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Biological Effects of Nonionizing Electromagnetic Radiation

VOLUME III

NUMBER 1

SEPTEMBER, 1978

A DIGEST OF CURRENT LITERATURE

A Quarterly Publication Produced for
National Telecommunications and Information Administration
and United States Navy

FRANKLIN RESEARCH CENTER
Science Information Services Organization

BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

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by
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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

September, 1978 Volume III, Number 1

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PREFACE

Biological Effects of Nonionizing Electromagnetic Radiation is a publication research and prepared by the Franklin Research Center, Science Information Services Organization, under contract with the U.S. Navy and administered by the National Telecommunications and Information Administration.

This digest serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and radiofrequency radiation) are compiled, condensed, and disseminated on a regular basis. *Biological Effects of Nonionizing Electromagnetic Radiation* is intended to be a highly useful current awareness tool for scientists engaged in research or related activities. The great number and diversity of relevant publications make imperative the availability of this service to persons whose work requires that they keep abreast of current developments in the field.

Biological Effects of Nonionizing Electromagnetic Radiation is published quarterly. The issues of Volume III, and future volumes, will include materials received during the preceding three months. Each issue will include news items and announcements, a listing of meetings and conferences, abstracts of current literature, and a directory of current research. Materials for which full text is not available will be included as summary abstracts.

ABBREVIATIONS AND ACRONYMS

A, amp - ampere(s)
Å - angstrom(s)
BRH - Bureau of Radiological Health
C - centigrade
cm - centimeter(s)
cps - cycles per second
dB - decibel(s)
EPA - Environmental Protection Agency
FDA - Food and Drug Administration
g - gram(s)
G - Gauss
GHz - gigahertz
HEW - Health, Education, and Welfare
hr - hour
Hz - hertz
IEEE - Institute of Electronic and Electrical Engineers
IMPI - International Microwave Power Institute
IU - international unit(s)
J - joule(s)
k - kilo--
l - liter(s)
m - meter(s)
m - milli--
M - mega--
mho - unit of measurement of conductivity
min - minute(s)
mo - month(s)
n - nano--
NBS - National Bureau of Standards
NIH - National Institutes of Health
NSF - National Science Foundation
NIOSH - National Institute for Occupational Safety and Health
NTIS - National Technical Information Service
Oe - oersted(s)
OSHA - Occupational Safety and Health Administration
OTP - Office of Telecommunications Policy
PHS - Public Health Service
rad - radiation absorbed dose
R - roentgen(s)
rpm - revolutions per minute
sec - second(s)
USAFSAM - U.S. Air Force School of Aerospace Medicine
USDA - U.S. Department of Agriculture
UV - ultraviolet
V - volt(s)
VA - Veterans Administration
W - watt(s)
Wb - Weber(s)
WHO - World Health Organization
wk - week(s)
wt - weight
yr - year(s)

μ - micro--

NEWS ITEMS

AIR FORCE IS PREPARING PAVE PAWS ENVIRONMENTAL IMPACT STUDY

The Air Force has announced that it will prepare a statement on the environmental impact of its new PAVE PAWS (Precision Acquisition of Vehicle Entry, Phased Array Warning System) radar facility at Otis Air Force Base, MA. Officials estimate that the impact statement may take 9 to 18 months to complete. A coalition, composed of several groups and individuals opposing PAVE PAWS, filed a lawsuit in Federal District Court in March, 1978, to force the Air Force to prepare an impact statement. The suit also seeks to halt all testing and operation of the radar facility until an independent environmental impact statement is completed. A pentagon spokesman said, however, that the Air Force has no intention of stopping the PAVE PAWS testing schedule while the environmental statement is being prepared. Low-power tests, begun in April, were said to emit less than 1 μW of microwave radiation, a level generally considered safe within even conservative standards.

New York Times April 13, 1978

GOVERNMENT REPORT SAYS MICROWAVE LEVELS MAY BE DANGEROUS

Nonionizing radiation is a "large and complex" area and "strong coordination is vital" among federal agencies responsible for controlling it, according to the General Accounting Office (GAO). In a March 29 report triggered by inquiries from Congresswoman Elizabeth Holtzman, GAO says nonionizing electromagnetic radiation sources "are increasing while the health efforts of such exposures at low levels is a controversial subject." Human exposure to high levels of nonionizing radiation--about 10,000 $\mu W/cm^2$ [*sic*]--increases body temperature and results in problems such as heat stress, cataract formation [*sic*], cardiovascular effects, testicular effects, and brainwave pattern changes, the GAO report states. The report adds that EPA "estimates that the potential danger from nonionizing radiation has risen dramatically since 1954" and that radio frequency and microwave sources are "increasing by 15 percent annually." It says that the major nonionizing radiation sources include 950 ultra-high- and very-high-frequency television stations, 7,800 AM and FM radio stations, and "millions of microwave ovens." "EPA states that these sources result in measurable exposures to the population and are becoming a major concern" because, the report says, the threshold for environmental damage from nonionizing radiation is not known, and the U.S. standard for extended human occupational exposure to microwave radiation is about 1,000 times greater than the Soviet Union's standard. According to one EPA deputy administrator, the median exposure level for roughly 98% of the U.S. general population is less than 1.0 $\mu W/cm^2$. He added, however, that "for between one and three percent of the population" exposure levels may be as high as 100 $\mu W/cm^2$ and that there "is a problem to be looked at" for a small segment of the population. EPA, under its authority to protect the U.S. population and environment from avoidable radiation exposure, could issue recommendations that would be published as guidance to all federal agencies in formulating radiation standards, according to the agency's charter. If EPA Administrator Douglas M. Costle determines that authority is inadequate to control nonionizing radiation, legislation would be necessary to authorize regulations and enforceable standards.

Chem. Regulation Reporter 2(2): 45-46; 1978.

BIOELECTROMAGNETICS SOCIETY FOUNDED

To enhance the exchange of scientific information and stimulate research concerned with the interaction of electromagnetic energy and acoustic energy with biologic systems, researchers have founded the Bioelectromagnetics Society. The society will publish a scientific journal, whose first slated appearance is summer, 1979, and a newsletter, which will replace the current *Bioeffects Newsletter* prepared by the Office of Naval Research. The society will also sponsor topical workshops and symposia and an annual meeting. Membership is open to persons who have made scientific contributions in the areas of electromagnetic- or acoustic-biologic interactions by independent research or to persons who have rendered some special service to these areas. Information regarding membership may be obtained from Bioelectromagnetics Society, P.O. Box 3651, Arlington, VA 22203.

UNIVERSITY OF UTAH BIOENGINEER DIES

Curtis C. Johnson, Professor and Chairman of Bioengineering, University of Utah died March 25 in Sandy, Utah. Dr. Johnson was internationally recognized for his work in bioinstrumentation and the biologic effects of microwaves. He was appointed Chairman of the Department of Bioengineering in 1974 and was subsequently appointed Research Associate Professor in the Department of Surgery and Research Professor in Electrical Engineering. Dr. Johnson's publications include two textbooks in electromagnetic theory, contributions to three other books in bioengineering, and more than 65 journal articles. He also filled several editorial positions. He holds seven patents. He served on numerous national and international committees, including the Committee on Radiation Protection and the National Committee of the International Union of Radio Science. Contributions to the Curtis C. Johnson Memorial Fellowship Fund, established in his memory, may be made payable to the

ville, MD. The microwave oven amendments would change the phrase "power density" to "plane-wave power density" because the original phrase is technically incorrect, delete the aperture limit specification for the leakage measurement instrument because the specification is redundant and unenforceable, and remove the 1-dB limit for the measurement instrument because the restriction is not technically feasible. The Committee also was briefed on Bureau activities and plans concerning other electronic product radiation safety standards, policies, and recommendations including the microwave diathermy standard, which is being prepared for publication as a proposed rule. Following discussion of the concerns of a clinician and investigator with respect to the emission limit and the availability of manufacturers willing to provide equipment that meets the standard, the Committee recommended that these concerns be addressed in the proposal. It also indicated that it recognizes the need for the standard and recommended that the Bureau proceed with publication of the proposed rule.

BRH Bull. 12(11): 1-2; 1978.

CALL FOR PAPERS FOR THE ELECTROMAGNETIC COMPATIBILITY SYMPOSIUM

Prospective authors are invited to submit papers for inclusion in the *Symposium Record* of the third bienniel Electromagnetic Compatibility Symposium & Exhibit, which is planned for May 1 through May 3, 1979, at Rotterdam, Holland. Topics of the symposium include social and economic impact of electromagnetic compatibility; electromagnetic pollution, control, and enforcement; electromagnetic compatibility hazards, biological effects of radio frequency energy, and measuring methods and instrumentation. Three copies of English summaries of up to 500 words with full address and phone number should be sent to Professor F. L. Stumpers, Elzentlaan 11, Eindhoven, Netherlands (Phone: 040-115512) no later than September 15, 1978. Best papers will be awarded monetary prizes.

SOVIETS DEVELOP LABOR-PAIN ELECTROANALGESIC DEVICE

Scientists in the Soviet Union have developed a method for controlling labor pain based on intermittent-action electroanalgesia without increasing the mean current by raising the pulse repetition rate only. A rubber ring mask is placed on the head of the patient for fixing the split cathode near the forehead, while the anode is set near the neck. The rhythmic pulses of a circuit are fed to a pulse repetition rate adjuster, connected to a pulse duration controller for transmission to a pulse shaper. The latter feeds an amplitude setter, which is connected to the anode via a protective circuit and current indicator. The protective circuit switches off the supply pack when the set threshold of current is exceeded, while a switch connects the constant duty cycle control circuit when the pain killing has to be turned on at the start of birth activity.

Sov. Inventions Illustrated (A07): 3; 1978

ITEMS FROM THE COMMERCE BUSINESS DAILY

☐ **FURTHER RESEARCH ON MICROWAVES.**

The Office Of Naval Research, Arlington, VA has contracted with the Board of Regents of the University of Washington, Seattle, WA for the above study. (April 3, 1978)

☐ **RESEARCH ON MICROWAVE DISPERSION AND ABSORPTION IN TISSUE.**

The Office of Naval Research, Arlington, VA has contracted with the Trustees of the University of Pennsylvania, Philadelphia, PA for the above study. (May 24, 1978)

☐ **RESEARCH ON THE EFFECTS OF PULSED MICROWAVE RADIATION FROM NAVY RADAR ON MAMMALIAN BLOOD CELLS.**

The Office of Naval Research, Arlington, VA has contracted with the Virginia Commonwealth University, Richmond, VA for the above study. (May 24, 1978)

☐ **RESEARCH ON THE MECHANISMS OF MICROWAVE-INDUCED BLOOD-BRAIN BARRIER ALTERATIONS.**

The Office of Naval Research, Arlington, VA has contracted with Wayne State University, Detroit, MI for the above study. (June 1, 1978)

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□ **INVESTIGATIONS INTO THE PERIPHERAL AND CENTRAL RECEPTORS MEDIATING EFFECTS OF MICROWAVE RADIATION ON BRAIN ACTIVITY.**

The Procurement Office, National Institute of Environmental Health Sciences, Research Triangle Park, NC is soliciting proposals for the above study. (June 29, 1978)

MEETINGS AND CONFERENCES

INTERNATIONAL CONFERENCE ON LARGE HIGH VOLTAGE ELECTRIC SYSTEMS: 27th Session

Date: August 30-September 7, 1978
Place: Paris, France: UNESCO Conference Bldg.
Sponsor: International Conference on Large High Voltage Electric Systems (CIGRE)
Requests for Information: CIGRE, R. Pelissier, Sec. Gen., 112, bd Haussmann F-75008, Paris, France

EIGHTH EUROPEAN MICROWAVE CONFERENCE

Date: September 4-7, 1978
Place: Paris, France: Hotel Meridien
Sponsor: Societe des Electriciens, des Electroniciens et Radioelectriciens (Groupment des Industries Electriques)
Requests for Information: Professor E. Constant, Conference Chairman, Centre Hyperfrequences et Semiconducteurs, Universite des Sciences et Techniques, BP 36, 59650, Villeneuve d'Ascq, France

Selected Bibliography of Papers to be Presented:

MICROWAVE FIELD INFLUENCE ON SOME CHEMICAL AND BIOLOGICAL OBJECTS. (invited paper)
A. I. Tereshchenko

PASSIVE SUBCUTANEOUS TEMPERATURE MEASUREMENTS FOR INVESTIGATION OF THERMOREGULATION.
A. Mamouni, Y. Leroy, Y. Houdas, Y. Moschetto

SLOTTED CYLINDER ANTENNA FOR SELECTIVE ELECTROMAGNETIC HEATING INSIDE THE HUMAN BODY.
W. Buck

MULTIMODE SQUARE WAVEGUIDE APPLICATORS FOR MEDICAL APPLICATIONS OF MICROWAVE POWER.
S. S. Stuchly, M. A. Stuchly

CLINICAL APPLICATION OF MICROWAVE THERMOGRAPHY AT THREE FREQUENCIES.
P. C. Myers, N. L. Sadowsky, A. H. Barrett

A SIMPLE MICROWAVE GAUSSIAN-BEAM LAUNCHER FOR SELECTIVE PARTIAL-BODY EXPOSURES OF BIOLOGICAL SUBSTANCES.
P. S. Neelakantaswany, K. K. Gupta, D. Banerjee

EFFECTS DUE TO MICROWAVES IN AN ENZYME-SUBSTRATE SYSTEM.
C. W. Smith

NEW PROBES FOR ELECTROMAGNETIC FIELDS.
A. Deficis, E. Gimonet, A. Priou

SECOND EUROPEAN THERMOGRAPHIC CONGRESS

Date: September 11-15, 1978
Place: Barcelona, Spain: Palacio de Congresos
Sponsor: European Thermographic Assoc.
Requests for Information: General Secretariat, Cruz Blanca, Pelayo, 40, Barcelona-1 Espana. Telef. (93)301 78 78
Content: Sessions on thermography in ecology, in breast pathology, and on cancer in general will be included.

AMERICAN ACADEMY OF OCCUPATIONAL MEDICINE: Thirteenth Annual Meeting

Date: September 20-22, 1978
Place: Williamsburg, VA
Sponsor: American Academy of Occupational Medicine (AAOM)
Requests for Information: AAOM, 150 N. Wacker Dr., Chicago, IL 60606

NINETEENTH INTERNATIONAL CONGRESS ON OCCUPATIONAL HEALTH

Date: September 25-30, 1978
Place: Dubrovnik, Yugoslavia
Sponsor: Permanent Commission & International Assoc. of Occupational Health (PCIAOH)--organized by Assoc. of Occupational Health of Yugoslavia (AOHY) & Inst. for Medical Research & Occupational Health
Requests for Information: Professor M. Saric, Inst. for Medical Res. & Occupational Health, 41000 Zagreb, 158 Mose Pijade, POB 291, Yugoslavia

WESTERN OCCUPATIONAL HEALTH CONFERENCE

Date: October 12-14, 1978
Place: Los Angeles, CA: Hyatt Regency Hotel
Sponsor: American Industrial Hygiene Assoc., Health Physics Society; Western Occupational Medical Assoc. (WOMA); Western Assoc. Industrial Nurses; American Society Safety Engineers
Requests for Information: B. H. Bravinder, WOMA, Box 201, Alamo, CA 94507

EIGHTEENTH HANFORD LIFE SCIENCES SYMPOSIUM: Biological Effects of Extremely-Low-Frequency Electromagnetic Fields

Date: October 16-18, 1978
Place: Richland, WA
Sponsor: Battelle-Northwest
Requests for Information: Mrs. Judith A. Rising, Biology Dept., 331 Bldg., Battelle-Northwest, Richland, WA 99352

INTERNATIONAL MICROWAVE SYMPOSIUM

Date: March 30-April 2, 1979
Place: Orlando, FL: Sheraton Twin Towers
Sponsor: Inst. Electrical & Electronic Engineers (IEEE)--Microwave Theory & Techniques Group
Requests for Information: R. E. Henning College of Engineering, Univ. South Florida, Tampa, FL 32620

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS: Region 6 Annual Conference

Date: April 25-27, 1979
Place: Sacramento, CA
Sponsor: Inst. of Electrical & Electronics Engineers (IEEE)--Sacramento Section
Requests for Information: R. J. Paul, 2700 Watt Ave., Room 4132, Sacramento, CA 95821

INSTITUTE OF ELECTRICAL & ELECTRONICS ENGINEERS CONFERENCE (ELECTRO 79)

Date: May 22-25, 1979
Place: New York, NY: The Coliseum
Sponsor: Inst. of Electrical & Electronic Engineers (IEEE)--Region One
Requests for Information: W. C. Weber, Jr., ELECTRO, 999 N. Sepulveda Blvd., El Segundo, CA 90245

0331 ELECTROMAGNETIC DOSIMETRY VIA NON-PERTURBING TEMPERATURE PROBES. Kantor, G.; Bassen, H. (U.S. Dept. Health, Education & Welfare, Bureau of Radiological Health, Electromagnetics Branch, 5600 Fishers Lane, Rockville, MD 20852).

Microwave-induced temperature elevations in actual and simulated biologic tissue are being measured via various temperature probes, designed to minimally perturb internal field distributions that exist in the tissue in the absence of such probes. One probe, developed for Bureau of Radiological Health (BRH), incorporates as a sensor a stable birefringent crystal (lithium-tantalate) chip (1 mm diameter). The sensor is interrogated via light, directed by a fiber-optic-glass waveguide. Precise temperature calibrations using NBS-calibrated standards are performed on this and other temperature probe prototypes. The degree of interaction and perturbation of internal fields is studied in simulated biologic tissue using thermographic camera techniques. Dosimetric studies in simulated tissues, objects, and living animals exposed to high level (50-200 mW/cm^2 microwave fields will be performed in conjunction with BRH's and National Institute of Health's researchers. (1/78-12/78)

Supporting Agency:HEW, PHS, FDA, BRH

0332 MICROWAVE RADIATION EFFECTS—OCCUPATIONAL EXPOSURE TO RADAR. Robinette, C. D. (Natl. Acad. Sciences, 2101 Constitution Ave. N.W., Washington, DC 20037).

To assess the possible risks to human health from exposure to microwaves, a follow-up study of Navy veterans of the Korean War is being conducted. The retired records of naval technical schools have been used to construct the study population of approximately 20,000 men who were occupationally exposed to radar (equipment repair) and 20,000 controls who served as equipment operators. Follow-up information has been obtained from existing records and computer tapes for: (1) mortality by cause of death for the years 1955-1974, (2) morbidity in Navy hospitals for 1950-1959, (3) morbidity in Veterans Administration hospitals for 1963-1976, and (4) claims for disability compensation, up to 1976. A measure of occupational exposure to radar, an exposure index, has been developed and calculated for all men who died (except those who died from accidents) and for a random 5% of all others. Analysis has been completed, and a final report is being prepared. (1/77-12/77)

Supporting Agency:HEW, PHS, FDA, BRH

0333 A PRELIMINARY SURVEY OF VETERANS WHO MAY HAVE BEEN EXPOSED TO CATARACT PRODUCING RADIATION. McAfee, R. D.; Cazenavette, L. L.; Holland, M. G.; Robinette, C. D. (U.S. Veterans Admin. Hosp., 1601 Perdido St., New Orleans, LA 70140).

The National Academy of Sciences, National Research Council, Medical Follow-up Agency will cooperate in enlarging an original pilot study to a full scale investigation of electronic technicians who may have been exposed to microwave radiation (as well as controls). The names and addresses of selected groups of veterans to whom a shadowgraph device will be mailed will be obtained, and the Medical Follow-up Agency will also participate in the statistical interpretation of the data. (12/77-11/78)

Supporting Agency:U.S. Veterans Admin.

0334 MICROWAVE THAWING OF FROZEN TISSUE. Lehr, H. B.; Holst, H. I.; Ketterer, F. D. (Univ. Pennsylvania, Sch. Medicine, Dept. Surgery, 36th & Hamilton Walk, Philadelphia, PA 19104).

The objectives of these experiments are: (1) to measure the unknown electrical properties of frozen tissue, (2) to calculate the heating potential distributions of solid organs and develop equipment to apply microwaves evenly to these organs, and (3) to prove that properly prepared frozen solid organs are viable in mammals. Direct measurements of the electrical properties of ice, physiologic saline with cryoprotectants, gelatin molds, and frozen mammalian tissue will be performed. The thawing equipment will comprise commercially available microwave ovens in different frequency ranges, and the mammalian test organs will be rabbit and canine kidney. (4/78-3/79)

Supporting Agency:HEW, PHS, NIH, NIAMDD

0335 BEHAVIORAL EFFECTS OF MICROWAVES ON RATS. Reiter, L. W.; Gray, L. E (Environmental Protection Agency, Environmental Biology Div., Durham, NC 27711).

Neonatal Sprague-Dawley rats are being exposed to microwaves from 4 to 16 hr/day in anechoic chambers for the first 3 wk following birth to study the effects on central nervous system development. Neurologic (reflex) and behavioral (spontaneous locomotor activity and social behavior) development is being measured. (10/77-9/78)

Supporting Agency:EPA

0336 ELECTROMAGNETIC RADIATION EFFECTS ON BRAIN TISSUE PERMEABILITY. Oscar, K.; Stokes, N. (U.S. Army, Mobility Equipment Res. & Development Command, Fort Belvoir, VA 22060).

The functional relationship of microwave parameters to changes in the permeability of small inert polar molecules in the blood-brain barrier of rats will be determined. Rats will be exposed to pulsed and continuous wave microwave energy to assess the uptake of low molecular weight saccharides and anti-

cancer drugs in certain areas of the brain. A quantitative radioactive isotope method, which uses a highly diffusible substance as an internal standard, will be employed to measure the loss of a labeled test substance to the brain tissue as a function of different microwave exposure parameters. (10/77-9/78).

Supporting Agency:U.S. Dept. Defense, Army

0337 DESIGN, CONSTRUCTION AND TESTING OF AN ANECHOIC CHAMBER FOR RFR STUDIES. Naber, T. (Emerson Electric Company, 24003 Ventura Blvd., Woodland Hills, CA 91302).

An anechoic chamber facility that will provide for controlled environmental testing of biologic specimens exposed to radio frequency radiation (RFR) will be designed, installed, and tested. The anechoic structure will absorb scattered RFR, allowing the exposure fields for biologic experiments to be well defined. The chamber will operate in the 1-10 GHz frequency band. An environmental control system will keep the inside of the chamber at a constant temperature; it will provide temperatures between 55 and 95 F. This will allow measurement of synergistic effects of RFR and environmental temperatures. The chamber will be constructed in the RF laboratory at Brooks Air Force Base, and the contractor will provide measurements of the anechoic properties of the chamber. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Air Force

0338 MICROWAVE IRRADIATION OF BRAIN THROUGH CRANIOPLASTY. Sutton, C. H. (Univ. Miami, Sch. Medicine, Dept. Oncology, 1400 N.W. 10th Ave., Miami, FL 33124).

This project is part of a broader program that supports the Comprehensive Cancer Center for the State of Florida as a multi-disciplinary cancer center. The center's participants are involved in clinical and basic cancer research, cancer education at all levels, and intensive community outreach programs throughout Florida. Cooperative programs have been established with the state's other universities, the American Cancer Society, and Dept. of Health, Education & Welfare. The overall objectives of this program are the establishment of a core of excellence in cancer research for the State of Florida and the development of interrelationships with other cancer-directed interests in the State (and nation). (6/77-5/78)

Supporting Agency:HEW, PHS, NIH, NCI

0339 OCCUPATIONAL EXPOSURE TO MICROWAVES AND CONGENITAL MALFORMATIONS IN OFFSPRING. Stellman, J. (American Health Foundation, Inc., Occupational Health and Toxicology Div., 1370 Ave. 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 evaluated. In addition, the relationship of such exposure to fertility, pregnancy outcome among their wives, and the incidence of illnesses and symptoms purportedly related to radio frequency exposure will be assessed. By means of a retrospective mail survey of physical therapists with occupational exposure to radio-waves and a control group without such exposure, exposure data, work history, family, reproductive and medical histories will be collected. The survey questionnaire and study protocol are being finalized, and the pretest should be conducted in fiscal year 1978. (5/77-9/78)

Supporting Agency:HEW, PHS, FDA, BRH

0340 BIOCHEMICAL PREPARATION AND SPECTROSCOPIC INVESTIGATION OF SYNTHETIC AND NATURALLY OCCURRING BIOMEMBRANE SYSTEMS. Thompson, T. E.; Gaber, B. P. (Univ. Virginia, Sch. Medicine, Dept. Biochemistry, Box 246, Charlottesville, VA 22901).

The data on possible interactions of continuous wave and pulsed non-ionizing electromagnetic radiation with biomembrane systems will be obtained to substantiate or refute the implications of low-level effects and aid in establishing a safety level. The University of Virginia will establish a biochemical facility in the Naval Research Laboratory's (NRL) Optical Techniques Branch. The contractor will furnish synthetic and naturally occurring biomembrane systems. Spectroscopic experiments will then be performed in collaboration with the contractor using the existing laser spectroscopic facility located in the Optical Techniques Branch at NRL. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Navy

0341 NAVY ENVIRONMENT: TEMPERATURE INCREASE IN TISSUE SPHERES EXPOSED TO MICROWAVES FROM NAVAL OPERATIONS. Kritikos, H.; Schwan, H. P. (Univ. Pennsylvania, Sch. Engineering & Applied Sciences, Dept. Bioengineering, 4001 Spruce St., Philadelphia, PA 19104).

When microwave fields generated by Navy radar encounter human tissue, heat may be generated. It is vital that the temperature distribution of the heat be determined. Calculations have been made of the temperature inside spheres (such as the human head) without considering redistribution of heat due to blood flow. This research will compare the deposited energy with the resulting steady-state temperature distribution in the sphere, assuming physiologically appropriate values for the tissue blood flow and thermal conductivity. This is a theoretic study requiring a highly sophisticated computer program to solve the necessary equations.

All calculations will be performed using the Univac 70/90 computer located in the Moore School of the University of Pennsylvania. To facilitate computations, a portable remote terminal will be purchased. (10/76-9/77)

Supporting Agency:U.S. Dept. Defense, Navy

0342 MICROWAVE EFFECTS ON EXCITABLE MEMBRANE SYSTEMS. Cleary, S. F.; Liu, L.; Hoffman, R. (Virginia Commonwealth Univ., Sch. Basic Science & Graduate Studies, 901 W. Franklin St., Richmond, VA 23284).

The effect of electric fields at microwave frequencies on the induction of action potentials in excitable membrane systems will be investigated. The objective of the research is to differentiate between effects due to the impressed microwave electric field as contrasted with other microwave-specific thermal and nonthermal effects. A waveguide irradiation technique will be used to expose the algae *Chara australis* and other excitable cell systems to low intensity microwave radiation in the frequency range of from 2 to 4 GHz in a thermostated irradiation chamber. Initially, continuous wave microwaves will be employed, followed by pulse-modulated fields. The cell systems will be of sufficient size to permit the measurement of action potentials with electrodes exterior to the waveguide, minimizing interactions between the microwave field and the detection system. Prior to microwave exposure the mean threshold electric field strength for the induction of the action potential will be determined by a variable amplitude pulsed current stimulator. Thresholds will be redetermined during and after exposure of the cell system to microwave radiation of known field strength. Variations in the excitation threshold will be interpreted in terms of the summation of the field strengths of the impressed stimulus and the microwave field. The independent variables to be investigated will be microwave field strength, microwave frequency, pulse duration and amplitude, latency for recovery of pre-exposure threshold, and temperature. (2/78-1/79)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Environmental Health Sciences

0343 MICROWAVE CATARACTOGENESIS. Ferri, E. (U.S. Dept. Health, Education & Welfare, Bureau of Radiological Health, 5600 Fishers Lane, Rockville, MD 20852).

The effect of microwave radiation on the eye will be determined with emphasis on the histopathology and biochemistry of cataract formation, as well as dosimetry and frequency parameters. The approaches to be taken include: (1) determination and physical characterization of microwave fields with exposure apparatus under use conditions, (2) construction of phantom eyes for estimation of intraocular temperature and calorimetric determination of absorbed dose in the eye, (3) opthalmic inspection of irradiated rabbit eyes, histopathologic study of irradiated lenses from experimental animals, and comparison with lenses from humans known to have prior exposure to microwaves, (4) measurement of changes in absorbic acid in rabbit eyes at various post-irradiation intervals after acute and repetitive exposures, and (5) comparison of the cataractogenesis associated with either pulsed or continuous wave (CW) sources and effects of repetitive low-level exposure on a cataract prone species. Heat alone has been ruled out as the causative factor involved in alterations of ascorbate in the microwave-irradiated rabbit eye. Increased intraocular temperature occurring during microwave irradiation is not the sole causative factor in microwave cataractogenesis. Histopathologic changes associated with the development of microwave cataracts were studied in serial sections of preserved rabbit eye lenses at post-irradiation intervals ranging from 12 hr to 123 days. It was found that during the first 2 days post-irradiation, lens fibers in the posterior subcapsular cortex became hydropic with slight swelling or with many tiny vesicles. This was interpreted as an initial response to microwave heating. During the fourth day, epithelial cells migrated from the equator posteriorly under the capsule and numerous mitotic figures indicated proliferative activity. In the ensuing 5 days, swollen "balloon cells" appeared at the equator or in the posterior cortex; these appeared to represent abortive attempts of the cells to differentiate into new lens fibers as they normally do. The posterior migration of epithelial cells and transformation of some of them into "balloon cells" have been described previously as a characteristic response to ionizing radiation. (10/76-9/77)

Supporting Agency:U.S. Dept. Defense, Navy

0344 PROGRAM ON THE QUANTITATION OF THE EFFECTS OF THE ELECTROMAGNETIC ENERGY ON HUMAN TISSUE. Guy, A. W. (Univ. Washington, Medical Rehabilitation Res. & Training Center, 15th Ave. N.E., Seattle, WA 98105).

The purpose of this investigation is to advance the existing knowledge on the human body and to provide realistic guidelines for safety standards of human exposure. The electromagnetic field patterns from external sources of energy, both in and exterior to the tissues of human subjects and test animals, will be established quantitatively. The test animals will be exposed to the various continuous wave and modulated electromagnetic sources at both thermal and nonthermal lower levels, and the energy in the tissues will be monitored. The physiologic and behavioral characteristics of the animals will be observed before, during, and after exposure to electromagnetic radiation. The time and power density thresholds for cataract production will be determined in animals exposed to microwave radiation. Safe human exposure levels will be determined, taking into proper account the source, configuration, frequency, and location. The theoretic analysis involves the solution of Maxwell's equation for the absorbed power by

biologic systems for a host of different geometries. The experimental studies involve controlled exposure of test animals to select sources of electromagnetic energy with the aim of quantifying observable effects and changes on the biologic systems. (10/76-9/77)

Supporting Agency:HEW, Office Human Development Services, Rehabilitation Services Admin.

0345 USE OF SYNAPTOSOMES AS AN EXPERIMENTAL MODEL FOR EVALUATING THE EFFECT OF ELECTROMAGNETIC RADIATION (EMR) ON NEURAL MEMBRANE FUNCTION. Millar, D. B.; Christopher, J. P. (U.S. Navy, Biochemistry Div., Bethesda, MD 20014).

Synaptosomes will be used as a neural membrane model to evaluate the potential hazard that electromagnetic radiation (EMR) poses to military personnel during performance of critical, defense-related tasks. Synaptosomes will be prepared from guinea pig brains and purified by density gradient centrifugation. Neural membrane function will be reflected by changes in the permeability of isolated synaptosomes. Permeability will be monitored by the uptake of radiolabeled choline, release of radiolabeled calcium, and by the measurement of internal membrane viscosity with appropriate fluorescent probes. The results will serve as baseline values for permeability in the absence of EMR. Synaptosomes will then be exposed to radiation of various doses with a frequency of 2.8 GHz (radar). Power levels will be determined as specific absorption rates, and proper thermal controls will be employed in each case. Threshold values for EMR-neural membrane interaction will be determined in this manner. Neuropharmacologic drugs will then be screened for those that minimize the effect of EMR on the stability of synaptosomes. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Navy

0346 FACTORS AFFECTING THE COLD ACCLIMATION OF CONTAINER-GROWN WOODY ORNAMENTAL PLANTS. Maronel, D. M.; Stolz, Lockard, R. G. (Univ. Kentucky, Dept. Horticulture, Agricultural Experiment Station, Limestone & Euclid, Lexington, KY 40506).

An attempt will be made to determine the effect of electromagnetic fields on organogenesis of in vitro cultured woody plants. Magnolia seedlings have been propagated for cold hardiness studies, and experimental procedures are being worked out for determination of abscisic acid (ABA) content in hardy and non-hardy magnolia plants. Translocation studies of ABA in magnolia seedlings has also been initiated. In vitro callus cultures of *Betula lenta*, *Cornus Florida*, and *Abelia grandiflora* have been established, and attempts are now being made to reproduce large quantities of these callus tissues for cold hardiness studies. Production of callus tissue from nine other woody plant species has not been successful. Mycorrhizal fungi have been isolated from roots of woody plants and are being reproduced in large quantities using aseptic culture techniques. Experiments for determining the effect of mycorrhizal fungi on termination of plant growth and subsequent cold hardiness are being instituted. A model production field and container nursery and experimental growth chambers have been designed and are being constructed for growing plants used in cold hardiness and plant growth studies. The effects of electromagnetic fields on plant growth are also being conducted. Results suggest that electromagnetic effects are species specific. No increase in germination of herbaceous ornamental plants has been found. (10/77-9/78)

Supporting Agency:U.S. Dept. Agriculture, Cooperative State Res. Service, KY

0347 EFFECTS OF ACUTE ELECTROMAGNETIC RADIATION ON THE CENTRAL NERVOUS SYSTEM: MORPHOLOGICAL STUDY OF HYPOTHALAMIC AND SUBTHALAMIC REGIONS. McKee, A. E.; Dorsey, C. H. (U.S. Navy, Experimental Pathology Dept., Bethesda, MD 20014).

The effects of microwave irradiation on the central nervous system (CNS) will be investigated. Morphologic studies of the CNS will be conducted to evaluate and characterize histologic alterations. Efforts will be made to establish thresholds relative to time and power densities and to determine whether morphologic changes are reversible or permanent. Morphologic changes in the CNS of Chinese hamsters following exposure to acute continuous wave microwave irradiation will be evaluated by light and transmission electron microscopy. Two groups of Chinese hamsters, each divided into two subgroups, will be used in this study. The first group will be irradiated at a frequency of 1.7 GHz and at power densities of 10 and 25 mW/cm^2. The second group will be irradiated at a frequency of 2.45 GHz and at power densities of 10 and 25 mW/cm^2. The exposure time will range from 30, 60, and 120 min. Animals from each group will be sacrificed either immediately after exposure or after a recovery period of 15 days. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Navy

0348 SLOW CHANGES IN BLOOD BRAIN BARRIER IN THE RAT FOLLOWING EXPOSURE TO MICROWAVE RADIATION. Gruenau, S. P.; Rapoport, S. I. (U.S. Navy, Behavioral Sciences Dept., Bethesda, MD 20014).

Techniques are being developed at National Institute of Health for measuring subtle changes in blood-brain-barrier (BBB) permeability in local regions of the brain with a time resolution of .5 hr. An absolute sensitivity of 10^{-9} cm/sec, and a standard error of about 20%. This technique has been used to measure BBB permeabilities of glycerol, mannitol, sucrose, and inulin, independent of variations of cerebral blood flow. The technique has demonstrated how long and to what extent microwave radiation induces changes in the BBB. Rats will be exposed to 2,450 MHz pulsed microwave radiation, pulse repetition rate 500 Hz, and 2 μsec pulse duration for a

period of .5 hr at power densities $\leq$15 mW/cm^2. At various times following the irradiation, the BBB permeability to ^{14}C sucrose in different parts of the brain will be assayed by the above-described technique. Because animal sacrifice is required for the measurement, different animals will be used for different times. Animals subjected to both sham and experimental radiation will be studied. The time course over days of microwave-induced changes in the BBB permeability will be determined. Future plans include searching for long-lasting BBB changes in animals chronically exposed to about 100 mW/cm^2 at various pulse repetition rates and pulse widths. Irradiation values that cause BBB changes will provide guidelines for the formulation of safe human exposure levels for naval personnel. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Navy

0349 EFFECTS OF MICROWAVE RADIATION ON THE BEHAVIORAL DEVELOPMENT OF LEARNING PROCESSES: ACUTE AND CHRONIC EXPOSURE. Maitland, G.; Thomas, J. R. (U.S. Navy, Behavioral Sciences Dept., Bethesda, MD 20014).

The overall objective of this research is to determine whether acute and chronic exposures to low power levels of microwave radiation produce effects on the acquisition of new behaviors. It is important to determine whether the learning process is modified by microwave radiation levels similar to those produced by the electromagnetic emitting equipment operated by naval, surveillance, and communication systems. Acquired behavior is weaker and more susceptible to environmental influences than maintained well-established behavior. Established effects of low-level radiation on the development of behavior can be used to aid in specification of permissible levels of exposure across a range of frequencies for military personnel under functionally similar conditions. The methodology involves several new behavioral techniques that have been developed for studying repeated acquisition of behavioral chains with individual subjects. These techniques, which have proved to be extremely sensitive to the effects of a range of environmental variables, will be used to measure low-level radiation effects on behavior acquisition in animals as modified by several important radiation parameters. Frequency (initially 1 to 3 GHz), modulation values, and exposure time will be explored. Acute exposures as well as continuous exposures under chronic conditions (up to 90 days) will be emphasized. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Navy

0350 AN INVESTIGATION OF THE MECHANISM OF MICROWAVE INDUCED CHANGES IN MEMBRANE PERMEABILITY. Finch, E. D. (U.S. Navy, Div. Medical Biochemistry, Bethesda, MD 20014).

This research will determine the interaction mechanisms responsible for microwave-induced changes in membrane permeability and, in particular, elucidate the role of modulation and temperature. Radioisotopic methods will be employed to monitor the membrane transport properties of mammalian cells exposed to microwave radiation. Studies will be carried out systematically to determine the exact dependence of any observed permeability changes on modulation and temperature. To further elucidate the interaction mechanisms responsible for any observed permeability changes, dynamic measurements will be used to monitor structural changes that occur in the biologic membrane and its environment during a single microwave pulse. These data will help identify the mechanism of interaction of the microwave field with the biologic membrane. The transport data combined with the dynamic measurements should identify thresholds for any observed effects. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Navy

0351 BIOLOGIC CONSEQUENCES OF PULSED VERSUS CONTINUOUS WAVE RADIOFREQUENCY RADIATION (RFR). Cain, F. (Georgia Technical Res. Inst., Atlanta, GA).

See Current Research 0352. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Air Force

0352 BIOLOGICAL CONSEQUENCES OF PULSED VERSUS CONTINUOUS WAVE RADIO FREQUENCY RADIATION (RFR). Guy, A. W.; Chou, C. K. (Univ. Washington, Sch. Medicine, Dept. Rehabilitation Medicine, 500 17th Ave., Seattle, WA 98122).

This contract will provide data regarding the relative abilities of continuous wave (CW) and pulsed (P) radio frequency radiation (RFR) to produce biologic effects and determine whether the rapid rise and fall of electric and magnetic fields of P RFR are more stressful than CW RFR. Test animals will be exposed in both P and RFR fields to establish relative biologic effects. Effects will be characterized as to frequency, incident power, absorbed power, pulse and modulation characteristics, tissue temperature, and duration of exposure. This is a multi-source contract. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Air Force

0353 THE THERAPEUTIC RATIO AND EXPERIME[illegible] RADIOTHERAPY. Phillips, T. L.; F[illegible] K.; Goldstein, L.; Begg, A. C.; Harris, J. (Univ. California, Sch. Medicine, 551 Parn[illegible] Ave., San Francisco, CA 94122).

A group of experimental systems that allow the determination of quantitative endpoints in normal tissue and in tumors in the mouse will be used to search for improved therapeutic methods. Measurement of normal tissue damage to be applied include pulmonary lethality, esophageal lethality, renal lethality, whole brain lethality, intestinal crypt

cell assay, skin reaction grade assay, and the mouse bone marrow colony-forming unit assay. Tumor endpoints to be applied include the EMT6 mouse mammary tumor in vivo as a solid tumor, tumor located in the leg or flank as pulmonary microcolonies and as pulmonary macrocolonies. Assay methods will include in vivo treatment and in vitro assay, lung nodule assay, and regrowth delay time assay. Additional tumor systems to be employed include the Yuhas pulmonary carcinoma, the colon 26 and 36 carcinomas, the Lewis lung carcinoma, and the B16 melanoma. Using these systems, the damage to normal tissue versus tumor will be determined, and combinations or individual radiation regimens yielding improved tumor kill for a given normal tissue damage determined. The measured therapeutic ratio will be compared for various tumor types and for various specific critical normal tissues. Methods of enhancing tumor damage vs normal tissue damage to be explored include the effect of multiple or hyperfractionation of the radiation dose, the effect of alterations in radiation dose rate, the effects of anti-cancer chemotherapeutic agents, the effects of chemical radiation protective of sensitizing compounds, the relative effectiveness of high linear energy transfer heavy particles, including 15 MeV neutrons, helium ions, carbon, neon, and argon ions, and the effects of hyperthermia on tumor and normal tissue. (5/78-4/79)

Supporting Agency:HEW, PHS, NIH, NCI

0354 THE EFFECT OF MICROWAVE RADIATION ON ANIMAL BEHAVIOR. Monahan, J. C. (Dept. Health, Education & Welfare, Bureau of Radiological Health, Biological Effects Div., 5600 Fishers Lane, Rockville, MD 20852).

The effects of microwave radiation on the behavioral matrix of three animal species (monkeys, rats, mice) will be determined. Special emphasis will be given to determining threshold radiation levels and the effects of frequency, as well as environmental conditions. Monkeys will be trained to perform behavioral tasks, shown to be sensitive to variables that produce changes in learning and memory. The subjects will then be irradiated (2,450 MHz continuous wave) during task performance, and their behavioral responses will be analyzed. The effect of long-term repeated exposures to microwaves (915 MHz continuous wave) will be evaluated in terms of learned behavioral patterns in a classical conditioning paradigm. Rats will also be employed to evaluate the effect of 915 MHz continuous wave radiation on a learned avoidance behavior (taste aversion). In a separate but related study, mice will be used to evaluate the noxious stimulus properties of 2,450 MHz continuous wave radiation. Both active and passive avoidance behavioral procedures will be employed, and the effects of environmental conditions and radiation thresholds will be evaluated. The results of the studies involving monkeys strongly suggest an interactive effect between microwave radiation and fenfluramine, a serotonin depleter. The studies employing mice and rats have shown that microwaves can act as a noxious stimulus that results in behaviors that allow the subject to avoid or escape the radiation. In addition, the environmental temperature can significantly alter the radiation threshold necessary to produce these behavioral changes. (10/76-9/77)

Supporting Agency:HEW, PHS, FDA, BRH

0355 ELECTROMAGNETIC DOSIMETRY VIA IMPLANTABLE ELECTRIC FIELD PROBES. Bassen, H. (Dept. of Health, Education & Welfare, Bureau of Radiological Health, Electromagnetics Branch, 5600 Fishers Lane, Rockville, MD 20852).

Electric field strengths within simulated and actual living animals and man are to be measured during exposure to low-level (1-10 mW/cm^2) radio frequency (RF) and microwave radiation. Miniature dipoles (1.5 mm) with microelectronic diode chips and high resistance-detected signal leads have been developed using thin film technology. Both 3-axis probes (containing three orthogonal dipoles) and single axis probes have been fabricated and evaluated in simulated biologic tissue objects. With a proper low-dielectric-constant insulator surrounding the probe tip, internal electric field strengths in finite objects (small spheres and rectangles) exposed to low-level microwave radiation (450-2,450 MHz) may be accurately measured. Measured data agree with theoretically predicted values within ± 2 or ± 4.5 dB, using only free space calibration factors for the probe. Proximity to dielectric interfaces (boundaries between air and simulated muscle) does not affect the probe's accuracy. Efforts to improve absolute accuracy, increase the frequency range to 100 MHz, and reduce probe size are under way. The development of a readily available, biocompatible probe should be complete in fiscal year 1978. Applications in the dosimetric measurement of fields with a living cat's brain, a human skull filled with simulated brain material, and a rabbit's eye have begun with promising initial results. (10/76-9/77)

Supporting Agency:HEW, PHS, FDA, BRH

0356 NAVY ENVIRONMENT: INTERACTIVE MECHANISMS AND EFFECTS OF LOW-LEVEL MILLIMETER WAVES ON LIVING CELLS. Motzkin, S. M.; Rosenthal, S. W. (Dept. Chemistry, Polytechnic Inst. New York, Graduate Sch., 333 Jay St., Brooklyn, NY 11201).

Mechanisms that underlie the effects of microwaves at the cellular and subcellular level will be studied. Using millimeter waves in the frequency range between 30 and 60 GHz, attempts will be made to define the field specific effects and mechanisms that occur when microwaves interact with biologic systems. In the first year, the necessary millimeter wave equipment will be set up in an appropriate facility, and a test chamber will be developed for retaining microorganisms and tissue culture cells for exposure to the microwaves. Once the exposure systems are complete, several Soviet experiments will be duplicated. In addition, pre-

liminary studies will investigate permeability and transport in mitochondria. In the second year, mitochondrial characteristics and functions will be examined with respect to permeability, facilitated transport, active transport, cytochrome oxidase, electron transport, and adenosine triphosphatase. Studies will be undertaken with red blood cell membranes. (10/76-9/77)

Supporting Agency: U.S. Dept. Defense, Navy

0357 NAVY ENVIRONMENT: DETERMINATION OF BOUND WATER IN BIOLOGICAL TISSUE AND ENERGY DISSIPATED IN BOUND WATER BY LOW-LEVEL MICROWAVES. Grant, E. H.; Sheppard, R. J. (Univ. London, Campden Hill Rd., W8 7AH, London, England).

This study will elucidate the role of bound water in microwave energy absorption, which leads to undesired effects in humans exposed to low-level microwaves generated by naval operations. Dielectric (permittivity and conductivity) measurements will be made on low density lipoproteins of human serum. These lipoproteins have varying amounts of bound water, depending on the source. The absorption of microwave energy (at several frequencies) by bound water will be studied, and an attempt will be made to characterize the dielectric parameters of bound water. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Navy

0358 MUTAGENIC EFFECTS OF MICROWAVES. Buchta, F. L. (Dept. Health, Education & Welfare, Bureau of Radiological Health, Genetic Studies Section, 5600 Fishers Lane, Rockville, MD 20852).

The possible mutagenic effects of low-level 2,450-MHz microwave radiation are being investigated. Auxotrophic bacteria are exposed in liquid culture under carefully controlled temperature and absorbed dose levels. Locus reversion is monitored by plating on appropriate indicator media. Exposures have been carried out at levels of 50, 100, and 200 mW/g absorbed dose using 30-min radiation times and a controlled exposure temperature of 37 C. (10/76-10/77)

Supporting Agnecy: HEW, PHS, FDA, BRH

0359 FLUORESCENT DYES AS EMR PROBES. Friend, A. W. (U.S. Navy, Electromagnetic Radiation Div., Bethesda, MD 20014).

No method for directly observing electromagnetic radiation (EMR) interactions at cellular levels within living tissues is currently available. Fluorescent dyes have been found to act as optical probes of transmembrane action potentials in cells. This research will investigate the possibility that fluorescent dyes may also be able to detect the fluctuating transmembrane potentials induced by external EMR fields at frequencies into the radio frequency (RF) range. Fluorescent dye molecules will be attached to cell membranes. Their fluorescence and absorption characteristics at optical frequencies will be monitored as functions of fluctuating transmembrane potentials in both the audio and low RF ranges. The frequency responses and signal to noise ratios of absorption, fluorescence, and electrochromism will be plotted for a series of merocyanine dyes. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Navy

0360 POSSIBLE EFFECTS OF MICROWAVES ON NERVES. Brandt, H. E. (U.S. Army, Harry Diamond Lab., 2800 Powder Mill Rd., Hyattsville, MD 20783).

The possible effects of microwave radiation on the propagation of action potentials in nerve fibers will be determined. A computer program for integrating the perturbed Hodgkin-Huxley equations (nonlinear diffusion equation) will be developed to calculate the effect of various current field perturbations on nerve pulse shape and velocity. The possible interactions of perturbing fields with the cell membrane resulting in alternations of the ion gating mechanisms will be investigated, and thermal effects will be calculated. The penetration of an external radio frequency field through surrounding tissue and into an axon will be calculated in addition to the effect of such a perturbation on action potential transport. (10/77-9/78)

Supporting Agency: U.S. Dept. Defense, Army

0361 WORKSHOP ON THE PHYSICAL BASIS OF MICROWAVE INTERACTIONS WITH BIOLOGICAL SYSTEMS. Anonymous. (U.S. Navy, Office Naval Res., 800 N. Quincy St., Room 724, Arlington, VA 22217).

Under joint sponsorship with the Navy, a workshop was held in June of 1977 to discuss the mechanism of interaction of microwave radiation with biologic systems and appropriate methods of measurement of physical parameters. The proceedings have been published and are available. The workshop generated interest in this complex problem among new areas of the scientific community and brought new ideas to the forefront. A more concentrated follow-up workshop will be held in 1979. (1/77-12/77)

Supporting Agency:HEW, PHS, FDA, BRH

0362 HYPERTHERMIA--A DIFFERENTIAL RADIOSENSITIZER IN VIVO. Gibbs, F. A. (Utah Higher Education System, Sch. Medicine, Dept. Radiology, 1400 E. 2nd St., Salt Lake City, UT 84112).

The potential of hyperthermia as a radiosensitizer will be evaluated for a rapidly proliferating normal murine tissue (duodenal crypt lining epithelium), a slowly-turning-over normal murine tissue (spinal cord), as well as a slow-growing (slow line) and a fast-growing (S102F) C3H mouse mammary tumor. This combination of tissues will allow the assessment of

hyperthermic radiosensitization for both the early and late effects on normal tissue and on tumors with widely varying growth kinetics. The hyperthermia will be induced locally via a 915 MHz microwave system, and the effects on the tissues will be assayed, respectively, by microcolony crypt survival, hind-leg dysfunction, tumor growth delay and local tumor control (TCD50/120). Several temperatures and heating intervals will be studied as will heating before and after x-irradiation. The therapeutic indices for tumor versus normal tissue will be determined for the various protocols. The long-term goal is to assess the feasibility of introducing hyperthermia as an adjuvant for clinical radiation therapy. (5/77-4/79)

Supporting Agency:HEW, PHS, NIH, NCI

0363 BOSE-EINSTEIN CONDENSATION IN BIOLOGICAL SYSTEMS. Wu, T. (State Univ. New York, Sch. Science & Mathematics, Dept. Physics, Vestal Parkway E., Binghamton, NY 13901).

Biological systems contain dipolar elements (H-bonds, proteins, DNA that are capable of electric oscillations at certain specific frequencies. Longitudinal electric modes in a frequency range of 10^{11}-10^{12}/sec are typical. A model created by Frohlich suggests that if energy is supplied above a critical rate to the branch or branches of electric modes, Bose-Einstein Condensation into the lowest energy state occurs. Hypothetically, this phenomenon provides a means of energy storage for life-sustaining biologic processes, such as, cell division and protein synthesis. Several recent Russian experiments provide strong support for the Frohlich theory. These experiments involve the microwave irradiation of living organisms. A criticism of Frohlich's theoretic model is analyzed, and a possible alternative microscopic approach to this problem is proposed using perturbation theory. In light of recent Russian and American political developments concerning microwaves, this problem takes on added interest and may be a theoretic means of explaining, in terms of straightforward physical concepts, a very complex set of bioprocesses. (2/78-1/79)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. General Medical Sciences

0364 STUDY OF BRAIN METABOLISM USING RAPID MICROWAVE HEATING. Stavinoha, W. B. (Univ. Texas, Sch. Medicine, Dept. Pharmacology, 7703 Floyd Curl Dr., San Antonio, TX 78284).

The technique of microwave inactivation of the enzymes of the rat brain will be applied to the study of the neurochemistry of the brain. The time required for enzyme inactivation will be on the order of 200-400 msec for the rat and 50 msec for the mouse. Rats monitored by electroencephalograph will be sacrificed by microwave enzyme inactivation while either awake, in slow wave sleep, or in paradoxical sleep. The following neurochemicals will be analyzed in regions of the brain: (1) neurotransmitters: acetylcholine, 5HT, GABA; (2) cyclic nucleotides: cyclic adenosine monophosphate and cyclic guanosine monophosphate; (3) high energy compounds: adenosine triphosphate, adenosine diphosphate, adenosine monophosphate, Pi, creatine phosphate, and glucose metabolism. Studies will also be done on the correlation of cyclic nucleotides and the cholinergic and adrenergic systems, cyclic nucleotides and compromised nutrient delivery, glucose metabolism in regions of the brain with barbituates and ethanol, and acetylcholine synthesis rate in the brain with therapeutic agents. (3/78/2/79)

Supporting Agency: HEW, PHS, Alcohol Drug Abuse & Mental Health Admin., NIMH

0365 NAVY ENVIRONMENT: NON-IONIZING RADIATION EFFECTS ON MUSCLE AND NERVE CELLS--SAFETY OF ELECTROMAGNETIC RADIATION. Portela, A.; Perez, J. C. (Natl. Council Science & Technical Res., Rivadavia 1917, Buenos Aires, Argentina).

The response of cellular and subcellular structures to non-ionizing electromagnetic radiation will be investigated to discriminate between thermal and direct field (nonthermal) effects. In vitro and in vivo studies of effects on nerve and muscle cells will be performed first. Dielectric properties of biologic molecules and tissues will be studied as well as the microwave effects on bound water. The combined effect of electromagnetic fields and other environmental factors also will be studied. (10/77-9/78)

Supporting Agency:U.S. Dept. Defense, Navy

0366 RADIATION THERAPY ONCOLOGY GROUP. Plenk, H. P.; Speiser, B. L.; Roland, T. A.; Sause, W. T.; Matthes, D. C. (Radiation Center Latter Day Saints Hosp., 325 8th Ave., Salt Lake City, UT 84103).

Instrumentation to improve heating by microwaves and thermometry of hyperthermia and radiation will be combined in an attempt to improve the results of radiation therapy in advanced cancer. Specifically, basic development of equipment and of measurements with a 434-MHz applicator will be carried out. Newly developed solid state probes to measure heat in depth within microwave fields will be tested. (4/78-3/79)

Supporting Agency:HEW, PHS, NIH, NCI

0367 BIOLOGICAL THERMOMETRY SYSTEMS USING OPTICAL SENSORS. Christensen, D. A.; Johnson, C. C. (Utah Higher Education System, Sch. Engineering, Dept. Bioengineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

Considerable success has been achieved in this

project toward the development of a nonmetallic temperature probe that uses a small optical sensor positioned at the end of a fiberoptic bundle. Important biologic applications of such a nonperturbing temperature probe include the monitoring of microwave biohazards, microwave thawing of organs and blood, microwave-induced hyperthermia, and other applications where conventional metallic probes perturb the fields and cause temperature errors. Both the optical etalon type of sensor and a newly-developed semiconductor band edge sensor have proven capable of temperature measurements in the laboratory with the range and accuracy required for biologic studies. The semiconductor sensor is especially suited for small diameter (<0.25 mm) probes. Some additional effort is needed in integrating these probes into thermometry systems that are optically and electronically stable and have the convenience of direct readout in degrees Celsius. To improve stability, an optical reference channel will be added to the system to cancel optical source variations (the major cause of instability), either by separate photodetection or by optical beam chopping followed by ratioing. To obtain direct readout despite an inherently nonlinear calibration curve, a digital read-only memory programmed with the calibration curve will be used. These improvements, which will be field tested, are intended to make the nonperturbing thermometry system more attractive for wide-spread practical use. (4/78-3/79)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. General Medical Sciences

0368 STUDY OF THE EFFECTS OF MICROWAVE RADIATION ON THE CENTRAL NERVOUS SYSTEM. Albert, E. N. (George Washington Univ., Sch. Medicine & Health Sciences, Dept. of Anatomy, 2121 Eye St., N.W., Washington, DC 20006).

Microwave-induced changes in the cytoplasmic components of the neuron and some of their terminals are being explored, and the effects of microwaves on the blood-brain-barrier and neuronal interconnections are being studied. Two-mo-old Chinese hamsters, acclimatized for 10 days prior to exposure, are divided into three groups receiving 2,450, 1,700, or 3,000 MHz, respectively, continuous wave microwave radiation at power densities of 0, 10, or 25 mW/cm^2, resp., for 30 min, 1, 2, or 3 hr/day, resp. One group of animals in each category is sacrificed immediately after exposure, while another group is sacrificed 1 to 2 wk after exposures. Morphologic evaluations of the entire brain are performed. Emphasis is placed on scrutinizing the structural appearance of the neuron cell body, axonal and dendritic swelling, myelin degeneration, and synaptic endings. A recovery phenomenon is being sought. Acute irradiation of Chinese hamsters with 2,450 MHz microwaves at a power density of 10 mW/cm^2 caused alterations in the permeability of the blood-brain barrier to horseradish peroxidase (HRP) in some vessels. The altered permeability of the microvasculature was not confined to any particular region of the brain. This applied only to molecules of 40,000 molecular weight or less (HRP molecular weight=40,000). Larger molecules were not tested. Whether this pattern will persist for longer or chronic exposures and/or other frequencies cannot be predicted presently. These observations represent data obtained from animals showing a strong positive reaction. Blood vessels showing weak or pale reaction product were not evaluated. It was noted that some vessels from control and experimental animals showed a weak positive reaction that might have been caused by endogenous peroxidase or some other factor. (5/77-4/78)

Supporting Agency:HEW, PHS, FDA, BRH

0369 DETECTION, SURVIVAL AND CONTROL OF PLANT PATHOGENIC BACTERIA ON SEEDS AND PLANT PROPAGATIVE MATERIAL. Ries, S. M. (Univ. Illinois, Agricultural Experiment Station, Dept. Plant Pathology, Urbana IL 61801).

The effect of microwave irradiation on pathogen survival in infested seed and propagative plant parts will be investigated. Several phytobacterial diseases overseason in infected plant parts, frequently in seeds. Hot water dips, prolonged storage, or pesticide treatments of infected seeds have been moderately successful in reducing pathogen numbers in seed sources, but these methods are expensive, time consuming, and involve pesticide usage. The application of microwave heat, a physical treatment, would be extremely quick and very inexpensive. *Pseudomonas glycinea*, infested soybean seed, will be the model for these studies. *P. glycinea* is seed-borne in all soybean cultivars. Although probably present in a hypobiotic state, there may be a moisture differential between the moisture content of the seed and the bacterium. This moisture differential will be exploited by irradiating with microwaves. Selective death of the pathogen should occur before seed death, if the pathogen has a higher moisture content than the seed. Infected seed will be adjusted to a selected moisture content, irradiated for varying periods, and assayed for germinability and for *P. glycinea*. Preliminary evidence suggests that soybean seed at 6% moisture can be irradiated for 2 min with a complete destruction of *P. glycinea* and without reducing seed germinability. (10/77-9/78.

Supporting Agency:U.S. Dept. Agriculture, Cooperative State Res. Service, IL

0370 A NEW TECHNIQUE FOR ELIMINATION OF CELLS CAUSING DEATH IN BONE MARROW TRANSPLANT PATIENTS. Kessler, S.; Scher, I. (U.S. Navy, Immunopathology Div., Bethesda, MD 20014).

A technique for isolating large numbers of cells belonging to B- or T-lymphocyte subpopulations will be developed. Analysis of the functional and morphologic characteristics of such subpopulations has been hindered by the difficulty in their isolation. However, such analysis is critical to the understanding of the fundamental mechanisms underlying

the rejection of allogeneic transplanted tissues, which is the major obstacle to successful bone marrow transplantation in lethally-irradiated military personnel. The development of these isolation procedures will allow for the depletion of subpopulations of cells involved in graft rejection, without influencing other cellular populations necessary for successful engraftment. Uniform-sized latex (acrylic) microspheres containing colloidal iron will be synthesized. The chemical composition of these microspheres is such that they can be easily complexed with molecules such as specific immunoglobulins, and/or fluorescent dyes. Initial studies will be designed to test the overall feasibility of this approach by separation of B- from T-lymphocytes using anti-Ig as the functional probe of the microspheres. A powerful magnetic field will then be used to separate lymphocytes with microspheres attached (B-cells) from unassociated lymphocytes (T-cells). Later studies will utilize reagents prepared to isolate lymphocyte subpopulations known to influence graft rejection. (10/77-9/78)

Supporting Agency: U.S. Dept. Defense, Navy

0371 FREEZING AND ELECTROMAGNETIC THAWING OF PLATELETS. Popovic, V. P.; Schaffer, R. E.; Popovic, P.; Stein, S. F.; Cain, F. L. (Emory Univ., Sch. Medicine, Dept. Physiology, 1364 Clifton Rd. N.E., Atlanta, GA 30322).

The best method for cryopreservation of platelets is being sought. It is known that human platelets can be frozen and water-bath thawed with a recovery of one-half of cells. After freezing and thawing, the survival time of platelets is shorter than that of fresh cells. Using a rat model to assess recovery and survival of platelets, freezing rate and thawing rate of platelets is varied to determine the most effective technique for supercooling, freezing, storing, and thawing of platelets. The investigators are attempting to improve the quality of frozen platelets by using electromagnetic devices and much faster thawing rates than were previously possible. (4/78-3/79)

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

0372 ELECTROMAGNETIC RADIATION AND BIOLOGICAL SYSTEMS. Adey, W. R.; Bawin, S. M.; Sheppard, A.; Sagan, P. M. (U.S. Veterans Admin. Hosp., 11201 Benton St., Loma Linda, CA 92357).

The interactions between weak ultra-high-frequency (450 MHz) electromagnetic fields and the central nervous system will be studied. The investigation will continue research that has disclosed power windows and modulation frequency windows for these interactions. Studies of interactions between weak electromagnetic fields and calcium ion binding in the central nervous system will be continued and will serve as reference for experiments involving amino acids and other putative neurotransmitters. Chick and cat cerebral tissues will be compared in their response to field stimulation. Performances of neonate chicks and ducklings exposed to 450 MHz fields will be compared in a series of behavioral measurements ranging from free behavior to sophisticated behavioral tasks, including variation of an interresponse time schedule. Schedule-controlled behavior in monkeys will be tested under similar field conditions. There will be continued collaboration with the Bureau of Radiological Health in measurements of field gradients in tissue as correlates of neurochemical responses. Recent developments in theoretic physics will be applied in modeling non-linear responses of the central nervous system to weak perturbations of the extracellular environment. (3/78-2/79)

Supporting Agency:HEW, PHS, FDA, BRH

0373 LOCALIZED RADIOFREQUENCY HYPERTHERMIA FOR TREATING LUNG CANCER. Wolf, G. L. (U.S. Veterans Admin. Hosp., 4101 Woolworth Ave., Omaha, NB 68105).

The use of local hyperthermia plus radiation, versus radiation alone, is being compared in the treatment of lung cancer. Qualifying patients are randomly assigned to one of the treatment groups. Localized hyperthermia is obtained with a radiofrequency device. Both subjective and objective responses to therapy are monitored throughout the study. (2/78-1/79)

Supporting Agency:U.S. Veterans Admin.

0374 A STUDY TO DETERMINE THE RF PARAMETERS THAT AFFECT THE BRAIN AND BEHAVIOR AT LOW POWER DENSITY. Frey, A. H. (Randomline, Inc., Huntingdon Valley, PA 19006).

The effects of exposure to electromagnetic energy on irritability, aggression, and motor coordination are being studied. In one experiment, irritability and aggression in male Sprague-Dawley rats as affected by electromagnetic energy (EM) exposure was investigated by placing animals in a pain-induced aggression situation by intermittent pinching of their tails. In a second experiment, the motor coordination or balances of male Sprague-Dawley rats as affected by EM exposure was investigated by measuring the ability of animals to stay on a rotating rod during rotation at various speeds and directions. Experiment I showed a clean cut "docility" effect of exposure to EM energy in rats undergoing the stress of pain-induced aggression

procedure. The exact nature of the effect and the appropriate label for the effect remain to be defined. The effect occurs at low power levels as defined in biologic investigations of EM energy effects. The power levels used, however, were above those generally found in the environment. The threshold for the EM energy parameters used was a peak power between 0.05 mW/cm^2 and 0.1 mW/cm^2. The measurements given, although exact, were considered to be correct within an order of magnitude because of the perturbing effect of the animal and any apparatus in the EM field. Experiment II showed that pulsed modulated EM energy had an adverse effect on motor coordination or balance as defined by use of the rotating rod test. The effect occurred at low power densities usually defined in biologic experiments. The threshold for the effect with the energy parameters used was a peak power between 0.4 mW/cm^2 and 2.8 mW/cm^2. The measurements given, although exact, were considered to be correct within an order of magnitude because of the perturbing effect of the animal and any apparatus in the EM field. (2/77-5/78)

Supporting Agency:HEW, PHS, FDA, BRH

0375 MAPPING OF MICROWAVE FIELDS SURROUNDING HUMAN SUBJECTS UNDER DIATHERMY TREATMENT. Lehmann, J. F. (Univ. Washington, Medical Rehabilitation & Training Center, 15th Ave. N.E., Seattle, WA 98105).

The contours of equal field intensity around human subjects will be measured and plotted while the subjects are irradiated with electromagnetic energy by microwave diathermy equipment operating at 915 and 2,450 MHz. All measurements will be performed in an anechoic chamber to allow precise field intensity levels around the subject. Human volunteers will be placed in the anechoic chamber in a position that is typical of diathermy treatments. The position of the subject will depend on the area to be treated. Selected areas of the body that are frequently treated with diathermy will be used—tight joints, anterior and posterior shoulder, contractor of the biceps, the lower back, and contractors of the thighs. The selected area will be treated with microwave applicator operating at 915 and 2,450 MHz. An X-Y-A coordinate tracking system with a National Bureau of Standards (NBS) energy density probe attached will be shielded and placed in the anechoic chamber. The device will be computer-controlled to follow isobars of power densities with limit switches to set the area that is to be scanned. The computer will position the probe and also plot the field intensity levels in relation to distance from the diathermy applicator. The facility will allow many short-period measurements, which will reduce the time of microwave exposure. Instrumentation will include a NBS power meter, which measures the power density in an electromagnetic field and a commercially available X-Y-Z tracking system. The power meter operates at a frequency of 10-3,000 MHz accurate to 1.0 dB. The NBS probe is attached to this system so that it can be moved in any of three coordinates. A zero point is set by the operator, and this is placed in the computer. A grid is then set up, and the computer directs the tracking system to move in the increments defined, 1 cm-2 cm, etc. The computer than moves the probe throughout this grid while recording the power density measurements at each point. Thermistor power meters will be used to monitor the incident and reflected power going to the applicator. (10/76-9/77)

Supporting Agency:HEW, Office Human Development Services, Rehabilitation Services Admin.

0376 MEASUREMENT OF MUSCULATURE BLOOD FLOW INDUCED BY MICROWAVE DIATHERMY. Lehmann, J. F. (Univ. Washington, Medical Rehabilitation Res. & Training Center, 15th Ave. N.E., Seattle, WA 98105).

The quantitative relationship between doses of microwave diathermy and deep musculature blood flow increase and rate change will be determined. The disappearance rate of ^{125}I injected into deep musculature will be monitored by a scintillation counter before and after heating by microwave radiation. By comparing resting levels of blood flow and the increase in blood caused by the microwave heating, the rate of change in blood flow due to the temperature increase will be calculated. The values will then be related to the amount of power required to cause the increase and also the rate at which this energy was delivered to the tissue. In a 20-min preliminary session the subject will be familiarized with the general procedures to be followed during the measurement session. One or two x-rays of the front part of the thigh will be taken to determine the position of certain structures (muscle-fat boundary, femur) that will underlie the diathermy applicator. Areas that are particularly sensitive to x-rays (gonads) will be protected by a lead apron. During the experimental session, 0.05 ml (one drop) of a radioisotopically labeled iodine-antipyrine compound will be injected into a forearm (or thigh muscle) through an extremely fine (1/100 inch thick, 27 gauge) needle. Since only one injection per individual will be allowed, this experiment will be divided into two parts. Some subjects will participate in Part I and some, Part II. In Part I, injection of isotope will be in a resting forearm or thigh. In Part II, injection of the isotope will be made into a forearm or thigh muscle over which is strapped a small, light weight isotope counting probe. (10/76-9/77)

Supporting Agency:HEW, Office Human Development Services, Rehabilitation Services Admin.

0377 CELLULAR INJURY AS INDICATED BY ULTRASTRUCTURAL ALTERATIONS (MICE). Stephens,

R. J. (Stanford Res. Inst. Internatl., 333 Ravenswood Ave., Menlo Park, CA 94025).

No descriptive information is available. (6/77-5/78)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. General Medical Sciences

5674 MICROWAVE MAGIC. *(Eng.)* Bateman, J. B. (Office Naval Res., Branch Office, London, England, FPO New York, NY 09510). 29 pp.; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A048060]. (13 refs)

A critical review of a symposium on the results of current French research on the biological effects of microwaves is presented. The symposium covered the following topics: microwave research in the United States and France; microwave dosimetry and physical measurement; the biological effects of a black box device, invented by A. Priore, that reportedly causes implanted animal tumors to regress and prevents the development of fatal disease in rodents infected with trypanosomes; biological research on the effects of microwaves relating to yeast growth, insect metamorphosis and morphogenesis, lipid metabolism, the reticuloendothelial system, and plasma coagulation; medical applications of microwaves relating to radiometry of tumors, selective tumor heating, the fixation of radiotherapeutic substances by tumors, and the thawing of blood pellets; and industrial applications involving food thawing and food sterilization. In general, French research was seen to be empiric with little regard for fundamental mechanisms. Little attention was given to the reporting of details about the physical equipment used and especially to dosimetry and thermometry.

5675 THE INFLUENCE OF ELECTROSTATIC AND MAGNETIC FIELDS ON MUTATION IN *DROSOPHILA MELANOGASTER* SPERMATOZOA. *(Eng.)* Diebolt, J. R. (Dept. Biology, Univ. North Carolina at Charlotte, Charlotte, NC 28223). *Mutat Res* 57(2): 169-174; 1978. (23 refs)

Wild-type *Drosophila melanogaster* males, 4-6 days of age, were exposed to a inhomogeneous (- or + polarity) electrostatic field (0.3 kV/cm) or to a homogeneous magnetic field (0.9266 tesla) for 24 hr to determine the effect of weak electrostatic and moderately strong magnetic fields on the production of sex-linked recessive lethal mutations in mature sperm. After treatment the males were left with females for 48 hr. Since a recently inseminated female is reluctant to mate a second time within a 24-hr interval, it is considered that the males mated with the females only two or possibly three times. Thus, it is considered that only mature sperm were sampled in the study. Neither the electrostatic nor the magnetic field significantly increased the sex-linked recessive lethal mutation frequency in mature sperm.

5676 REGENERATIVE REACTIONS OF RAT ORGANISM FOLLOWING MICROWAVE IRRADIATION (2,400 MHz). *(Rus.)* Tikhonchuk, V. S. (Inst. Biophysics, USSR Acad. Sciences, Moscow, USSR). *Biull Eksp Biol Med* 85(2): 170-171; 1978. (4 refs)

At intervals ranging from 2 to 30 min, 736 mongrel male rats were exposed to a microwave field (2,400 MHz, power density 100-800 mW/cm^2, 2x). At constant power density, the survival rate of the animals increased with the interval between the two irradiations; this relationship was described by a logistic curve. The survival rates were 2%, after exposure to 100 mW/cm^2 for 14.3 min; 2.5%, after 4.1-min exposure to 200 mW/cm^2; 2%, after 2.5-min exposure to 300 mW/cm^2; 5%, after 1.8-min exposure to 500 mW/cm^2; and 1%, after 1.2-min exposure to 800 mW/cm^2. The rate of the regenerative processes was found to be inversely proportional to the power density of the field. At constant regeneration level, the relationship between the power density and the interval between the irradiation was described by a linear function. The findings indicate the constant rate of the regenerative reactions at a given effect level.

5677 LOCAL HIGH-FREQUENCY HYPERTHERMIA OF THE BROWN-PIERCE CARCINOMA IN THE URINARY BLADDER OF RABBITS. *(Ger.)* Harzmann, R. (Lehrstuhl und Abteilung fur Urologie, Universitat Tubingen, Calwer Strasse 7, D-7400 Tubingen, W. Germany); Bichler, K. H.; Gericke, D.; Altenahr, E.; Dietzel, F.; Erdmann, D. *Urologe* [*A*] 17(2): 130-134; 1978. (19 refs)

The effect of local inductive high-frequency hyperthermia (500 kHz, wavelength 600 m, 30-300 W, temperature 43 C for 30 minutes) on Brown-Pierce carcinoma of the urinary bladder was studied in 47 rabbits. The hyperthermic treatment caused a temperature increase of 6.7 C in the center of the tumor compared with the lumen of the urinary bladder. The average survival time of the heat-treated animals was significantly longer than that of the untreated controls (28-38 days versus 82-120 days). After the transplantation, the take rate was 91-93.8% of untreated carcinomas but only 33.3% in the case of in vivo heat-treated tumors. The findings indicate the therapeutic effectiveness of inductive hyperthermia in the treatment of Brown-Pierce carcinoma.

5678 ELECTROMAGNETIC FIELDS AND VENTRICULAR-INHIBITED PACEMAKERS. *(Fre.)* Birmann, L. (Service de Medecine et de Cardiologie, Centre Medico-Chirurgical et Obstetrical, Strasbourg-Schiltigheim, France); Friedrici, R.; Sacrez, A. *Bull Soc Sci Med Grand Duche Luxemb* 114(1): 5-10; 1977.

Electrical and electromagnetic fields capable of interfering with the proper function of ventricular-inhibited pacemakers, which detect spontaneous depolarization complexes of the cardiac activity are reviewed. The filters with which such pacemakers are equipped offer relatively efficient protection against most electromagnetic fields. Parasitic signals, whose frequency is identical with or close to that of the QRS, may cause functional disturbances. Muscular potentials generated by the contraction of skeletal muscles near the pacemaker may also interfere with the proper function of the latter. Electromagnetic fields of high energy and

at frequencies over 100 MHz, such as, those generated by the ignition system of automobiles, may also cause interferences. Such high-frequency radiation is, however, effectively absorbed by the tissues, and the pacemaker is protected against them by its capsule.

5679 ELECTROMAGNETIC SYRINGE. *(Eng.)* Taylor, L. S. (Dept. Electrical Engineering, Univ. Maryland, College Park, MD 20742). *IEEE Trans Biomed Eng* 25(3): 303-304; 1978. (0 refs)

A hyperdermic syringe for directly injecting radio frequency and microwave fields into deep tissues in vivo is described. The syringe consists of a subminiature rigid coaxial waveguide, which connects to the generator at one end and terminates in a needle-like configuration that radiates the field at the other end. The radiator is obtained simply by open-ending the outer conductor and having the inner conductor extend out beyond for the proper length. A needle radiator was constructed that effected a voltage standing wave ratio of less than 1.1:1 at a frequency of 2,450 MHz when the radiator was embedded in a phantom material, which had the same dielectric permittivity and loss tangent as human muscle tissue. Thermographs of heating in phantom material injected with 25 W of microwave power for 30 sec using a syringe with an outside diameter of 0.76 mm demonstrated the feasibility of this type of device for a variety of applications and experimental uses. Waveguides of the type used here are commercially available with diameters down to 0.20 mm, presenting the possibility for microwave injection into very delicate tissues. The device has possible applications in diathermy and in experiments investigating the effect of electromagnetic fields on biologic systems.

5680 CARCINOGENIC PROPERTIES OF IONIZING AND NON-IONIZING RADIATION: VOLUME II -- MICROWAVE AND RADIOFREQUENCY RADIATION. *(Eng.)* Dwyer, M. J.; Leeper, D. B. (Biomedical Resources, The Franklin Inst. Res. Lab., Science Information Services, Philadelphia, Pa). NIOSH Contract No. 210-76-0145, 39 pp.; 1978. [available through the Superintendent of Documents, U.S. Government Printing Office, Washington, CD 20402, DHEW (NIOSH) Publication No. 78-134] (84 refs)

A review of the literature dealing with the carcinogenic properties of microwave (MW) and radio frequency (RF) radiation is presented. In general, there is little scientific or medical literature relating to actual or possible carcinogenic effects of RF or MW radiation. The strongest evidence comes from a recent WHO study, the North Karelian Project. The evidence is circumstantial, consisting of little more than a possible correlation between an RF/MW-induced increase in cardiovascular disease and a rise in the incidence of cancer. There have been unconfirmed and unscientifically reported allegations of RF/MW-induced cancer in one incident at Philco-Ford, at the United States Embassy in Moscow, and at the Boeing Corporation. An increased incidence of leucosis and leukemia in chronically irradiated Swiss albino mice has also been reported, but without follow-up. The biomedical literature, on the other hand, reports a variety of other problems including behavioral, neurologic, biochemical, hematologic, genetic, developmental, and degenerative disorders and cellular transformations. Although these latter effects do not directly relate to cancer, the possibility of carcinogenicity at very high cumulative doses and the possible enhancement of already carcinogenic or potentially carcinogenic situations by occupational exposure to RF/MW radiation should be closely examined.

5681 AN ABSOLUTE REACTION RATE MODEL FOR THE RESPONSE OF *B. SUBTILIS* TO MICROWAVE RADIATION. *(Eng.)* Wayland, J. R.; Brannen, J. P. (Sandia Lab., Albuquerque, NM 87115). 4 pp.; 1977. [available through U.S. Energy Research and Development Admin., Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830, Document No. SAND 76-9301C]. (8 refs)

A theoretic foundation for the study of biologic responses to electric and magnetic fields was developed. Absolute reaction rate theory is used to predict the response of spores of *Bacillus subtilis niger* in a microwave field. An arrhenius plot for the inactivation of the spores in a microwave electrical field reveals qualitative agreement between the theoretical predictions and experimental observations. The data suggest that temperature and electric effects are interdependent. This information is important in understanding the problems associated with the classification of biologic responses as thermal or nonthermal.

5682 USE OF LOCAL ELECTROMAGNETIC HYPERTHERMIA IN ONCOLOGY. *(Rus.)* Aleksandrov, N. N. (Scientific Res. Inst. Oncology Medical Radiology, Belorussian SSR Ministry of Public Health, USSR; Savchenko, N. E.; Fradkin, S. Z.; Zhavrid, E. A. *Vopr Onkol* 23(5): 3-13; 1977. (95 refs)

Studies on the possible uses and action mechanisms of local high-frequency electromagnetic hyperthermia in cancer therapy are reviewed. Electromagnetic local hyperthermia increases the blood flow, capillary pressure, the permeability of the cell membranes, and the intensity of metabolic processes. High frequency electromagnetic therapy is assumed to intensify the immune response of the body. The frequencies commonly used range from 915 to 2,450 MHz. It was reported that local hyperthermia (43-43.5 C for 45-60 min) caused complete disappearance of anaplastic breast carcinoma in 20-25% of the treated mice. Local electromagnetic hyperthermia (42.8 C for 60 min) was given to 17 patients with malignant tumors of the limbs in conjunction with normothermal or slightly hypothermal perfusion with reduced doses of chemotherapeutic drugs and thermosensitizing and acidifying agents. Complete disappearance of the tumor was seen in six patients after the treatment. In another report, considerable re-

duction of tumor size was achieved in most of the 70 patients with malignant tumors of the skin, soft tissues, and breast who underwent combination therapy with X-ray, telegammatherapy, and electromagnetic local hyperthermia. Destructive changes were seen also in radioresistant tumors.

5683 MAMMALIAN AUDITORY RESPONSES TO 3.0 GHZ MICROWAVE PULSES. *(Eng.)* Cain, C. A. (Dept. Electrical Engineering, Bioacoustics Res. Lab., Urbana, IL 61801); Rissmann, W. J. *IEEE Trans Biomed Eng* 25(3): 288-293; 1978. (16 refs)

Experiments involving the exposure of cats, dogs, chinchillas, and human subjects to short microwave pulses (less than 20 μsec) at a frequency of 3.0 GHz were performed to assess the effect of such exposure on auditory sensation. In agreement with results obtained at different microwave frequencies by other investigators, the threshold energy density per pulse for the small animals remained relatively constant as pulse width and peak power were varied. The energy density per pulse needed to evoke auditory responses in cats ranged from 8.7 $\mu J/cm^2$ to 14 $\mu J/cm^2$. Chinchilla thresholds were similar and ranged from a low of 7.5 $\mu J/cm^2$ to a high of 20 $\mu J/cm^2$. The average of the thresholds for beagle dogs was 5.0 $\mu J/cm^2$. The average threshold energy density of microwave pulses that could be heard by human subjects was 10.6 $\mu J/cm^2$. However, three out of eight subjects could not hear pulses below 20 μsec in width at maximum peak power settings. Inability to hear microwave pulses was correlated with hearing losses at frequencies beyond 8 kHz.

5684 ACTIVATION OF ENZYME PREPARATIONS IN SUPER-HIGH FREQUENCY ELECTROMAGNETIC FIELD. *(Rus.)* Popadich, I. A. (Dept. Analytical Chemistry, Moscow Inst. Food Industry, Moscow, USSR); Gubiev, Iu. K.; Kulikova, L. S. *Pishch Tekhnol* (2): 112-114; 1978. (2 refs)

The effect of high-frequency electromagnetic field (2,450 MHz, length of exposure 5-20 sec) on the amylolytic activity of a 0.01% aqueous solution of Amylosubtilin G10X was studied in the temperature range of 20-65 C. The treatment caused an average increase of 70% in the amylolytic activity of the preparation compared with that of the unexposed control and with the 20-25% increase caused by convective heat treatment. The increase was a function of the length of the treatment and of the applied high-frequency energy. Longer treatment with reduced high-frequency energy caused a slight reduction in the amylolytic activity compared with the control. Maximum effect was achieved when the rate of heat-up did not exceed 1.8-2 C/sec.

5685 EFFECT OF UHF FIELD ON IMMUNOGENESIS OF MICE WITH NORMAL REACTIVITY AND IMMUNOSUPPRESSION INDUCED BY RUBOMYCIN. *(Rus.)* Lopatin, V. F. (Scientific Res. Inst. Medical Radiology of USSR Acad. Medical Sciences, Obninsk, USSR); Vatin, A. E.; Dedenkov, A. N. *Antibiotiki* 23(4): 358-361; 1978. (12 refs)

The effect of whole-body irradiation with ultrahigh-frequency radiowaves (15 W, 30 min) on the normal and rubomycin-depressed (10 mg/kg) immune response was studied in male CBA mice immunized with sheep erythrocytes. The animals were irradiated at different dates before or after immunization and after immunization and rubomycin treatment. The immunologic parameters studied were the weight of the thymus and spleen, the karyocyte count in the spleen, and the number of antibody-forming cells in the spleen per 10^6 karyocytes. Irradiation, applied 24 hr before, on the day of, or 48 or 72 hr after immunization as well as irradiation applied 48 hr after immunization and 24 hr after rubomycin treatment caused significant ($p<0.05$) increase in the number of antibody-producing cells. The increase in the antibody-producing cells in the spleen of the mice with normal immune response was at least 3-fold, and the exposure caused about 1.8-fold increase in the antibody-producing cell count in the spleen following immunosuppression with rubomycin. There were no significant changes in the other parameters.

5686 EFFECT OF ELECTROMAGNETIC FIELD ON THE GROWTH AND DEVELOPMENT OF PLANTS. *(Rus.)* Bel'skii, A. I. (Kostroma, USSR). *Elektron Obrab Mater* (6): 69-71; 1978. (5 refs)

The effect of electromagnetic field generated by high-voltage electric transmission lines on the growth, development, and crop yield of cherry trees, and tomato, pepper, and corn plants was studied in model experiments. The electromagnetic field (parameters and exposure time not given) caused about 1/3 reduction in the longitudinal growth of the plants compared with the untreated control, and the yearly growth of the exposed plants was also smaller than that of the controls. The cherry trees developed fruit 2-3 yr after planting, but the control trees required 4-5 yr. The crop yield of the exposed cherry trees was 15-20.7 kg versus 12-18 kg of the controls. The exposure also increased the crop yields of the tomato, pepper, and corn plants. The exposed plants were more resistant to fungi and insects than were the controls. Exposure to excessively intense electromagnetic field caused stunted and deformed growth of the plants.

5687 HIGH-FREQUENCY CURRENTS: INDICATIONS AND CONTRAINDICATIONS. *(Fre.)* Chantraine, A. (Division de Medecine Physique et de Reeducation, Hopital cantonal (Beau-Sejour), Universite de Geneve, Geneva, Switzerland). *Z Unfallmed Berufskr* 70(4): 202-208; 1977. (0 refs)

The indications and contraindications of short-wave electrotherapy are presented. Treatment with high-frequency electrical fields is indicated during the subacute stage of various inflammatory (post-traumatic, metabolic) reactions, in chronic inflam-

mation, gonarthrosis, sinusitis, and adnexitis. The treatment improves the supply of nutrients indispensable to tissue repair, facilitates the elimination of certain metabolites, and has sedative effect. The length of one session is usually 15-20 min but only 3-6 min in subacute sinusitis and adnexitis. The dose should be low initially (50 W) and increased to 150-200 W later. The treatment is contraindicated in sclerosis and other conditions accompanied by impaired heat dissipation, in pregnancy, and in patients with foreign bodies, especially metallic ones, in their bodies. The treatment of tumors may cause the spread of tumor cells.

5688 EFFECT OF SUPER-HIGH FREQUENCY ENERGY ON MATTER. *(Rus.)* Tereschenko, A. I. (No affiliation given). *Radiotekhnika* (1): 4-15; 1978. (27 refs)

Studies on the uses and effects of microwave energy on matter are reviewed. Microwave ovens are used increasingly for the preparation and and warm-up of meals; such treatment has no harmful effect on the meal, and it sometimes improves the nutrient value of the food. Microwave radiation is highly effective in the sterilization and pasteurization of foods, in disinfection, and in therapy. When used as therapy, microwave radiation increases the capillary pressure, the permeability of cell membranes, and intensifies metabolic processes in the irradiated tissues.

5689 HAZARD AT A DISTANCE: EFFECTS OF EXPOSURE TO THE ELECTRIC AND MAGNETIC FIELDS OF HIGH VOLTAGE TRANSMISSION LINES. *(Eng.)* Marino, A. A. (Veterans Admin. Hosp., Irving Ave. and Univ. Pl., Syracuse, NY 13210); Becker, R. O. *Med Res Eng* 12(5): 6-9; 1977. (31 refs)

Possible hazards associated with high voltage overhead electrical transmission lines are discussed. It is shown that for a proposed 765-kV transmission line, electric fields ranging from 48-90 V/cm are present within 100 feet from the center line. Individuals who live near high voltage transmission lines undergo chronic exposure to fields of comparable intensity to those which have been found to produce biologic effects in laboratory studies. In one study, rats developed bone tumors when exposed to electric fields of 70 V/cm, and in another study, electric fields of about 4 V/cm were found to interfere with the growth pattern of flatworms. Extremely low frequency fields of 35 V/cm have been found to depress the growth rate of chicks. An electric field of 6,000 V/cm has been reported to kill mammalian cells in cell culture. Electric fields of 0.04 V/cm have been shown to affect human reaction time performance. Based on these and other experiments, it is concluded that high voltage overhead electrical transmission lines probably cause biologic effects in individuals living near such lines. The EPA published a notice in the *Federal Register* in March of 1975 requesting data on the health hazards of high voltage transmission lines but has not yet begun to analyze the information submitted. In the Soviet Union, nationwide rules and regulations governing the nature and extent of permissible exposure to high voltage transmission lines were promulgated in 1970. According to these rules, working conditions are not limited or controlled where the electric field is less than or equal to 50 V/cm. If the electric field is greater than 250 V/cm, all workers must wear protective clothing or employ some protective device. For electric fields between the two values, the permissible duration of exposure without protective measures is limited.

5690 MICROWAVE APPLICATORS FOR LOCALIZED HYPERTHERMIA TREATMENT OF MALIGNANT TUMORS. *(Eng.)* Mendecki, J. (Montefiore Hosp. and Medical Center, Albert Einstein Coll. Medicine, Bronx, NY 10467); Friedenthal, E.; Botstein, C.; Sterzer, F.; Paglione, R.; Nowogrodzki, M.; Beck, E. *J Bioeng* 1(5/6): 511-518; 1977. (3 refs)

The design and performance of small microwave applicators used in conjunction with 915- and 2,450-MHz generators for inducing hyperthermia in malignant tumors are described. One particular applicator consists of a tapered waveguide loaded with a low-loss high-dielectric-constant ceramic. When such an applicator is in direct contact with tissue, the voltage standing wave ratio is typically less than 2.25:1 (more than 85% of the power fed into the applicator penetrates into the tissue). When this applicator was placed on the surface of a mouse mammary adenocarcinoma approximately 10 mm in diameter, the temperature in the center of the tumor was raised to about 43 C in 90 sec using 1.25 W of power at 2,450 MHz. This applicator has been successfully used in preliminary clinical studies of patients with basal cell carcinoma, skin metastases from breast cancer, and malignant melanoma. In a 66-yr-old female with basal cell carcinoma of the left posterior neck, one part of the lesion was exposed to hyperthermia (43 C, 45 min) using the applicator immediately followed by a radiotherapy dose of 300 rad, while another part of the lesion was treated with the same dose of radiotherapy alone. Both parts were treated three times weekly. Following six sessions (1,800 rad), the tumor part treated with combined therapy disappeared completely, while the rest of the tumor required a cumulative radiation dose of 6,000 rad to achieve total eradication. Another type of applicator described is a coaxial type that can be readily inserted into natural body cavities, suggesting possible use in the treatment of cancers of the rectum, colon, bladder, vagina, and esophagus. Another potential application of coaxial applicators is their use as interstitial implants into tumors. Of particular interest may be applicators having geometries that more closely conform to the shape of the areas to be treated and that have deliberate changes in the power distribution across the treatment area. Also of interest are coaxial units equipped with directive reflectors so that a particular area within a body cavity

can be raised to the treatment temperature with the other areas remaining cool. Preliminary in vivo measurements with an applicator of this type have recently been reported.

5691 TISSUE REACTIONS TO LONG-TERM ELECTRICAL STIMULATION OF THE CEREBELLUM IN MONKEYS. *(Eng.)* Brown, W. J. (Div. Neuropathology and Neurological Surgery and Brain Res. Inst., UCLA Center for the Health Sciences, Los Angeles, CA); Babb, T. L.; Soper, H. V.; Lieb, J. P.; Ottino, C. A.; Crandall, P. H. *J Neurosurg* 47: 366-379; 1977. (13 refs)

Light and electron microscopic observations of the cerebellar histopathology and neural damage found in rhesus monkey brains *(Macaca mulatta)* that had stimulated and unstimulated electrodes implanted on the cerebella for 2 mo are reported. Electrode pairs were placed bilaterally over the paravermal cortices in six monkeys. Charges of 0.5, 2.4, 4.8, 10, and 22 μcoulombs (C)/phase (ph) were delivered for 205 hr by a commercially available neurostimulator with stimulation parameters used in clinical trials (1-msec charge-balanced asymmetrically-biphasic pulses at 10 pulses/sec). In every monkey, the leptomeninges overlying the electrodes were thickened. The meningeal reaction, however, was usually markedly greater around stimulated electrodes than around the corresponding unstimulated electrode, and the intensity of the reaction was directly related to the charge delivered. The only charge that did not result in detectable ultrastructural changes was 0.5 μC/ph or approximately 7.35 $\mu C/cm^2$/ph. Since it has been shown that a charge as low as 0.1 μC/ph is sufficient to activate cerebellar efferent activity, the finding that a charge of 0.5 μC/ph does not injure the cerebellum indicates that it may be possible to use a physiologically effective stimulus to the cerebellum for long periods of time without producing cerebellar damage or raising the threshold for effective stimulation. In all of the above monkeys, injury such as severe molecular layer attenuation, Purkinje cell destruction, gliosis, myelinated axon degeneration, collagen intrusion, and increased local polysaccharide levels never was found more than 1-2 mm from the edges of the electrode arrays.

5692 POTENTIAL GENETIC RISKS FROM STATIONARY MAGNETIC FIELD. *(Eng.)* Roessner, P. (Inst. Hygiene and Epidemiology, 100 42 Prague 10, Srobarova 48, Czechoslovakia); Matejka, M. *J Hyg Epidemiol Microbiol Immunol* 21(4): 465-467; 1977. (6 refs)

The mutagenic effect of a stationary magnetic field (SMF) alone or in combination with the mutagen tris(1-aziridinyl)phosphine oxide (TEPA) on a pseudodiploid Dede line of Chinese hamster cells was studied. After formation of a continuous layer (48 hr of cultivation), the cells were exposed for 15 min to a 1,500-G SMF. In combination experiments, TEPA at a concentration of 10^{-6} molar was applied to the cell medium 24 hr before SMF exposure. When the cells were fixed 8 hr after exposure to SMF alone, the percentage of aberrant cells was 4.0% compared with a control value of 0.5%. Cells exposed to SMF and TEPA and fixed 8 hr later showed an aberration percentage of 13.5%, suggesting an additive effect produced by SMF and TEPA, since TEPA alone resulted in an 8.0% aberration frequency. Cells fixed 48 hr after exposure to SMF and TEPA also showed an additive effect (14.0% aberrant cells). These results support the hypothesis that exposure to SMF may induce aberrations in Dede cell lines, and it is suggested that SMF is one environmental factor that might contribute to the induction of genetic changes in mammals as well.

5693 HYPERTHERMIA AS AN ADJUNCT TO CANCER THERAPY. *(Eng.)* Robinson, J. E. (Univ. Maryland, Sch. Medicine, Baltimore, MD 21201). *J Bioeng* 1(5/6):467-469; 1977. (0 refs)

The role of hyperthermia in cancer therapy is discussed, and reference is made to the potential usefulness of microwave technology in such therapy. There is evidence that hyperthermia may increase the effectiveness of both radiation treatment and some chemotherapeutic drugs. Hyperthermia appears to offer a therapeutic advantage in cancer patients by increasing tumor damage while protecting critical normal tissues. This therapeutic advantage is supported by data which indicate the following: the thermal sensitivity of tumor cells is greater than that of normal cells; the hyperthermal radiosensitization of some tumors is greater than that of the normal tissues; in contrast to radiation sensitivity, the thermal sensitivities at normal temperatures of poorly oxygenated cells is as great or greater than that of well oxygenated cells; and the poor blood flow associated with many tumors may yield differential tumor heating. The role of microwave technology in such therapy is in producing and controlling the thermal fields necessary for the treatment. There is also a need for the development of noninvasive techniques for determining thermal patterns produced by microwave irradiation or other heating sources. Noninvasive temperature measurement by microwave thermography is in the beginning stage of development.

5694 MICROWAVE ENZYME INACTIVATION SYSTEM: ELECTRONIC CONTROL TO REDUCE DOSE VARIABILITY. *(Eng.)* Brown, P. V. (Dept. Microwave Res. and Medical Neurosciences, Div. Neuropsychiatry, Walter Reed Army Medical Center, Washington, DC 20012); Lenox, R. H.; Meyerhoff, J. L. *IEEE Trans Biomed Eng* 25(2): 205-208; 1978. (14 refs)

Electronic circuitry for reducing the dose variability of typical 2,450-MHz microwave enzyme inactivation systems is described. The length of microwave exposure is regulated by a timing circuit, which counts the number of energy pulses that the load receives. Output power is controlled by a leveler circuit, which uses a feedback loop that varies the magnet current of the tube to keep the delivered power at a fixed value. The control

electronics has the additional capacity to operate in an integrating mode. The circuit integrates the energy delivered; when the total energy delivered reaches a preset level, the triac drive and thus the magnetron is shut off. The circuits described are able to maintain output power within 2% of a set point and the exposure time to within 3 msec of the desired value. Without electronic control, the exposure time typically varies by 50 msec and the output power by 15%. The electronics are compatible with any 220 V single phase commercial microwave power source.

5695 INCREASE IN X-RAY SENSITIVITY OF CANCER AFTER EXPOSURE TO 434-MHZ ELECTROMAGNETIC RADIATION. *(Eng.)* Holt, J. A. G. (Inst. Radiotherapy and Oncology, Western Australia, 21 McCourt St., Leederville, W. A. 6007). *J Bioeng* 1(5/6): 479-485; 1977. (7 refs)

The use of 434-MHz electromagnetic radiation to increase the X-ray sensitivity of tumors is reported. The study involved three groups of 52 patients suffering from ear, nose, or throat cancer. One group received X-ray treatment alone at a total dose of 6,000 rad. A second group received X-irradiation (total of 3,500-3,600 rad) under 3 atmospheres of hyperbaric oxygen at 37 C. The third group of patients received 20 min of 434-MHz radiation followed by a 15-min waiting period prior to X-irradiation (total dose of 5,400 rad). The calculated dose required to reduce tumor cell survival by 63% on the exponential part of the survival curve (D_o) was 140 rad for patients treated with X-rays only, 51 rad for the hyperbaric group, and only 8 rad for patients receiving 434-MHz radiation in addition to X-rays. The rate of clinical clearance of the primary tumor and lymph nodes was 81% for patients receiving 434-MHz radiation in combination with X-rays compared with only 32% for patients receiving X-radiation only and 61% for patients X-irradiated under hyperbaric conditions. In additional experiments, 13 patients received whole-body hyperthermia by a hot wax bath method at 41.8 C, and the calculated D_o value for these patients was 50-60 rad. Four patients treated with 7-MHz radiation had D_o values greater than 60 rad. The increased radiation sensitivity induced by 434-MHz radiation appeared to be partly thermal and partly nonthermal in origin. The nonthermal origin is evidenced by the fact that the induced sensitivity of the tumor to X-rays persisted for up to 30 min after 434-MHz irradiation, even when the cancer was at normal temperature.

5696 MODELS OF MEMBRANES OF CEREBRAL CELLS AS SUBSTRATES FOR INFORMATION STORAGE. *(Eng.)* Adey, W. R. (Dept. Anatomy and Physiology, Brain Res. Inst., Univ. California, Los Angeles, CA 90024). *BioSystems* 8: 163-178; 1977. (52 refs)

The interaction of extremely low frequency and very-high-frequency electric fields with brain tissue is discussed with particular emphasis on the effects of such fields on calcium efflux and the process of recall. The exposure of freshly isolated chicken cerebral hemispheres to a 147-MHz field at 0.8 mW/cm^2 has been shown to result in an increased calcium efflux of more than 15% at amplitude modulation frequencies between 9 and 20 Hz. In contrast, the exposure of chicken and cat cerebral hemispheres to frequencies below 30 Hz has been shown to result in decreased calcium efflux. Studies of electroencephalogram (EEG) interactions in cats exposed to low level 147-MHz radio fields amplitude modulated at biologic frequencies between 0.5 and 30 Hz were conducted in which spontaneously occurring brief trains of EEG waves were first identified in cortical and subcortical structures. Each train had a characteristic frequency or signature which the cats were trained to produce in response to a light flash. Failure to produce the EEG rhythm pattern was punished by stimulation of the cortical frontal eye field. The effects of the modulated radio field were then tested during both training and extinction of the response. The radio field was modulated at the same frequency as the EEG rhythm signature in a specific brain structure. In the training tests, when the modulated radio field was present, the level of correct performances was higher than in the absence of fields. In extinction trials, the correct response declined slowly over 45-60 days, even though there was no punishment for failure to respond. In the absence of the fields, extinction of the learned response occurred within 1 or 2 days. The EEG changes were anatomically localized, highly specific in frequency, and occurred as transient patterns. It is suggested that the components of such electric fields running through the extracellular spaces and at cell surfaces in cerebral tissue can exercise a relatively specific influence on the process of recall, despite their miniscule amplitudes in comparison with transmembrane electric gradients.

5697 NONINTRUSIVE ACOUSTIC TEMPERATURE TOMOGRAPHY FOR MEASUREMENT OF MICROWAVE AND ULTRASOUND-INDUCED HYPERTHERMIA. *(Eng.)* Johnson, S. A. (Mayo Clinic, Rochester, MN 55901; Christensen, D. A.; Baxter, B.; Greenleaf, J. F.; Rajagopalan, B. *J Bioeng* 1(5/6): 555-570; 1977. (20 refs)

The measurement of microwave- and ultrasound-induced hyperthermia by nonintrusive ultrasound temperature tomography is discussed in terms of theory and experimental evidence to support the theory. Microwave heating and ultrasound heating are the candidates of choice for the application of hyperthermia in such areas as cancer therapy because of the short response time of milliseconds or less, localization of heating effects (microwaves can be applied to areas of several square centimeters or larger with controlled depth of penetration), and ease of regulation by an electronic control system using ultrasound and point probe thermometry. The theory and experimental evidence on ultrasound reconstruction methods for determining temperature indicate that the temperature of homogeneous materials of known composition

(with temperature coefficients similar to water) may be measured to an accuracy of less than 0.5 C in a 1 cm^3 volume when a time resolution of 1 nsec is used in measuring the ultrasound propogation time through the material. Proportionally smaller temperature changes may be measured by increasing the linear dimensions of the measurement region, by increasing the resolution of propagation time measurements, or by imaging materials of larger temperature coefficient. At present, ultrasound reconstruction methods for determining temperature depend on theories developed for analysis of transmission data, and these theories limit the use of temperature reconstruction to those areas of the body, such as the breast, where reflection and absorption effects are minimal. The development of ultrasound reflection thermometry techniques would enable more accurate control of hyperthermia therapy in other areas of the body where bone or air are present.

5698 APPLICATIONS OF THE ABSOLUTE REACTION RATE THEORY TO BIOLOGICAL RESPONSES IN ELECTRIC AND MAGNETIC FIELDS. *(Eng.)* Brannen, J. P.; Wayland, J. R. (Sandia Lab., Albuquerque, NM 87115). 29 pp; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. SAND76-0057]. (41 refs)

A theoretic foundation for the study of biologic responses to electric and/or magnetic fields is presented. The formulation is based on absolute reaction rate theory and the effects of fields on reaction rates. Derivations that expand the theory to include field-effect are given, and the theory is applied to observations of the spores of *Bacillus subtilis niger* in a microwave field. The theoretic results are in qualitative agreement with experimental observations, and a preliminary analysis of the microwave data suggests that absolute reaction rate theory is applicable to electric field effects. It is suggested that there is no reason to suspect that magnetic fields will be an exception.

5699 IN VIVO BIOELECTROCHEMICAL CHANGES ASSOCIATED WITH EXPOSURE TO EXTREMELY LOW FREQUENCY ELECTRIC FIELDS. *(Eng.)* Marino, A. A. (Veterans Admin. Hosp., Syracuse, NY 13210); Berger, T. J.; Austin, B. P.; Becker, R. O.; Hart, F. X. *Physiol Chem Phys* 9(4/5): 433-441; 1977. (16 refs)

Male Sprague-Dawley rats, 21-24-days old, were continuously exposed to a 60-Hz electric field of 150 V/cm intensity for 1 mo to determine the generalized effect of such exposures. Data from 10 separate experiments indicated that the following changes were produced in at least some of the experiments: depressed water consumption, depressed body weight, increased adrenal and pituitary weights, and altered serum concentrations of albumin, hydroxycorticosterone, and glutamic oxaloacetic transaminase. The observed changes are consistent with, but do not categorically establish, the hypothesis that a power frequency electric field is a biologic stressor. To establish the nonthermal nature of the above effects, the induced current in the rats was measured; it was found that 0.68 μA was induced at 150 V/cm with a corresponding current density of about 11.1 mμA/cm^2. Assuming the rat to be a uniform mass with a resistivity of 100 ohm/cm, then the total power dissipated is about 2.3×10^{-12} W, which is too low to produce heating.

5700 A NEW NON-PERTURBING TEMPERATURE PROBE USING SEMICONDUCTOR BAND EDGE SHIFT. *(Eng.)* Christensen, D. A. (Dept. Bioengineering and Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112). *J Bioeng* 1(5/6): 541-545; 1977. (9 refs)

A nonperturbing temperature probe that can be used in applications involving microwave-induced hyperthermia is described. The temperature probe uses a small 0.250 mm gallium-arsenic semiconductor sensor affixed to the distal end of a fiber bundle and relies on the wavelength-dependent absorption of light whose wavelength matches the band gap energy of the semiconductor. One or two fibers of the bundle transmit .905-micron light from a pulsed light-emitting diode and narrowband filter combination to the sensor where it is transmitted through the gallium-arsenic and reflected back into one or two receiving fibers for detection by a silicon photodiode and digital display. Changes in the sensor temperature are observed as changes in received light intensity, which may be related to temperature by a calibration curve. A temperature test of a prototype probe was performed with a calibrated water bath and thermocouple monitor, and it was determined that the probe had a range of at least 33-47 C (limited by the testing apparatus) with several more degrees of range expected with improved testing conditions. Instabilities and scatter in the displayed intensity corresponded to about ± 0.1 C and appeared to be due primarily to short-term variations in the source intensity. A technique for cancelling source fluctuations, which involves a reference channel and electronic ratioing before the display, is being developed to improve the accuracy of the probe to better than 0.1 C. The small tip size of the probe and its inherent sensor stability make the probe useful for temperature monitoring in biologic experiments.

5701 RF DIELECTRIC PROPERTIES MEASUREMENT SYSTEM: HUMAN AND ANIMAL DATA. *(Eng.)* Toler, J.; Seals, J. (Biomedical Res. Group, Electromagnetic Effectiveness Div., Systems and Techniques Lab., Engineering Experiment Station, Georgia Inst. Technology, Atlanta, GA 30332). 87 pp.; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB-274 776]. (21 refs)

An in vivo probe measurement system for accurately measuring the electrical properties (relative dielectric constant and conductivity) of a wide variety of sample materials, such as standard liq-

uids, phantom modeling materials, and in vivo tissue is described. The system is based on relating the impedance of a short monopole antenna in air to its impedance in dielectric media. The applicable frequency range of the system is 10-100 MHz, which can be scanned on either a discrete or swept frequency basis. The in vivo probe-network analyzer system provides relative dielectric constant and conductivity data that compare within ± 5% of available reference data. With the aid of the above system, phantom modeling materials can be mixed such that the electrical characteristics of living biologic systems will be duplicated, making these materials useful for studies examining the effects of absorbed radiation on biologic systems.

5702 THE VISCOMETRIC THERMOMETER: A NON-PERTURBING INSTRUMENT FOR MEASURING TEMPERATURE IN TISSUES UNDER ELECTROMAGNETIC RADIATION. *(Eng.)* Chen, M. M. (Univ. Illinois at Urbana-Champaign, Urbana, IL 61801; Cain, C. A.; Lam, K. L.; Mullin, J. *J Bioeng* 1(5/6): 547-554; 1977. (14 refs)

A non-perturbing viscometric thermometer probe for measuring temperature in biologic tissues exposed to electromagnetic radiation is described. The viscometric thermometer is based on the measurement of temperature-dependent viscosity of a fluid flowing slowly through a small capillary at the tip of the thermometer probe. For sufficiently low velocities, the flow resistance is directly proportional to the viscosity. Several prototypes of the viscometric thermometer probe were constructed and tested to verify the practicality of the concept. The finished probes had outer diameters of 1.2-2.0 mm and lengths of about 50 mm. A number of fluids, including distilled water, castor oil, mineral oil, and ethylene glycol, were used as the sensing media; flow rates varied from 3×10^{-4} to 2×10^{-3} ml/sec. Relative to water, mineral oil did not absorb microwave energy; whereas, ethylene glycol was highly absorbing. A mixture of two or three fluids could be used to obtain any desired loss characteristics. The sensitivity of the probe could be varied over very wide ranges depending on the capillary diameter, the working fluid, and the flow rate. Advantages of the probe include its simplicity and thermal and mechanical ruggedness. Frequent recalibration is not necessary, and the probe should be autoclavable. Another advantage of the probe is that the probe body material and sensing fluid can be chosen so that their electrical and thermal properties match closely those of the tissue, thus minimizing any electrical and thermal perturbations.

5703 EXTREMELY LOW FREQUENCY VERTICAL, 45-HZ ELECTRIC FIELD EXPOSURE OF RATS: A SEARCH FOR GROWTH, FOOD, AND WATER CONSUMPTION, BLOOD METABOLITE, HEMATOLOGICAL, AND PATHOLOGICAL CHANGES. *(Eng.)* Mathewson, N. S.; Oosta, G. M.; Levin, S. G.; Diamond, S. S.; Ekstrom, M. E. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, Bethesda, MD 20014). 59 pp; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A045417]. (21 refs)

Several experiments were performed in which young male Sprague-Dawley rats were exposed for 28 days to sinusoidal 45-Hz vertical electric fields in nonmetallic cages at field strengths of 0, 2, 10, 20, 50, and 100 V/m (root mean square) to verify the existence of lowered growth rates for rats exposed to such fields and to determine if food and water consumption, serum metabolite concentrations, or parameters of a complete blood count were perturbed. No biologically important differences were found for any of the variables studied. No statistically significant differences were observed in any experiment where six groups of 16 animals were exposed to the above field strengths for the following variables: water consumption, serum or plasma cholesterol, serum or plasma triglycerides, white blood bount, segmented neutrophils, lymphocytes, adrenal weights, and spleen weights. Histopathological analyses also failed to reveal any significant differences between rats exposed to the above field strengths. The most unequivocal results were obtained from an experiment in which 48 animals were used in both control and 20 V/m-exposed groups. No significant differences were observed for any of the variables and no dose relationships were found for any of the above variables.

5704 HYPERTHERMIA IN ANIMAL AND HUMAN BODIES INDUCED BY ELECTROMAGNETIC FIELDS. *(Eng.)* Chen, K. M. (Dept. Electrical Engineering and Systems Science, Michigan State Univ., E. Lansing, MI 48824); Rukspollmaung, S. *J Bioeng* 1(5/6): 531-539; 1977. (6 refs)

Methods of inducing hyperthermia in tumors embedded in simulated animal and human bodies using electromagnetic fields were investigated. The body was considered to be homogeneous with certain electrical properties, and the tumor was assumed to be a local region with a conductivity that differs from that of the surrounding tissue. Electric fields of 1 V/m at various frequencies were used to produce hyperthermia. It was shown that part-body irradiation with high-frequency 15-MHz electric fields was effective for internal tumors, especially those with lower conductivities; however, this scheme of irradiation was not capable of heating surface tumors selectively. Whole-body irradiation with the same high-frequency field did not produce a local heating effect at the tumor. At the microwave (2,450 MHz) and ultra-high-frequency (600 MHz) frequency ranges, it was found that the application of a focalized electromagnetic radiation at the tumor may create hot spots at various locations away from the tumor instead of heating the tumor. A scheme for locally heating a surface tumor with a nonuniform electromagnetic wave of 500 MHz is proposed in which the incident electric field in the cells directly above and under the tumor is directed in the opposite direction of the incident

electric field at the tumor in order to create a concentrated induced field in the tumor. This type of nonuniform electromagnetic field can be synthesized by an array of aperture radiators.

5705 THERMAL RESPONSE IN *MACACA MULATTA* EXPOSED TO 15- AND 20-MHZ RADIOFREQUENCY RADIATION. *(Eng.)* Krupp, J. H. (Radiation Physics Branch, Radiation Sciences Div., USAF Sch. Aerospace Medicine, Aerospace Medical Div., Brooks Air Force Base, TX 78235). 13 pp; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A045508]. (5 refs)

Rhesus monkeys *(Macaca mulatta)* were exposed to 15- and 20-MHz radio frequency radiation for 3 hr at power levels approximating 15-25 times the maximum permissible exposure limits for man to evaluate the effect of such exposures on body core temperature. The 20-MHz exposures were performed at incident power densities of 1,270 and 760 mW/cm^2, and the 15-MHz exposures were done at 1,025 and 775 mW/cm^2. At all four irradiation conditions, mean rectal temperatures rose quickly during the first 30 min of exposure, then leveled off, and then fluctuated slightly or continued a slow rise for a time as thermoregulatory mechanisms were brought into play. A comparison of all four irradiation conditions with respect to temperature rise indicated some frequency times time interaction. There was a suggestion that the higher frequency increased the body temperature more during the first hour and then maintained the higher level throughout the 3-hr exposure period. For example, monkeys exposed to 20-MHz fields at a power density of 760 mW/cm^2 showed a mean rectal temperature rise of from 38.46 to 39.28 C during the first 60 min of exposure, and their mean rectal temperature at the end of the 180-min exposure period was 39.46 C. Monkeys exposed to 15-MHz fields at a power density of 775 mW/cm^2 showed a mean rectal rise of from 38.56 to 39.01 C during the first 60 min of exposure, and their mean rectal temperature at the end of the 180-min exposure was 39.06 C. These observations conform to the concept of a thermal burden based on absorbed power, which has been shown to be frequency dependent.

5706 COMPARISON OF THE HEATING PATTERNS OF SMALL MICROWAVE (2450 MHZ) APPLICATORS. *(Eng.)* Magin, R. L. (Lab. Chemical Pharmacology, DTP, DCT, Natl. Cancer Inst., Natl. Inst. Health, Bethesda, MD 20014); Kantor, G. *J Bioeng* 1(5/6): 493-509; 1977. (15 refs)

Heating patterns of typical circular, rectangular, and slab-loaded 2,450-MHz microwave applicators were studied in planar dielectric phantoms, tumor models, and actual mouse tumors to determine the effective volume heated by such applicators. It is concluded that a simple consideration of applicator size and tissue penetration depth is not sufficient to predict the temperature distributions within small animal tumors. The half-power widths and depths of heating give a better estimate of the effective heating volume, but factors such as tumor size, shape, and blood flow greatly influence the steady state temperature distribution. Small microwave applicators concentrate their heating within the tumor, but the deposition of energy is not uniform as seen by uneven steady state temperature distributions within live tumors. The nonuniform deposition of microwave energy and the large tumor-to-ambient air temperature gradient are suspected reasons for the relatively poor intratumor temperature uniformity. Careful consideration of the characteristics of the applicator, tumor, and temperature-sensing methods is necessary to generate temperatures within small animal tumors, which are uniform enough for meaningful biologic results to be obtained.

5707 KIDNEY MODEL FOR STUDY OF ELECTROMAGNETIC THAWING. *(Eng.)* Burdette, E. C. (Electromagnetic Effectiveness Div., Engineering Experiment Station, Georgia Inst. Technology, Atlanta, GA 30332); Karow, A. M. *Cryobiology* 15(2): 142-151; 1978. (36 refs)

The use of electromagnetic heating, such as 2,450-MHz microwaves, for thawing large organs after cryopreservation is discussed. In contrast to other techniques of thawing, this technique has been shown to yield functioning dog kidneys that had been frozen at temperatures of -20 C to -80 C. In one particular experiment, 9 of 17 dogs survived from 2-14 mo on a single kidney that had been treated with 1.4 molar dimethylsulfoxide, held at -80 C for 15 min, and thawed in a microwave oven. From a theoretic standpoint, the Method of Moments has been applied to determine the electromagnetic field distribution within whole organs; this method is capable of predicting the locations of any potential regions of nonuniform heating in the material for realistic geometric models with varied and arbitrary contours. At the present time a computer program based on the Method of Moments is being used to predict the field intensity within sample models represented by circular and elliptical cylinders with a plane electromagnetic wave incident on the sample.

5708 EFFECTS OF ELECTROMAGNETIC FIELDS ON ISOLATED NERVE AND MUSCLE PREPARATIONS. *(Eng.)* Chou, C. K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, Univ. Washington Sch. Medicine, Seattle, WA 98195); Guy, A. W. *IEEE Trans Microwave Theory Tech* 26(3): 141-147; 1978. (25 refs)

Isolated frog sciatic nerves, cat saphenous nerves, rabbit vagus nerves, superior cervical ganglia, and rat diaphragm muscles (maintained at a constant temperature by Ringer's solution) were exposed in an S-band waveguide either parallel or perpendicular to a 2,450-MHz microwave field to investigate the effect of the field on nerve action potential and muscle contractile tension. As long as the temperature of the nerves or muscles was kept constant, no changes in amplitude or conduction characteristics

or in contraction were observed over continuous wave specific absorption rates (SAR) of 0.3-1,500 W/kg and pulsed peak SAR of 0.3-220 kW/kg. Changes observed at the highest power levels were due to associated increases in temperature and were duplicated by increasing the solution temperature. No direct electric field stimulation of nerve axons, ganglia, or muscles was observed during microwave irradiation.

5709 EXPERIMENTS WITH A 915 MHZ HYPERTHERMIA SYSTEM FOR CANCER TREATMENT. *(Eng.)* Johnson, C. C. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112); Durney, C. H.; Plenk, H. P. *J Bioeng* 1(5/6): 519-529; 1977. (24 refs)

Experiments involving the use of 915-MHz radiation for the induction of hyperthermia in animal and human tumors are reported. Preliminary experiments with a dog showed the necessity of providing surface cooling to avoid unacceptably high skin temperatures. Using a system with surface temperature control, a cat with a salivary gland tumor was given six treatments. The 8 cm by 4 cm tumor was treated with the surface temperature not exceeding 43 C. Midtumor temperature rose as high as 46 C, and the back surface of the tumor was typically raised to 39-41 C. After the sixth treatment, the tumor was almost completely necrosed, but there was also considerable skin necrosis. When the same system was applied to a Saint Bernard dog with a 10-cm diameter tumor in the left front wrist, the surface temperature was again controlled to about 43 C; however, the back surface of the tumor could not be raised higher than about 39 C. Considerable tumor necrosis was observed, followed by apparent healing. However, the tumor later regrew. A series of five treatments were administered to a human subject who had several subsurface tumors resulting from bladder tumor metastasis. The treatments consisted of raising the surface temperature to about 43 C for 45 min. One tumor that was treated by 915-MHz microwave hyperthermia plus X-ray irradiation regressed completely; whereas, another tumor, treated with X-ray alone, regressed substantially but not completely.

5710 CYTOLOGICAL EFFECTS OF 2450 MHZ CW MICROWAVE RADIATION. *(Eng.)* Lin, J. C. (Dept. Electrical Engineering and Physical Medicine and Rehabilitation, Wayne State Univ., Detroit, MI 48202); Peterson, W. D. *J Bioeng* 1(5/6): 471-478; 1977. (26 refs)

Cultured human skin fibroblasts and lymphoblasts were exposed to 2,450-MHz continuous wave microwave radiation in a constant temperature waveguide exposure chamber to investigate the effect of irradiation on the growth and viability of these cells in the absence of a measurable temperature rise. At incident power densities ranging from 10-500 mW/cm^2, which corresponded to energy absorption rates of 235-1,200 mW/g, a 15-min exposure of the cells to radiation did not alter either growth or viability in comparison with unirradiated controls. These results suggest that previously reported observations to the contrary may have been due to selective heating of a fraction of the cells in flasks and vials used as sample holders during the irradiation process.

5711 HYPERTHERMIA DOSE DEFINITION. *(Eng.)* Atkinson, E. R. (Natl. Cancer Inst., Div. Cancer Treatment, Bethesda, MD 20014). *J Bioeng* 1(5/6): 487-492; 1977. (17 refs)

Fractional unit of cell kill (F), calculated from time, temperature, and somewhat arbitrary assumptions regarding cytotoxicity and chemical reaction kinetics is proposed as a unit of hyperthermia dosage. This hyperthermia dose unit definition incorporates a nonlinear weighting factor in the procedure that is already in use for computing hyperthermia exposure in degree-hours above an arbitrary temperature. It may loosely be interpreted as the percentage of cells killed by such a treatment applied to in vitro tissue culture. Without the nonlinear temperature-dependent weighting factor, the degree-hour figure is simply proportional to the total energy transferred or confined to the patient during treatment.. The absence of a nonlinear weighting factor makes long exposure to low temperatures entirely equivalent to brief exposures to high temperatures in direct contradiction to experience. It must be recognized that the dose defined by F will not generally 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. Although the simple assumptions of chemical reaction kinetics used in arriving at the expression for F ignore more sophisticated considerations of cell kinetics, it is felt that in a typical clinical situation insufficient data will be available to incorporate these refinements, while the functional form of F will remain unchanged over sufficiently narrow ranges of applicability. If more refined data are available, the proposed model may be easily modified accordingly.

5712 ELECTRICAL STIMULATION OF SOFT TISSUE GROWTH (LETTER TO EDITOR). *(Eng.)* Howes, R. M. (The Johns Hopkins Hosp., Dept. Surgery, Baltimore, MD 21205); Lipson, S. D.; Hoopes, J. E. *South Med J* 71(4): 484; 1978. (5 refs)

Electrical stimulation of soft tissue growth in a 73-yr-old woman treated for postherpetic neuralgia involving the right hemithorax is reported. Treatment was begun with fluphenazine hydrochloride and amitriptyline as well as with transcutaneous electrical stimulation (parameters not specified). Relief of symptoms was dramatic; however, 4 mo after the initiation of therapy, the patient became aware of an increase in the size of her right breast and pain associated with the use of the stimulator. Physical examination at 7 mo revealed a right breast slightly larger than the left (20.3

cm from the suprasternal notch to the nipple on the right compared with 19.7 cm on the left). Excisional biopsy of a 2 by 1 cm soft, not freely movable mass just above the right areola revealed ductal ectasia. This case raises the question as to the feasibility of electrical stimulation of soft tissue growth. Although the growth of tissue in this case could perhaps be partially explained on an iatrogenic basis, it seems more reasonable that the unilateral breast enlargement, which occurred at the stimulation electrode site, was secondary to the externally applied electrical current. More importantly, this case provides interesting speculations concerning the effects of bioelectric fields on human growth processes.

5713 MICROWAVE IRRADIATION FIXATION FOR STUDIES OF POLYPHOSPHOINOSITIDE METABOLISM IN BRAIN. (Eng.) Soukup, J. F. (Dept. Physiology and Pharmacology, Duke Univ. Medical Center, Durham, NC 27710); Friedel, R. O.; Shanberg, S. M. *J Neurochem* 30(3): 635-637; 1978. (32 refs)

The efficacy of microwave irradiation fixation for analyzing polyphosphoinositide (PPI) metabolism in rat brain was investigated by comparing recoveries of PPI and PPI incorporated ^{32}P-orthophosphate from unfixed brains, frozen brains, and microwave-irradiated brains of male Sprague-Dawley rats. Microwave fixation was achieved by irradiation of the whole animal in a microwave oven delivering 1,300 W at a frequency of 2,450 MHz for 30-45 sec. Recovery of triphosphoinositide (TPI: 441 ± 16 to 550 ± 10 nmoles/g) and TPI-incorporated ^{32}P (53 ± 5 to 84 ± 4 ncuries/g) from irradiated brains was equal to or greater than recoveries from frozen brains, and both of these fixation techniques produced greater recoveries than that obtained from unfixed brains. The recovery of diphosphoinositide from irradiated brains was comparable to that from frozen brains. In irradiated brains, TPI losses never exceeded 10% from any region at any age; DPI losses were greater from the brainstem than cerebellum or cerebral cortex and generally were greater than TPI losses (20-25%). There were no significant differences in the percentage of PPI loss and the percentage of PPI-incorporated ^{32}P-orthophosphate loss. These results indicate that microwave irradiation fixation is more effective in preventing postmortem degradation of PPI than fixation by freezing. Also, using the microwave fixation technique, it was demonstrated that activation of brain neurotransmitter receptors results in an increased turnover of PPI polar group moieties; these effects were not demonstrated in similar studies using freeze fixation techniques.

5714 THE EFFECT OF ELECTRIC FIELDS ON OSTEOPOROSIS OF DISUSE. *(Eng.)* Martin, R. B. (West Virginia Univ. Medical Center, Morgantown, WV 26506); Gutman, W. *Calcif Tissue Res* 25(1): 23-27; 1978. (18 refs)

The effect of electrical stimulation on osteoporosis of disuse was studied in male Sprague-Dawley rats. The right thigh and leg of 35 evaluable rats were placed in a plaster cast to achieve disuse of the limb. Electrical stimulation of the immobilized limb was performed in 16 of these 35 rats and was achieved by applying a 200-V peak-to-peak 30-Hz signal to the limb via insulated electrodes. One group of nine electrically-stimulated rats received the treatment for 1 hr in the morning and 1 hr in the afternoon; the stimulation was reduced to 1 hr/day on weekends. Another group of seven electrically stimulated rats was treated for 8 hr/weekday and 1 hr/weekend day. In control rats, immobilization produced significant atrophy of bone mass. However, osteoporosis did not occur in the immobilized limbs of electrically stimulated rats. Also, femoral shafts electrically stimulated for 8 hr/day for an average of 23 days were larger and heavier than those treated for 2 hr/day for an average of 33 days. No tumors or other malformations were observed either by gross examination of the electrically stimulated femurs or in histologic sections. The results confirm previous findings indicating that a noninvasive electrical field can offset the effects of disuse osteoporosis in rats but fail to produce any evidence of previously reported electrically-induced bone tumors.

5715 MW INTERFEROMETERS FOR BIOLOGICAL STUDIES. *(Eng.)* Griffin, D. W. (Univ. Adelaide, Adelaide, South Australia). *Microwave J* 21(5): 69-72; 1978. (5 refs)

The use of microwave interferometers for recording small surface movements in biologic subjects is discussed. Both magic tee hybrid and three-port circulator designs are covered; the latter design is more sensitive for a given source power. The microwave generator can be a simple klystron or a relatively elaborate signal generator. Square wave amplitude modulation at a repetition frequency of 1 kHz is required so that a selective amplifier type standing wave indicator can be used as a receiver to drive an x-y plotter. The amplitude of movement of a test subject that can be accurately recorded is a small fraction (about 1/10) of the operating wavelength of the interferometer. An interferometer of the three-port circulator design operating at a frequency of 9.3 GHz was used to measure chest movement and various hand and foot movements of a test subject in an ordinary room. The recorded results demonstrate accurate detail in the movement associated with various physiologic functions and the potential for more advanced studies involving correlation with recordings of other effects.

5716 RADIATION PROTECTION ACTIVITIES - 1976. *(Eng.)* Office of Radiation Programs (Environmental Protection Agency, Washington, DC 20460). 186 pp; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB-273 469]. (173 refs)

Radiation protection activities of several Federal agencies are reviewed in an annual report. With

regard to nonionizing radiation, only the Environmental Protection Agency's Office of Radiation Programs and the Food & Drug Administration's Bureau of Radiological Health (BRH) activities are discussed in detail. The BRH began the process of generating a draft performance standard for microwave diathermy applicators, and several major compliance actions were taken. Studies by the EPA relating to microwaves and radio frequency (RF) radiation included urban area environmental measurements, measurements of RF levels in buildings, source distribution analysis for both RF and microwaves, and population exposure studies, as well as experiments on the biologic effects of nonionizing radiation. The BRH studies involved marine radar exposure, theoretic dosimetry, and a miniature microwave field probe. The EPA prepared to let a contract to evaluate and summarize 6,000 pages of comments in response to its request for information on the health and environmental effects of extra-high voltage power transmission lines.

5717 RF RADIATION ABSORPTION PATTERNS: HUMAN AND ANIMAL MODELING DATA. *(Eng.)* Guy, A. W.; Webb, M. D.; McDougall, J. A. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, Univ. Washington Sch. Medicine, Seattle, WA 98195). 77 pp; 1977. [available through Dept. Health, Education, and Welfare, National Inst. Occupational Safety and Health, Div. Biomedical & Behavioral Sci., Cincinnati, OH 45226, Publication No. 77-183. (11 refs)

A technique for modeling radio frequency (RF:10-300 MHz) radiation absorption patterns in animals and humans is reported. Various models of animals and humans were exposed to RF fields produced by different sources. Power absorption patterns and the rate of power absorption at specific anatomical locations within the models were thermographically recorded. These parameters were recorded under simulated RF industrial exposure conditions using a near-field synthesizer. The results of the modeling research demonstrated the validity of this technique for predicting the magnitude and distribution of RF-induced power absorption in humans and animals. The utility of the technique for the extrapolation of animal data to human RF exposure thresholds was also firmly established.

5718 RESEARCH NEEDS FOR ESTABLISHING AN ENVIRONMENTAL MICROWAVE RADIATION SAFETY STANDARD. *(Eng.)* Elder, J. A. (Experimental Biology Div., Health Effects Res. Lab., Environmental Protection Agency, Research Triangle Park, NC 27711). 13 pp; 1976. [available through National Technical Information Services, Springfield, VA 22161 Document No. PB 273 232]. (12 refs)

Research needs for establishing an environmental microwave radiation safety standard are outlined. It is recommended that epidemiologic and clinical investigations be performed on groups of workers and others exposed to both high and low power densities of microwave radiation. Special emphasis should be placed on potentially heat-sensitive civilian sub-populations. In particular, behavioral, immunologic, and teratologic effects should be investigated. Chronic low-level studies of animals exposed to power densities approximating the present occupational exposure guide of 10 mW/cm^2 are also recommended. Emphasis should be placed on possible sensitive test systems, such as, the developing embryo, immune defense system, central nervous system, chromosomes, eye lens, and male reproductive organs. Research is also needed to determine the basic mechanisms of radio frequency effects on molecular and cellular components and the loci of interaction as a function of power density and frequency. Biologic systems, such as, the brain, heart, ear, and lymphocyte as well as model studies including anthropomorphic models should be emphasized. Support should be continued for surveys to systematically evaluate the frequencies and intensities of electromagnetic radiation in the environment, and the results should be incorporated into the design of laboratory bioeffects studies, particularly chronic studies. Means must also be taken to assure that biologic effects, including negative effects, be related to quantitative measurements of absorbed power so that the data can be extrapolated to man.

5719 ENVIRONMENTAL IMPACT OF ELECTRICITY TRANSMISSION. *(Ger.)* Moeller, K. (Institut fur Allgemeine Elektrotechnik und Hochspannungstechnik, RWTH, Aachen, W. Germany). *Elektrizitaetswirtschft* 77(1): 26-31; 1978. (25 refs)

Studies on the biological effects of electric and electromagnetic fields are reviewed. Electric fields with potentials of up to 20 kV/m had no marked effect on the reaction time, pulse rate, and blood pressure of test persons. The exposure even delayed somewhat the normal increase of the reaction time, i.e., it had a slight stimulating effect. Slight but significant increase in heart rate but no significant changes in respiration rate and blood pressure were seen in rats exposed to an electric field of 80 kV/m for 2x 4 hr during a 16-hr period. The changes observed in test persons exposed simultaneously to electric field (20 kV/m) and magnetic field (induction 0.3 mtesla) were the same as those seen during exposure to the electric field alone. The findings do not support evidence of health hazards from electric and magnetic fields generated by power transmission lines.

5720 RADIOLOGICAL SAFETY BY DESIGN—I A U.S. VIEWPOINT. *(Eng.)* Gundaker, W. E. (Bureau Radiological Health, Food and Drug Admin., Rockville, MD). *Ann Occup Hyg* 20(3): 305-311; 1977. (4 refs)

The development of product performance standards under the Radiation Control for Health and Safety Act is described along with administrative procedures by which the standards are enforced. Under the Act, the Food & Drug Administration may prescribe performance standards for products emitting

both ionizing and nonionizing electromagnetic and particulate radiation as well as sonic, infrasonic, and ultrasonic waves. Types of products that fall within the definitions of equipment covered by the act include x-ray machines, television receivers, accelerators, diathermy units, laser products, microwave ovens, and ultrasonic cleaners. The provisions of a performance standard may include a definition of the maximum level of radiation emission permissible from an electronic product and a procedure for testing the product and measuring the emitted radiation. At present six performance standards have been promulgated, with two of them applying to nonionizing radiation sources. A microwave oven standard, which is applicable to all ovens manufactured after October 6, 1971, limits radiation leakage from an oven at 5 cm from the external surface to 1 mW/cm^2 at the time of manufacture and to 5 mW/cm^2 during the lifetime of the oven. The act also contains a mechanism for ensuring that all radiation safety defects in products are appropriately corrected. Between October 1968 and February 1977, there were 189 compliance actions involving defective and noncompliant products. Of these compliance actions, 26 involved microwave ovens.

5721 WHERE DOES SPACE BEGIN? MAY SOLAR ENERGY BE USED WITHOUT RESTRICTION? *(Ger.)* Panzram, H. (Feuerbachstr. 10, 6000 Frankfurt/M., W. Germany). *Naturwiss Rundsch* 31(4): 148-150; 1978. (0 refs)

A country's legal jurisdiction of the upper part of the atmosphere is discussed. A study was performed in the US on satellite solar stations. Celesium cell reflectors were positioned so that solar energy was continuously absorbed and reflected to earth through microwaves. It is theorized that if the energy was too concentrated, deaths, bodily injury, property damage, and possible damage to the environment may result.

5722 BIOLOGICAL AND MEDICAL PROBLEMS OF THE USE OF RADAR WAVES. II. MEDICAL PROBLEMS (PROTECTION AND SURVEILLANCE OF THE EXPOSED PERSONNEL). *(Fre.)* Delahaye, R. P. (Service de Radiologie, Hopital Begin, 69, avenue de Paris, 94160 Saint-Mande, France). *Radioprotection* 12(4): 359-377; 1977. (104 refs)

Studies on the effects of radar waves on exposed personnel and general problems of radiation protection are reviewed. Medical examinations of 226 persons exposed to radar waves with a peak intensity of 1 mW for 3-13 yr failed to reveal significant pathologic changes, but 25% of the personnel had subjective complaints that could be related to the exposure (sensation of heat in the face and hands, tinnitus, abnormal fatigue, headache and pain in the eyeballs). Neurovegetative disorders (asthenic syndrome, cardiovascular dystonia, and diencephalic syndrome, somnolence, insomnia, sensory disturbances, and EEG changes) were reported in the USSR to occur in persons exposed to microwaves with intensities below 10 mW/cm^2. Other investigators observed mild hypothyroidism accompanied by thyroid hyperplasia and increased adrenocorticotropic hormone secretion by the pituitary gland. Cataracts of the eye were found in a man subjected to a radiation intensity of 100 mW/cm^2 (frequency 2,000-3,000 MHz) and in another after 2 mo exposure to 10-12-cm microwaves. The literature indicates the need for regular medical checkups of personnel exposed to microwaves.

5723 THE BIOLOGICAL EFFECTS OF MICROWAVES. *(Fre.)* Berteaud, A. J. (No affiliation given). *La Recherche* 9(85): 65-66; 1978. (3 refs)

State-of-art report on the biologic effects of microwaves based on studies presented at the International Symposium on the Biological Effects of Electromagnetic Waves held in Airlie, Virginia, in the fall of 1977 is discussed. In a wide range of frequencies, electromagnetic waves have biologic effects other than thermal. Microwaves were found to increase the permeability of the hematoencephalic barrier due to the increased formation of intercellular bridges. Microwaves were also reported to interfere with interferon formation and lymphocyte and macrophage stimulation (no specific data given). Hormonal effects of microwaves were observed during long-term exposure of *Drosophila* and certain other larvae. The effects of microwaves are reversible; irreversible effects can be produced only by other factors, e.g., x-rays acting simultaneously with microwaves. The increased radiation and drug sensitivity of tumor cells heated to 41-42 C indicates the potential value of microwave hyperthermia as an adjuvant method in cancer therapy.

5724 EXPERIENCE WITH DECIMETER-WAVE THERAPY IN THE COMPLEX TREATMENT OF PATIENTS WITH PEPTIC ULCER. *(Rus.)* Zhgun, A. A. (N. N. Burdenko Principal Clinical Hosp., Moscow, USSR); Ushakov, A. A.; Aloiants, G. A.; Rebrov, V. G. *Vopr Kurortol Fizioter Lech Fiz Kult* (3): 38-41; 1977. (3 refs)

Complex treatment that included local decimeter-wave therapy (20 and 40 W, 10-15 min/session, 8-12 sessions) was given to 113 patients with ulcers of the duodenal bulb, to 23 with gastric ulcer, and to 3 with gastroduodenitis. The bioelectric activity of the stomach was investigated in 91 patients. Of these, 48 were treated with 20 W and 43, with 40 W. Significant inhibition of the motor activity of the stomach was observed in 62 patients during or immediately after irradiation; the bioelectric activity returned to the original level immediately after the session in six of these patients. The inhibitory effect was most marked in patients with hypermotoric dyskinesia of the stomach. The initial gastric pH was 1-8.4. After treatment, reduction of the gastric acidity was seen in 28 patients in the corpus of the stomach and in 25 patients in the antral part, while the acidity of the corpus and antral part increased

in 5 and 7 patients, respectively. The findings indicate the great value of decimeter wave therapy in the complex treatment of ulcer patients with pronounced motor and secretory disorders of the stomach and duodenum.

5725 EFFECT OF UHF MAGNETIC FIELD ON THE DEVELOPMENT OF COLLATERAL ARTERIES AND LYMPHATICS (AN EXPERIMENTAL STUDY). *(Rus.)* Pas, A. I. (Dept. Normal Anatomy, I. P. Pavlov First Leningrad Medical Inst., Leningrad, USSR). *Vopr Kurortol Fizioter Lech Fiz Kult* (4): 65-68; 1977. (8 refs)

The effect of a therapy course with ultra-high-frequency magnetic field (15 or 30 W) on the development of collateral arteries and lymphatics was studied in 216 albino rats. The treatment was initiated 3-4 days after the dissection of the femoral artery or removal of the popliteal lymph nodes. Compared with the non-irradiated controls, the magnetic field accelerated the development of the collateral arteries, improved their structure, and facilitated lymph drainage through collateral lymphatics and reserve lymphatic vessels. The magnetic field of 15 W had more favorable effect (better structure of arteries, more marked and prolonged effect on lymph flow through superficial lymphatics) than the magnetic field with 30 W. (Parameters of field, duration and number of sessions not given.)

5726 CYTOLOGICAL EFFECTS OF MICROWAVE RADIATION IN CHINESE HAMSTER CELLS IN VITRO. *(Eng.)* Alam, M. T. (Direction des Laboratoires, Ministere des Affaires Sociales, 20045 Chemin Ste-Marie ouest, Ste-Anne de Bellevue, Quebec, Canada, H9X 3L2); Barthakur, N.; Lambert, N. G.; Kasatiya, S. S. *Can J Genet Cytol* 20(1): 23-30; 1978. (14 refs)

The cytologic effects of exposing a CHO-K1 subclone of parental Chinese hamster ovary cells to 2,450-MHz microwave radiation at power levels of 25-200 W for 30 min under both temperature-controlled and uncontrolled conditions were investigated. Cells irradiated under hypothermic conditions (29 C) at power levels of 75-200 W showed no significant increase in the mean number of chromosomal breakages per cell in comparison with control cells. In contrast, cells irradiated with only 25 W under uncontrolled temperature conditions (49 C) showed significant increases in chromosome breakages over control cells. In addition to chromosomal breakage, these cells also exhibited nuclear vacuoles and pycnotic and decondensed chromosomes. These changes can be directly attributed to temperature elevation which also resulted in partial cell death (6% as determined by trypan blue test).

5727 A METHOD FOR THE EXPOSURE OF MINIATURE SWINE TO VERTICAL 60 HZ ELECTRIC FIELDS. *(Eng.)* Kaune, W. T.; Phillips, R. D.; Hjeresen, D. L.; Richardson, R. L.; Beamer, J. L. *IEEE Trans Biomed Eng* 25(3): 276-283; 1978. (9 refs)

A clear Plexiglas exposure system for subjecting Hanford miniature swine to vertical 60-Hz single-phase electric fields is described. Each pig was placed on a metal ground plane, and the impedance between the pig's body and the metal ground plane was 2-3 kohms with all four feet on the ground. The normalized swine short circuit current was 6.9 μA/(kV/m), which made the root mean square voltage of the pig's body about 17 mV/(kV/m). Even at a high exposure field strength of 30 kV/m, the potential difference between the pig's body and ground (or a grounded watering system) would be less than 0.5 V. With a grounded anesthetized pig supported in a standing position by a nonconducting holder, the electric potential at 7.5 cm above the back of the pig was 1,200 V relative to ground at 2.9 kV/m unperturbed field strength; this corresponds to an average field strength of 16 kV/m. The threshold field strength for shocks and corona discharge in the system was greater than 55 kV/m unperturbed field strength and for hair stimulation about 40 kV/m. Behavioral tests indicated that there was some field perception, via an unknown mechanism, at unperturbed field strengths of as low as 30 kV/m. During measurements of the sensitivity of swine to small 60-Hz mouth-to-drinking nozzle currents, a significant increase in the perception threshold was found as the open-circuit nozzle voltage was reduced from 35-V peak to 2.5-V peak. This unexpected result suggests that swine respond to transient discharges from sources with rather low open-circuit voltages and illustrates the importance of designing electric field exposure systems so that such transient discharges cannot occur.

5728 A SEQUENTIAL STIMULATOR FOR ELECTRICAL RESTORATION OF THE MICTURITION REFLEX. *(Eng.)* Naumann, S. (Dept. Electrical Engineering, McMaster Univ., Hamilton, Ontario, Canada); Milner, M. *IEEE Trans Biomed Eng* 25(3): 307-311; 1978. (25 refs)

A sequential vesical stimulator for the electrical restoration of the micturition reflex is described. The stimulator is designed to deliver 4 W to an impedance of 100 ohms at a separation of 12 mm edge to edge between the transmitting and receiving coil systems which are inductively coupled. Sequential pulsing is achieved by using three carrier frequencies of 190, 160, and 130 kHz. The stimulator was implanted in a normal sow anesthetized with sodium thiopentone. The sow voided well while under anaesthetic, and there were no visible signs of current spread. The sow was also stimulated 2 days postoperatively while conscious, and no evidence of pain or current spread was observed. Further clinical trials are required to fully assess the device.

5729 NEW INTERFERENCE SENSING DEMAND PACEMAKER FUNCTIONS. *(Eng.)* Brownlee, R. R. (Dept. Electrical Engineering, Pennsylvania State Univ., University Park, PA 16802); Tyers, G. F.; Neff, P. H.; Hughes, H. C. *IEEE Trans Biomed Eng* 25(3): 264-269; 1978. (19 refs)

Newly developed and tested analog and digital control functions for eliminating electromagnetic interference (EMI) with demand cardiac pacemakers are described. A modified common configuration with analog control function is described in which a second EMI sensing channel is incorporated to minimize inhibition from pulsatile radio frequency (RF) artifacts that occur at normal cardiac rates. This second receiver channel is intentionally designed to be insensitive to QRS signatures by proper design of the EMI pass-QRS reject filter. Additionally, an input detector is employed in the EMI channel that is sensitive to and demodulates high level RF signals so that a mode control signal is developed to prevent inhibition of the resettable astable oscillator via the blocking function preceding the oscillator. A new demand pacemaker configuration employing digital control functions is also described. In this system, a basic clock is employed in conjunction with countdown and decoding circuitry to provide the basic fixed pacing rate, the development of a refractory interval, and the development of the rate and event counting discriminator required for the detection of continuous or burst interference with frequencies that fall within the QRS passband. These digital timing and control functions are under adaptive command of a dual channel receive system that is essentially identical to the dual input channels employed for protection against normal cardiac rate EMI in the analog functions described above. Both qualitative comparative tests and quantitative direct measures have provided evidence of the improved EMI performance of the new functions described. Both commercial devices and the new functions with the EMI channel omitted were subject to inhibition under a variety of direct input signal conditions and indirectly by the human sensor method. Prevention of inhibition was obtained with the new functions when the EMI detection channel was activated.

5730 EFFECTS OF WEAK ELECTROMAGNETIC FIELDS ON *PHYSARUM POLYCEPHALUM*: MITOTIC DELAY IN HETEROKARYONS AND DECREASED RESPIRATION *(Eng.)* Marron, M. T. (Univ. Wisconsin-Parkside, Kenosha, WI 53141); Goodman, E. M.; Greenebaum, B. *Experientia* 34(5): 589-591; 1978. (20 refs)

The effect of exposing *Physarum polycephalum* cultures to a 75-Hz electromagnetic field (2.0 G and 0.7 V/m) on respiration rate and mitotic cell cycle length was investigated. The rate of respiration in exposed cultures was depressed by about 15-20%, which was about the same depression rate as that observed for the mitotic cell cycle. The mean times to second post-fusion mitosis for exposed cultures ranged from 15.41-17.27 hr compared with 14.79-16.53 hr for control cultures. When microplasmodia from both control and exposed cultures were mixed in equal volumes, the onset of synchronous mitosis in the mixed culture was delayed such that the mean time to second post-fusion mitosis (14.99-16.78 hr) was between the values for control and exposed cultures. The length of the mitotic cycle in the mixture appeared to depend on the amount of each type of culture in the mixture; however, the data are too sparse to determine a precise relationship. It is suggested that weak low frequency electromagnetic fields may interfere with either energy generating processes or with the transport of essential metabolites in *Physarum*.

5731 DEVELOPMENT OF AN RF NEAR-FIELD EXPOSURE SYNTHESIZER (10 to 40 MHZ). *(Eng.)* Greene, F. M. (Electromagnetics Div., Natl. Bureau Standards, Boulder, CO 80302). 43 pp; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB-266 442]. (14 refs)

The design, fabrication, and testing of a prototype radio frequency (RF) near-field synthesizer for use by NIOSH in evaluating RF biologic hazards to industrial personnel are outlined. The synthesizer is capable of simulating near-field exposure conditions commonly encountered in the work environment over a frequency range of 10-40 MHz. The synthesizer can be used to generate a fairly pure (high impedance) electric field and a fairly pure (low impedance) magnetic field over the above frequency range. These two fields can be adjusted essentially independently over wide ranges of magnitude, phase difference, and relative spatial orientation to simulate various near-field configurations. The maximum RF driving power required is 1 kW for each field system, depending on the frequency and field level used. Tuning data is available for nine calibration frequencies within the above frequency range.

5732 EFFECT OF STATIONARY MAGNETIC FIELD ON BIOLOGICAL SYSTEMS (COMMENT ON THE PAPER OF V. M. ABASHIN AND G. I. EVTUSHENKO). *(Rus.)* Bresler, S. E. (Leningrad Inst. Nuclear Physics, Leningrad, USSR). *Biofizika* 23(1): 180; 1978. (5 refs)

The statement, presented in another paper, that magnetic fields have no effect on biological objects is refuted. Liquid crystals and lipids, which are diamagnetic, occur generally in living organisms, are oriented by magnetic fields of medium intensity (scores of Oersteds), and form ideally oriented layers. Since biologic membranes contain enzymes, that are sterically oriented due to their hydrophobic properties, the change in the orientation of lipids in magnetic fields is bound to affect the orientation and activity of enzymes and transport systems. Therefore, the action of magnetic fields on biologic systems is fully possible and compatible with the laws of physics.

5733 AN ELECTROPHYSIOLOGICAL APPROACH TO NEURAL AUGMENTATION IMPLANTATION FOR THE CONTROL OF PAIN. *(Eng.)* Mullen, J. B. (Dept. Surgery, Div. Neurosurgery, Duke Univ. Medical Center, Durham, NC 27710); Walker, C. F.; Nashold, B. S. 2(1/2): 65-67; 1978. (3 refs)

An electrostimulation technique, which eliminates untoward side effects associated with the random

placement of stimulating electrodes on the nerve, for the management of chronic pain secondary to peripheral nerve injury is described. The anatomic organization of the injured nerve is first mapped in terms of sensory responses to 100-μsec square wave pulses that are applied to fasciculi at a 33-Hz repetition rate. After collating the sensory response data, the fasciculi that conduct sensory information from the painful area are dissected away from the remainder of the nerve, and permanently implantable biocompatible stimulating electrodes are then circumferentially placed on the isolated bundles. Using this implantable stimulation system, the isolated fasciculi are restimulated to ensure paresthesiae in the affected areas without creating a motor contraction. Upon achieving a satisfactory distribution of paresthesiae, the electrodes are secured around the isolated group of fascicles, and an inductively coupled radio frequency receiver is implanted subcutaneously in a location accessible to the patient for transmitter antenna placement. Several days postoperatively, the patient is given a low power radio frequency transmitter tuned to match his receiver. The transmitter and receiver together act as an alternating polarity pulse neural stimulator with no net direct current component. The most satisfactory results have been achieved with a stimulation frequency of 25-100 Hz. Amplitude and pulse width are adjusted to produce the greatest degree of pain relief. The results to date indicate that nerve mapping with interfascicular electrode placement has achieved a superior quality of pain relief with fewer side effects when compared with former random radial placement of electrodes.

5734 EFFECT OF SURFACE COOLING AND BLOOD FLOW ON THE MICROWAVE HEATING OF TISSUE. *(Eng.)* Foster, K. R. (Dept. Bioengineering, Univ. Pennsylvania, Philadelphia, PA 19174); Kritikos, H. N.; Schwan, H. P. *IEEE Trans Biomed Eng* 25(3): 313-316; 1978. (15 refs)

The effects of thermal convection due to blood flow and heat transfer from the tissue surface into space on the steady state temperature distribution in microwave-irradiated tissue were determined using a one-dimensional heat transport equation. The steady-state temperature increase in tissue following microwave irradiation with penetration depths equal to 0.1 and 1.0 cm (corresponding to 10 and 2 GHz, respectively) was calculated. In both cases the total absorbed power was 100 mW/cm^2, and the incident power was at least two-fold higher. Thermal convection (due to blood flow) and conduction were found to result in the heating of deeper tissue levels than expected from the microwave absorption profile. Assuming an incident microwave intensity of 10 mW/cm^2 that is totally absorbed by the tissue with a penetration depth of 1.0 cm, the steady state increase in surface temperature of the tissue was calculated when each of the three cooling mechanisms (thermal conduction, blood flow, and surface cooling) was sequentially turned off. In comparison with the situation of normal blood flow, surface cooling, and thermal conductivity where an increase of 0.8 C in surface temperature was calculated, increases in surface temperature of 1.0, 1.9, and 9.6 C were calculated for zero surface cooling, zero thermal conductivity, and zero blood flow, respectively. It is suggested that measurements of the temperature rise in microwave-irradiated models with the same shape and dielectric properties as tissue can be used to estimate the microwave power deposition pattern in tissue but not the resulting steady-state tissue temperature increase.

5735 MICROWAVE AND RADIOFREQUENCY RADIATION. *(Eng.)* Michaelson, S. M. (Dept. Radiation Biology and Biophysics, Sch. Medicine and Dentistry, Univ. Rochester, Rochester, NY). 101 pp; 1977. [available through Regional Office for Europe, World Health Organization, Copenhagen, Denmark, Document No. ICP/CEP 803]. (365 refs)

Literature on the biologic effects and health implications of exposure to microwave and radio frequency radiation is reviewed. General categories of information covered include biophysical properties of microwave and RF radiation, biomedical studies in experimental animals, and clinical and epidemiologic studies for the human population. The effects of microwave and RF radiation are reviewed in terms of the following specific subject areas: cellular effects, reproductive capacity, visceral pathophysiology, hematopoietic effects, endocrine and biochemical effects, cardiovascular effects, nervous system effects, cutaneous perception of microwaves, electromagnetic hearing, effects on the ocular lens, results obtained from epidemiologic and clinical studies, and protection guides and standards. Problems associated with studies in the above areas are discussed, and recommendations are made for future research in these areas.

5736 INCREASE IN BRAIN TISSUE OXYGEN AVAILABILITY INDUCED BY LOCALIZED MICROWAVE HYPERTHERMIA. *(Eng.)* Bicher, H. I. (Dept. Radiation Medicine, Roswell Park Memorial Inst., 666 Elm Street, Buffalo, NY 14263). *Adv Exp Med Biol* 94: 347-351; 1978. (8 refs)

The effect of localized hyperthermia on oxygen levels and on the delivery of oxygen to brain tissue upon breathing of gas was examined in 40 anesthetized cats. Oxygen electrodes were used to determine tissue pO_2 levels, and hyperthermia was produced by microwaves in the frequency of 2,450 MHz delivered through a specially designed 5-cm circularly polarized applicator. A rise in tissue pO_2 values paralleled the application of microwaves and closely followed changes in tissue temperature. TpO_2 increased shortly after the rise in temperature and then decreased as the brain cooled off. A small rise in blood pressure and cerebral blood flow was also seen. Breathing O_2 for 1 min caused a small rise in TpO_2. Local hyperthermia caused an increase in the response (threshold 37.5 C) that was proportional to local brain temperature. It is concluded that local hyperthermia is an effective

method for temporarily blocking oxygen autoregulation, thereby increasing brain tissue oxygen levels.

5737 EFFECTS OF A BRIEF MAGNETIC EXPOSURE ON CEREAL GERMINATION AND SEEDLING GROWTH. *(Eng.)* Gusta, L. V. (Crop Development Centre, Univ. Saskatchewan, Saskatoon, Sask. S7N 0W0); Kirkland, K. J.; Austenson, H. M. *Can J Plant Sci* 58(1): 79-86; 1978. (9 refs)

The effect of magnetic exposure (0-4,000 G) on seed germination, seedling growth, emergence rate, and membrane permeability was examined in Bonanza barley *(Hordeum vulgare L.)*, Neepawa wheat *(Triticum aestivum L.)*, and wild oats *(Avena fatua L.)* under controlled conditions. No significant effect on the germination rate of Bonanza barley or wild oat seeds was seen at 16 or 21 C; however, there was a significant increase in the rate of germination at 16 C of Neepawa wheat seed treated at higher strengths. The dry weights of Neepawa wheat, Bonanza barley, and wild oats were similarly unaffected by magnetic treatment. The emergence rates of control wheat seedlings were the same for seeds treated with 0, 375, or 4,000 G. However, barley seeds imbibed for 10 hr prior to exposure grew slower than seedlings from magnetically treated dry seeds. Neither the imbibition rate nor membrane permeability of barley and wheat seeds were affected by exposure to 0 and 375 G. It is concluded that under the controlled conditions, brief exposure of dry seeds of four species of cereals had little or no effect on germination, seedling growth, emergence rate, and membrane permeability.

5738 CORRELATION OF EEG WITH CLINICAL FINDINGS IN PERSONNEL OCCUPATIONALLY EXPOSED TO HIGH-FREQUENCY RADIATION. *(Cze.)* Klimkova-Deutschova, E. (Institut pro dalsi vzdelavani lekaru a farmaceutu, Belehradska 130, 120 00 Prague, Czechoslovakia); Salomanova, Z.; Schwartzova, K. *Cesk Neurol Neurochir* 40/74(3): 124-128; 1977. (10 refs)

Clinical and electroencephalographic (EEG) findings obtained for 103 persons occupationally exposed to high-frequency electromagnetic radiation (no data given) are presented. The personnel were aged 22-61 yr (av age 38.3 yr), and the length of exposure was 1-18 yr (av 4.6 yr). Clinical examinations revealed vegetative changes in 97 cases (Group 1), pseudoneurasthenia with minor organic symptoms in 32 (Group 2), and completely normal findings were obtained for 19 subjects (Group 3). In Group 1 the electrocardiographic (ECG) findings were normal in 24.5%, borderline in 45.6%; disturbed wakefulness was found in 19.3%. The EEG was abnormal in 29.8%; a midline lesion was found in 10.5%; focal changes were seen in 7%, and synchronization in 12.8%. In Group 2, the EEG was normal in 15.3%, borderline in 46.8%; disturbed wakefulness was seen in 18.7%. Abnormal EEG was seen in 21.8%, midline lesion in 18.7%, focal changes in 18.7%, and synchronization in 21.8%. In Group 3 (clinically normal subjects), midline lesion was not seen at all; the ECG was normal in 15.7%, borderline in 57.8%; disturbed wakefulness was seen in 32.5%. Abnormal EEG was seen in 31.5%, focal changes in 2.1%, and synchronization in 10.5%. The abnormal EEG showed high-amplitude sharp waves similar to spike potentials. The findings indicate that slight EEG changes were considerably more frequent than truely abnormal ones (synchronization and focal changes) and that EEG is valuable in the assessment of exposure to electromagnetic fields in clinically unremarkable cases.

5739 ARTIFICIAL OSSIFICATION OF A MUSCULAR FLAP USED FOR PLASTIC TRANSPLANTATION INTO A BONE CAVITY UNDER THE INFLUENCE OF ELECTRIC CURRENT. *(Rus.)* Tkachenko, S. S. (Dept. Military Traumatology and Orthopedics, S. M. Kirov Military Medical Acad., Leningrad, USSR); Mussa, M.; Rutskii, V. V. *Biull Eksp Biol Med* 85(3): 356-359; 1978. (10 refs)

The effect of direct current (19-20 μA) on the ossification of a gastrocnemius muscle flap implanted into an artificial tibial cavity was studied in adult rabbits. The size of the tibial defect was 7 x 10 mm. The flap was fixed in the cavity by a central feeding pedicle, and a silver wire electrode was implanted in the flap. Group 1 (18 animals) was treated with the direct current for 3-4 wk, using the electrode as an anode. Group 2 (16 animals) was treated in the same manner, after which the polarity of the electrode was changed for continued treatment for 4-8 wk. No ossification was seen in the untreated control after the surgery, but marked periosteal and endosteal osteogenic reaction without trabeculae was seen in Group 2 about 90 days after surgery. Compared with the control and Group 1, marked ossification, appearance of trabeculae, and restoration of the integrity of the tibia were seen in Group 2. The findings indicate the stimulating effect of electric current on ossification and on the restoration of the anatomic integrity of the bone.

5740 INFLUENCE OF ATMOSPHERIC ELECTRIC IMPULSE FIELDS ON DRIVING PERFORMANCE TEST. *(Ger.)* Kirmaier, N. (Inst. fur Biomedizinische Technik, Museuminsel, D-8000 Munich 22, W. Germany); Schauerte, W.; Beierlein, H. R.; Breidenbach, H. *Munch Med Wochenschr* 120(11): 367-370; 1978. (9 refs)

The effect of positive electrostatic constant field with imposed square-wave impulses (60 V, impulse voltage 4 V, 10 Hz) on the driving performance of 100 experienced drivers (18-55 yr old) was studied in a double-blind test. The electrical field, generated by a unit installed on the car's sun visor, improved the general driving performance by 8.5-11.5%, reduced the frequency of errors by 22.7%, slightly improved the recognition of traffic signs, caused a 3.9-4.5% increase in the average speed without any increase in the maximum speed, and reduced the reaction time by 2.7%. The flicker fusion frequency was increased by 0.7%. The incidence of subjective complaints after the driving

test (headache, fatigue, and nervousness) was significantly lower after driving test performed while exposed to the electric field than it was after tests without electric field.

5741 EXPERIMENTAL STUDY OF THE INFLUENCE OF ELECTROMAGNETIC FIELDS ON THE ELECTROCARDIOGRAPHIC INDICES. *(Rus.)* Tvildiani, D. D. (Tbilisi State Medical Inst., Tbilisi, USSR); Chlaidze, T. I. *Soobsch Akad Nauk Gruz SSR* 88(1): 221-224; 1977. (9 refs)

The effects of a constant magnetic field (55-125 Oe, length of exposure 5-60 min), a pulsed constant magnetic field (1.3-3.3 Hz, 38-48 Oe), a constant magnetic field with alternating polarity (125 Oe), and of a constant magnetic field of very low intensity (2-5 Oe, length of exposure 10-300 min) on the electrocardiogram (ECG) were studied in 40 rabbits. The high-intensity fields caused increased and deformed P and T waves, decrease and inversion of the P and T waves, and undulating changes in the R and S wave amplitudes. The changes produced by the magnetic field of very low intensity were similar and sometimes even more pronounced. The ECG changes were caused basically by the horizontal component of the magnetic field. The pulsed magnetic field and the field with alternating polarity caused more marked and persistent changes than the constant magnetic field.

5742 EFFECTS OF A HIGH-TENSION ELECTRIC FIELD ON THE SECRETION OF ANTIDIURETIC HORMONE IN RATS. *(Eng.)* Carmaciu, R. (Dept. Physiology, Inst. Medicine and Pharmacy, Bucharest, Romania); Groza, P.; Daneliuc, E. *Physiologie* 14(2):79-83; 1977. (16 refs)

White male Wistar rats were exposed to high-tension-type electric fields to examine the effects of such fields on the secretion of antidiuretic hormone (ADH). The mean plasma ADH concentration for 16 experimental rats exposed to an electric field of 100 kV/m at a frequency of 50 Hz over a single exposure period of 120 min was 7.33 ± 1.26 μunits/ml, which was significantly greater than the control value of 2.68 ± 0.54 μunits/ml. When rats were exposed to the same electric field over a period of 360 min, a 30% reduction in diuresis from 1.1 to 0.75 ml/hr/animal was observed in relation to controls. Exposure to the above electric field also resulted in behavioral changes, which included to and fro movements, piloerection, and after an interval of 5-10 min, a quiet and prostrate behavior.

5743 RADIATION SAFETY HANDBOOK FOR IONIZING AND NONIONIZING RADIATION. *(Eng.)* Kincaid, C. B. (Bureau Radiological Health, Food and Drug Admin., Public Health Service, 5600 Fishers Lane, Rockville, MD 20857). 71 pp; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB-262 109]. (0 refs)

A radiation safety handbook for ionizing and nonionizing radiation has been developed primarily for users of radiation sources throughout the Food & Drug Administration. The safety procedures for nonionizing radiation apply to equipment that generates or utilizes radiation in the energy range below approximately 1,000 electron V. Included in the handbook are definitions of terms, the specification of units used throughout the handbook, procedures relating to warning signs and labels, and specific safety procedures for microwave and radio frequency sources, laser radiation, and ultraviolet radiation. The safety procedures include engineering controls and safety mechanisms on radiation sources, protective equipment for personnel, personal exposure limits, medical surveillance procedures, and responsibilities of employees working near radiation sources. Appropriate radiation protection standards are included in an appendix.

5744 RADIOLOGICAL QUALITY OF THE ENVIRONMENT IN THE UNITED STATES, 1977. *(Eng.)* Feldmann, K. L. (Office Radiation Programs, Environmental Protection Agency, Washington, DC 20460). 312 pp.; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB-274 229]. (274 refs)

Individual and population dose data for ionizing and nonionizing radiation sources in the United States are reported as part of the EPA's dose assessment program for evaluating the radiologic quality of the environment. General environmental surveys of dose data relating to nonionizing radiation sources have been completed in seven cities in the Eastern United States, and the data and population exposure implications for the first four of these cities are presented in the present report. The results to date suggest that probably 99% of the urban population is exposed at levels which would be permitted even under the Soviet standard of 1 $\mu W/cm^2$. The general environmental data cannot be used to estimate the levels to which the remaining 1% of the population is exposed. Further information will require a detailed analysis of specific sources and a detailed knowledge of the locations of persons exposed to such sources.

5745 TEMPERATURE AND CORTICOSTERONE RELATIONSHIPS IN MICROWAVE-EXPOSED RATS. *(Eng.)* Lotz, W. G.; Michaelson, S. M. (Biomedical Div., Naval Aerospace Medical Res. Lab., Naval Air Station, Pensacola, FL 32508). *J Appl Physiol* 44(3): 438-445; 1978. (26 refs)

The influence of 2,450-MHz continuous wave whole-body exposure on the rat adrenal cortex was investigated by measuring plasma corticosterone and colonic temperature in unanesthetized male rats. The rats were exposed in the far field of a horn antenna for 30 or 60 min at power densities of 0, 13, 20, 30, 40, 50, or 60 mW/cm^2 or for 120 min at 0, 13, 20, 30, or 40 mW/cm^2. The average energy absorption rate of the rats was 0.16 W/kg absorbed per mW/cm^2 incident. Colonic temp-

erature was significantly elevated after exposures to power densities of 13 mW/cm^2 or greater; progressively larger increases occurred after higher intensity exposures. Plasma corticosterone was significantly elevated above control levels only after exposures at 50 or 60 mW/cm^2 for 30 or 60-min exposures and at 20, 30, and 40 mW/cm^2 for 120-min exposures. The relationship between the increased levels of circulating corticosterone and colonic temperature suggested that the increases in corticosterone levels may reflect a level of physiologic response to the body temperature elevations caused by microwave exposure.

5746 RF LESION GENERATION. *(Eng.)* Burton, C. V. (2545 Chicago Ave., Minneapolis, MN 55404). *Appl Neurophysiol* 39(2): 77-79; 1976/1977. (2 refs)

The medical technique of radio frequency (RF) lesion generation is discussed with particular emphasis on adverse effects, such as, skin burns resulting from improperly designed dispersive electrodes. In neurosurgical use, the usual current densities of RF lesion generation range from 100-500 mA at a frequency of approximately 100-500 kHz. Tissue coagulation is not due to the heating of the electrode itself but rather to the flow of current between the electrodes, with electron density being focused at the active electrode due to its relatively small surface area. Heat is generated by the resistance (impedance) of the surrounding tissue to this current flow. In such a system, no real difference exists between the active and indifferent (also termed dispersive) electrode, other than surface area. If the surface area of the dispersive electrode is not adequately large, heat lesions can also be produced in surrounding tissue. For this reason, particular attention must be directed at the dispersive electrode, which usually is not connected to a thermal monitoring system. Although the actual incidence of skin burns from improper dispersive electrodes has not been studied, informal industrial surveys indicate that the problem is quite significant. It has been recommended that the surface area of a dispersive electrode be a minimum of 100 times larger than the surface area of the active electrode.

5747 HIGH-ENERGY ELECTRICAL CURRENT AND MYOCARDIAL DAMAGE. *(Eng.)* Resnekov, L. (Hosp. Box 423, Univ. Chicago Medical Center, 950 East 59th St., Chicago, IL 60637). *Med Instrumen* 12(1): 14-26; 1978. (32 refs)

Clinical complications associated with the use of direct current shock for the management of cardiac dysrhythmias are reviewed. In one study, a complication incidence of 14.5% was recorded among 220 patients treated by synchronized electroversion using a standard damped sinusoidal waveform. The incidence of complications was 6% at an energy level of 150 J and increased to more than 30% at 400 J. Complications included elevation of serum enzyme levels, hypotension, electrocardiographic evidence of myocardial damage, pulmonary and systemic emboli, ventricular dysrhythmias, and evidence of cardiac failure. It is concluded that there is rarely an indication for exceeding an energy level of 300 J in patients presenting with long-standing atrial fibrillation. Animal studies using trapezoidal waveforms indicate that there may be a dose weight response; however, delivering more than 1 A/kg body weight is associated with morphologic changes in the myocardium and ultrastructural disruption of mitochondria. These effects become greater as the amperage is increased, and permanent myocardial fibrosis may result. Retrospective studies in man have not shown a good relationship between body weight, failure to defibrillate, and energy level settings with damped sinusoidal waveforms. It is recommended that the parameters for safe and efficient electrical defibrillation of the heart be studied and determined.

5748 RF CELL CULTURE IRRADIATION SYSTEM WITH CONTROLLED TEMPERATURE AND FIELD STRENGTH. *(Eng.)* Guy, A. W. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine RJ-30, Univ. Washington Sch. Medicine, Seattle, WA 98195). 52 pp; 1977. [available through Dept. Health, Education, and Welfare, National Inst. Occupational Safety and Health, Div. Biomedical & Behavioral Sci., Cincinnati, OH 45226, Publication No. 77-182]. (11 refs)

A unique radio frequency (RF) cell culture irradiation system with controlled temperature and field strength is described. This method was used in determining human RF exposure thresholds in the frequency range from direct current to 1,000 MHz. With a power source capable of providing a net power of 600 W to the system, electric field strengths as high as 100 V/cm in a 5-ml sample can be achieved, producing a maximum specific absorption rate of approximately 2×10^5 W/kg. The culture medium temperature can be controlled and measured up to 100 MHz by monitoring the feedline impedance, which is dependent on culture medium temperature. Constant temperatures below 37 C can be maintained at field strengths in excess of 25 V/cm. The information that can be obtained with this system is needed to fill information gaps for standards criteria development.

5749 EFFECTS OF ELECTRIC FIELDS ON LARGE ANIMALS: SECOND INTERIM REPORT. *(Eng.)* Batelle Pacific Northwest Labs. (Batelle Blvd., Richland, WA 99352). 65 pp; 1977. [available through Electric Power Research Inst., 3412 Hillview Ave., Palo Alto, CA 94304, Document No. EPRI EA-458]. (4 refs)

The planning and construction of housing and experimental facilities for the chronic exposure of Hanford Miniature Swine to 30 kV/m electric fields at a frequency of 60 Hz are outlined. The swine will be kept in individual stalls fabricated from nonconducting grating placed on an embossed steel floor decking. There will be two rows of contiguous stalls separated by a central aisleway. Two separate enclosures will cover the experimental and

control groups of pigs, each a quonset-type modular structure of fiberglas-reinforced plastic with polyurethane foam thermal insulation. All hardware will be nonconducting. A steel ground grid will be in the concrete ground pad and will surround the enclosure to provide a fixed ground plane; all conducting materials in the facility will be bonded to this common ground. The electrode system with vibration damping is complete. Using a test transformer, the field over the area to be occupied by swine is vertical to within 2 degrees and constant in magnitude to within 6%. The system capacitance is 1,150 picofarads. Breeding of the F_0 generation of swine is nearing completion, and preliminary growth data and blood chemistry are being collected. The goal is to obtain 40 female piglets of similar size and shape so that dosimetry will be comparable. Using full-scale models of pigs, surface fields and dosimetry are being characterized. This data, plus data collected for a related study on small animals, will provide a basis for defining the internal dose received by the swine and for extrapolating results to man.

5750 MICROWAVE RADIATION-PATTERN MEASUREMENTS IN THE PRESENCE OF BIOLOGICAL SPECIMENS. *(Eng.)* Bigu Del Blanco, J. (Anatomy Dept. Queen's Univ., Kingston, Ontario, Canada); Romero-Sierra, C. *IEEE Trans Electromag Compat* 20(1):248-258; 1978. (27 refs)

Power density measurements at an X-band microwave frequency of 9.2 GHz were conducted in an anechoic chamber in the presence and absence of some biologic specimens to illustrate the limited validity of free-space power density as a biologic and behavioral exponent of microwave radiation effects. Thermographic analysis and microwave radiometry were used to complement the measurements. The biologic specimens used in the experiments included anaesthetized (to insure immobility) animals and plant vegetation. The physical dimensions of the specimens ranged from less than the free-space wavelength to approximately 10 times the free-space wavelength. Dramatic differences in the radiation patterns attributable to the large disturbance introduced by the biosystem on the imposed electromagnetic fields were observed. The disturbance of free-space power density measurements by the specimens depended on the specimen's physical size, shape, and orientation with respect to the microwave electric field.

5751 FIELD INTERACTION WITH BIOLOGICAL MATTER. *(Eng.)* Schwan, H. P. (Dept. Bioengineering, Univ. Pennsylvania, Philadelphia, PA 19174). *Ann NY Acad Sci* 303: 198-213; 1977. (43 refs)

Electric field interactions with biologic matter are reviewed. Field values of the order of kilovolts/centimeter are probably needed to orient polar macromolecules significantly. Various interactions at the cellular level depend strongly on cellular size and may occur at field levels as low as 1 V/cm or less for unusually large unicellular organisms. They appear to be largely caused by field-generated forces and the dipole moments induced by the electric field. These forces emerge above the thermal level at a threshold field-strength that is inversely related to cell size. For the usual cellular size, required field values produce significant heating, resulting from ionic movement. Strong membrane interactions leading to membrane breakdown correspond to the order of hundreds of millivolts across the membrane. Corresponding field-strength values in the medium are comparable to those that yield significant field-generated forces. Classical membrane excitation phenomena occur at field levels of the order of 1 V/cm and current densities of approximately 1 mA/cm^2. Corresponding membrane potentials are in the range of 1-10 mV. Weak membrane interactions corresponding to a fraction of a millivolt have been reported for central nervous system tissues. Some fish species display still higher sensitivities corresponding to values below 1 μV/cm, with the highest sensitivity near 0.01 μV/cm in sea water. These highest sensitivities are achieved by a sampling of the field over large distances with special organs and the use of narrow bandwidth characteristics. Corresponding membrane sensitivities are below 0.1 μV across the membrane and above noise level over a rather narrow frequency range of a few hertz. Extraordinary weak field effects have been reported corresponding to tissue field gradients of the order of 10^{-7} V/cm. These effects, if shown to be related to more complex interactions at the membrane level, would require the development of new concepts.

5752 BIBLIOGRAPHY OF REPORTED BIOLOGICAL PHENOMENA ('EFFECTS') AND CLINICAL MANIFESTATIONS ATTRIBUTED TO MICROWAVE AND RADIO FREQUENCY RADIATION. NINTH SUPPLEMENT TO BIBLIOGRAPHY OF MICROWAVE AND RF BIOLOGIC EFFECTS. *(Eng.)* Glaser, Z. R.; Brown, P. F.; Allamong, J. M.; Newton, R. C. (Nat'l. Inst. for Occupational Safety and Health, Div. Criteria Documentation and Standards Development Priorities and Res. Analysis Brank, Rockville, MD 20857). 66 pp.; 1977. [available through Nat'l. Inst. Occupational Safety & Health, 5600 Fishers Lane, Rockville, MD, DHEW (NIOSH) Publication No. 78-126]. (575 refs)

Approximately 575 additional references on the biologic responses to radio frequency and microwave radiation are included in a ninth supplement to the bibliography of world literature. This supplement brings to more than 4,600 the number of listed references. Although particular attention has been paid to the effects on humans of nonionizing radiation at the radio frequency and microwave frequencies, this supplement includes a few references to recently issued reports on biologic studies involving pure electric or magnetic fields (alternating or static), extremely low frequency fields, and ultrasound. Other citations include such topics as biomedical studies using electromagnetic pulse radiation, high voltage (Kirilian) photography, biologic dosimetry, the effects of electromagnetic radiation (EMR) on implanted electronic cardiac pacemakers, some therapeutic applications of EMR (including wound healing and bone regeneration),

microwave exposure limits, regulations and standards, and such diverse applications as tissue fixation, insect control, and electroanesthesia. The citations are arranged alphabetically by author (where possible) and contain as much information as possible so as to assure effective retrieval of the original documents. Soviet and East European literature is included in detail. Relevant presentations (unpublished as yet) made at technical meetings are included in a separate section of the supplement. Another section contains unsigned reports and articles, arranged in chronologic order. A chronology of the previous supplements (and the addenda and revisions) is listed in an appendix to the supplement.

5753 HIGH GRADIENT MAGNETIC SEPARATION OF ERYTHROCYTES. *(Eng.)* Owen, C. S. (Dept. Pathology, Dept. Biochemistry and Biophysics, Univ. Pennsylvania Medical Sch., Philadelphia, PA 19104). *Biophys J* 22(2): 171-178; 1978. (7 refs)

A high gradient magnetic separation (HGMS) technique was used to retain red blood cells (RBC) containing paramagnetic methhemoglobin (induced by oxidizing the iron atoms in cell hemoglobin to the ferric state) from cell suspensions that also contained diamagnetic cells. The physical retention of paramagnetic cells was effected by flowing a cell suspension through a high magnetic field (33,000 G) in a column packed with fine steel wire. In one experiment washed packed cells from freshly drawn human whole blood were used in the separation of RBS containing methhemoglobin from diamagnetic RBC containing oxyhemoglobin. More than 90% of the cells in the diamagnetic cell sample were passed by the column, and more than 90% of the paramagnetic cells were retained by the column in this experiment. The degree of retention decreased with increased fluid flow velocity or with decreased magnetic field. At flow rates ranging from 1.4-3.3 cm/min, the percentage of cells retained varied from 86-96% in a 30,000-G field. When the field was lowered to 15,000 G, the same flow rates yielded smaller retention values ranging from 76-92%. In a second experiment, paramagnetic RBC were separated from white blood cells using a fresh suspension of spleen cells from a mouse. At a flow rate of 1 cm/min, the passed fraction typically contained 6-20% of the amount of hemoglobin in the original cell suspension and 60-90% of the original number of small nucleated cells that resisted lysis in Tris-ammonium chloride. The recovered RBC amounted to 60-80% of the original amount.

5754 CHROMOSOME BAND INDUCING EFFECT OF HIGH FREQUENCY ELECTROMAGNETIC FIELD. *(Eng.)* George, K. (Dept. Botany, Univ. Jos, Nigeria); George, M. *Indian J Exp Biol* 16(3): 390-393; 1978. (21 refs)

Germinated broad bean seedlings *(Vicia faba)* were grown in paper pots kept at a distance of 10 cm from a tesla coil transmitting high frequency (1.6 MHz) electromagnetic radiation (peak-to-peak voltage, 45 V) to study the effects of such a field on chromosomal aberration. The plants were subjected to this treatment for periods ranging from 6-24 hr before the root tips were fixed for microscopic examination. An examination of chromosomes of treated cells undergoing mitosis revealed that most of the aberrations produced were of one type--bandedness due to apparent fragmentation of chromosomes. This type of aberration was noticed during all stages of mitosis and for all exposure periods studied. The bandedness and fragmented appearance of the chromosomes seemed to be due to the dispersal of chromatin material from specific regions giving rise to gaps of achromatic lesions. A possible mechanism of the gap formation in chromatids and consequent band production on chromosomes is that these phenomena are the result of localized unfolding and despiralization of chromatin fibers at the interband regions. This could be effected by solubilization and dispersal of deoxyribonucleic acid (DNA) binding heterochromatin specific nucleosteric proteins from the microenvironment around the interband regions by the high frequency radiation directly or indirectly by the concentrated stimulation of DNA-dependent histone inactivating enzymes. It is concluded that high frequency is characteristically a chromosome band inducing agent.

5755 ELECTROMAGNETIC POLLUTION - HOW SAFE IS SAFE? *(Eng.)* Peat, D. (No affiliation given). *Sci Dimension* 10(1): 20, 22; 1978. (0 refs)

Hazards of electromagnetic pollution are discussed in light of the increasing number of electromagnetic-generating devices in the United States. To assist in the establishment of realistic safety standards for electromagnetic radiation exposures, the National Research Council and the Department of Defense are collaborating in a program of research aimed at a better understanding of the biologic effects of electromagnetic radiation. The research falls into two broad areas: the use of phantom models to accurately measure the amount of radiation absorbed by the body at different frequencies and the use of laboratory animals to examine the harmful effects of radiation both with high dose rates for short times and low dose rates over long periods. Heating effects, changes in the blood-brain barrier, damage to the testes, and possible changes in the central nervous system will be investigated.

5756 PUBLIC AWARENESS OF RADIATION HAZARDS. *(Eng.)* Anonymous (No affiliation given). *Med Res Eng* 12(5): 2, 4-5, 15; 1977. (0 refs)

The rapidly increasing public awareness of the proven and potential risks of man-made radiation in the environment is discussed. One example involves a proposed 765-kV electric line for which a construction permit was issued in 1976 by the New York State Public Service Commission (NYSPSC). As a result of a continuing series of actions and

objections by a local organization, Upstate People for Safe Energy Technology, the staff of the NYSPSC has now reported that chronic exposures to the 765-kV transmission lines probably would cause biologic effects in humans. Moreover, the originally proposed 250-ft wide right-of-way has now been changed to a protective zone of about 550 ft wide under the lines. As another example of public and scientific awareness of potential radiation hazards, scientists from the Woods Hole Oceanographic Institute have joined with the local population in Massachusetts to question the safety of radar bases on Cape Cod. The United States General Accounting Office has stated in a report that the "EPA admits that it does not know the scope of the radiation danger, that it does not have the resources to find out, and that its limited staff is unable to develop needed standards and guidance based on what it does know." A relatively comprehensive list of radiation hazards to which American people are exposed has recently become available in a report from the National Council on Radiation Protection and Measurements. However, the report deals with radiation exposure from consumer products and does not include such potential sources as television and radio transmitters and high-voltage power lines.

5757 DIFFERENTIAL BLOOD CELL SEPARATION USING A HIGH GRADIENT MAGNETIC FIELD. *(Eng.)* Paul, F. (Dept. Haematology, Faculty Medicine, Southampton General Hosp., South Lab. and Pathology Block, Tremona Road, Southampton SO9 4XY, England); Roath, S.; Melville, D. *Br J Haematol* 38(2): 273-280; 1978. (9 refs)

A technique for separating erythrocytes from whole blood using a high gradient magnetic field is described. The technique makes use of the magnetic property of iron in reduced hemoglobin and employs a cylindrical filter containing stainless steel wire mesh, which is placed between the poles of an electromagnet. A sodium dithionite solution is used as both the reducing agent and the carrier. In one experiment, using applied magnetic fields of 0-1.4 tesla and flow rates ranging from 1.9-12.9 x 10^{-4} m/sec, it was shown that above 0.5 tesla the capture of erythrocytes was directly proportional to the applied magnetic field at all flow rates. In another experiment with the flow rate set at 3.0 x 10^{-4} m/sec and the applied magnetic field set at 1.2 tesla, it was shown that only erythrocytes were retained by the filter. To ensure that a large number of leucocytes and platelets were injected into the column during this experiment, the column was deliberately overloaded with blood. This resulted in only 41.4% of the erythrocytes being captured compared with over 90% under ideal conditions. Scanning electron microscope photographs of erythrocytes before and after separation did not indicate any sign of surface damage to the red blood cells. The present study demonstrates that the intrinsic magnetic property of hemoglobin may be used to separate erythrocytes from other blood cells. It is also demonstrated that the level of separation depends on the ratio of the applied magnetic field to the flow velocity. Therefore, for a given separator, if the magnetic field strength is doubled, the same level of separation can be obtained at twice the flow rate.

5758 MICROWAVE RADIATION LEAKAGE FROM MICROWAVE-EXCITED LIGHT SOURCES (LETTER TO EDITOR. *(Eng.)* Outred, M. (Dept. Physics, The Polytechnic North London, Holloway Road, London N7 8DB, England); Howard, C. *J Phys E Sci Instrum* 11(3): 276-277; 1978. (2 refs)

Microwave radiation leakage measurements were recorded at 10 cm from an inert gas-filled electrodeless discharge tube (EDT) using a probe calibrated at 2.45 GHz. Sealed fused silica tubes filled with various low pressure inert gases were used together with two 3/4-wave Broida cavities—one having a small aperture capable of accepting a 7-mm outer diameter tube and the other having a larger aperture for accepting 10-mm outer diameter tubes. There was no measurable microwave power leakage from the cavity provided that the discharge was contained within the cavity. However, microwave leakage appeared as soon as the discharge emerged above the top of the cavity and reached a maximum when the discharge completely filled the EDT. At incident powers of 150 W, the maximum leakage for the small aperture ranged from less than 1.0 mW/cm^2 for helium gas to 12.7 mW/cm^2 for argon gas; for the large aperture, the leakages were greater ranging from 3.2 mW/cm^2 for helium to 18.0 mW/cm^2 for argon. In another experiment, the cavities were placed onto an EDT blank, which was connected to a vacuum system. This was done since a microwave discharge, using the appropriate inert gas, is normally run as part of the degassing procedure in the preparation of EDTs. The EDT blank was placed just within the 3/4-wave cavity, and 200 W were fed into the cavity. The discharge extended for several centimeters beyond the top of the cavity, and for both 3/4-wave cavities the microwave power leakage radiation was considerably higher than for the sealed EDT. A 1/4-wave cavity was also used and was placed on the EDT blank in such a way that the discharge extended symmetrically about the cavity position. The highest microwave power leakage occurred for the 1/4-wave cavity, and values greater than 10 mW/cm^2 were recorded, even at distances of 50 cm from the discharge tube for all inert gases. The small aperture cavity gave the lowest microwave power leakage values, and for all cavities, the leakage radiation was highest for argon and lowest for helium.

5759 PROTON RELAXATION OF MALIGNANT AND EMBRYONIC MOUSE CELLS. *(Eng.)* Vucelic, D. (Inst. Physical Chemistry, Faculty Sciences, Studentski trg 16, P.B. 550, 11000 Beograd, Yugoslavia); Macura, S.; Neskovic, B.; Djuric, L. J.; Ajdaric, Z. *Stud Biophys* 68(3): 179-185; 1978. (20 refs)

Proton relaxation times at 90 MHz for malignant L-929 cells and normal embryonic cells from C_3H mice were measured in 0.8% sodium chloride solution using nuclear magnetic resonance spectrometry. The

relaxation time of the pure cells was about twice to three times shorter than that for the corresponding tissue. In the temperature range of 4-37 C, the relaxation time was not temperature dependent. Using a pulse gradient method, a coefficient of self diffusion was obtained that was about one order of magnitude lower than that for pure water. In the temperature range of 4-37 C, malignant cells had a relaxation time that was about 30-40% higher than that for normal cells. This difference is considerably less than that for the corresponding tissues where differences ranging from 30-300% have been reported.

5760 A DANGEROUS INTIMACY: THE ZAPPING OF AMERICA (BOOK REVIEW). *(Eng.)* McGinty, L. (No affiliation given). *New Scientist* 78(1099): 163; 1978. (1 ref)

A book about the way in which research into the hazards of microwave radiation has been blocked by the military and business establishments in the United States is discussed in relation to the differences in opinion which exist between American and Soviet scientists concerning such hazards. The book is a meticulous and careful documentation of the influence that the Pentagon and the giant corporations exerted to reinforce the prejudices of American scientists against Russian microwave research. Opposition to the American view that electromagnetic radiation causes no ill effects, other than those from heating, surfaced when physicians began to notice that many of their patients were radar technicians or worked in the electronics industry. The most prominent example was from an opthlamologist who noticed an extraordinarily high number of eye cataracts among patients in these industries. The discovery in 1962 that Russians were beaming low level microwave power at the United States embassy in Moscow has led to serious work on low level electromagnetic radiation, and such research is slowly eroding the American consensus position on microwaves.

5761 POTENTIAL HAZARDS: THE ZAPPING OF AMERICA. (BOOK REVIEW). *(Eng.)* Anonymous (No affiliation given). *Science* 200(4342): 643-644; 1978. (1 ref)

The Zapping of America is critically reviewed. The central theses of the book are that exposure to low-level radio frequency and microwave radiation does have hazardous biologic effects and that the Defense and State Departments have misled the public concerning their knowledge of these effects. The book covers research on nonthermal effects done in the West over the past decade and the exchange of information between the East and the West on the subject. There are numerous reports of electromagnetic radiation effects on hematopoiesis and on the central nervous system in animals, and there are studies suggesting a microwave-induced neurasthenic syndrome (in East European occupational groups) and increases in chromosomal aberrations as well as cataract formation at high levels of exposure. The book notes several specific cases of accidental human exposure with subsequent pathology but often implies causal relations without obvious grounds for doing so. There are some technical errors in the book, and there is no way to connect citations in the text with the references listed. Moreover, the use of cited materials is sometimes careless. The book does draw attention to some important issues, including the potentially high occupational exposure from radio frequency plastic sealers and the lack of Western epidemiologic studies on the effects of microwave exposure.

5762 PREFACE: SPECIAL ISSUE ON ELECTROMAGNETICS AND CANCER. *(Eng.)* Johnson, C. C. (No affiliation given). *J Bioeng* 1(5/6): 465; 1977. (0 refs)

Selected papers from a workshop on electromagnetics and cancer, which was held in conjunction with the 1977 International Microwave Symposium and sponsored by the Institute of Electrical and Electronic Engineers' Microwave Theory and Techniques Society, are briefly discussed. The topics covered include biologic and clinical studies, one of which describes the early clinical results of using 434 MHz radiation for cancer therapy. Other topics discussed are thermometry (including new methods for electromagnetic radiation), microwave hyperthermia systems, and dosimetry. Contributions to the development of microwave applicators and hyperthermia systems are described, and a theoretic technique for analyzing microwave power distribution in homogeneous tissue is discussed.

5763 ELECTROSURGICAL DEVICE INTERFERENCE WITH IMPLANTED PACEMAKERS (LETTER TO EDITOR). *(Eng.)* Furman, S. (Montefiore Hosp. and Medical Center, Bronx, NY); Parker, B.; Ruggera, P. S. *JAMA* 239(18): 1910; 1978. (5 refs)

Problems that can arise from the use of an electrosurgical apparatus in a patient with an implanted pacemaker are discussed along with methods for their prevention. Inhibition of the pacemaker will occur only if the plate or tip of the cautery is immediately adjacent to the pulse generator or electrode. If separated by several centimeters, normal pacemaker function or reversion to fixed-rate operation is expected. If the plate of the electrosurgery is placed on the skin directly over the generator or intracardiac electrode and the tissue layer is thin, the circumscribed current flow may cause local necrosis or so intensely affect the generator as to cause its permanent malfunction. A large plate with good electrical contact, remote from the generator, will avoid this problem. If the generator or lead comes into contact with the cautery, current flow will occur through the heart, causing myocardial burn and possible ventricular fibrillation. Application of the plate or active cauterizing electrode at least 15 cm from the pulse generator or electrode tip in the heart and brief applications of current should avoid any difficulty. The current draft of the *Proposed Standard for Per-*

formance and Safety of Electrosurgical Devices warns about the possible interference of electrosurgical devices with cardiac pacemakers.

5764 BIOLOGIC EFFECTS OF ELECTROMAGNETIC FIELDS (LETTER TO EDITOR). *(Eng.)* Pastakia, B. (Univ. Wisconsin Hosp., Madison, WI 53706). *New Engl J Med* 298(24): 1366; 1978. (14 refs)

The biologic effects of electromagnetic fields are discussed in relation to the possible hazard associated with magnetic fields and radio frequency energy utilized in nuclear magnetic resonance (NMR) zeugmatography. Alternating magnetic field above 100 G (varying at 10-100 Hz) evoke a visual response (magnetophosphene) in the retina. A preliminary study in man showed that a 1-G (45 Hz) magnetic field has a slight but statistically significant effect on cognitive skill. Moreover, experiments associated with the Navy's proposed project Sanguine have shown that mitotic delay occurs in slime molds exposed to 60-75 Hz at levels of 2 G, a low level compared with the 1,000-G fields necessary for whole-body NMR zeugmatography. A Soviet survey of industrial workers has related pathologic changes in the hands and cardiovascular system to magnetic fields of moderate strength (hundreds of gauss at the hands and somewhat less at the trunk). Another study indicated that serum levels of triglycerides are elevated a day or two after exposure to a magnetic field of 1 G (45 Hz). It is concluded that it still remains to be proved that magnetic fields and radiowaves used in NMR whole-body zeugmatography are less hazardous than the ionizing radiations used by imaging devices now available.

5765 TYROSINE HYDROXYLASE ACTIVATION AND TRANSMITTER RELEASE FROM CENTRAL NORADRENERGIC NEURONS BY ELECTRICAL FIELD STIMULATION. *(Eng.)* Bustos, G. (Dept. Neurobiology, Inst. Biological Sciences, Catholic Univ., Santiago, Chile); Roth, R. H.; Morgenroth, V. H.; Hancke, J. L. *Naunyn Schmiedebergs Arch Pharmacol* 301(3): 149-156; 1978. (37 refs)

To investigate tyrosine hydroxylase activation and transmitter release from central noradrenergic neurons, an in vitro system was developed. Hippocampal tissues slices from adult male Sprague-Dawley rats were electrically stimulated with monophasic rectangular pulses of 4-msec duration at frequencies of 5-40 Hz (60 V) for periods of up to 20 min in superfusion chambers, which permitted continuous superfusion during stimulation. A stimulus-dependent increase in tyrosine hydroxylase activity was found after a stimulus was applied for 5 min at frequencies of 5, 10, and 20 Hz. Tyrosine hydroxylase activity was directly related to the number of pulses applied; however, the enzyme activity per pulse of stimulation remained constant regardless of the time period and frequency of stimulation used. The superfusion system was also used to study the spontaneous and electrically evoked release of labelled norepinephrine from hippocampal slices. Stimulation of the slices for only 1.0 min at 40 Hz produced a marked increase in the release of exogenously taken up tritiated norepinephrine. The electrically evoked release of labeled norepinephrine previously taken up into hippocampal slices was dependent on the presence of calcium in the superfusion medium and on the number of pulses of stimulation applied. The electrically evoked release of labeled norepinephrine increased continuously and in a non-linear fashion as the frequency of stimulation was raised from 5 to 10 to 20 to 40 Hz. A rapid release of label per pulse of stimulation occurred up to frequencies of 10 Hz. Thereafter, and up to frequencies of 40 Hz, the label released per pulse of stimulation occurred at a slower rate. These experiments demonstrate that the concomitant use of superfusion and electrical stimulation of hippocampal slices seems to provide a simple and reliable system for studying transmitter synthesis regulation and its relationship, if any, to transmitter release in central noradrenergic neurons.

5766 BIOLOGICAL EFFECTS OF ELECTRIC AND MAGNETIC FIELDS OF EXTREMELY LOW FREQUENCY. (BOOK REVIEW). *(Eng.)* Schwan, H. P. (No affiliation given). *Health Phys* 34(3): 283-284; 1978. (1 ref)

Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency is reviewed. The book covers much of the same material as the National Academy of Sciences-National Research Council's report on "Biologic Effects of Electrical and Magnetic Fields Associated with Proposed Project Seafarer;" however, it frequently arrives at different conclusions. Most of the book deals with experimental literature citing hematologic, biochemical, physiologic, and behavioral effects. Biologic effects of magnetic fields are discussed in the last chapter, and an extended table summarizes the literature from more than a hundred references. The text does not discuss the extensive knowledge that has been gained with regard to the interaction of electricity with biologic systems. The book is valuable in its coverage of macroscopic and bioengineering considerations, including how electrical fields in air couple into the human or animal body. The book is recommended for the health physicist and environmental biophysicist.

MEETING ABSTRACTS

5767 HYPERTHERMIA AND ACUTE DEATH IN MICE EXPOSED TO MICROWAVE WITH AND WITHOUT HEAD SHIELDING (MEETING ABSTRACT). *(Eng.)* Nakamura, W. (Aichi Cancer Center, Nagoya, Japan); Nishimoto, Y. *J Radiat Res* 19(1): 43-44; 1978. (0 refs)

The effects of uniform microwave hyperthermia was investigated in 12-wk-old LAF_1 and ddy/SLC mice of both sexes. A domestic microwave oven (National NE-4500; frequency 2,450 MHz, wavelength 12 cm,

output power 400 W) was used as microwave generator. Using radish as a phantom, it was shown that fairly uniform and constant heating was possible in an acrylic acid resin tube when the latter was kept in an iron can and separated from the radiator with a water layer. In the tube, the extent of increase in anal temperature of mice was reciprocally proportional to the body weight of the animals. The elevated temperature in abdomen, liver, lung, and brain was 81, 75, 71 and 57% of that induced in the rectum, respectively. The anal temperature that was critical for acute death was estimated to be around 44 C. Shielding of the head with aluminum foil did not protect the mice from acute death.

5768 ON THE FATE OF IRON DEPOSITED IN THE HYPOTHALAMUS DURING ELECTRICAL STIMULATION (MEETING ABSTRACT). *(Eng.)* Clark, J. S. (Dept. Anatomy, Univ. Bristol, Bristol BS8 1TD, England). *J Physiol (Lond)* 277: 18P-19P; 1978. (7 refs)

A modification of the metal sulphide precipitation technique was developed to determine the fate of iron deposited in the hypothalamus during electrical stimulation. Adult female rats were anaesthetized with sodium pentobarbitone and an insulated steel electrode (20 μm diameter) was lowered into the anterior hypothalamus, and a direct current of 30 μA (anodal) was passed for 180 sec. After fixation of the brain in a 1% double aldehyde fixative in phosphate buffer pH 6.2 and sectioning at 60 μm on a freezing microtome, the iron was precipitated with a 0.25% solution of ammonium sulphide. The localization of the iron precipitate was then emphasized by application of the sulphide-silver method for intensification of heavy metals. Neurones and their processes in the area around the electrolytic lesion were stained with Golgi-like clarity, due to the uptake of the deposited iron. The distribution of the iron in the brain and the time course of its removal was investigated, and the electrophysiologic implications of the results are discussed.

5769 STUDIES CONCERNING THE EFFECTS OF PROTRACTED PRENATAL EXPOSURE TO A NON-THERMAL LEVEL OF 2450 MHZ MICROWAVE RADIATION IN THE PREGNANT RAT (MEETING ABSTRACT). *(Eng.)* Jensh, R. P. (Dept. Anatomy, Thomas Jefferson Univ., Philadelphia, PA); Ludlow, J.; Weinberg, I.; Vogel, W. H.; Rudder, T.; Brent, R. L. *Teratology* 17(2): 48A; 1978. (0 refs)

To determine the effects of protracted prenatal exposure to nonthermal microwave irradiation, pregnant Wistar rats (12) were exposed to 2,450 MHz microwave radiation in an anechoic chamber 8 hr daily throughout pregnancy (mean=115 hr). Concurrent control animals were placed in the chamber for similar time periods. All animals were killed on day 22 of gestation; their uteri exteriorized; and fetal positions and resorption sites recorded. All fetuses were dissected using Wilson's cross-sectional technique. Data were analyzed and compared with historic baseline control groups. No significant differences among groups were observed for the following parameters: initial maternal weight, term maternal weight, maternal weight gain, embryonic and fetal resorption rates, abnormality rate, and term fetal and placental weights. Using these parameters as indices, the results indicate that exposure of pregnant rats to a nonthermal but threshold level of 2,450 MHz microwave radiation does not adversely affect the offspring.

5770 INFLUENCE OF A 5000 GAUSS MAGNETIC FIELD ON THE BIOLOGICAL SYSTEMS (MEETING ABSTRACT). *(Eng.)* Iwasaki, T. (Natl. Inst. Radiological Sciences, Chiba, Japan); Ohara, H.; Matsumoto, S.; Matsudaira, H. *J. Radiat. Res.* 19(1): 48; 1978. (0 refs)

The possibility that exposure to an almost uniform strength 5,000 G magnetic field can affect biologic systems was investigated. Chinese hamster ovary (CHO) cells, growing in a plastic flask, were exposed to the magnetic field for 8 hr at room temperature. After the exposure, the cells were dispersed and replated to examine cellular growth and multiplicity, and colony forming ability. Naturally synchronous plasmodia of *Physarum polycephalum* were exposed at S-G_2 or M-S-G_2 for 7-8 hr at 24 C and examined for mitosis delay. Fertilized or early cleavage eggs of *Xenopus laevis* also were exposed (up to 72 hours) to evaluate delay in embryonic development. No biologic effects occurred in the three systems studied.

5771 SUPPRESSION OF MURINE ALLOGRAFT REJECTION BY WHOLE-BODY MICROWAVE HYPERTHERMIA (MEETING ABSTRACT). *(Eng.)* Liburdy, R. P. (U.S. Air Force Sch. Aerospace Medicine, Brooks Air Force Base, TX 78235). *Fed Proc* 37(6): 1281; 1978. (0 refs)

To test for possible effects on immune function, allograft rejection of EL-4 cells in microwave-pretreated Balb/c mice was investigated. Microwave pretreatment consisted of brief 10-min thermogenic exposures to 2.6 GHz radiation (25 mW/cm^2; 1.5 C increase in core temperature) delivered at 0900 and 1500 hr for 10 days. On day 11 mice were challenged with a subcutaneous transplant of EL-4 cells. Rejection phase to EL-4 cells began at 9.3 ± 0.6 (n=20) days in the microwave-pretreated group compared with 7.5 ± 0.3 (n=20) days in sham-irradiated mice. Nonthermogenic microwave pretreatment (5 mW/cm^2) did not alter allograft response. Plasma corticosteroid levels were elevated in mice immediately following thermogenic microwave exposure only: 150 ± 15 ng/ml compared with 45 ± 7 ng/ml for sham-irradiated mice. Intramuscular administration of hydrocortisone sodium succinate at 4 mg/kg for 10 days prior to EL-4 transplant suppressed the allograft response; onset of rejection occurred at 10.1 ± 0.6 (n=20) days compared with 7.4 ± 0.5 (n=20) days for the steroid and control groups, respectively. The results suggest that thermogenic microwave stress is associated with steroid release and immunosuppression of the allograft response.

5772 EFFECTS OF CHRONIC NON-THERMAL EXPOSURES OF PULSED MICROWAVES ON A REPAIR-DEFICIENT MUTANT OF *ESCHERICHIA COLI* (MEETING ABSTRACT). *(Eng.)* Dutta, S. K. (Howard Univ., Washington, DC); Nelson, W. H.; Blackman, C. F.; Brusick, D. J. *Mutat Res* 53(1): 91-92; 1978. (0 refs)

Fractions of the *Escherichia coli* repair-deficient mutant, *polA*$^-$, and a normal strain, *polA*$^+$, were exposed to pulsed microwaves of 1, 10, and 20 mW/cm^2 at 8.6, 8.8, and 9.0 GHz for 1, 5, 10, and 15 hr to determine the effects of chronic non-thermal microwave irradiation. At 1 mW/cm^2, no significant deviations could be detected in the repair indices (the ratio of percent survival of the repair-deficient mutant to the percent survival of the normal strain). When the cells were irradiated at 10 and 20 mW/cm^2, repair indices of 0.4 to 0.9 were observed for exposures of $\geq$10 hr. Heating/cooling curve data, which were used to establish absorbed energy, demonstrated that the temperature rises associated with 10 mW/cm^2 were approximately 2 C to 4 C, and with 20 mW/cm^2 they were approximately 6 C to 8 C. Experiments were conducted to determine whether changes in the repair indices at prolonged exposures were due to a rise in temperature of the samples. The results showed that temperatures up to 39 C did not produce repairable DNA damage. It was apparent that the lower repair indices obtained were due to nonthermal effects of pulsed microwaves at 10 mW/cm^2. Effects obtained at power levels above 10 mW/cm^2 could be due to combined effects of both heat and microwave exposures.

5773 FUNDAMENTAL DIFFERENCES BETWEEN SIMPLE HYPERTHERMIA AND 434 MHZ EFFECTS: PROOF OF THERMIC AND NON-THERMIC EFFECTS OF 434 MHZ E.M.W. (MEETING ABSTRACT). *(Eng.)* Holt, J. A. G. (Inst. Radiotherapy and Oncology, Leederville, Western Australia 6007, Australia). *Am J Roentgenol* 130(1): 188; 1978. (0 refs)

The thermal and non-thermal effects of microwave radiation are discussed with emphasis on the therapeutic implications. The radiosensivity value of various cancers has been calculated from clinical observations of their responses to X-ray therapy. Microwave radiation at 434 MHz does heat normal tissues but preferentially heats living cancer tissue. Measured temperatures in cancer colonies after 434 MHz radiation do not exceed the temperatures reached by simple hyperthermia. However, the X-radiation sensitivity increase may be 5 to 10 times greater after 434 MHz than after 41.8 C. Such large increases in X-ray sensitivity cannot be demonstrated when 434 MHz microwaves follow the X-ray therapy. Therapeutic regimens of sequential 434 MHz and X-ray therapy, while preventing a cancer temperature rise of more than 2 C during the 434 MHz radiation, reveal similar large increases in X-ray sensitivity. The magnitude of the ratio of X-ray sensitivity of human cancer after 434 MHz microwaves radiation and simple heating to similar temperatures indicates that 434 MHz microwave radiation affects cancer, independent of the temperature rise it creates.

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This quarterly digest presents current awareness information on the biological effects of nonionizing electromagnetic radiation. (microwave and radio frequency) in the range of 0 Hz to 100 GHz. The effects of magnetic and electric fields (static and alternating) are also covered. Each issue contains abstracts of English and foreign current literature, summaries of ongoing research investigations, news items, and a directory of meetings and conferences.

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