs)

A safety control system that has been developed to provide fail-safe protection for operators and users of high-power microwave and radio frequency (RF) generators is described. The system uses multiple fail-safe RF detectors to monitor the presence of transmitted or radiated power together with door status sensors that monitor access points to the hazardous exposure area. Digital logic is then used to determine potentially hazardous situations, i.e., when a person could be in a location where high field strengths exist. Once such a situation is detected, the controller activates visible and audible alarms, and the high-power source is turned off via redundant relays. This equipment has been reliably operated with several high-power RF/microwave generators. A commercially available version of the system is in use in a laboratory exposure chamber in conjunction with several high-power generators.

6288 THE WORLD OF MICROWAVES. *(Eng.)* White, J. F. (No affiliation given). *Microwaves* 22(6): 22, 29, 107; 1979. (0 refs)

Public fears, generated by the mass media, over misconceptions about the effects of microwaves are discussed. New York City has held up approval of a Coast Guard microwave communication tower that would only broadcast 1 W or less; yet television and radio stations routinely radiate 10-200 kW at wavelengths more closely approaching penetrating and resonance conditions in the human body than those of microwaves. Some microwave ovens carry a warning that although no harmful effects have been found, pregnant women should be careful regarding their use.

6289 ORIENTATION OF THE CATFISH IN HOMOGENEOUS AND INHOMOGENEOUS ELECTRIC FIELDS. *(Rus.)* Baraniuk, G. V. (Lab. General Physiology of Reception, I. P. Pavlov Inst. Physiology, USSR Acad. Sciences, Leningrad, USSR). *Fiziol Zh SSSR* 65(5): 673-677; 1979. (10 refs)

The orientation of catfish (*Ictalurus nebulosus*) in homogeneous and inhomogeneous electric fields was studied in an aquarium equipped with a labyrinth. When a horizontally directed weak electric field with a current density of 1.5×10^{-11} A/mm and a specific resistance in water of 15 Ohms/m was applied, the catfish demonstrated a compass orientation with a precision of about 20 degrees. The lowest current density gradient in which the catfish exhibited the orientation behavior was 3.6×10^{-12} A/mm^2/mm. Since similar fields occur in the natural habitat of the catfish, it is postulated that catfish use the current density gradient for directed movements in an inhomogeneous field.

6290 INTERFERENCE WITH CARDIAC PACEMAKERS BY DIATHERMY TESTED IN VARIOUS SIMULATION MODELS. *(Ger.)* Gebhardt, U. (Abteilung Innere Medizin I, Medizinische Fakultat der RWTH Aachen, Goethestrasse 27-29, D-5100 Aachen, W. Germany); Inrich, W. *Biomed Tech (Berlin)* 24(1/2): 10-16; 1979. (12 refs)

The susceptibility of pacemakers to interference by electromagnetic (EM) fields generated during diathermy treatment was assessed, and the results obtained with two simulation models were compared. One model was developed by the Association for the Advancement of Medical Instrumentation (AAMI) and the other was a new "worst-case" model, which used a 60-cm long electrode located only 0.5 cm under the surface. With this latter model, both the electric and the magnetic components could be taken into account. Pacemakers examined using the AAMI model were found to be greatly influenced by diathermal fields in the 27 MHz-434 MHz range, while pacemakers investigated by the "worst-case" model with a 2.45 GHz EM field showed no interference. Thus, the experimental series of measurements made in various diathermal fields revealed the differences between the two simulation models. The authors conclude that this form of diathermy therapy is regarded as uncritical provided it is carried out under pulse or electrocardiogram monitoring.

6291 PHYSICAL TREATMENT METHODS IN CHRONIC DISEASES OF VEINS. *(Ger.)* Muller, R. (No affiliation given). *Z Hautkr* 54(6): 257-261; 1979. (13 refs)

Physical treatment methods, particularly electrotherapy, for chronic diseases of the veins are reviewed. Electrotherapy involves both low-frequency and high-frequency techniques. In its simplest form, low-frequency therapy consists of constant galvanization. However, the combination of galvanization with simultaneous impulse current treatment is more favorable. High-frequency diathermy and ultra-high frequency treatment induce hyperemia, resorption of indurations, vasodilation, and relaxation.

6292 MAPPING OF MICROWAVE POWER TRANSMITTED THROUGH THE HUMAN THORAX. *(Eng.)* Yamaura, I. (Electrotechnical Lab., 5-4-1, Mukodaicho, Tanashi-shi, Tokyo 188, Japan). *Proc IEEE* 67(8): 1170-1171; 1979. (7 refs)

A point-by-point mapping of 2-GHz microwave power transmitted through the human thorax was attempted using a small aperture receiving antenna that consisted of a flanged, dielectric-loaded X band waveguide. The 2-GHz microwave signal was radiated from the backside of a normal male adult (24 yr

old, 56 kg in weight, 18-cm chest thickness in the vicinity of the abdomen) with the flange of a transmitting antenna pressing against the body. The transmitting antenna was an open-ended and flanged S band standard waveguide. The incident power on the subject was 200 mW, and the maximum power density was 8 mW/cm^2 as evaluated from its distribution inside the transmitting antenna. A mapping of the data showed that the attenuation of the left thorax was larger than that of the right thorax. A series of valleys originating in the upper part of the thorax was observed to run downward, growing deeper, and to curve to the left of the thorax, suggesting the shadow of the heart. Thus, the feasibility of using microwaves as an imaging medium inside the human body was demonstrated. However, the projection mechanisms of microwaves are different from those of ultrasonics or x-rays. Diffraction and interference effects make it difficult to reconstruct the internal structure from the strength of the received signal. An appropriate method for obtaining precise structure should be developed after all possible effects relating to microwave propagation in the human body are considered.

6293 CELLULAR AND MOLECULAR EFFECTS AND THE MECHANISM OF ACTION OF MICROWAVE ELECTROMAGNETIC FIELDS ON BIOLOGIC SYSTEMS. *(Rus.)* Arber, S. L. (No affiliation given). *Elektron Obrab Mater* (3): 59-65; 1978. (88 refs)

See Current Literature 6250 for description of this article.

6294 NECESSARY CONDITIONS FOR THE OBSERVATION OF THE BIOLOGIC EFFECTS OF MICROWAVES. *(Rus.)* Arber, S. L. (No affiliation given). *Elektron Obrab Mater* (1): 70-72; 1979. (13 refs)

The conditions necessary for the observation of the nonthermal biologic effects of microwaves are reviewed. Biologic effects are not usually observable at intensities at which the thermal effects are dominant. Previous experiments have demonstrated that exposure of an isolated turtle heart to an electromagnetic field of nonthermal intensity of 100 mW (absorbed dose 3.3 mW and temperature increase <0.5 C) caused bradycardia, while exposure to 300 mW caused tachycardia. Previous studies have also found that the nonthermal effect is a function of the length of exposure: no changes were seen in frogs exposed to 10 mW/cm^2 (wavelength 10.4 cm) for 0.1 hr/day for 20-100 days, but a single 2-hr exposure caused various electrophysiologic changes in the muscle cells. The authors conclude that the response time of a biologic system to irradiation with microwaves or electromagnetic waves of nonthermal intensities refers to the time necessary for the accumulation of sufficient energy to induce a change in the steric orientation and conformation of the macromolecule. The duration of the irradiation is approximately equal to the duration of the response.

6295 EXPERIMENTAL ALTERATION OF BIOMAGNETIC INTERACTIONS AMONG BEAN SEEDS. *(Eng.)* Brown, F. A. (Dept. Biological Sciences, Northwestern Univ., Evanston, IL 60201). *Experientia* 35(4): 466-468; 1979. (11 refs)

The effect of rotating fields on interactional patterns among bean seed (*Phaseolus vulgaris*) clusters was examined. Relative rates of water absorption by bean seeds distributed as four pairs of samples around the periphery of circular wooden tables were determined. Various experimental series included stationary tables, clockwise (CW) and counterclockwise (CCW) horizontally rotating (0.32-2 rpm) tables, and stationary tables on which an 18-cm horizontal alnico bar magnet rotated (0.32-2 rpm) either CW or CCW at the table center (same level as the beans). The interactional patterns among bean seed clusters in CW rotating fields (table or magnetic) were significantly different from those for bean clusters in CCW fields or for nonrotating controls. The apparent absence of a differential effect between CW table and CW magnetic rotation was unexpected. It is postulated that CW rotation shortens the range of interactions.

6296 DYNAMIC BIOMAGNETISM ASSOCIATES BEAN SEEDS. *(Eng.)* Brown, F. A. (Dept. Biological Sciences, Northwestern Univ., Evanston, IL 60201). *Experientia* 35(4): 468-470; 1979. (18 refs)

The observation that fields responsible for interactions between adjacent groups of bean seeds can penetrate from one Faraday cage into another led to an experiment designed to determine whether lining Faraday cages with 0.36-mm sheet mumetal would abolish such interactions. The sheet mumetal attenuated the static geomagnetic field to approximately 1% and any static biomagnetic field passing between two cages to about 0.01%. Measurements of water uptake by bean seeds (*Phaseolus vulgaris*) over 4 hr in four adjacent Faraday cages and in similar but mumetal-lined cages disclosed comparable interactional patterns among both cage types. Since the effectiveness of a mumetal shield essentially disappears for dynamic or oscillating magnetic fields, the results suggest that dynamic biomagnetic fields are involved in the interactions. The inverted relationship over time that was observed between the two cage types is probably due to geomagnetic attenuation.

6297 DETERMINATION OF THE HOMOGENEITY REQUIREMENTS OF THE ELECTRIC FIELD IN BIOLOGIC MATTER DURING THAWING IN UHF FIELD. *(Rus.)* Shestiperov, V. A. (No affiliation given). *Elektron Obrab Mater* (1): 73-77; 1979. (8 refs)

A mathematic approach was used to analyze the homogeneity requirements of the electric field used to thaw deep-frozen biologic materials (blood components and organs to be transplanted). The use of the electric field for thawing substantially

reduced the disproportion in the metabolism of the cells being thawed and consequently increased the number of viable cells by increasing the rate of temperature increase in the phase transition range. Although a highly homogeneous ultra-high frequency (UHF) field is generally required for the thawing of biologic materials, the homogeneity requirements are less severe at 433 and 915 MHz. Large-volume biologic materials should, therefore, be thawed at 433 or 915 MHz or by the combination of the UHF field and a liquid heat carrier.

6298 RADIOSENSITIVITY IN ELECTROMAGNETIC FIELDS. *(Rus.)* Zhuravlev, A. I. (K. I. Skriabin Moscow Veterinary Acad., Moscow, USSR); Zubkova, S. M. *Usp Sovrem Biol* 87(2): 245-257; 1979. (80 refs)

The relationship between the radiation protective effect of microwaves and their intensity was studied in rats exposed to a semilethal dose of 700 R of γ-radiation. Rats were exposed to 12.5-cm microwaves in 26 doses over a 6-wk period with intensities of 40, 10, and 1 $\mu W/cm^2$. The duration of each exposure was 30 min. Rats exposed to intensities of 40, 10 and 1 $\mu W/cm^2$ showed significant weight gain ($p<0.01$) compared to the controls receiving γ-radiation only. Rats exposed only to γ-radiation (dose, 700 R) had an average postradiation life span of 24 days. With microwave radiation of 1 $\mu W/cm^2$ intensity, mortality was 50% at day 16 and the average life span was 21 days. When radiation of intensity 10 $\mu W/cm^2$ was applied, the mortality was 30% at day 16 and the average life span was 26 days, giving results similar to those in rats exposed solely to γ-radiation of 600 R. With radiation intensity of 40 $\mu W/cm^2$, the mortality was 10% at day 16 and the average life span was 29 days. With microwaves of combined intensity (40+10+1 $\mu W/cm^2$), applied sequentially at 30-min intervals, mortality was 12% at day 16 and the average life span was 28 days. Microwaves of 40 and 40+10+1 $\mu W/cm^2$ effectively reduced injury from γ-radiation of 700 R; 40 $\mu W/cm^2$ was the optimal dose. Microwaves of warm intensities produced an antioxidizing effect inhibiting the development of γ-radiation-induced chain oxidation while the microwaves of cool intensities intensified oxidation in tissues.

6299 INVESTIGATION OF FLUORESCENCE POLARIZATION OF *CHLORELLA* CELLS AND PEA CHLOROPLASTS ORIENTED IN A MAGNETIC FIELD. *(Rus.)* Vasin, Iu. A. (Biology Faculty, M. V. Lomonosov Moscow State Univ., Moscow, USSR); Verkhoturov, V. N. *Biofizika* 24(2): 260-263; 1979. (11 refs)

Polarized light fluorescence properties were studied in suspensions of magnetically-oriented (15 kG) *Chlorella vulgaris* and pea chloroplasts. The *Chlorella* suspension consisted of cells in the autospore stage. The chloroplast suspension contained about 1.0 mg/ml chlorophyll. The fluorescence spectrum was polarized parallel or perpendicular to the plane of the photosynthetic membrane in the field of the electromagnet, after which the suspension was cooled to -196 C. The fluorescence spectral analysis of *C. vulgaris* demonstrated at least six components with respective wavelengths of 680, 685, 695, 715, 719, and beyond 735 nm. Similar results were obtained for pea chloroplasts.

6300 RESONANCE PHENOMENA IN THE ACTION OF MILLIMETER ELECTROMAGNETIC WAVES ON BIOLOGIC OBJECTS. *(Rus.)* Smolianskaia, A. Z. (Oncologic Res. Center, USSR Acad. Medical Sciences, Moscow, USSR); Gel'vich, E. A.; Golant, M. B.; Makhov, A. M. *Usp Sovrem Biol* 87(3): 381-392; 1979. (45 refs)

Studies concerning the resonance phenomena of the specific (nonthermal) effect of millimeter electromagnetic waves on biologic objects are reviewed. The resonance character of the specific effect was characterized by a very strong dependence of the biologic effect on wavelength. In some experiments even slight wavelength changes of <0.005 mm caused changes in the biologic effect. The specific biologic effect of microwaves in the millimeter range also demonstrated a very weak dependence on the energy flux density within a rather wide range. The dependence of the biologic effect on the wavelength and energy density remained unchanged even when the irradiation was accompanied by a slight temperature increase (by 1-2 C). This indicates that the thermal effect on the specific biologic effects produced by millimeter EM waves is of secondary importance compared to the effects of changes in wavelength and/or energy density.

6301 MICROWAVE THERAPY AND CONCEPTION. *(Bul.)* Dikova, K. (Scientific Inst. Obstetrics and Gynecology, Medical Acad., Sofia, Bulgaria); Ninova, V. *Akush Ginekol* 17(1): 29-32; 1978. (10 refs)

Eighty-seven women with inflammatory gynecologic diseases, 81 of whom were under 40 yr of age, underwent microwave treatment with a "Radar" apparatus. The women were subjected to microwaves of 30 W for 5-12 min/day for 12-15 days. Disorders in the menstrual cycle were observed in 9.54% of the patients after irradiation, but these changes disappeared rapidly after treatment. Twenty-five of 38 women who did not use contraceptives became pregnant after the treatment; this included 3/6 women with primary sterility and 22/32 with secondary sterility.

6302 HUMAN MAGNETIC AUDITORY EVOKED FIELDS. *(Eng.)* Reite, M. (Dept. Psychiatry, Univ. Colorado Medical Center, Denver, CO 80262); Edrich, J.; Zimmerman, J. T.; Zimmerman, J. E.

Electroencephalogr Clin Neurophysiol 45(1): 114-117; 1978. (7 refs)

Magnetoencephalographic averaged auditory evoked fields (AEF) to auditory click stimuli were recorded for four healthy adult males. The magnetoencephalogram (MEG) was recorded with an asymmetric second derivative SQUID gradiometer located in an aluminum shielded room. The subjects were positioned beneath the gradiometer on a wooden couch, with the bottom coil of the gradiometer approximately 2 cm from the scalp. Clicks were generated by feeding 1-msec square wave pulses through a buffer amplifier to a small cone speaker located in a sound-proofed box outside the aluminum room. A 4-m long, 1-cm diameter plastic tube that terminated in an airline-type plastic headset with two earpieces carried the sound stimulus from the speaker to the subject. The gradiometer output (raw MEG) was amplified and filtered with a bandpass of 5-15 cycles/sec. A dual channel signal averager, triggered by the same pulse generator that produced the clicks, was used for on-line averaging. Clicks were delivered at 250-msec intervals and the averaging time was 200 msec after each stimulus; 512 stimuli were averaged in each experiment. Sound transit time from the speaker to the subject was approximately 12 msec. In all subjects the gradiometer was initially positioned over a point about 1.5 cm anterior to the midpoint of the line connecting the temporal and central electrode positions. This position was thought to be in reasonable proximity to the primary auditory cortex. Well-defined MEG-AEF were obtained in all four subjects. Not all responses were the same, either among subjects, between hemispheres, or from one time to another in the same subject. Mapping studies indicated that, unlike conventional electroencephalogram auditory evoked potentials that have a widespread distribution, the evoked magnetic fields appeared to be localized to the general area of the primary auditory cortex and they diminished rapidly in amplitude as the gradiometer was moved away in any direction. The observation that magnetic evoked fields are quite localized in distribution suggests that they may be very useful research tools.

6303 MICROWAVE RADIATION INSTRUMENTATION. *(Eng.)* Mulholland, J. E. (General Electric Co., Valley Forge Space Center, Valley Forge, PA). *Microwave J* 22(5): 76-79, 81-82, 90; 1979. (10 refs)

Several commercially available radiation survey instruments were evaluated in both the far and near field of a radiating slot of known characteristics at 915 MHz. One instrument, a Holaday probe, read high by a factor of two or more under certain conditions, while another probe, Narda Model 8100, read high by a factor of five or more under certain conditions. Overall, it appears that present instrumentation techniques are inadequate to accurately measure near field parameters of an arbitrary radiating source. One reason for this is the use of sensors that have a large effective aperture and distort the radiating field. Also, auxiliary equipment such as handles and lead wires interact with the fields, further distorting the radiation pattern. Another inadequacy of present instrumentation techniques is that the coupling of an arbitrary radiating slot (such as a leak in a microwave enclosure), which is most likely a high impedance source, to a sensor probe loads this source and tends to lower the measured value. Since the near field of a slot radiator of simple geometric shape with well defined field boundary conditions has many components (both in-phase and quadrature), the location of a sensor element or combination of elements becomes a dominant factor in the variation of measured values. Thus, an isotropic sensor may not be the best choice for a particular measurement.

6304 EFFECT OF LOW-INTENSITY UHF-FIELD ON OXIDATIVE PROCESSES OF THE BRAIN AND LIVER. *(Rus.)* Belokrinitskii, V. S. (Biologic Hygiene Res. Lab., Kiev Scientific Res. Inst. General and Communal Hygiene, Kiev, USSR); Tarasiuk, N. E. *Vrach Delo* (3): 102-105; 1979. (14 refs)

The effects of exposure to low-intensity ultra-high frequency (UHF) fields (wavelength 12.6 cm) on the succinate dehydrogenase, malate dehydrogenase, lactate dehydrogenase, and glucose-6-phosphate dehydrogenase activities; on the intensity of oxygen uptake by mitochondria; and on the effectiveness of oxygen utilization were studied in the brain and liver of 82 albino rats immediately or 30 days after irradiation. All animals were exposed for 3 hr daily: the first three groups were exposed to 5, 10, and 50 $\mu W/cm^2$ on 10 consecutive days; group 4 was exposed to 5 $\mu W/cm^2$ for 10 days and to 10 $\mu W/cm^2$ for 10 additional days; and group 5 was exposed to 5, 10, and 50 $\mu W/cm^2$ for 10 days each. Immediately after exposure, increased redox enzyme activities, increased oxygen uptake by the mitochondria, and slightly impaired oxidative phosphorylation by the mitochondria were seen in groups 1-3. The redox enzyme activities were also increased in groups 4 and 5, but the oxygen uptake and the oxidative phosphorylation by the mitochondria were reduced. Thirty days after exposure, the redox enzyme activities in groups 1-3 were still slightly increased, but the respiratory and phosphorylating functions of the mitochondria were normal. In groups 4 and 5, the redox enzyme activities remained elevated and the respiratory and phosphorylating functions of the mitochondria were still reduced 30 days after exposure.

6305 BIOEFFECTS OF EXTREMELY LOW-FREQUENCY ELECTROMAGNETIC FIELDS: VARIATION WITH INTENSITY, WAVEFORM, AND INDIVIDUAL OR COMBINED ELECTRIC AND MAGNETIC FIELDS. *(Eng.)* Goodman, E. M. (Univ. Wisconsin-Parkside, Kenosha, WI 53141); Greenebaum, B.; Marron, M. T. *Radiat Res* 78(3): 485-501; 1979. (22 refs)

The effects of extremely low frequency electromagnetic fields (EMF) on the myxomycete *Physarum polycephalum* were studied. Prolonged exposure (up to 400 days) to either continuous wave (75 Hz) or frequency modulated wave (76 Hz) EMF (0.1-2.0 G, 0.035-0.7 V/m) lengthened the mitotic cycle and depressed the respiration rate. These effects persisted indefinitely in the presence of the EMF without changes in magnitude beyond those due to the normal variability of the organism. Similar but weaker effects were observed when either a 0.7-V/m electric field or a 2.0-G magnetic field was applied individually. The individual field effects appeared to be additive for respiration but not for the nuclear division rate. The response was independent of field intensity for fields applied simultaneously at levels below 0.14 V/m and 0.4 G. No threshold was observed for simultaneously applied electric and magnetic fields; however, indirect evidence suggested that either the electric or magnetic field was below threshold at levels of 0.14 V/m and 0.4 G, respectively. Frequency modulation of the fields seemed to have no major effect on the above responses.

6306 ENHANCEMENT OF IONIZING RADIATION EFFECT ON THE TESTES OF RATS BY MICROWAVE OR ULTRASOUND-INDUCED HYPERTHERMIA. *(Eng.)* Abadir, R. (Dept. Radiology, Univ. Missouri Medical Sch., Columbia, MO 65212); Harman, J.; Fahim, M. *J Med* 10(1/2): 1-12; 1979. (20 refs)

The effects of hyperthermia produced by microwaves or ultrasound alone or in combination with x-rays on the testes of sexually mature rats were investigated. Ultrasound treatment (1 W/cm^2) or microwave treatment (12.2 cm wavelength, 30 W) was given for 5 min, followed in some cases by 600 rads of x-ray treatment; other rats received the x-ray treatment only. Moderate disruption of spermatogenesis was observed in groups of rats treated with each of the three modalities alone; the precentages of affected tubules were 56% for ultrasound, 68% for microwaves, and 72% for x-rays. Severe disruption of spermatogenesis was observed in rats treated with x-rays in combination with microwaves; 85% of the tubules were affected in these rats. Although the heat induced by ultrasound was lower (37.6) than that induced by microwaves (39.9 C), it was more destructive when combined with x-rays, resulting in complete disruption of spermatogenesis and affecting 100% of the tubules. Thus it is possible that nonthermal effects occurred.

6307 EFFECT OF LOCAL HYPERTHERMIA INDUCED BY MICROWAVES AND X-RAYS ON WALKER'S CARCINOMA IN THE RAT. *(Ger.)* Bruckner, V. (Institut fur Biophysik und Strahlenbiologie, Universitat Hamburg, Martinistrasse 52, 2000 Hamburg 20, W. Germany); Zywietz, F.; Jung, H. *Strahlentherapie* 155(1): 44-50; 1979. (19 refs)

The effects of hyperthermia induced by microwave radiation of frequency 2,450 Hz (wavelength in air 12.25 cm) and/or local x-ray irradiation (1,130 rads, dose rate 100 rads/min) on the survival of 4-mo-old male BDI rats were studied in rats implanted subcutaneously with solid Walker carcinoma 256. All animals were irradiated with either x-rays or microwaves 7-8 d after the transplantation of 5 x 10^6 tumor cells into the right hind leg. Group 1 animals served as controls. Group 2 rats were subjected to microwave hyperthermia for 30 min to raise the tumor temperature to 41 C. Group 3 animals were irradiated with x-rays only and group 4 rats received the same dose of x-rays 10 min after 30 min of hyperthermia. The tumor weight was 2-6 g at the beginning of the treatment. The 30-day survival rates were 17% in group 1, 27% in group 2, 57% in group 3, and 75% in group 4, indicating that hyperthermia, irradiation, and the combination of the two treatments significantly increased the survival rate. The average survival of the animals was 8.28 days in group 1, 9.82 days in group 2, 10.83 days in group 3, and 11 days in group 4.

6308 EFFECT OF A SELECTIVE β_2-ADRENOCEPTOR AGONIST, PROCATEROL, ON TISSUE CYCLIC AMP LEVEL. ITS DETERMINATION AFTER TISSUE FIXATION BY MICROWAVE IRRADIATION. *(Eng.)* Saitoh, Y. (Lab. Biological Res., Otsuka Pharmaceutical Co., Ltd., Tokushima, Japan); Hosokawa, T.; Igawa, T.; Irie, Y. *Biochem Pharmacol* 28(8): 1319-1322; 1979. (20 refs)

Determination of tissue cyclic adenosine monophosphate (cAMP) using rapid tissue fixation by microwave irradiation was used to investigate the effect of procaterol (PCL), a selective β_2-adrenoceptor agonist, on cAMP levels in male albino Wistar rat tissue. Tissue fixation was accomplished by exposing conscious rats to microwaves from a commercial oven (frequency, 2,450 MHz and power output, 1.3 kW). The intravenous injection of 1 µmole/kg of observed 2 min after injection, at which time there were 2- to 3-fold increases in the heart and liver PCL into conscious rats caused an increase in cAMP levels in the trachea, heart, liver, and skeletal muscle. The peak level was observed 2 min after injection, at which time there were two- to threefold increases in the heart and liver and six- to eightfold increases in trachea and skeletal muscle. PCL-induced alterations in cAMP levels in trachea and skeletal muscle were characterized by their long duration (over 2 hr). The duration of the PCL action reflected sustained stimulation of β-adrenoceptor-linked adenylate cyclase activity. The phosphodiesterase inhibitor 3-isobutyl-1-methylxanthine (50 µmoles/kg, subcutaneously) was very effective in enhancing PCL-induced increases in cAMP in trachea, lung, and skeletal muscle. Tissue cAMP levels were found to respond to PCL in a dose-dependent manner; the minimum effective doses of PCL needed to increase tissue cAMP were 1, 10, 10, and 100 nmoles/kg for skeletal muscle, trachea, lung, and heart, respectively.

The stimulatory action of PCL on heart cAMP levels was less than that of isoproterenol, a nonselective β-adrenoceptor agonist. Consequently, it appears that PCL-induced increases in cAMP were mediated by β_2-adrenoceptors rather than by β_1-adrenoceptors. Thus, tissue fixation by microwaves enabled the in vivo measurement of the tissue content of cAMP and the determination of the β-adrenoceptor responses to procaterol.

6309 CLINICAL FEATURES OF THE EFFECT OF ELECTROMAGNETIC FIELDS IN CONTACT ELECTRIC WELDING. *(Rus.)* Abramovich-Poliakov, D. K. (Dept. Clinical Industrial Pathology, Kharkov Scientific Res. Inst. Industrial Hygiene and Occupational Diseases, Kharkov, USSR); Kleiner, A. I.; Kolodub, F. A.; Krakovskaia, S. P.; Nedbailo, F. P.; Panova, V. N.; Smolianinova, N. S.; Trikoza, V. A.; Shteingerts, L. A. *Vrach Delo* (4): 106-110; 1979. (0 refs)

The effects of electromagnetic fields generated during electric welding (field intensity of the magnetic component 85,000-100,000 A/m, pulse duration 0.1-0.2 sec) on 211 electric welders were studied. One hundred and thirteen subjects not exposed to electromagnetic fields were used as controls. Seventy-eight percent of the welders and 72% of the controls were 20-29 yr old. Thirty-nine percent of the welders had been on the job for 3-5 yr, and the remainder, for less than 3 yr. Neurasthenia and asthenia were demonstrated by 37% of the welders and 9% of the controls ($p<0.05$); among the welders, the incidence of these syndromes increased with increasing length of employment. Functional cardiopathy was found in 4.7% of the welders and in 0.8% of the controls ($p<0.05$); metabolic changes in the myocardium (increase in the T wave in the thoracic leads) were seen in 58% of the welders and in 37% of the controls; and increased leukocyte counts were found in the peripheral blood in 17% of the welders and in 10% of the controls ($p<0.05$). Conjunctivitis and blepharoconjuctivitis were observed in 2.8% and 5.7%, respectively, of the welders. No such changes were observed in the controls. Pathologic changes of the eye, nose, and throat were seen in 29% of the welders and in 7% of the controls ($p<0.05$). The findings indicate that the working conditions of electric welders should be improved and regular medical examinations should be scheduled.

6310 EFFECT OF A LOW-FREQUENCY (50 Hz) ELECTRIC FIELD ON THE BODY. *(Rus.)* Gabovich, R. D. (A. A. Bogomolets Kiev Medical Inst., Kiev, USSR); Koziarin, I. P. *Gig Sanit* (1): 11-15; 1979. (7 refs)

The effects of electric fields of 50 Hz were studied in male albino rats that were exposed to electric fields with intensities of 7, 12, and 15 kV/m for 30 min/day for 4 mo. Significant increases were seen in the summation threshold index (15 versus 12 for the controls) and in the latent period of the unconditioned reflex (74.6 versus 47.6 msec) in the group exposed to 7 kV/m. At 7 kV/m, the hepatic glycogen level was significantly reduced (3,653.2 versus 5,269.2 mg%, $p<0.01$). The effects of the electric field were most pronounced in the group exposed to 15 kV/m: the swimming time was reduced (from 3.6 to 2.5 min, $p<0.01$) as was the brain cholinesterase activity (from 1,029.8 to 791.7 μmoles/g/hr, $p<0.05$), the liver glycogen level (to 3,668.7 mg%, $p<0.05$), and the iron saturation of blood transferrin (from 0.26 to 0.16 absolute units, $p<0.01$). In the same group, various parameters were increased: the summation threshold index (to 19.2, $p<0.01$), the latent period of unconditioned reflexes (to 78.8 msec, $p<0.01$), the blood cholinesterase activity (from 118.3 to 138.2 μg/ml/min, $p<0.01$), the blood residual nitrogen level (from 24.1 to 31.6 mg%, $p<0.01$), the blood urea level (from 28.8 to 43.1 mg%, $p<0.01$), the blood glucose level (from 72 to 90.8 mg%, $p<0.05$), and the blood ceruloplasmin level (from 37.6 to 46 absolute units, $p<0.05$).

6311 HIGH-FREQUENCY HYPERTHERMIA IN CARCINOMA OF THE URINARY BLADDER: EXPERIMENTAL AND CLINICAL RESULTS. *(Ger.)* Bichler, K. H. (Lehrstuhl und Abteilung fur Urologie, Universitat Tubingen, Calwer Strasse 7, 7400 Tubingen, W. Germany); Harzmann, R. *Therapiewoche* 29(13): 2229-2233; 1979. (18 refs)

Experimental and clinical results obtained with high-frequency hyperthermia in the treatment of carcinoma of the urinary bladder are presented. The experimental series involved 30 rabbits with transplanted Brown-Pearce carcinoma that were subjected to local hyperthermia; 30 tumor-bearing untreated animals served as controls. The best treatment results were obtained with hyperthermia of 43 C for 30 min: the frequency of lymph node metastases was reduced to 30% from 70% for the controls; liver metastases were reduced to 20% from 50% for the controls; and the survival time was increased to 79 days from 36 days for the controls. In a second experimental series, the tumors were exposed to hyperthermia and then subsequently transplanted into rabbits; hyperthermia reduced the "take rate" from 100% to 20%. In the clinical series, eight patients with urinary bladder carcinoma were subjected to intracavitary hyperthermia of 43 C for 30 min at weekly intervals. Progressive tumor necrosis was seen after the 7th day, and in some cases, the tumor disappeared. The results of both the experimental and clinical series demonstrated that hyperthermia had a selective antitumor effect.

6312 COMBINATION OF CARMINOMYCIN WITH UHF HYPERTHERMIA IN THE TREATMENT OF SARCOMA 180. *(Rus.)* Lopatin, V. F. (Scientific Res. Inst. Medical Radiology, USSR Acad. Medical Sciences, Obninsk, USSR); Dedenkov, A. N.; Vatin, A. E. *Antibiotiki* 24(8): 619-622; 1979. (19 refs)

The tumor-inhibiting effects of local ultra-high

frequency (UHF) hyperthermia (41.5-42 C for 30 min), carminomycin (1.3 mg/kg, by intravenous injection), and their combination were studied in CBA mice with a subcutaneous transplanted sarcoma 180. The tumor site was exposed to the UHF field (dose not given) 5 min after the injection of carminomycin and the tumor-inhibiting effects were evaluated 10 days after treatment. Hyperthermia, carminomycin, and their combination produced tumor inhibition effects of 56%, 31%, and 92%, respectively ($p<0.05$ relative to the untreated animals). To produce a 92% tumor inhibition with carminomycin only, 4.3 mg/kg were required. The measurement of the carminomycin level in the tumor 1 hr after administration demonstrated the selective accumulation of the antibiotic in the tumor under the effect of local hyperthermia. The findings indicate that UHF hyperthermia has an independent tumor-inhibiting effect; it also promotes the selective accumulation of carminomycin in the tumor.

6313 THE HISTORICAL GROWTH AND DEVELOPMENT OF RADIATION CONTROL IN SOUTH AFRICA (LETTER TO EDITOR). *(Eng.)* Le Roux, P. R. (No affiliation given). *Health Phys* 36(3): 466-467; 1979. (0 refs)

Radiation control measures implemented in South Africa from 1948 to the present are discussed. Attention is now being focused on the control of nonionizing radiation sources such as microwaves, lasers, and ultrasonic devices. With the recent amendment of the Hazardous Substances Act of 1973 (Act 15 of 1973), provision has been made for the control of the manufacture and sale of electronic products. Safety requirements similar to those applicable in other countries are to be prescribed by regulations. An exemption certificate will be required for every new type and model of hazardous electronic equipment prior to sale on the South African market. The control of nonionizing radiation equipment will be directed exclusively toward assuring beforehand that such products are safe for use; compliance monitoring and any resulting corrective action will have to be performed before such equipment is marketed.

6314 RETINAL DAMAGE EXPERIMENTALLY INDUCED BY MICROWAVE RADIATION AT 55 mW/CM^2. *(Eng.)* Paulsson, L. E. (Res. Lab. Electronics, Chalmers Univ. Technology, S-412 96 Goteborg, Sweden); Hamnerius, Y.; Hansson, H. A.; Sjostrand, J. *Acta Ophthalmol (Kbh)* 57(2): 183-197; 1979. (13 refs)

The effect of 3,100-MHz pulsed microwave radiation on the rabbit retina in vivo was investigated using fundus photography, blood-retinal barrier tracers, and light and electron microscopy after either a single 1- to 1.5-hr exposure or after up to 53 repeated 1-hr exposures during a 3-mo period. The mean intensity of microwave irradiation was 550 W/m^2 with a pulse peak intensity of 1.3×10^6 W/m^2. The pulse duration was fixed at 1.4 μsec, and the pulse repetition rate was 300 Hz. Electron microscopy of repeatedly exposed retinas revealed degenerative changes in the retinal neurons. The neurons appeared depleted of their cytoplasmic constituents and often contained phagolysosomal structures with myelin bodies. There were many degenerating synaptic boutons. The glial cells displayed reactive changes. A single exposure appeared to be sufficient to induce similar although much less extensive changes. These ultrastructural changes were not demonstrated by the other methods used. A single microwave exposure followed by the induction of a 70-100% increase in blood pressure did not enhance blood-retinal barrier permeability to tracers. There was no evidence of blood-brain barrier leakage. These findings indicate that lesions observable by electron microscopy can be produced in the rabbit eye at power levels lower than the cataractogenic threshold.

6315 THYROID MORPHOLOGY AND ACTIVITY DOES NOT RESPOND TO ELF ELECTROMAGNETIC FIELD EXPOSURES. *(Eng.)* Lafreniere, G. F. (Behavioral Neurobiology Lab., Laurentian Univ., Sudbury, Ontario, Canada P3E 2C6); Persinger, M. A. *Experientia* 35(4): 561-562; 1979. (10 refs)

Measurements of blood triiodothyronine and thyroxine and of thyroid follicle and perifollicular mast cell numbers were performed in albino Wistar rats that had been exposed either perinatally or as adults to extremely low-frequency (ELF) magnetic fields. In eight experiments, 40 rats (180-200 days old, 5 rats/experiment) were exposed for 5 days to one of three 0.5-Hz magnetic field intensities (produced by rotating horseshoe magnets), to a sham field condition (0.5 Hz variation, if any, below 10^{-9} tesla [T]), or to normal colony room conditions. The three field intensities (peak-to-peak) were 10^{-6} T, 10^{-7} T, and 10^{-8} T. Half of the rats exposed under the above conditions had been exposed perinatally (2.5 days before to 2.5 days after birth) to 10^{-3} to 10^{-4} T intensity 0.5-Hz magnetic fields, while the other half had been exposed to the sham field condition. Rats exposed either perinatally or as adults to these magnetic field intensities displayed no significant alterations in either thyroid morphology or circulating hormone levels. The absence of statistically significant interactions between perinatal and adult conditions appears to eliminate the likelihood that early (perinatal) ELF exposure alters thyroid response when the adult organism is exposed again to the ELF field.

6316 THE INFLUENCE OF THE MAGNETIC FIELD ON PHOTOSENSITIVE RADICAL REACTIONS. *(Rus.)* Kadnikov, V. I. (A. M. Gor'kii Khar'kov State Univ., Khar'kov, USSR); Kobizskoi, V. I. *Pisma Zh. Tekh Fiz* 4(22): 1367-1370; 1978. (9 refs)

The influence of the magnetic field on photosensitive processes in aqueous solutions of several organic molecules and on the formation of photolytic products (e.g., the hydrated electron) was studied.