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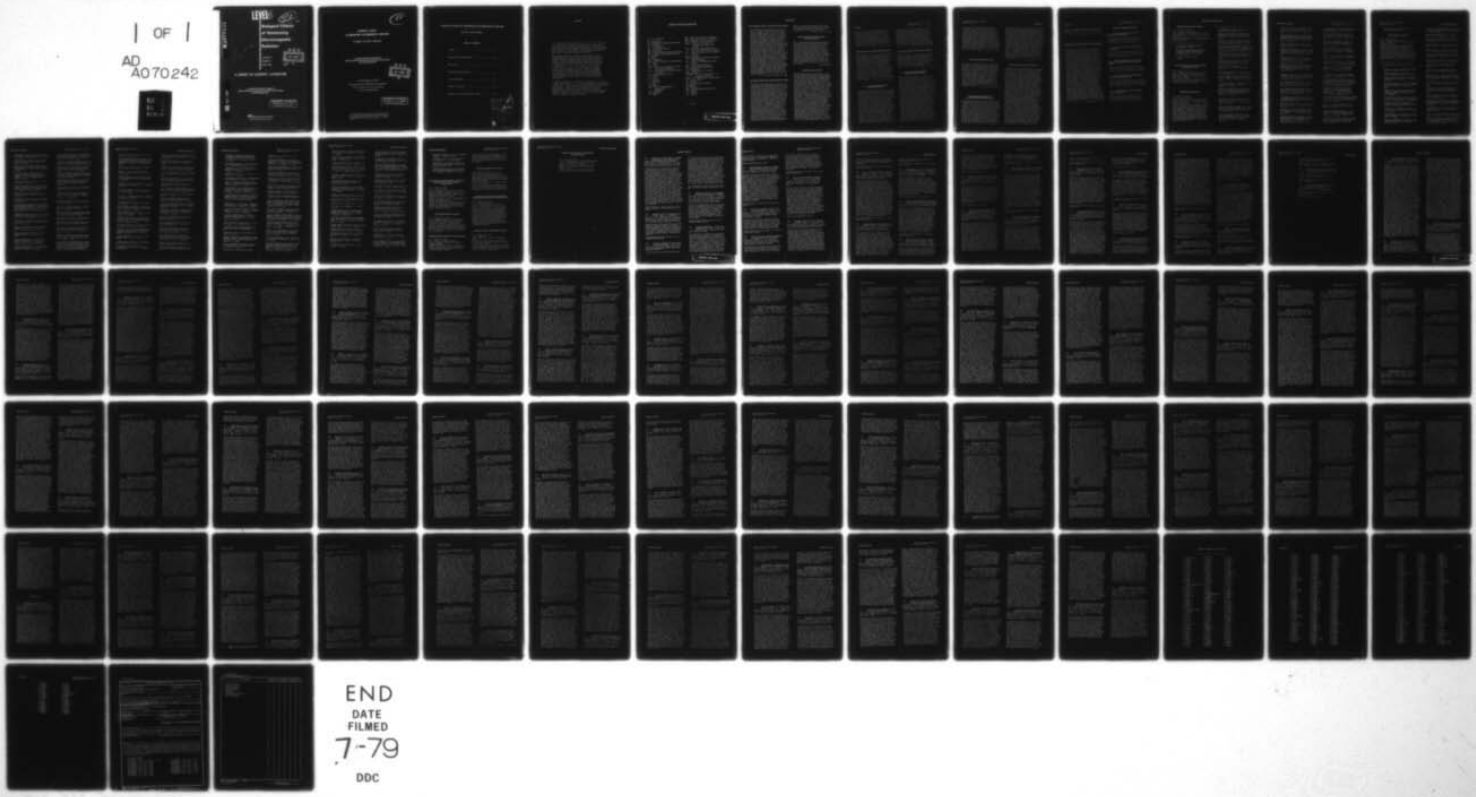

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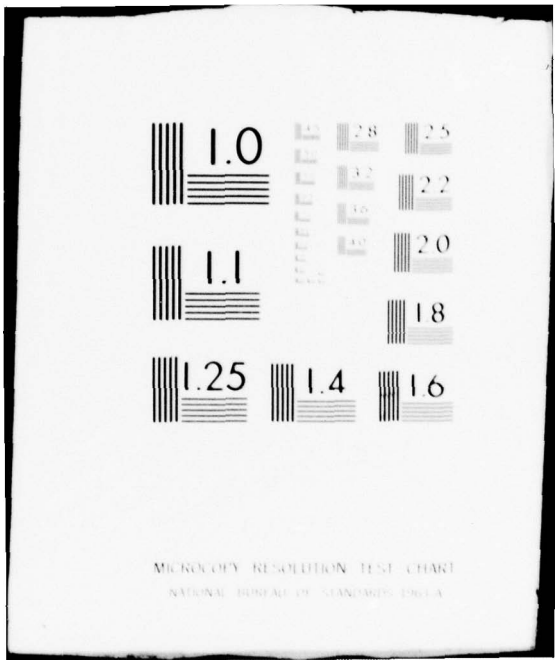
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Biological Effects of Nonionizing Electromagnetic Radiation

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NUMBER 4
JUNE, 1979

A DIGEST OF CURRENT LITERATURE

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

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OF NONIONIZING ELECTROMAGNETIC RADIATION

A Digest of Current Literature

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Literature Selected and Abstracted
by
Biomedical Group, Science Information Services Organization

Bruce H. Kleinstein, Ph.D., J.D., Project Manager

Gary Freedman, Managing Editor

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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

June, 1979 Volume III, Number 4

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PREFACE

Biological Effects of Nonionizing Electromagnetic Radiation is a publication researched and prepared by the Franklin Research Center, Science Information Services Organization, under contract to the National Telecommunications and Information Administration (NTIA); funding provided by the U.S. Navy under interagency agreement with NTIA.

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 other radio frequency 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 the 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 Standard
NIH - National Institutes of Health
NSF - National Science Foundation
NIOSH - National Institute for Occupational Safety and Health
NTIA - National Telecommunications and Information Administration
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--

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NEWS ITEMS

SENATE COMMITTEE REPORT CALLS FOR MORE RADIATION RESEARCH

The Senate Committee on Commerce, Science and Transport, in a report on radiation health and safety issued in December, 1978, is calling for "experimental and epidemiological studies to determine the biological and/or behavioral effects of long-term exposure to low-levels of all forms of radiation." But it is particularly concerned by the uncertainty surrounding the effects of long-term exposure to nonionizing electromagnetic radiation, such as microwaves. "Research on the health effects of nonionizing radiation has been given an unacceptably low priority throughout the Federal establishment. Only about $9 million are spent each year for research on the biological effects of nonionizing radiation." The committee endorses the research priorities of the National Telecommunications and Information Administration. These are (1) experimental research on the effect of long-term, low-level exposures; (2) studies of persons exposed at work and in the home; (3) investment in basic research; and (4) improved measurement techniques and methods for extrapolating from animal experiments. The committee also wants OSHA to give greater priority to the control of radiation hazards--particularly from nonionizing radiation. For example, it wants OSHA to reexamine its current voluntary standard on nonionizing radiation (which, surveys show, is widely disregarded) and make a mandatory standard. Standards for nonionizing radiation in the environment outside the workplace should be considered and the Office of Technology Assessment should investigate the impact of such standards.

New Scientist 181(1138): 156; 1979.

BRH COMPILES MICROWAVE-OVEN-LABELING EXEMPTION GUIDELINES

A document entitled "Guidelines for Exemption from the Microwave Oven Labeling Requirements of 21 CFR 1030.10(c)(6)(i)" has been compiled and is available from the BRH. The guidelines were developed to aid in the preparation and evaluation of petitions for exemption from the labeling requirements of the microwave oven performance standard. The standard requires that a label be attached to microwave ovens to remind users of certain safety precautions. The warning must read as follows: "Precautions for use to avoid possible exposure to excessive microwave energy: Do not attempt to operate this oven with: (a) object caught in door, (b) door that does not close properly, (c) damaged door, hinge, latch, or sealing surface." The standard also permits the Bureau to approve a request for exemption from displaying this warning if it finds the oven will not exceed the allowable emission limits when operated under the conditions listed on the label. The Bureau developed the guidelines after reviews of exemption requests submitted by several manufacturers indicated that more definitive guidance on specific tests and criteria was needed for use in preparing and evaluating such submissions. In addition to providing a uniform methodology whereby both manufacturers and the Bureau can determine whether a specific oven model qualifies for exemption from the labeling requirements, the document also contains a summary of the rationale used for developing each of the tests and criteria.

BRH Bulletin 13(1): 5; 1979.

MICROWAVE BIOEFFECTS AND RADIATION SAFETY ONE-DAY SHORT COURSE

IMPI, in cooperation with the Radiation Protection Services of the British Columbia Ministry of Health, is sponsoring a 1-day short course dealing with microwave bioeffects and radiation safety to be held June 15, 1979 at the Four Seasons Hotel in Vancouver, British Columbia, Canada. The program will include the basic principles and concepts of radio waves and microwaves, microwave biophysics, biologic and pathophysiologic effects of microwave radiation, protection standards, control of exposure in Canada, low frequency power line studies, and measurement of potentially hazardous fields. A panel discussion moderated by Dr. M. Wayne Greene, head of the Radiation Protection Services of the British Columbia Ministry of Health will conclude the session.

IMPI News Release

RADAR BIOEFFECTS TO BE STUDIED

Biologic effects caused by typical radars will be studied by researchers at the University of Washington, Seattle, WA, under contract to Wright-Patterson Air Force Base, OH to determine if low-power radar signals, on the order of 1 mW/cm^2 at 450 MHz, have adverse effects on humans. Absorption at 450 MHz will be determined thermographically using an infrared scan on a gelatin-filled human mock-up. Comparable absorption will then be induced in rats at 2,450 MHz, with concurrent postirradiation analysis of the test animals. After the proper power level is determined, 20 rats will be irradiated for 3 mo (with 20 control animals) in a pilot test sometime next year to "shake down" the system. If all goes well, 100 rats will then be irradiated for 3 mo using 100 waveguides, with 100 inactive waveguides for the control animals. "Since most radars use rotating pulsed beams, we'll irradiate the rats using groups of pulses," says Dr. A. William Guy, project engineer. A microprocessor will be used to control signal transmission with a representative irradiation pattern being 10 pulse groups per sec using 10-usec pulse widths and a duty cycle of 0.005. Characteristics of the incident radiation will be varied to simulate a number of radars. The rats will be exposed to circularly polarized signals using 20-cm diameter waveguides, and Guy expects 60-70% of incident energy to be absorbed by the rats. The 3-yr study was initiated in October, 1977 with $887,000 allocated for the first 18 mo, and $1.2 million forthcoming for the second 18 mo. "There's never been a microwave study conducted in the US for this long and at these power levels," states Guy.

"Long-term studies haven't been conducted in the past because funding just hasn't been available," he explains. "Researchers typically only have enough funding to irradiate animals for a few days." According to Guy, about $63 million was spent for bioeffects research during the last 5 yr, with average contracts in the $50,000-$100,000 range. The study was funded partially because of the growing concern over the effects of low-power electromagnetic radiation, and because of nonthermal effects reported in Soviet research.

Microwaves 17(12): 16; 1978.

SWEDISH RESEARCHERS CITE HARMFUL MICROWAVE BIOEFFECTS

Microwave radiation can affect respiration, the heart, and the cerebral cortex, according to an article in *FOA Tidningen*, the journal of Sweden's National Defense Research Institute. Animal studies revealed that microwave energy can also trigger changes in hormone activity and influence the hematopoietic system. Test animals, chiefly mice, were placed at various distances from a 2.45-GHz generator to achieve radiation intensities of 100, 10, and 1 mW/cm^2. Experiments on mice revealed that a radiation intensity of 100 mW/cm^2 can be fatal when maintained for 6 min, while tests on frogs revealed that pulsed energy at 0.6 $\mu W/cm^2$ is sufficient to affect heartbeats and to increase blood pressure. Other deleterious effects observed include a reduction in the number of cells that react to noise and pain, and changes in pupil reaction. Sweden currently has a radiation ceiling of 1 mW/cm^2, which is one-tenth the U.S. standard.

Microwaves 18(2): 39; 1979.

HEALTH EFFECTS FROM RADIO FREQUENCY RADIATION TO BE STUDIED

The American Health Foundation, under contract with the BRH, has initiated a study of the possible adverse health effects associated with exposure to low-level radio frequency radiation from microwave and shortwave diathermy equipment. The contract calls for a group of male physical therapists and their offspring to be studied through the use of a mailed questionnaire, with several followups planned for nonrespondents. The feasibility of conducting such a survey was determined by a pretest, and the full-scale survey was initiated in October 1978 with the mailing of questionnaires to male members of the American Physical Therapy Association. The objective of the study is to determine whether physical therapists or their offspring suffer adverse health effects related to occupational use of diathermy equipment. For the therapists, the study will consider such health effects as cataracts, high blood pressure, sterility, and persistent fatigue, dizziness, insomnia, or headaches. For the offspring, fetal and infant mortality, low birth weight, and congenital malformations will be evaluated. Therapists are being asked to supply information about medical and work histories for themselves and their wives. Items regarding smoking, as well as exposure to ionizing and nonionizing radiation and to chemicals, are included in the questionnaire. Analysis of the data will attempt to relate health and reproductive outcomes to the use of diathermy equipment so the possible associations can be identified. Although sources generating radio frequency energy have increased greatly in the past 30 yr, there have been relatively few studies of the possible biologic effects in human populations. The present study will provide a basis for the development of guidance concerning occupational and general population exposures.

BRH Bulletin 13(2): 3-4; 1979.

SHORT WAVE DIATHERMY RELIEVES HERPES ZOSTER SYMPTOMS

British physician, Dr. F. R. C. Manning, citing the therapeutic benefits of short-wave diathermy to the spinal cord in the treatment of nearly 400 herpes zoster cases, refutes claims that the effects are merely psychosomatic. According to Manning, "a large body of local practitioners and their patients will bear witness to the fact of the rapid relief of symptoms, particularly of postherpetic neuralgia, that this simple treatment can afford."

Br Med J 1(6158): 274; 1979.

BRH DEVELOPS TEST FACILITY TO SUPPORT MICROWAVE DIATHERMY STANDARD

A facility for measuring the electrical properties of the phantoms of simulated fat and muscle tissue that are used in evaluating microwave diathermy applicators has been developed and put into operation by the Electromagnetics Branch of the BRH's Division of Electronic Products. Such measurements are needed to determine whether the dielectric properties of the phantoms--such as conductivity and permittivity--are within the limits set by the proposed performance standard for microwave diathermy equipment, and also to support Bureau studies of other agencies' clinical programs in microwave-induced hyperthermia treatments of cancer. Three methods for making routine dielectric measurements on liquid and semisolid materials at microwave frequencies presently are being used in the facility: (1) an impedance probe method, (2) a short-line method, and (3) a two-impedance method. Installation of a Bureau-developed semi-automated network analyzer with automatic calibration and correction features has made it possible to obtain accurate results with all three techniques. The impedance probe method, which was developed by the Georgia Institute of Technology and modified by the Bureau, shows promise for highly accurate and repeatable measurements on liquids and semisolids. The technique involves the use of a tiny monopole antenna inserted into the sample material. The input impedance of the probe depends on the properties of the sample, and these properties can be derived from a network analyzer measurement of the probe's input impedance. The short-line method is the most widely used technique for dielectric measurements and can be used with solids, liquids,

and semisolids. The network analyzer enables a very accurate determination of the properties of a sample in a shorted line. The two-impedance method was developed by the Bureau and is similar to the shorted-line method, except measurements are made on both a shorted line and a terminated line. Use of the network analyzer makes this technique feasible and accurate. Further work in progress on the network analyzer system, when combined with precision sample holders and probes which also are under development, is expected to improve the Bureau's dielectric measurement facility to a state-of-the-art system for microwave measurements. It is anticipated that this facility will be used to provide assistance to other university and government laboratories as well as to Bureau programs.

BRH Bulletin 13(1): 1-2; 1979.

BRH EVALUATES DIATHERMY APPLICATORS

Techniques for evaluating the relative effectiveness and safety of microwave diathermy applicators have been developed by the BRH. The effectiveness of an applicator is determined by measuring the heating patterns induced in phantoms in order to obtain the rate of energy deposition or specific absorption rate (SAR). The safety is determined by measuring the microwave leakage at 5 cm from the boundary of the phantom/applicator combination. According to the proposed standard, a leakage of not more than 10 mW/cm^2 at an SAR of 235 W/kg is required for safety. The Bureau already has evaluated several 2,450- and 915-MHz hyperthermia applicators for such clinical users as the Radiation Oncology Therapy Group and is continuing to perform similar evaluations for others.

BRH Bulletin 13(1): 2; 1979.

STUDY SHOWS NO EFFECT ON MORTALITY FOLLOWING OCCUPATIONAL EXPOSURE TO RADAR

An epidemiologic study of a large group of U.S. naval enlisted men occupationally exposed to radar over 20 yr ago has shown that the men's exposure to microwave radiation had no adverse effects on long-term mortality patterns or on hospitalized illness around the time of exposure. The study, which was supported by a BRH contract, was conducted by the Medical Follow-up Agency of the National Research Council, National Academy of Sciences, under the direction of Dr. Dennis Robinette and Mr. Seymour Jablon. The study population included approximately 40,000 men who served in the Navy during the Korean War period of 1950 to 1954. Of these men, approximately 20,000 were electronic equipment repair personnel who had maximum potential for exposure, and 20,000 were equipment operators who had minimal potential for exposure. The exposures were assessed in terms of occupational duties, length of time in occupation, and power of equipment at the time of exposure. The health indexes studied included mortality by cause of death, hospitalization during service, later hospitalization in Veterans Administration facilities, and disability compensation. Data on these health indexes were obtained largely through the use of automated record systems. Because the types of information obtained were limited by the availability of data on computer tapes, other aspects of health and exposure relevant to possible microwave effects could not be investigated. For example, it was not possible to determine hospital care outside the Navy and Veterans Administration system, the frequency and nature of less serious medical conditions during and after service, reproductive performance, health of offspring, or employment history after discharge from service. An extension of the study to investigate these other questions is possible, however, since a subsample of living men with high and low exposure patterns during service can be identified for individual followup.

BRH Bulletin 13(3): 1; 1979.

SOLAR POWER SATELLITE BIOEFFECTS HIGHLIGHTED

Commenting on the environmental impact of the proposed Solar Power Satellite (SPS) transmission system, Dr. Peter E. Glaser, Vice President of Engineering Sciences, Arthur D. Little, Inc., states that the SPS microwave transmission system must be designed so that the range of frequencies and microwave power flux densities will meet future international standards. At present, various standards for microwave exposure have been established, ranging from 10 mW/cm^2 for the U.S. to 0.01 mW/cm^2 for the Soviet Union. Whereas the U.S. standard is based on microwave heating of body tissue, the Soviet Union's standard is based on possible effects on the central nervous system, even at low exposure levels. Glaser points out that the SPS will incorporate several fail-safe features to assure control of microwave beam pointing and instantaneous shutoff of power to the microwave generators. Failure of the microwave beam-pointing system would not result in exceeding the Eastern European guidelines for microwave exposure. Predictions, analyses, and measurements of the SPS's specific microwave-induced biologic effects will be an essential component of the development program. Glaser adds that in addition to direct biologic effects, interference with electronic equipment, medical instrumentation, and electric devices must be avoided. Any sensitivity of such equipment to the low level of microwave exposure will have to be determined; if required, industrywide standards will have to be established. Possible effects, if any, on birds flying through the microwave beam also will have to be established, notes Glaser. Preliminary evidence indicates that birds can be affected at levels of microwave exposure greater than 20 mW/cm^2 of radiation in the X-band. The evidence suggests that birds avoid such exposure. Glaser concludes that the effects of microwave exposure on aircraft flying through the beam must also be considered. He notes, however, "the shielding of the metal

fuselage and the very short time of flight through the beam are unlikely to result in significant human exposure."

Adv Astronaut Sci 27(Part 1): 287-317; 1978.

U.S. EMBASSY EMPLOYEES IN MOSCOW NOT AFFECTED BY MICROWAVES

A medical study released by the State Department reported no evidence of health problems caused by microwave radiation beamed at the U.S. Embassy in Moscow. However, the report cautions that more investigation is required to determine long-range effects. The report is based on a 2-yr study conducted by Baltimore's Johns Hopkins University School of Hygiene and Public Health, which reviewed the records of nearly 4,500 State Department employees and their dependents who lived in Moscow between 1953 and 1976. The records were compared with those of other diplomatic families who served elsewhere in Eastern Europe and who were not subjected to known microwave bombardment. The study, which was begun in the summer of 1976, concentrated on over 1,800 employees at the Moscow embassy during the period and 3,000 of their dependents. A comparison group of over 2,500 employees at nine Eastern European posts and 5,000 of their family members were also identified. No differences were observed between the two groups with respect to cancer morbidity. A relatively high proportion of cancer deaths in both female employee groups was discovered, but no satisfactory explanation was found. The report also notes that the population studied was relatively young and that it was still too early to be able to detect long-term mortality effects except for those who had served in the earliest period of the study. Another problem cited in the report is that the highest exposure at the embassy--up to 18 $\mu W/cm^2$--was for the relatively short period of June 1975 to February 1976. The report recommends that the group with the highest exposure be contacted again in another 3 yr for a medical update, and that a surveillance system be developed to track deaths in the entire population that was studied.

Microwaves 18(1): 27; 1979.

ITEMS FROM THE COMMERCE BUSINESS DAILY

☐ **EXPLORATORY EVALUATION OF VIDEO DISPLAY TERMINAL OPERATOR STRESS/STRAIN**

The contracting officer, National Institute for Occupational Safety and Health, 5600 Fishers Lane, Room 8-29, Rockville, MD is soliciting proposals for the above study. (January 11, 1979)

☐ **STUDY OF EFFECT OF ELECTRICAL STIMULATION OF THE CEREBELLUM**

The National Institute of Neurological and Communicative Disorders and Stroke, NIH, Bethesda, MD has contracted with the University of Minnesota for the above study. (January 23, 1979)

☐ **CONTINUED RESEARCH ON THE EFFECT OF RADIO FREQUENCY AND MICROWAVE ENERGY ON THE NERVOUS SYSTEM**

The Office of Naval Research, 800 N. Quincy St., Arlington, VA 22217 has contracted with the University of Pennsylvania, 3451 Walnut St., Philadelphia, PA 19104 for the above study. (February 26, 1979)

☐ **A STUDY ENTITLED "THE EFFECTS OF MICROWAVE RADIATION ON CEREBRAL METABOLISM."**

The Environmental Protection Agency, Contracts Management Division (MD-33), Office of Administration, Research Triangle Park, NC will negotiate with Duke University Medical Center, Durham, NC for the above study. (February 28, 1979)

☐ **PRE- AND POST NATAL EXPOSURE OF SQUIRREL MONKEYS TO 2450 MHz EMR**

The Environmental Protection Agency, Office of Administration, Research Triangle Park, NC has contracted with Stanford Research Institute International, 333 Ravenswood Ave., Menlo Park, CA 94025 for the above study. (March 9, 1979)

MEETINGS AND CONFERENCES

AMERICAN INDUSTRIAL HYGIENE CONFERENCE

Date: May 27-June 1, 1979
Place: Chicago, IL: Palmer House
Sponsor: American Industrial Hygiene Assoc. (AIHA); American Conference of Governmental Industrial Hygienists (ACGIH)
Requests for Information: W. E. McCormick, American Industrial Hygiene Association, 475 Wolf Ledges Parkway, Akron, OH 44311

Selected Bibliography of Papers to be Presented:

RF AND MICROWAVE STANDARDS IN CANADA.
M. Rappacholi, M. Stukley

NIOSH CRITERIA DOCUMENT AND RECOMMENDED OCCUPATIONAL EXPOSURE STANDARDS FOR RF AND MICROWAVE RADIATION: A STATUS REPORT.
R. F. Boggs, Z. Glazer, T. K. Tielman

BIOLOGICAL EFFECTS OF MICROWAVE.
S. Cleary

1979 CLEVELAND ELECTRICAL ELECTRONICS CONFERENCE AND EXPOSITION (CECON 79)

Date: June 5-7, 1979
Place: Cleveland, OH: Cleveland Convention Center
Sponsor: Institute of Electrical & Electronics Engineers (IEEE)--Region 2, Cleveland Section
Requests for Information: M. Lapine, 2728 Euclid Ave., Cleveland, OH 44115
Content: Topics will include biomedical--medicine, biology, and biologic effects; standards--national, international, performance, regulatory

MICROWAVE POWER SYMPOSIUM 1979

Date: June 11-15, 1979
Place: Monte Carlo, Monaco
Sponsor: International Microwave Power Institute
Requests for Information: Int'l Microwave Power Institute, Box 634, SUB 11, Univ. Alberta, Edmonton, Alberta, Canada T6G 2E0
Content: Topics will include fundamental properties, microwave power generation, transmission and rectification, industrial microwave systems, microwave instrumentation and measurement, microwave properties of materials, industrial applications, food industry applications, medical and biological applications, biological effects of microwaves, domestic and catering microwave ovens, microwave field distribution and measurement, energy balance of microwave processes, equipment safety, RF interference and frequency allocations, economics and marketing of microwave ovens.

Selected Bibliography of Papers to be Presented:

ELECTROMAGNETIC WAVES AND LIVING SYSTEMS. A. J. Berteaud (C.N.R.S., Thiais, France)

MEDICAL ASPECTS OF INTERACTION BETWEEN MICROWAVES AND LIVING SYSTEMS. B. Servantie (Centre de Recherches du Service de Sante des Armees, France)

MICROWAVE APPLICATIONS IN DIAGNOSIS AND THERAPY. M. Gautherie (Institut National de la Sante et de la Recherche Medicale, Strasbourg, France)

MEASUREMENTS AND INSTRUMENTATION IN INVESTIGATION OF THE BIOLOGICAL EFFECTS OF ELECTROMAGNETIC WAVES. A. Priou, A. Deficis (Departement Etudes et Recherches en Micro-ondes, C.E.R.T., France)

MICROWAVE RADIATION PROTECTION STANDARDS. M. A. Stuchly (Nonionizing Radiation Section, Radiation Protection Bureau, Environmental Health Centre, Canada)

MEASUREMENTS OF COMPLEX DIELECTRIC CONSTANT OF HUMAN SERA AND ERYTHROCYTES. B. Bianco, *et al.* (Consiglio Nazionale delle Ricerche, Italy)

MICROWAVE DOSIMETRY MEASURING DEVICE. K. Dzieciolowski, *et al.* (Polish Acad. Science, Poland)

TOTAL RADIATION EXPOSURE USING LIQUID CRYSTALS AND THERMOLUMINESCENCE. G. E. Fanslow (U.S.A.)

EFFECTS OF CHRONIC LOW LEVEL MICROWAVE RADIATION ON SLEEP PATTERNS IN THE RAT. M-J. Klein, *et al.* (Centre de Recherches de Medecine Aeronautique, France)

EFFECTS OF MICROWAVES ON THE SENSITIVITY OF MICE TO A CURARE-LIKE DRUG. J-C. Dumas, *et al.* (ONERA/C.E.R.T., France)

CHANGES IN THE LEVEL OF ATP, ADP, AND AMP IN DEVELOPING RAT BRAIN FOLLOWING REPEATED WHOLE-BODY 2,450 MHz MICROWAVE IRRADIATION. A. Jamakosmanovic, L. M. Shore (Inst. Physiology and Biochemistry, Yugoslavia)

THE EFFECT OF 2,450 MHz RADIATION ON TWO SOIL BORNE PATHOGENIC FUNGI (*Botrytis cinerea*, *Fusarium*). M. Diprose, *et al.* (Univ. Sheffield, Sheffield, England)

NECESSARY CONDITIONS FOR OBSERVATION OF BIOLOGIC EFFECTS OF MICROWAVE RADIATION. S. L. Arber (Scientific Res. Inst. of Health Resorts and Physiotherapy, USSR)

EEG ACTIVITY UNDER THE CONDITION OF SINGLE ACUTE WHOLE-BODY MICROWAVE 2,450 MHz IRRADIATION IN DEVELOPING RATS. M. Drecun, L. M. Shore (Inst. Physiology and Biochemistry, Yugoslavia)

EFFECT OF 10-GHz PULSED ELECTROMAGNETIC RADIATION AT SAR 1 W/kg ON *Escherichia coli*. S. K. Dutta, C. Chambers (Howard Univ., Washington, DC)

STUDIES CONCERNING THE EFFECTS OF NON-THERMAL PROTRACTED PRENATAL 915-MHz MICROWAVE RADIATION ON PRENATAL AND POSTNATAL DEVELOPMENT IN THE RAT. R. P. Jensch, *et al.* (Thomas Jefferson Univ., Philadelphia, PA)

LOW-LEVEL MICROWAVE RADIATION AND DIGESTIVE TRANSIT. R. Santini, *et al.* (Institut National des Sciences, France)

INDUCED FIELDS AND POWER ABSORPTIONS WITHIN THE HUMAN HEAD BY ELECTROMAGNETIC PLANE WAVE IRRADIATION USING AN ELLIPSOIDAL MODEL. H. Taha Al-Hafid, *et al.* (Coll. Engineering, Univ. Mosul, Iraq)

ELECTROMAGNETIC POWER DISTRIBUTION INDUCED IN BIOLOGICAL TISSUES IN A CLOSED ENVIRONMENT. P. Bernardi, *et al.* (Istituto di Elettronica, Universita di Roma, Rome, Italy)

NUMERICAL SIMULATION OF ELECTROMAGNETIC ENERGY AND TEMPERATURE DISTRIBUTION IN A CANCEROUS BREAST IRRADIATED BY MICROWAVES. R. Zimmer, *et al.* (Faculte de Medecine de Strasbourg, Strasbourg, France)

TEMPERATURE DISTRIBUTION IN ELECTROMAGNETICALLY IRRADIATED CYLINDERS SIMULATING LIVING TISSUES. G. Gerosa, *et al.* (Istituto di Elettronica, Universita di Roma, Rome, Italy)

IN VIVO TEMPERATURE/HEAT FLOW SENSING IN MICROWAVE FIELDS. G. M. Samaras, *et al.* (Univ. Maryland, Sch. Medicine, College Park, MD)

USE OF CONFORMAL MICROSTRIP ANTENNAS FOR BIOMEDICAL APPLICATIONS OF MICROWAVES. A. Van de Capelle, P. J. Luypaert (Katholieke Universiteit Leuven, Leuven, Belgium)

THE EFFECTS OF MICROWAVES (9.7 GHz) ON THE IN SITU MEMBRANE-BOUND ACETYLCHOLINESTERASE IN THE VAGAL HEART SYSTEM. W. Young, *et al.* (San Jose State Univ., San Jose, CA)

EFFECTS OF FETAL EXPOSURE OF MICE TO R.F. RADIATION. J. C. Nelson, *et al.* (Wayne State Univ., Detroit, MI)

WIDE BAND (1-10 GHz) CHARACTERIZATION OF ELECTRICAL PROPERTIES OF TISSUE EQUIVALENT BOLUS. A. Y. Cheung, *et al.* (Univ. Maryland, College Park, MD)

BIOLOGICAL EFFECTS OF RADIOFREQUENCY AND MICROWAVE RADIATION AND THEIR RELEVANCE TO OCCUPATIONAL SAFETY AND HEALTH STANDARDS IN THE UNITED STATES. R. F. Cleveland, *et al.* (Equitable Environmental Health, Inc., U.S.A.)

AN INTERNATIONAL PROGRAM ON NONIONIZING RADIATION PROTECTION. M. J. Suess (World Health Organization, Denmark)

TOWARDS PRUDENT DEFINITION OF NONIONIZING RADIATION HAZARD. H. Aamlid, M. Brady (Norwegian Nonionizing Radiation Committee, Norway)

NONIONIZING ELECTROMAGNETIC R.F. AND U.H.F. RADIATIONS: APPLICATIONS AND HAZARDS. M. Vautrin (Institut National de Recherche et de Securite, France)

DRAFT REQUIREMENTS FOR SAFETY IN INDUSTRIAL MICROWAVE HEATING EQUIPMENT. M. Kleinpeter (Commission Electrotechnique Internationale, France).

PRESENT AND FUTURE MEDICAL USES OF MICROWAVES, ESPECIALLY IN CANCER THERAPY. M. Gautherie (INSERM, France)

MICROWAVE THERMOGRAPHY (68 GHz AND 30 GHz) AND BREAST CANCER. M. Gautherie, *et al.* (Faculte de Medecine de Strasbourg, Strasbourg, France)

COMBINED METHODS OF DOSIMETRY IN MICROWAVE HEATING. Y. Leroy, *et al.* (Universite des Sciences et Techniques de Lille, Lille, France)

COMPUTER-CONTROLLED MULTIPLE BEAM MICROWAVE THERMOTHERAPY. G. M. Samaras (Univ. Maryland, Sch. Medicine, College Park, MD)

MICROWAVE RADIOMETRY AT 9 GHz: APPLICATION TO BREAST CANCER AND OTHER TUMOR SITES. PRELIMINARY RESULTS. M. Gautherie, *et al.* (Universite de Strasbourg et Universite des Sciences et Techniques de Lille, Lille, France)

MEASUREMENT OF HYPERTHERMIA OF HEALTHY AND TUMOR-BEARING MICE IN A 432-MHz FIELD BY MICROWAVES AND INFRARED THERMOGRAPHY AND BY THERMOCOUPLES. J. Robert, *et al.* (Laboratoire de Biophysique, Nancy, France)

INHIBITION OF ACUTE EXPERIMENTAL VIRAL INFECTIONS BY WHOLE-BODY MICROWAVE (2,450 MHz) HYPERTHERMIA. S. Szmigielski (Center for Radiobiology and Radioprotection, Poland)

EFFECT OF LOCALIZED MICROWAVE HEATING ON RAT EMBRYOS. V. P. Popovic (Emory Univ., Sch. Medicine, Atlanta, GA)

TREATMENT OF EXPERIMENTAL NEOPLASMS BY LOCAL MICROWAVE (2,450 MHz) HYPERTHERMIA. W. Roskowski, *et al.* (Center for Radiobiology and Radioprotection, Poland)

ELECTROMAGNETIC WAVE APPLICATOR FOR HYPERTHERMIA. CHOICE OF FREQUENCY BANDS AND POWER LEVELS ACCORDING TO TUMOR DEPTH. D. Michel, S. Lefeuvre (France)

FOCUSSING LONG-WAVE THERMOGRAPHY. J. Edrich (Univ. Denver, Denver, CO)

BIOELECTROMAGNETICS SYMPOSIUM

Date: June 18-22, 1979
Place: Seattle, WA: Univ. Washington
Sponsor: USNC/URSI (Commissions A and B); Bioelectromagnetics Society
Requests for Information: A. W. Guy, Technical Program Committee Chairman, Bioelectromagnetics Symposium, c/o Dept. Rehabilitation Medicine, Univ. Washington School of Medicine, Seattle, WA
Content: Behavioral effects; Central Nervous System effects; diagnostic applications; dosimetry; extra low frequency effects; exposure systems and instrumentation; hyperthermia and therapeutic applications; immunological and hematopoietic effects; macromolecular and cellular effects; mutagenic and developmental effects; sensory effects; thermometry

Selected Bibliography of Papers to be Presented:

KEYNOTE ADDRESS, FROM MICE TO MAN. W. A. G. Voss

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EM RESEARCH PROGRAM: INSTITUTE OF BIOLOGICAL PHYSICS, ACADEMY OF SCIENCES, USSR. I. G. Akoev

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DIFFERENTIAL HEATING OF THE CORTEX, HYPOTHALAMUS AND RECTUM IN THREE SPECIES BY 2,450-MHz MICROWAVES. V. Bruce-Wolfe, D. L. Reeves, D. R. Justesen

THERMAL EFFECTS ON COLONIC AND REGIONAL BRAIN TEMPERATURE IN UNANESTHETIZED RATS EXPOSED TO 2450 MHz MICROWAVES. W. M. Williams, S-T. Lu, S. M. Michaelson

MODIFICATION OF MICROWAVE BIOLOGICAL END-POINTS BY INCREASED RESTING METABOLIC HEAT LOAD IN RATS. S-T. Lu, N. Lebda, S. Pettit, S. M. Michaelson

MICROWAVE MODIFICATION OF THERMOREGULATORY BEHAVIOR: THRESHOLD AND SUPRATHRESHOLD EFFECTS. E. R. Adair, J. B. Pierce

MICROWAVES AFFECT THERMOREGULATORY BEHAVIOR IN RATS. S. Stern, L. Margolin, B. Weiss, S-T. Lu, S. M. Michaelson

MICROWAVE EFFECT ON THE PARAMETERS OF THE MODEL SYNAPTIC MEMBRANE. O. V. Kolomitkin, V. I. Kuznetsov, I. G. Akoev

EVIDENCE OF NEUROPATHOLOGY IN CHRONICALLY IRRADIATED HAMSTERS BY 2450 MHz MICROWAVES AT 10 mW/cm^2. E. N. Albert

ELIMINATION OF MICROWAVE EFFECTS ON THE VITALITY OF NERVES AFTER ACTIVE TRANSPORT HAS BEEN BLOCKED. D. I. McRee, H. Wachtel

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MICROWAVE SHORT-TIME EXPOSURE EFFECT ON GONADS. A. Ch. Achmadieva, E. N. Smirnova, I. G. Akoev

CHANGES IN THE ELECTROCARDIOGRAMS OF RATS AND DOGS EXPOSED TO DC MAGNETIC FIELDS. C. T. Gaffey, T. S. Tenforde

CARDIOVASCULAR RESPONSE OF RATS EXPOSED TO 60-Hz ELECTRIC FIELDS. D. I. Hilton, R. D. Phillips

DUAL ACTIONS OF MICROWAVES ON SERUM CORTICOSTERONE IN RATS. S-T. Lu, S. Pettit, S. M. Michaelson

ENDOCRINE FUNCTION IN RHESUS MONKEYS AND RATS EXPOSED TO 1.29 GHz MICROWAVE RADIATION. W. G. Lotz

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MODIFICATION OF THE EXTENDED BOUNDARY CONDITION METHOD FOR MODELS OF MAN AT AND ABOVE THE RESONANT FREQUENCY. M. J. Hagmann, F. S. Stenger, P. W. Barber

ELECTRIC AND MAGNETIC FIELD INTENSITIES AND ASSOCIATED INDUCED BODY CURRENTS IN MAN IN CLOSE PROXIMITY TO A 50 kW AM STANDARD BROADCAST STATION. R. A. Tell, E. D. Mantiply, C. H. Durney, H. Massoudi

A MICROWAVE DIATHERMY APPLICATOR. M. A. Stuchly, S. S. Stuchly, G. Kantor

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THRESHOLD VALUES FOR MAGNETO- AND ELECTROPHOSPHENES--A COMPARATIVE STUDY. P. Lovsund, P. A. Oberg, S. E. G. Nilsson

STUDIES OF MUTAGENIC EFFECTS OF MAGNETIC FIELDS IN BACTERIA. S. C. Causey, F. P. Hungate

SHORT-TERM EXPOSURE OF RHESUS MONKEYS TO 20,000 GAUSS STEADY MAGNETIC FIELD. J. H. Battocletti, A. Sances, Jr., S. Salles-Cunha, R. E. Halbach, F. J. Antonich, J. Nelson, J. Mykelbust

AN IMPROVED IMPLANTABLE ELECTRIC FIELD PROBE FOR MICROWAVE DOSIMETRY. H. Bassen, K. Franke, S. Neuder, E. Aslan

AN NONPERTURBING TEMPERATURE PROBE SYSTEM DESIGNED FOR HYPERTHERMIA MONITORING. D. A. Christensen, R. J. Volz

AN OPTICAL NONPERTURBING PROBE FOR TEMPERATURE MEASUREMENTS IN BIOLOGICAL MATERIALS EXPOSED TO MICROWAVE RADIATION. F. Cavatorta, P. E. Schoen, J. P. Sheridan

COMMERCIAL MICROWAVE HAZARD METERS: A LABORATORY EVALUATION. W. A. Herman, D. M. Witters, Jr.

A HIGH-SENSITIVITY, ULTRA-BROADBAND RADIATION PROBE. S. Hopfer, Z. Adler

DOSIMETRIC USE OF SCHOTTKY DIODES. W. A. Herman

POWER DENSITY FLUX MEASUREMENTS. T. M. Babij, H. Trzaska

CONSIDERATIONS AND CRITERIA FOR A RECOMMENDED STANDARD FOR OCCUPATIONAL EXPOSURE TO RADIOFREQUENCY AND MICROWAVE FIELDS. R. F. Boggs, Z. R. Glaser, J. K. Kielman

DEVELOPMENT OF OCCUPATIONAL EXPOSURE RECOMMENDATIONS: OBSERVATIONS ON THE USES OF RF/MICROWAVE ENERGY. Z. R. Glaser, R. F. Boggs, R. F. Cleveland, J. K. Kielman

MEASURED MODULATION WAVEFORM OF LEAKAGE RADIATION MICROWAVE OVENS. H. S. Ho, W. P. Edwards

MICROWAVE-INDUCED PRESSURE WAVES IN A MODEL OF BIOLOGICAL TISSUE. R. G. Olsen, W. C. Hammer

ELECTROMAGNETIC EXPOSURE EFFECTS ON THE VISUAL SYSTEM OF A FLYING INSECT. S. S. Sandler, W. Peros

RADIATION OF OPEN WAVEGUIDES APPLICATION TO BIOMEDICAL PROBES. J. Audet, J. Ch. Bolomey, Ch. Pichot

A CORRUGATED WAVEGUIDE APPLICATOR. Q. Balzano, O. Garay, C. H. Sutton

MEASURED INTERNAL ELECTRIC FIELD IN PHANTOM HUMAN HEADS EXPOSED TO LEAKAGE RADIATION FROM MICROWAVE OVENS. H. S. Ho, W. P. Edwards, H. Bassen

MEASUREMENTS OF ELECTOMAGNETIC ACTIVITIES OF THE HUMAN BODY IN THE FREQUENCY REGION 1 kHz-2 GHz. B. Enander, G. Larson

MICROWAVE DIATHERMY TREATMENT OF THE HUMAN THIGH: THE SIMULTANEOUS MEASUREMENT OF MUSCLE BLOOD FLOW (MBF) AND TEMPERATURE OF THE HUMAN THIGH DURING MICROWAVE DIATHERMY. K. M. Sekins, A. F. Emery, J. F. Lehmann, W. B. Nelp, D. Dundore

IMMUNOLOGIC ASPECTS IN CANCER TREATMENT BY MICROWAVE HYPERTHERMIA. W. Roszkowski, S. Szmigielski, M. Janiak

MICROWAVE EFFECTS ON ENERGY LEVELS OF BRAIN AND MALIGNANT BRAIN TUMOR. A. P. Sanders, D. J. Schaefer, W. T. Joines

ELECTRICAL STIMULATION OF ALVEOLAR BONE. D. B. Harrington, T. A. Chen, P. Mollica, F. Davis

IN VIVO STUDY OF 60 Hz ELECTRIC FIELD EFFECTS. D. M. Koltun, S. N. Ackerman, D. M. Weissfeld, J. M. Seto, Y. J. Seto

GROWTH OF RATS AND MICE EXPOSED TO 60 Hz ELECTRIC FIELDS. R. D. Phillips, J. H. Chandon, D. I. Hilton, R. L. Sheldon

EFFECTS OF EXPOSURE TO 60 Hz ELECTRIC FIELDS ON GROWTH AND DEVELOPMENT IN THE RAT. L. D. Montgomery, L. G. Smith, M. R. Sikov

CHRONIC EXPOSURE OF RATS TO 100-MHz (CW): ASSESSMENT OF BIOLOGICAL EFFECTS. R. J. Smialowicz, E. Berman, S. J. Bursian, J. B. Kinn, C. G. Liddle, L. W. Reiter, C. M. Weil

THE EFFECT OF PRENATAL MICROWAVE EXPOSURE ON THE DEVELOPMENT OF BEHAVIORAL RESPONSES IN THE MOUSE. J. C. Monahan

DEVELOPMENT ALTERATIONS IN RATS FOLLOWING IN VIVO EXPOSURE TO 500 $\mu W/cm^2$, 2450 MHz MICROWAVES. S. J. Mizumori, R. H. Lovely, R. R. Johnson, A. W. Guy

THE EFFECT ON THE HEART RATE OF EMBRYONIC QUAIL OF 2450 MHz ELECTROMAGNETIC WAVES. P. E. Hamrick, D. I. McRee

TERATOGENICITY OF 27.12 MHz RADIOFREQUENCY RADIATION IN RATS. J. M. Lary, D. L. Conover, E. D. Foley, P. L. Hanser

STUDIES CONCERNING THE EFFECTS OF NON-THERMAL PROTRACTED PRENATAL 2450 MHz MICROWAVE IRRADIATION ON PRENATAL AND POSTNATAL DEVELOPMENT IN THE RAT. R. P. Jensh, W. H. Vogel, J. Ludlow, T. McHugh, R. L. Brent

EXPOSURE OF PREGNANT MICE TO 2.45 GHz MICROWAVE RADIATION. D. I. McRee, P. Nawrot

TERATOGENIC EFFECTS OF RF RADIATION ON MICE. J. C. Nelson, J. C. Lin, M. E. Ekstrom

OBSERVATIONS OF RAT FETUSES AFTER IRRADIATION WITH 2.45 GHz (CW) MICROWAVES. E. Berman, H. B. Carter, D. House

TERATOLOGY IN RATS EXPOSED TO 2450 MHz MICROWAVES AT INTENSE AND INTERMEDIATE DOSE RATES. M. E. Chernovetz, D. Reeves, D. R. Justesen

XII INTERNATIONAL CONFERENCE ON MEDICAL AND BIOLOGICAL ENGINEERING/V INTERNATIONAL CONFERENCE ON MEDICAL PHYSICS

Date: August 19-24, 1979
Place: Jerusalem, Israel
Sponsor: Israel Society for Medical & Biological Engineering (ISMBE); International Federation for Medical & Biological Engineering (IFMBE); Internat'l Organization for Medical Physics (IOMP); Israel Society for Medical Physics (ISMP)
Requests for Information: Dr. A. Werner, Chaim Sheba Medical Center, Dept. Oncology, Sackler School of Medicine, Tel-Hashomer, Israel
Content: Tentative topics include artificial organs, biomaterials, biomechanics, clinical engineering, diagnostic radiology, hazards and safety, health physics, nonionizing radiation, medical instrumentation, and radiation dosimetry

NINTH EUROPEAN MICROWAVE CONFERENCE

Date: September 17-21, 1979
Place: Brighton, England: The Brighton Centre
Sponsor: The Institution of Electrical Engineers; Institution of Electronic and Radio Engineers
Requests for Information: Professor Peter Clarricoats, European Microwave Conference Chairman, Dept. Electrical & Electronic Engineering, Queen Mary Coll., Mile End Rd., London, E.1. 4NS, England
Content: Topics will include microwave technology and instrumentation

ENGINEERING IN MEDICINE AND BIOLOGY: 32nd Annual Conference

Date: October 6-10, 1979
Place: Denver, CO: Denver Hilton Hotel
Sponsor: Alliance for Engineering in Medicine and Biology (AEMB)
Requests for Information: Mrs. P. I. Horner, Administrative Director, Alliance for Engineering in Medicine and Biology, 4405 East-West Highway, Suite 404, Bethesda, MD 20014
Content: Topics will include bioelectric signals--EKG, EEG, EMG; biomaterials; biotelemetry; non-invasive diagnostic technology; biomedical transducers; mathematical models and simulation; microprocessors in biomedical applications; standards and regulations

WESTERN OCCUPATIONAL HEALTH CONFERENCE

Date: October 11-13, 1979
Place: San Francisco, CA: Fairmont Hotel
Sponsor: Western Occupational Medical Assoc. (WOMA); American Industrial Hygiene Assoc. (AIHA); Health Physics Society (HPS); American Society of Safety Engineers (ASSE); Western Assoc. Occupational Health Nurses (WAOHN)
Requests for Information: B. H. Bravinder, WOMA, Box 201, Alamo, CA 94507
Content: Topics will include Fundamentals and New Directions in Industrial Hygiene; Fundamentals of Radiation Safety; Magnetic Fields in New and Old Technologies and Their Potential Biomedical Effects

INTERNATIONAL RADIATION PROTECTION ASSOCIATION: SECOND ASIAN REGIONAL CONGRESS ON RADIATION PROTECTION

Date: November 19-23, 1979
Place: Manila, Philippines
Sponsor: Philippine Association for Radiation Protection; Japan Health Physics Society
Requests for Information: Dr. Celia T. Anatalio, Congress President, Director, Radiation Health Office, Ministry of Health, San Lazaro Compound, Rizal Avenue, Sta. Cruz, Manila, Philippines
Content: Topics will include environmental radiation hazards and protection, medical radiation hazards and protection, nuclear power and irradiation facilities, dosimetry, public education and acceptance, research and new developments in radiation protection, regulations, codes and standards, nonionizing radiation, special topics on radiation protection, and health physics training and manpower development

RADIOLOGICAL SOCIETY OF NORTH AMERICA: Annual Meeting

Date: November 25-30, 1979
Place: Atlanta, GA
Sponsor: Radiological Society of North America (RSNA)
Requests for Information: Ms. A. Swenson, RSNA, Suite 1150, Oak Brook Regency Towers, 1415 W. 22nd St., Oak Brook, IL 60521
Content: Topics will include diagnostic radiology, therapeutic radiology, nuclear medicine, ultrasound, pediatric radiology, neuroradiology, physics, cardiovascular radiology, and radiobiology

INTERNATIONAL RADIATION PROTECTION ASSOCIATION:

Fifth International Congress

Date: March 9-14, 1980
Place: Jerusalem, Israel: Jerusalem Convention Center
Sponsor: Israel Health Physics Society; Internat'l Radiation Protection Assoc. (IRPA)
Requests for Information: Israel Health Physics Society, c/o Soreq Nuclear Research Center, Yavne 70600, Israel
Content: Sessions will cover all aspects of protection against ionizing and nonionizing radiation

0439 QUANTIFICATION AND MEASUREMENT OF INTERNAL ELECTROMAGNETIC FIELDS INDUCED IN FINITE BIOLOGICAL BODIES BY NONUNIFORM ELECTROMAGNETIC FIELDS. Chen, K. (Michigan State Univ., Sch. Engineering, Dept. Electrical Engineering & Systems Science, Engineering Building, East Lansing, MI 48824).

A theoretic basis will be developed for quantification and measurement of internal electromagnetic fields induced in finite biologic bodies by nonuniform electromagnetic fields. Experimental confirmation will be sought by use of implantable probes in simulated models. A theoretic study of implanted probes and their response within the medium will be made. The Army is using electromagnetic radiation to provide communication links; to probe the battle environment for enemy presence, equipment, and activities; to control defensive ordnance; and to control guidance of ordnance. Individual and cumulative levels of these radiated energies are becoming a considerable concern because of their effects on the natural environment and on man. The theoretic method will be tested on numeric solution of a tensor integral equation quantifying the internal electromagnetic field induced in a finite, heterogeneous biologic body by an incident, non-uniform electromagnetic field. In this method the body is subdivided into a selected number of small sub-volumes, and the individual electric properties determined. Measurements with sample probes immersed in various simulant media will determine parameters for testing the theoretic derivations of probe interactions. (funding period 4/76-n/a)

Supporting Agency:U.S. Dept. Defense: Army, Army Material Development & Readiness Command, Army Res. Office

0440 TERATOGENIC STUDY OF MICROWAVE RADIATION IN MICE. Staples, R. E.; McRee, D.; Nawrot, P. S. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Inst. Environmental Health Sciences, Lab. Environmental Toxicology, P.O. Box 12233, Research Triangle Park, NC 27709).

Groups of pregnant Charles River CD1 mice are being exposed to 5, 21, and 30 mW/cm^2 of constant or pulsed electromagnetic radiation at 2,450 MHz from days 1 through 6 or days 6 through 15 of gestation. All mice will be autopsied at day 18 of gestation and fetuses will be examined for gross external, visceral, and skeletal changes. (funding period 00/79-n/a)

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

0441 BIOLOGICAL INTERACTIONS WITH AND HAZARDS OF MICROWAVE RADIATION. Larsen, L. E.; Jacobi, J. H. (U.S. Dept. Defense: Army, Medical Res. & Development Command, Neuropsychiatry Div., Washington, DC 20012).

In order to protect the health and effectiveness of military units and affected civilian populations in microwave and radio frequency environments, system developers and agencies responsible for safety standards will provide technical information to the surgeon general. This requires an analysis of the biophysics and bioeffects attributable to nonionizing radiation under laboratory conditions that reasonably simulate operational exposures. Basic and applied research on the problem of microwave and radio frequency interactions will be performed at all levels of analysis from the cellular and molecular to metazoan physiology, pathophysiology, and behavior. This requires (1) development of measurement systems for dosimetric analysis ex vacuo, in vitro, and in situ; (2) evaluation of frequency, power level, polarization and modulation as important parameters of the radiation; and (3) use of low level energy to assess the functional state of cells and tissues. (funding period 7/71-cont.)

Supporting Agency:U.S. Dept. Defense: Army, Medical Res. & Development Command, Walter Reed Army Inst. Res.

0442 NEUROBEHAVIORAL TOXICITY OF DEVELOPMENTAL EXPOSURE OF JAPANESE QUAIL TO MICROWAVE IRRADIATION. Tilson, H. A.; McRee, D. I.; Mitchell, C. L. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Inst. Environmental Health Sciences, Behavioral Toxicology Group Section, P.O. Box 12233, Research Triangle Park, NC 27709).

The long-term neurobehavioral effects of perinatal exposure of Japanese Quail eggs (*Coturnix coturnix iaponica*) to 2,450 MHz continuous wave microwave irradiation at a power density of 5 mW/cm^2 for the first 12 days of development will be assessed. Sexual and reproductive behaviors, a battery of behavioral and neurologic measurements, learning and retention, and baseline performance on an operant schedule will be evaluated. (funding period 10/77-9/78)

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

0443 TUMOR RADIOCHEMOTHERAPY: EFFECTS OF ULTRASOUND AND HEAT. Hahn, G. M.; Marmor, J. B. (Stanford Univ., Sch. Medicine, Dept. Radiology, Stanford, CA 94305).

The interaction of x-irradiation and chemotherapy with hyperthermia generated by ultrasound and microwaves in effecting tumor cures in laboratory animals will be investigated. Specifically, the effects of ultrasound and microwaves in cells will be examined in vitro and in vivo at temperatures above 37 C. Combined treatments of x-irradiation (or chemotherapy) and ultrasound- and microwave-induced hyperthermia will be quantitated in tissue culture systems and in experimental tumors. Both cell survival studies of EMT-6 tumors as well as tumor cure experiments with EMT-6 and other tumors will be performed. Combinations that prove promising

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will be examined for possible clinical applications. Equipment to carry out laboratory, and eventually clinical studies, will be developed. (funding period 12/77-11/79)

Supporting Agency:HEW, PHS, NIH, NCI

0444 NAVY ENVIRONMENT: MECHANISMS OF MICROWAVE-INDUCED BLOOD-BRAIN BARRIER ALTERATIONS. Lin, J. C.; Noonan, S. M. (Wayne State Univ., Sch. Engineering, 5950 Cass Ave., Detroit, MI 48202).

Microwave fields, such as those emitted by radar equipment, have been shown to alter the blood-brain barrier system in rats. At this time, the mechanisms of this alteration are not known. The objective of this research is to determine the possible interaction mechanisms with the use of biochemical and biophysical analyses. The first phase of this study will be directed toward the biophysical aspects of absorbed energy inside the rat brain. Emphasis will be placed on any direct correlation between absorbed energy and observed alteration in permeability. The second phase will deal with the implications of pulsed microwave-induced thermoelastic displacement of, and stress in, the brain tissue. In addition, any physical manifestations of change as might be seen by electron microscopy of the specific regions of the brain that show permeability changes will be investigated. (funding period 4/78-cont.)

Supporting Agency:U.S. Dept. Defense: Navy, Office Naval Res.

0445 THE EFFECT OF MICROWAVE RADIATION ON THE HEART OF EMBRYONIC QUAIL. Hamrick, P. E.; McRee, D. I. (U.S. Dept. HEW, Public Health Service, NIH, Natl. Inst. Environmental Health Sciences, Microwave Res. Section, P.O. Box 12233, Research Triangle Park, NC 27709).

This project will determine if and how microwave radiation interacts with the embryonic quail heart or causes a change in heart rate. If a heart rate effect is found, the change in heart rate as a function of absorbed microwave energy will be studied. Changes in heart rate due to temperature changes will be controlled. (funding period 10/77-9/78)

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

0446 EFFECTS OF 2450 MHz MICROWAVE RADIATION ON BIOLOGICAL MATERIALS AT CELLULAR LEVEL. Hamrick, P. E.; McRee, D. I. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Environmental Health Sciences, Microwave Res. Section, P.O. Box 12233, Research Triangle Park, NC 27709).

The objectives of this project were to determine how 2,450 MHz microwave radiation interacts with biologic material at the cellular and macromolecular level, to observe any effects of this interaction, and to relate the amount of microwave energy absorbed to the effects. Biologic systems employed in the study were: bacteria and bacteriophage, solutions of DNA, 2-4 cell stage embryos from mice, rabbit erythrocytes, and rat lymphocytes. The temperature, humidity, and other growth conditions were carefully monitored to eliminate any effects not intrinsically caused by the microwave radiation. Very few nonthermal differences between exposed and control samples were detected. (funding period 10/76-9/78)

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

0447 PHYSICAL SCIENCE COLLABORATIVE RESEARCH. Atkinson, E. R.; Kim, Y. W.; Mahendroo, P.; Bull, J. M.; Vanecho, D. A. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Cancer Inst., 9000 Rockville Pike, Bethesda, MD 20014).

Physical science collaboration is being conducted in automated tissue culture colony counting, millimeter wave spectroscopy of tumor cells, whole body hyperthermia patient treatment, whole body hyperthermia animal studies, toxicity of chemotherapeutic agents at elevated temperatures, nonthermal effects of microwaves, precision measurement of size of biologic objects, mass spectroscopy of biopolymers and unnatural isotopes, nuclear magnetic resonance of membrane specific proteins, human thermoregulation, receptor site tertiary structure by electron spin resonance, dielectric properties of normal and tumor tissues, pion production at low energies in the laboratory frame, tissue sensitizers for ionizing radiation, microwave imaging techniques, ultrasonic temperature measurement, liquid crystal effects in biologic materials, optical and viscometric techniques for temperature measurement, and actin and myosin mechanics. (funding period 10/76-9/78)

Supporting Agency:HEW, PHS, NIH, NCI

0448 MICROWAVE EXPOSURE SYSTEMS AND MICROWAVE DOSIMETRY. McRee, D. I. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Inst. Environmental Health Sciences, Microwave Res. Section, P.O. Box 12233, Research Triangle Park, NC 27709).

Exposure systems for bioeffects research and test techniques for measuring energy absorption are being developed. The waveguide system for exposing isolated neurons to 2,450 MHz microwave radiation has been modified so that longer survival times and constant temperatures of the nerves during exposure can be achieved. Small thermistor probes have been used to measure deep colonic temperatures in pregnant mice during exposures to 2,450 MHz microwave radiation. Using the temperature profiles measured in the dead animals to calculate average absorption rates, the results agreed well with both calculated and measured whole-body absorption reported in the literature. A system for exposing groups of marine animals to different intensity levels simultaneously

without significant perturbation of the microwave field by the location and orientation of the animals has been developed and tested. (funding period 10/76-9/78)

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

0449 EFFECTS OF MICROWAVES ON NEURAL RESPONSE. McRee, D. I.; Wachtel, H. (U.S. Dept. HEW, Public Health Service, NIH, Natl. Inst. Environmental Health Sciences, Microwave Res. Section, P.O. Box 12233, Research Triangle Park, NC 27709).

The effect of microwave radiation on neurologic response will be determined. Isolated neurons, such as, the abdominal ganglion of *Aplysia*, the sciatic nerves of frogs, and the saphenous nerves of cats will be exposed to continuous wave, pulsed, and modulated microwave radiation in the power density range of 1-10 mW/cm^2. The effects of the radiation on the strength-duration of a stimulus to produce an action potential, amplitude of the response, and conduction velocity will be investigated. Fatigue and recovery of the neurons under rapid, multiple stimulation will also be studied. A series of experiments to determine if continuous wave, 2,450 MHz microwave radiation increases the fatigue rate or changes the vitality of the frog sciatic nerve were completed. The frog sciatic nerves were exposed in a waveguide to specific absorption rates of 100, 50, and 20 W/kg. The nerves were stimulated with twin pulses (separated by 5-msec intervals) at a repetition rate of 500 pulses/sec to accelerate the rundown time. Distinct changes in the excitability and refractoriness of the exposed nerve were seen in comparison to the control nerve. The vitality of the nerve was affected and was greater for the higher dose rates. (funding period 10/76-9/78)

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

0450 TISSUE INTERACTIONS WITH NONIONIZING ELECTROMAGNETIC FIELDS. Adey, W. R.; Bawin, S. M.; Sheppard, A. R.; Sagan, P. M.; Bishop, D. F. (U.S. Veterans Admin. Hosp., Dept. Medicine & Surgery, 11201 Benton St., Loma Linda, CA 92357).

The biologic effects of environmental electromagnetic (EM) fields at extra low frequencies, very high frequencies, and microwave frequencies will be studied with special reference to interactions with the central nervous system. A multifaceted research program will examine (1) molecular biology of cell membrane surfaces and macromolecular mechanisms in weak electric field transduction; (2) microphysiology of cellular responses to EM field exposure, performed on special brain tissue preparations, invertebrate ganglion cells, bone cell cultures, and red and white blood cell elements; (3) behavior and correlated biochemistry of chicks, rats, cats, and monkeys, with observations on free and learned behavior, and on biologic rhythms; and (4) biophysical models of macromolecular transductive coupling of natural and imposed weak EM fields. (funding period 10/78-n/a)

Supporting Agency:U.S. Veterans Admin., Dept. Medicine & Surgery

0451 DETERMINATION OF TIME-DOSE MICROWAVE RADIATION TO INACTIVATE *B. ANTHRACIS* SPORES IN BONE MEAL. Whitford, H. W.; Newton, R. W. (Texas A & M Univ., College Station Campus, Sch. Veterinary Medicine, College Station, TX 77843).

The time and intensity of microwave radiation required to inactivate *B. anthracis* spores suspended in bone meal will be determined. Researchers will (1) determine the time/heat responses of bone meal at different microwave intensities; (2) inoculate bone meal with *B. anthracis* (Sterne strain) spores; (3) expose bone meal-spore mixture at different microwave intensities for varying periods of time; (4) rehydrate bone meal with medium and determine presence or absence of viable spores; and (5) calculate the time-dose of microwave required to inactivate spores. (funding period 5/77-1/79)

Supporting Agency:Texas A & M Univ. System

0452 EFFECTS OF LONG AND SHORT TERM EXPOSURE TO EMR ON SPECIFIC LEARNED BEHAVIOR OF ANIMALS. Gage, M. I. (EPA, Office of Res. & Development, Health Effects Res. Lab., Research Triangle Park, NC 27711).

The lowest levels of microwave exposure needed to alter the ability of rodents and primates to learn, remember, and perform specific behavioral tasks will be determined. Conditions of electromagnetic radiation exposure that alter behavioral performance and changes in conditions of exposure that alter the effects of specific power densities of radiation on behavior also will be determined. Learning and previously trained operant behavior in rodents and monkeys will be measured, and performance after single exposures or during the course of chronic exposures will be compared with baseline behavior. Current work has shown that increased ambient temperature exacerbates the effect of a given power density of microwaves on behavior of rats. The next phase will be to repeat these experiments with monkeys. (funding period 10/77-10/81)

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

0453 NONLINEAR INTERACTIONS OF ELECTROMAGNETIC WAVES WITH BIOLOGIC MEMBRANES. Barnes, F. S.; Hu, C. J.; Igor, G. R.; Bottger, B. (Univ. Colorado, Boulder Campus, Sch. Engineering & Applied Science, 1200 University Ave., Boulder, CO 80302).

The nonlinear interaction of electromagnetic (EM) waves with biologic membranes will be examined in addition to the effect of EM fields on the alignment of long chain molecules in the presence of cells. Theoretic calculations indicate that there should

be a small direct current component associated with the application of microwave and radio frequency fields that in turn would lead to an imbalance in the charged particle concentrations across the membrane. The size of this coefficient will be measured. The effect of electric fields on the orientation of long chain molecules can be observed with the use of birefringence and polarized light. This effect has been observed in plasma and, in this study, the effect will be sought in cell cultures. (funding period 9/78-8/79)

Supporting Agency:HEW, PHS, FDA

0454 HYPERTHERMIA PRODUCTION AND MEASUREMENT IN TISSUES. Christensen, D. A.; Johnson, C. C.; Durney, C. H.; Iskander, M. F.; Plenk, H. P. (Utah Higher Education System, Univ. Utah, Sch. Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

Hyperthermia for cancer therapy will be generated in tissues using prototype 915 MHz microwave applicators. New applicators will be designed and fabricated at lower frequencies for better tissue penetration. A temperature profile control system will be developed and evaluated using surface cooling and microwave power control loops. In situ temperature measurements will be made by nonperturbing GaAs semiconductor fiberoptic probes. Demonstration tests of the hyperthermia system will be performed in animals to demonstrate its therapeutic potential. (funding period 9/78-8/79)

Supporting Agency:HEW, PHS, NIH, NCI

0455 EFFECTS OF 2450 MHz MICROWAVES ON THE EMBRYONIC DEVELOPMENT, IMMUNOLOGY AND FERTILITY OF JAPANESE QUAIL. McRee, D. I.; Thaxton, J. P.; Parkhurst, C. R. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Inst. Environmental Health Sciences, Microwave Res. Section, P.O. Box 12233, Research Triangle Park, NC 27709).

The effects of microwave radiation on the embryonic development, immunology, and fertility of mature quail, which were exposed during development, are being investigated. Fertilized Japanese quail eggs were exposed to 2,450 MHz microwave radiation at an incident power density of 5 mW/cm^2 for the first 12 days of embryogenesis. The eggs were then transferred to a regular hatching incubator until hatch (17 days). Control eggs were treated identically except for the microwave exposure. No differences were found in the hatchability or development in the controls and exposed quail. The quail were then placed in regular feeding and housing facilities and were not exposed to any microwave radiation after hatch. Reproductive performance in the quail was monitored from 6 through 22 wk of age. Nonexposed controls of both sexes, as well as exposed females, performed normally. However, the exposed males did not. It was found that there were reduced sperm numbers, reduced sperm motility, and a decreased percentage of fertile eggs produced by control or exposed females when paired with exposed males. Mating behavior was normal in both exposed and nonexposed males. (funding period 10/76-9/78)

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

0456 EFFECTS OF CHRONIC EXPOSURE TO EMR ON IMMUNE DEFENSE MECHANISMS OF ANIMALS. Smialowicz, R. J. (EPA, Health Effects Res. Lab., Durham, NC 27711).

Rats will be exposed to 100-MHz continuous wave (CW) microwave radiation in utero and/or through early life to determine whether long-term exposure causes changes in lymphocyte function. The effect of 915 MHz on the immune function of exposed rats also will be determined. Rats will be exposed daily to a forward power of 500 W at 100 MHz (CW) under controlled, environmental conditions, throughout gestation and early post-natal life. Adult rats will be exposed for at least 20 hr/day to 915 MHz for 1-2 mo. Hematologic and immunologic indices will be measured and compared between sham- and microwave-exposed rats. Complete blood counts, enumeration of frequencies of B- and T-lymphocytes in lymph nodes, nitrogen-stimulated lymphocyte responses, and growth rates in rats will be compared. Rats are presently being exposed to 100 MHz in a chronic study. These rats were exposed in utero and will be exposed through 90 days of age. Data from rats sacrificed at 22 and 42 days of age showed no differences in the hematologic and immunologic indices measured between sham- and microwave-exposed rats. Exposure of rats to 915 MHz will begin in a few months. (funding period 3/78-3/79)

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

0457 EFFECTS OF MICROWAVES ON SISTER CHROMATID EXCHANGE IN BONE MARROW CELLS OF MICE. McRee, D. I.; Livingston, G. (U.S. Dept. HEW, Public Health Service, Natl. Inst. Health, Natl. Inst. Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, NC 27709).

The effects of whole body irradiation of the mouse on the number of sister chromatid exchanges (SCE) in bone marrow cells were investigated. The measurement of SCE constitutes the most sensitive indicator yet developed for detecting cytogenetic effects of mutagens and carcinogens. This assay was used to investigate potential mutagenic bioeffects of 2,450 MHz continuous wave microwave radiation by comparing the incidence of SCE in bone marrow cells of 12 exposed mice, 12 sham controls, and 12 standard controls. The animals were exposed from above for 8 hr/day to an incident power density of 20 mW/cm^2 (specific absorption rate determined to be 15.4 mW/g) for 28 days. Results after scoring more than 300 cells showed that the incidence of SCE's in the exposed group was not significantly different from that of the unexposed controls. The

value was approximately 3.0 exchanges per cell. (funding period 10/77-9/78)

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

0458 REMOTE STIMULATION BY RADIO-FREQUENCY TRANSMISSION. Glenn, W. W.; Gee, J. B.; Allison, T.; Goff, W. R.; Lange, R. C. (Yale Univ., Sch. Medicine, Dept. Surgery, 333 Cedar St., New Haven, CT 06510).

A method of long-term stimulation of the phrenic nerve will be developed specifically for the treatment of chronic ventilatory insufficiency. Clinical studies will include monitoring the electronic apparatus and the stimulation of the nerves by evaluating pulmonary function, nerve conduction, and diaphragm function. Of particular interest are those patients who exhibit upper airway obstruction combined with central alveolar hypoventilation. Stimulation parameters will be varied first in experimental animals and then in patients to minimize as much as possible the current delivered to the phrenic nerve and still provide adequate ventilation. Stimulation parameters will include current level, wave form, pulse interval, respiratory rate, and electrode design. Other studies will include the completion of a prototype totally implantable diaphragm pacemaker unit for patients. (funding period 1/78-12/79)

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

0459 X-RAY AND MICROWAVE HYPERTHERMIA FOR CANCER TREATMENT. Robinson, J. E.; Cheung, A. Y.; Samaras, G. M.; Harrison, G. H.; Sjodin, R. S. (Univ. Maryland, Baltimore Professional Sch., Sch. Medicine, Dept. Radiology, 1420 N. Charles St., Baltimore, MD 21201).

Researchers will design, construct, and test a system for simultaneously irradiating cell cultures with microwaves and x-radiation at pre-selected and controlled elevated temperatures between 37.5 and 45 C. Using this system, cells will be subjected to a range of microwave power levels at carefully controlled temperatures; the microwave power levels will range from a few mW/cm^2 to powers high enough to produce massive thermal cell killing in exposure times less than 1 min. Using cell survival and cell membrane damage as primary criteria, it will be determined whether the effects of microwave hyperthermia are different from water bath heating, and whether hyperthermia produced by pulsed microwave sources yields significantly different effects from those caused by continuous wave microwave sources operating at the same average power levels. It will also be determined whether there are significant differences between the effects of simultaneous x-irradiation and water bath heating, and simultaneous x-irradiation and microwave-induced hyperthermia. It is essential to determine the effects of strong electromagnetic fields (high microwave power) at elevated temperatures, since short exposures at high instantaneous power levels are being used to develop shaped thermal fields for hyperthermal treatment of cancer patients. (funding period 9/78-8/79)

Supporting Agency:HEW, PHS, NIH, NCI

0460 BEHAVIORAL AND BIOLOGICAL EFFECTS OF RESONANT ELECTROMAGNETIC POWER ABSORPTION IN RATS. Gandhi, O. P. (Utah Higher Education System, Univ. Utah, Sch. Engineering, Dept. Electrical Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

The behavioral and biologic effects of resonant electromagnetic power absorption in rats will be determined in order to develop realistic exposure criteria for military personnel. The parallel-plate waveguide will be used to generate plane waves for exposure of the experimental animals. Exposures will be made with animals oriented along the E, H, and K axes. Frequency will be established based on the frequency of peak absorption; frequencies of 0.5, 0.75, 1.0, 1.25, and 1.5 times this resonant frequency will be used. (funding period 5/74-n/a)

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

0461 INTERACTION OF DNA DOUBLE HELIX WITH E.M. FIELDS. Prohofsky, E. W.; Van Zandt, L. L.; Ascarelli, G. (Purdue Univ. Sch. Science, Dept. Physics, Executive Building, West Lafayette, IN 47907).

The interaction of DNA double helices with an electromagnetic field will be calculated. An effective charge model calculation, which should be a reasonable approximation for both far infrared and microwave regions, will be employed. The models will be refined by comparison with infrared absorption observations. The refined model will be used to predict microwave absorption. Comparison of these predictions with observed microwave effects will be carried out and correlations examined. Methods will be explored to determine the mechanism by which microwave action on vibrational modes can affect biologic processes. (funding period 9/78-8/79)

Supporting Agency:HEW, PHS, FDA

0462 IDENTIFICATION OF PERIPHERAL AND CENTRAL RECEPTORS MEDIATING THE EFFECTS OF MICROWAVE RADIATION ON THE BRAIN. Wilson, B. (Res. Triangle Inst., P.O. Box 12194, Durham, NC 27709).

One of the primary reported effects of microwave radiation is on the central nervous system. Basic studies to determine the interaction mechanisms are required. Recent findings have covered some deficits in the present understanding of the mechanisms of effects of microwave radiation on the activity of

the auditory system. Specifically, the thermo-acoustic expansion pulse hypothesis cannot account for the observed effect of pulsed microwave radiation on auditory nerve resulting from direct stimulation of cochlear hair cells. One set of experiments proposed is designed to elucidate the mechanisms of these effects of microwave radiation on auditory activity. Recordings of response of single units in auditory nerve and cochlear nucleus to microwave and acoustic stimuli will be used as the primary method for the first set of experiments. The ^{14}C-labeled 2-deoxyglucose method will also be used in some instances, however, to corroborate and complement the results obtained with the electrophysiologic method. An additional set of experiments is proposed to detect effects of nonionizing radiation on the activity of brain structures other than nuclei of the auditory system. For these experiments, the ^{14}C-labeled 2-deoxyglucose method will be used. Because the method allows for simultaneous, in vivo determination of glucose consumption at individual structures of the brain, effects on the activity of nuclei in sensory systems resulting from stimulation of peripheral receptors can be identified and separated from pervasive effects on brain activity resulting from radiation-induced shifts in the environment of central neurons. Possible effects on brain activity resulting from stimulation of vestibular and hypothalamic receptors will be evaluated, as will possible effects resulting from radiation-induced alterations in the permeability of the blood-brain barrier and in the binding of calcium ions in cerebral tissue. (funding period 00/78-n/a)

Supporting Agency:EPA, Office Energy Minerals & Industry

0463 EFFECT OF ENVIRONMENTAL AGENTS ON ONTOGENESIS AFTER PARENTAL EXPOSURE. Staples, R. E.; Cook, R. O.; McRee, D. I.; Nawrot, P. S. (U.S. Dept. HEW, Public Health Service, NIH, Natl. Inst. Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, NC 27709).

This project will determine the developmental toxicity and teratogenic potential of selected environmental agents on mammals by application of the test agents to the parent(s) before mating or to the dam during gestation. Studies will employ various types of noise up to 130 dB, microwaves, and solvents. (funding period 10/76-9/78)

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

0464 BIOPSYCHOLOGICAL STUDIES OF MICROWAVE RADIATION. Justesen, D. R.; Levinson, D. M. (Univ. Kansas Medical Center, Dept. Psychiatry, Sch. Medicine, 39th St. & Rainbow Blvd., Kansas City, KS 66103).

In progress is a behavioral-developmental-longevity study of C3H mice that were sham radiated or microwave radiated in utero (three exposures between days 9 through 15 of gestation: 2.45 GHz at 60-Hz sine modulation, 43-mW/g whole-body dose rate for 20 min in a multimode cavity; dams' $LD_{\%}$ = 10). The following observations have been made: (1) mortality of radiated pups of surviving dams was higher than that of controls, but there is little difference to date in death rates of weaned animals; and (2) indices of development (e.g., eye-opening, latency, growth of pelt, body mass) have been essentially the same for radiated and control animals. Future research will consider differences, if any, in longevity of animals and rate of development of spontaneous tumors in this mammary-tumor-prone strain of mouse. (funding period 9/77-8/79)

Supporting Agency:HEW, PHS, FDA, BRH

0465 IONIZING AND NON-IONIZING RADIATION BIOLOGY. Appleby, A. (Rutgers State Univ., New Brunswick Campus, Dept. Environmental Science, Agricultural Experiment Station, Old Queens Building, New Brunswick, NJ 08903).

The investigators will evaluate the effect of chronic low level microwave exposures on the mammalian anterior lens as they relate to cataract formation at various age levels. Fundamental data will be obtained relevant to the understanding of the chemical and biological processes involved in the interaction of radiation with organisms. The results will be used to develop practical means to inhibit, neutalize, or reverse the biologic damage caused by radiation. The mitotic index of chosen mammalian species of different age groups will be measured after various exposure periods, using a tritiated thymidine-autoradiographic technique, followed by observing cataract producing doses. The relative radiation sensitivity of experimental animals (e.g., rats) with or without treatment by radiated gas will be determined by standard procedures. Preliminary results on the test animals showed no significant changes in thyroid function following single or multiple exposures at various power levels. (funding period 7/71-6/81)

Supporting Agency:New Jersey State Government

0466 EFFECTS OF MICROWAVE IRRADIATION ON EMBRYONIC BRAIN TISSUE. Rioch, D. M. (Inst. Behavioral Res., Inc., 2429 Linden Lane, Silver Spring, MD 20910).

See Current Research 0418 for description of this research. (funding period 4/77-cont.)

Supporting Agency:U.S. Dept. Defense: Army, Medical Res. & Development Command, Environmental Protection Res. Div.

0467 EVALUATION OF MICROWAVE OVENS AS A POTENTIAL METHOD OF STERILIZATION. Lyon, T. C.; Brunner, D. (U.S. Dept. Defense, Army, Medical Res. & Development Command, Preventive Dentistry Div., Washington, DC 20012).

See Current Research 0415 for description of this research. (funding period 6/78-6/79)

Supporting Agency:U.S. Dept. Defense: Army, Medical Res. & Development Command, Inst. Dental Res.

0468 MINIATURE OMNI-DIRECTIONAL RF MONITOR PROBE. Ireland, W. C. (Westinghouse Electric Corp., P.O. Box 746, Baltimore, MD 21203).

See Current Research 0412 for description of this research. (funding period 4/77-n/a)

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

0469 NON-IONIZING, ELECTROMAGNETIC RADIATION--INFLUENCE ON CANCER CELLS. Riley, V. (Pacific Northwest Res. Foundation, Dept. Microbiology, 1102 Columbia St., Seattle, WA 98104).

No descriptive information is available. (funding period 12/78-11/79)

Supporting Agency:American Cancer Soc., Inc.

6022 DIELECTRIC BEHAVIOUR OF BIOLOGICAL MOLECULES IN SOLUTION. *(Eng.)* Grant, E. H.; Sheppard, R. J.; South, G. P. (Oxford: Oxford Univ. Press): 237 pp.; 1978. (353 refs)

A monograph on the dielectric behavior of biologic molecules in solution is presented. The book is divided into six chapters covering the following general subject areas: the role of dielectric studies in biophysics; dielectric theory; the measurement of permittivity; an analysis of experimental results; water and small biologic molecules; and proteins and larger structures. The book contains an extensive bibliography and is indexed by both author and subject. An example of how the knowledge of the dielectric properties of tissue can be used to evaluate the possibility of solving problems of biologic or medical importance is illustrated in connection with the use of microwaves and radiowaves for producing heat in tissues in the treatment of various diseases. The energy absorbed by a given tissue depends on the permittivity and conductivity at the frequency of radiation being used. If these electrical parameters are known, it is possible to build a phantom body of the appropriate shape to measure the isopower lines and hence evaluate the distribution in temperature throughout the medium. In connection with the use of radiowave- and microwave-induced hyperthermia for the treatment of malignant disease, there are reasons for believing that the dielectric behavior of normal and malignant cells may be sufficiently different to be optimistic about this therapeutic approach. Although a considerable amount of work will have to be done before the precise differences between the water structure in normal and malignant cells are understood, the method of external beam hyperthermia offers encouraging possibilities in the treatment of cancer. Studies of the dielectric properties of molecules and tissues are also important in relation to hazards of microwave radiation. For example, one form of biologic damage that can be caused by microwaves of appropriate intensity is cataract. The lens of the eye is vulnerable to microwave injury partly because of its poor blood supply resulting in fewer paths for heat transfer. It is also significant that the lens has a higher proportion of water, both free and bound, which causes the energy to be readily dissipated in the first place. It is suggested that future progress of dielectric methods in biophysics will depend on the ability to devise methods that measure rapidly the permittivity and conductivity of conductive solutions over a wide frequency range and on the understanding of the local structure of the region surrounding a biologic molecule in solution.

6023 HEALTH ASPECTS OF RADIO FREQUENCY AND MICROWAVE EXPOSURE: PART 2. *(Eng.)* Stuchly, M. A. (Radiation Protection Bureau, Health and Welfare Canada, Ottawa, Canada). 107 pp.; 1978. [available through Information Directorate, Dept. of Natl. Health and Welfare, Brooke Claxton Building, Ottawa K1A 0K9, Canada. Environmental Health Criteria Document No. 78-EHD-22]. (313 refs)

A comprehensive review of the health implications of exposure to radio frequency and microwave radiation in the frequency range of 10 MHz-300 GHz is presented. The biologic effects of such radiation are discussed in terms of human perception, hyperthermia, ocular effects, cellular effects, hematologic and immunologic effects, reproductive and developmental effects, cardiovascular effects, neuroendocrinologic effects, nervous system and behavioral effects, excitable cell systems, and the blood-brain barrier system. Epidemiologic and clinical studies on the effects of microwave and radio frequency radiation are also reviewed along with the setting of radiation protection standards. Major difficulties in assessing potential health hazards of human exposure to radio frequency and microwave radiation and in quantifying the results of the experiments with animals stem from the complex relationship between the exposure conditions and absorbed energy. Reliable methods of measuring the energy dose routinely do not exist. There appears to be a strong consensus among scientists that the great majority of the effects of exposure to radio frequency and microwave radiation is thermal in nature. Two new interesting effects investigated in the last few years, which may lead to establishing interaction mechanisms and a better understanding of observed effects, are changes in efflux of calcium ions and blood-brain barrier permeability. Calcium ion efflux through brain membranes is affected by extremely low frequency fields (6-20 Hz) or radio frequency fields that are amplitude modulated at these frequencies. Changes in the permeability of the blood-brain barrier have been observed at relatively low power density levels (about 10 mW/cm^2) at frequencies close to the resonant frequency of the rat. Further progress has been made in obtaining quantitative data on the effects of exposure to fields at relatively low average power densities (about 10 mW/cm^2) on the neuroendocrine and central nervous system of small animals and on fetal development following irradiation during critical stages of gestation.

6024 RETARDED TUMOR GROWTH AND GREATER LONGEVITY IN MICE AFTER FETAL IRRADIATION BY 2450-MHZ MICROWAVES. *(Eng.)* Preskorn, S. H. (Dept. Psychiatry, Univ. Kansas Sch. Medicine, Kansas City, KS 66103); Edwards, W. D.; Justesen, D. R. *J Surg Oncol* 10(6): 483-492; 1978. (36 refs)

The effect of fetal irradiation by 2,450-MHz microwaves on tumor growth in conventional CFW strain mice was studied in two separate experiments. In the first study, 48 mice were given four in utero treatments for 20 min/day with either sham radiation or with 2,450 MHz microwaves at a dose of 35 mW/g during days 11-14 of gestation. On day 16 postpartum, all of these mice were implanted with a homogenate of a lymphoreticular cell sarcoma. Commencing on day 19, they underwent a series of 36 daily exposures to the sham or microwave radiation. Fetal exposure to radiation, which elevated dams' colonic temperatures by an average of 2.24 C, was associated with a 13% incidence of tumors

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compared with a 46% incidence for fetally sham-irradiated mice. In a second experiment, all microwave-induced hyperthermal treatments were administered in utero; 84 CFW mice were given four radiation treatments in utero (35 mW/g for 20 min) on days 11-14 of gestation, and 60 mice were sham-irradiated in utero according to the same schedule. All of these mice were implanted with tumor homogenate on day 16 postpartum and were observed for 36 mo. At 2.5 mo after tumor implantation, the percentage of fetally irradiated mice with tumors was 15% compared with 37% for sham-irradiated controls. Subsequently, the difference narrowed; after the 4th mo, the final percentage of fetally irradiated mice with tumors (46%) exceeded that of controls (40%) slightly. Both tumor-bearing and tumor-free animals that had been irradiated as fetuses lived longer on the average than respective controls. Long-term augmentation of immunocompetency by in utero hyperthermia was believed to be responsible for the delayed induction of tumors and for the enhancement of survival.

6025 POTENTIAL TEMPERATURE RISE INDUCED BY ELECTROMAGNETIC FIELD IN BRAIN TISSUES. *(Eng.)* Kritikos, H. N. (Dept. Bioengineering, Univ. Pennsylvania, Philadelphia, PA 19174); Schwan, H. P. *IEEE Trans Biomed Eng* BME-26(1): 29-34; 1979. (12 refs)

The differential temperature rise induced by a 1,000-MHz electromagnetic field in a spherical region simulating a potential hot spot in the central region of a human head was determined, taking into account heat conduction and heat convection due to blood flow. For a heat deposition rate of 10 mW/g in a hot spot of 1 cm in radius, the differential temperature rise over the ambient tissues and blood was approximately 0.5 C. This was an interesting result considering that the heating potential in the hot spot region was larger than that occurring at the surface of the test object by a factor of 10-15. The reason for this relatively small temperature rise was the effect of blood circulation, which tends to wash out the temperature differences. The case under consideration involved an energy deposition of 10 mW/cm^3 in the hot spot, which corresponded to an incident flux of about 10 mW/cm^2 for the case of a cat brain as previously reported. For a given incident flux, the heating potential in the hot spot reduced rapidly with increasing head radius, and temperature elevations for man in the center of the head were much lower.

6026 RADIATION AND MICROWAVE THERAPY IN THE TREATMENT OF ADVANCED CANCER. *(Eng.)* Hornback, N. B. (Dept. Radiation Oncology, Indiana Univ. Sch. Medicine, 1100 W. Michigan St., Indianapolis, IN 46202); Shupe, R.; Shidnia, H.; Joe, B. T.; Sayoc, E.; George, R.; Marshall, C. *Radiology* 130(2): 459-464; 1979. (38 refs)

The effect of microwave-induced heat prior to radiotherapy (H + RT) was compared with that after radiotherapy (RT + H) in a nonrandomized study of 72 evaluable patients (38 males and 34 females; ages, 4-85 yr) with advanced cancer that did not respond to previous treatment. The histology of the cancer was squamous cell in 33 patients, adenocarcinoma in 25, malignant melanoma in 3, and miscellaneous in 11 patients. The primary tumor site was head and neck in 23 patients, gastrointestinal tract in 18, gynecologic in 16, breast in 4, genitourinary tract in 3, central nervous system in 2, bone in 2, and miscellaneous in 4 patients. Heat treatments were performed for 30 min either before or after radiotherapy using a standard European diathermy machine operating at a frequency of 433.92 MHz. Skin temperature measurements in the treatment port area increased 2.8-3.3 C; the highest intraoral temperature obtained was 40.2 C. Radiation doses varied from 50-600 rads/day and total tumor doses from 3,000-6,500 rads. Among 60 patients treated with H + RT, only 32 (53%) achieved a complete objective response compared with 11 of 12 (92%) who were treated with RT + H. There are 12 of 72 patients (17%) who are alive without any evidence of disease from 4-14 mo after therapy; 20 of 72 patients (26%) are alive with disease (treated area controlled) from 2-22 mo after therapy. No adverse reactions developed during microwave therapy, and no unusually severe normal tissue reactions were noted in any patients beyond those expected with radiation alone.

6027 STUDIES ON BLOOD-BRAIN BARRIER PERMEABILITY AFTER MICROWAVE-RADIATION. *(Eng.)* Merritt, J. H. (Radiation Sciences Div., USAF Sch. Aerospace Medicine, Brooks AFB, TX 78235); Chamness, A. F.; Allen, S. J. *Radiat Environ Biophys* 15(4): 367-377; 1978. (10 refs)

The effects of pulsed or continuous wave (CW) microwave radiation at frequencies of 1.2 or 1.3 GHz on blood-brain barrier permeability were examined in male Sprague Dawley rats. At a frequency of 1.2 GHz, the radiation was delivered at a pulse repetition rate of 1,000 pulses/sec, a pulse width of 0.5 msec, and peak powers ranging from 2-75 mW/cm^2. For radiation at 1.3 GHz, the radiation was pulsed at 1,000 pulses/sec over various power densities at a pulse width of 10 μsec. Some animals were irradiated in the CW mode with 1.3-GHz radiation. No transfer of parenterally-administered (femoral vein) fluorescein across the blood-brain barrier of rats was observed after 30 min of 1.2-GHz radiation at power densities ranging from 2-75 mW/cm^2. Increased fluorescein uptake was seen only when the rats were made hyperthermic in a warm air environment. When the effect of 20 min of exposure to 1.2-GHz radiation on the uptake of radiocarbon-labeled mannitol in the hypothalamus was examined, none of the radiation regimens used increased mannitol uptake into the brain parenchyma. When rats were irradiated at 1.3 GHz for 35 min at power densities of 0.1, 1, 10, and 50 mW/cm^2 in the CW mode, no difference in uptake of labeled mannitol was observed at any power level. An attempt to alter the permeability of the blood-brain barrier for serotonin with microwave radiation was also unsuccessful. Only in animals made hyperthermic

in a warm air environment was any uptake of the neurotransmitter noted. It appears that the brain must be made hyperthermic for changes in permeability of the barrier induced by microwave radiation to occur.

6028 ANENCEPHALUS, DRINKING WATER, GEOMAGNETISM AND COSMIC RADIATION. *(Eng.)* Archer, V. E. (Div. Surveillance, Hazard Evaluation and Field Studies, Natl. Inst. Occupational Safety and Health, Salt Lake City, UT 84101); Elwood, J. M. *Am J Epidemiol* 109(1): 88-99; 1979. (49 refs)

Mortality rates from anencephalus in Canadian cities over the period 1950-1969 were found to be correlated with city growth rate, horizontal geomagnetic flux (which is directly related to cosmic radiation intensity), and magnesium content in drinking water. City size appeared to have no direct association with deaths from anencephalus but did have an indirect association through its relationships with horizontal geomagnetic flux and city growth factor. An association of magnesium in tap water with city growth factor appeared to be just as strong as its association with anencephalus. An analysis of rates of anencephalus with simultaneous stratifications for both city growth factor and horizontal geomagnetism produced a surprisingly good separation of the associations of the two factors, yielding statistically significant differences. The analysis revealed a strong, possibly linear, relationship between low horizontal geomagnetic flux and high anencephalus rates when the city growth factor was low and consistently low rates of anencephalus when the city growth factor was high, regardless of horizontal geomagnetic flux. The hypothesis that anencephalus results from genetic damage produced by background radiation during the parent's lifetime is discussed, and it is concluded that the findings of the present study are consistent with the concept that background radiation has definite biologic effects on man. In a followup letter to the editor concerning this study, the negative association between anencephalus mortality and horizontal geomagnetic flux is refuted.

6029 LOW-INTENSITY MICROWAVE RADIATION AND THE VIRULENCE OF *AGROBACTERIUM TUMEFACIENS* STRAIN B6. *(Eng.)* Moore, H. A. (Dept. Physics, Bradley Univ., Peoria, IL 61625); Raymond, R.; Fox, M.; Galsky, A. G. *Appl Environ Microbiol* 37(1): 127-130; 1979. (13 refs)

The effect of low-intensity microwave radiation on the virulence of *Agrobacterium tumefaciens* strain B6 was investigated. When 48-hr cultures of virulent cells of *A. tumefaciens* strain B6 were exposed to 10,000-MHz radiation at an intensity of 0.58 mW/cm^2 for 30-120 min, their ability to produce tumors on potato and turnip disks was reduced by approximately 30-60%. To determine if this microwave-induced change in virulence was unique to strain B6, a similar microwave treatment was given to *A. tumefaciens* strain TT-107; a similar reduction in virulence of TT-107 was observed. The microwave exposure did not affect the viability of these bacteria or their ability to attach to a tumor-binding site nor did it induce thermal shock. The loss of virulence induced by microwave radiation was completely reversible within 12 hr after exposure. However, only about 75% of the virulence was restored when these bacteria were kept at 4 C for 12 hr after radiation exposure. Since restoration to full virulence was slowed when the bacteria were held at 4 C, the possibility that one or more metabolic processes affecting virulence are temporarily altered by microwave exposure cannot be excluded.

6030 BIOLOGICAL EFFECTS OF HIGH STRENGTH ELECTRIC FIELDS ON SMALL LABORATORY ANIMALS. ANNUAL REPORT: APRIL 1977 TO MARCH 1978. *(Eng.)* Battelle Pacific Northwest Laboratories. (Battelle Pacific Northwest Labs., Richland, WA 99352). 218 pp., 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. PC A10/MF A01). (11 refs)

The results of exposing rats and mice to 60-Hz electric fields at 100 kV/m for up to 60 days are reported. The exposures produced no statistically significant, reproducible effects except in behavioral experiments. Rats, given a choice, spent more time out of the electric field than in it at a field strength of 90 kV/m or greater. The results of three experiments showed trends that suggest the possibility of the following effects: decreased cell-mediated immunity, increased prostatitis, and increased excitability of synapses. In-depth studies are in progress to evaluate these potential effects. One measure of delayed hypersensitivity response (skin thickness) to keyhole limpet hemocyanin was decreased, but another (reaction diameter) was unchanged in exposed mice. In a replicate experiment, the effect was not statistically significant; however, the trend was consistent, i.e., the skin thickness in exposed mice was 22% less than that of sham-exposed animals. This potential effect will be studied in another experiment. It is possible that longer exposure durations (e.g., 4 mo) may enhance subtle effects not evident with the 30- and 60-day exposures employed in this study.

6031 EXPOSURE OF PRIMATES FOR ONE YEAR TO ELECTRIC AND MAGNETIC FIELDS ASSOCIATED WITH ELF COMMUNICATIONS SYSTEMS. *(Eng.)* Grissett, J. D.; Kupper, J. L.; Kessler, M. J.; Brown, R. J.; Prettyman, G. D.; Cook, L. L.; Griner, T. A. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). 315 pp.; 1977. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD-A055 399/0GA]. (12 refs)

Thirty experimental rhesus monkeys (matched with 30 controls) were exposed for 1 yr to electric and magnetic fields similar to or greater than those that would be experienced by humans living near the antenna of the Navy's proposed extremely low frequency (ELF) submarine communications system.

The experimental animals were exposed to fields equivalent in waveform to those experienced by living organisms in contact with the soil surface directly above the buried ELF antenna. The magnitude of the magnetic field (2 G) was 10 times greater than the average field along the ELF antenna. The electric field (20 V/m) was over 300 times greater than at the soil surface above and along the antenna, and it was two times greater than at the soil surface near the ground terminal. The electric field was applied to the animal via stainless steel bars that formed the walking surface of the floor of the environmental chamber. The ELF fields were on for 22 hr daily. The most significant finding was the difference in rate of weight gain between exposed and control male monkeys. The exposed males gained weight at a slightly faster rate than the control males, and at the end of 1 yr were approximately 11% heavier than the controls. The difference in weight was not accompanied by an increase in bone length measurements. The linear body measurement showing the most agreement with the growth rate difference was chest circumference. Blood urea nitrogen was lower ($p=0.05$) in exposed males; this is consistent with the growth rate findings. Gamma-glutamyl transpeptidase (GGTP) was lower in exposed males ($p=0.06$), and although consistently lower in exposed females, the difference was not significant ($p=0.37$). It appeared that the GGTP and growth rates observed in this study were consistent. Three serum enzymes (glutamic oxaloacetic transaminase, glutamic pyruvic transaminase, and creatine phosphokinase) were significantly ($p=0.05$) lower in exposed males than in control males for day plots in wk 1. Serum triglycerides were lower in exposed females ($p=0.05$ rank) than in control females. Respiratory quotient was also lower in the exposed females ($p=0.04$). The significance of these differences are at present unknown. There is no indication that the above findings have any adverse clinical significance, and both groups of animals appear healthy. It is recommended that these animals should continue to be exposed and that the data collection protocol should concentrate on identifying the mechanisms for these effects so that the long term effects can be predicted on the basis of physiologic theory. The sexual specificity of these results suggests that endocrine involvement should be studied extensively.

6032 OBSERVATIONS OF MOUSE FETUSES AFTER IRRADIATION WITH 2.45 GHZ MICROWAVES. *(Eng.)* Berman, E. (Health Effects Res. Lab., Experimental Biology Div. MD-72, Environmental Res. Center, EPA, Research Triangle Park, NC 27711); Kinn, J. B.; Carter, H. B. *Health Phys* 35(6): 791-801; 1978. (22 refs)

The effect of exposing pregnant CD-1 mice to 2.45-GHz continuous wave microwave radiation for 100 min daily at power densities ranging from 3.4-28 mW/cm^2 on gross external morphology of near-term fetuses was studied. At the highest power density exposure, the mean live fetal weight per litter was decreased significantly (0.89 ± 0.13 g versus 0.97 ± 0.15 g for sham-irradiated controls). The mean value for these irradiated litters was also lower than the mean of any other sham or irradiated group studied. Although the occurrence of cranioschisis was not different statistically at any one power density, there was a significantly higher occurrence in the irradiated group (sham = 0, irradiated = 7) when the occurrence of this anomaly was summed by all sham or irradiated groups. The total numbers of sham or irradiated litters with any anomaly were significantly different, with more than twice as many anomalous litters being seen in the irradiated group. Exposure of the dams for 100 min at the above power densities did not appear to be significant thermally. Estimates of the mean dose rate as determined with twin-well calorimetry ranged from 2.0-22.2 mW/g. It appears that microwaves at the range used in this study, especially at a power density of 28 mW/cm^2, are embryopathic.

6033 EFFECT OF MAGNETIC FIELD ON THE RECOMBINATION FLUORESCENCE OF PHOTOSYNTHETIC BACTERIA. *(Rus.)* Vozniak, V. M. (Inst. Photosynthesis, USSR Acad. Sciences, Pushchino, Moscow Oblast, USSR); Elfimov, E. I.; Proskuriakov, I. I. *Dokl Akad Nauk SSSR* 242(5): 1200-1203; 1978. (11 refs)

The effect of an electromagnetic field (0-900 G) on the recombination fluorescence of *Rhodopseudomonas sphaeroides* (wild strain), *Rhodospirillum rubrum*, and *Rh. sphaeroides* R-26 cells was studied. The electromagnetic field increased the fluorescence intensity of all cells; the increase was most pronounced in the *Rh. sphaeroides* (wild strain), and least pronounced for *Rh. sphaeroides* R-26. The fluorescence intensity increased with increasing field intensity, especially in the lower field intensity range.

6034 SURVIVAL OF MICROBIAL FILMS IN THE MICROWAVE OVEN. *(Eng.)* Page, W. J. (Dept. Microbiology, Univ. Alberta, Edmonton, Alberta T6G 2E9, Canada); Martin, W. G. *Can J Microbiol* 24 (11): 1431-1433; 1978. (7 refs)

The survival of microbial films in a Toshiba model ER776BT microwave oven operating at a frequency of 2,450 MHz and at a full power of 650 W was investigated. Air-dried films of *Escherichia coli*, *Saccharomyces cerevisiae*, and *Bacillus subtilis* spores on Amicon Microporous filters that were exposed to the above irradiation showed a 5-, 2-, and 0-log reduction of viable organisms, respectively. Suspensions of cells or spores in phosphate buffer that were irradiated under similar conditions showed 8 logs of killing within 30 sec for *S. cerevisiae*, 45 sec for *E. coli*, and within 10 min for *B. subtilis* spores. Complete killing of the vegetative cell suspensions was obtained with 60 sec of exposure and within 12 min of exposure of the spore suspension. These results are consistent with those of other investigators who showed that the death of microbes in suspension during microwave irradiation was equivalent to that expected by conventional heating. The microbes in the films

probably also suffer thermal death, but in their dehydrated state the heating achieved is probably less rapid and severe. It has been suggested that the object exposed to microwaves must be at least one-tenth the size of the wavelength to absorb microwave energy; this would make most microbes too small to act as individual targets for microwaves. However, the data in this study show that death does occur in the microbial films. These death rates probably are the result of exposure to the moist heat generated from the heated load. These results indicate the importance of proper sanitation of the interior of the microwave oven, especially in self-service areas where handling the oven is increased.

6035 EFFECT OF MICROWAVE RADIATION ON CEREBRAL CATECHOLAMINE METABOLISM. *(Rus.)* Grin', A. N. (Biologic and Hygienic Res. Lab., A. N. Marzeev Kiev Scientific Res. Inst. General and Communal Hygiene, Kiev, USSR). *Vrach Delo* (10): 129-130; 1978. (7 refs)

The effect of microwave irradiation (wavelength 12.6 cm, 50 and 500 $\mu W/cm^2$, 7 hr/day for 5-30 days) on the cerebral catecholamine level was studied in 132 male albino rats with an initial body weight of 180-450 g. In the groups exposed to 50 $\mu W/cm^2$, the epinephrine level was increased after 20-days exposure (0.05 µg/g compared with 0.04 µg/g measured before exposure and after 30-days exposure). The norepinephrine, dopamine, and dopa levels were slightly but significantly increased throughout the exposure. In the groups exposed to 500 $\mu W/cm^2$, the epinephrine, norepinephrine, and dopamine levels showed a significant increase during the first 10 days of exposure, which was followed by a steady decline to the end of the experiment. The decline in the dopa level was not preceded by any initial increase. These findings indicate the exhaustion of the sympatheticoadrenal system during long-term microwave irradiation with 500 $\mu W/cm^2$, and the stimulating effect of irradiation with 50 $\mu W/cm^2$.

6036 MAGNETIC FIELD EFFECTS ON RADICAL PROCESSES IN BIOLOGIC MEMBRANES. *(Ukr.)* Kadnikov, O. G. (Kharkov State Univ., Kharkov, USSR); Zaliubovs'kii, I. I.; Kobizs'kii, V. I.; Vitovtova, T. I. *Dopov Akad Nauk Ukr RSR* (10): 927-930; 1978. (12 refs)

The suitability of using magnetic fields (MF) to study reaction kinetics and mechanisms, and the properties of radicals in biologic membranes was analyzed. The effect of MF on the rate of oxygen consumption during auto-oxidation of unsaturated fatty acids was studied in model membrane structures, e.g., liposomes obtained by ultrasonic treatment of lipids from bull brain white matter. Changes in the reaction kinetics of free-radical oxidation of lipids (oxygen consumption, peroxide radical formation) altered the macroscopic characteristics (viscosity, surface tension) of the biomembrane lipid component exposed to a MF. The effect of MF on enzymes in biomembranes was studied based on the riboflavin (RF) oxidation rate in a constant MF. The concentration of the intermediary product decreased as a function of MF intensity. The increase in the oxidation rate of the reduced forms $RF{\cdot}H_2$ was related to MF sensitivity of the stages of intermediary radical $RF{\cdot}H_2$ interaction with the superoxide radical O_2^-; the magnetic effect was determined by a Δg mechanism. The effect of MF on electron transfer in the respiratory chain was studied in rat liver mitochondria; respiration was inhibited by 37 ± 5% in a 9-kE MF. This may be related to the participation of enzymes with metals of variable valence. Transformation of free radicals occurring in a MF was also studied during gamma-irradiation of a human serum albumin solution with ^{22}Na and ^{60}Co. A 9-kE MF increased the effectiveness of radical pair recombination by 1.8 ± 0.2%. This may explain the protective properties of a MF during the exposure of a living organism to ionizing radiation.

6037 EXPERIENCE WITH THE USE OF GLUCOCORTICOSTEROIDS AND MAGNETIC FIELDS IN THE INTENSIVE THERAPY OF SEVERE FORMS OF VIRAL HEPATITIS. *(Rus.)* Il'inskii, Iu. A. (Central Scientific Res. Inst. Epidemiology, USSR Ministry of Public Health, Moscow, USSR); Syzdykov, M. S.; Zhumanbaev, K. A.; Shvedova, A. I.; Kuz'min, A. I. *Sov Med* (9): 72-74; 1978. (14 refs)

The treatment of 18 patients with severe viral hepatitis with precoma or coma is described. In addition to basic therapy (glucose, Ringer's solution, potassium chloride, diuretics, Trasiol, Contrical, cardiac glycosides, neomycin or monomycin) all patients received prednisolone (360 mg/day), hydro-ortisone (1,000 mg/day), and adresone (300 mg/day). Ten of the 18 patients were clinically cured by this therapy. Five other patients who did not respond to this therapy subsequently were exposed to magnetic fields (450-550 Oe, 2x20 min/day for 1 wk, then 20 min/day for 8-10 days). Three patients had precoma and two were comatose. All five patients were cured clinically; the time necessary for the cure was 10-15 days shorter than in the 10 other patients who did not receive magnetic field therapy. The pigment metabolism, thymol test, and ALAT activity dropped to normal levels by the end of the magnetic field treatment. The findings indicate the therapeutic effectiveness of magnetic fields in viral hepatitis.

6038 EFFECTS OF HEAVY METAL IONS AND ELECTRICAL FIELD ON THE ELECTROKINETIC PROPERTIES OF MICROBIAL CELLS. *(Rus.)* Kul'skii, L. A. (Inst. Colloid and Water Chemistry, Ukrainian SSR Acad. Sciences, Kiev, USSR); Deinega, Iu. F.; Savluk, O. S.; Ul'berg, Z. R.; Marochko, L. G.; Dem'ianenko, A. P. *Dokl Akad Nauk SSSR* 244(1): 217-219; 1979. (3 refs)

The effects of Ag^+ and Cu^{++} ions and their combination with an electromagnetic field (10-30 V/cm, length of exposure 30 min) on the electrokinetic characteristics and survival of *Escherichia coli*

commune 734 were studied. The electrophoretic mobility of the cells increased with increasing field intensity. Exposure to the electric field increased the antimicrobial effect of Ag^+; at an Ag^+ concentration of 0.001 mg-ion/l, the cell count was 980/ml after exposure to 10 V/cm, 40/ml after exposure to 20 V/cm, and 2/ml after treatment with 30 V/cm. In a concentration range of 0.001-0.2 mg-ion/l, Cu^{++} ions alone had no antimicrobial effect, but an antimicrobial effect was seen in the combination of Cu^{++} ions (0.05-0.1 mg-ion/l) with electrical field (30 V/cm). The increased antimicrobial effect of Ag^+ and Cu^{++} ions in the electrical field was due to intensified sorption as a result of the increased negative charge of the cells.

6039 OCCUPATIONAL PATTERNS OF PATIENTS WITH LEUKEMIA AND LYMPHOGRANULOMATOSIS (ACCORDING TO DATA FOR THE KUIBYSHEV REGION). *(Rus.)* Plotnikov, Iu. K. (First Dept. Hosp. Therapy, D. I. Ul'ianov Kuibyshev Medical Inst., Kuibyshev, USSR). *Probl Gematol Pereliv Krovi* 23(1): 18-21; 1978. (26 refs)

The occupational pattern of 1,161 patients with leukemia or lymphogranulomatosis was studied by comparison with 1,215 matched non-cancer patients living in the same area. Patients exposed to ultra high frequency (UHF) or super high frequency (SHF) fields or ionizing radiation accounted for 2% of all patients with leukemia and lymphogranulomatosis, but only 1% of the controls were exposed to such factors ($p<0.001$). This group included 15 patients exposed to UHF and SHF fields, and 8 exposed to ionizing radiation. Seven patients had acute leukemia, 6 had chronic myelogenous leukemia, 6 had lymphocytic leukemia, and 4 had lymphogranulomatosis. The length of occupational exposure was 3-7 yr in 5 cases, 8-12 yr in 7, and over 12 yr in 11. The relative risk compared with the controls was 2.4 for acute leukemia, 2.1 for chronic myelogenous leukemia and lymphogranulomatosis, and 1.5 for chronic lymphocytic leukemia. There was no significant difference between the subgroups exposed to UHF or SHF fields and ionizing radiation in terms of relative risk.

6040 EFFECT OF ALTERNATING MAGNETIC FIELDS ON THE ACTIVITY OF CARBOHYDRATE METABOLIZING ENZYMES AND TISSUE RESPIRATION IN TESTICULAR TISSUE. *(Rus.)* Udintsev, N. A. (Tomsk Medical Inst., Tomsk, USSR); Khlynin, S. M. *Ukr Biokhim Zh* 50(6): 714-717; 1978. (25 refs)

The effect of single-time (24 hr) and repeated (6.5 hr/day for 5 days) exposure to an alternating magnetic field (50 Hz, 200 Oe) on the activity of carbohydrate metabolizing enzymes and oxygen consumption of testicular tissue was studied in 100 male albino rats up to 28 days after exposure. Following single-time exposure, there was no significant change in the cytoplasmic hexokinase activity and in the succinate dehydrogenase activity of the mitochondria, while the hexokinase activity of the mitochondria was decreased significantly compared with the non-exposed controls on day 2 (15.4 nmoles of NADPH per mg of protein per min versus 20 in the controls), the malate dehydrogenase activity of the mitochondria was reduced on day 2 (432 nmoles of NADH per mg of protein per min compared with 584 in the controls), and the cytochrome oxidase activity of the mitochondria was reduced on day 1 (4.2 U/mg/min versus 5.7 in the controls). The cytoplasmic glucose-6-phosphate dehydrogenase activity was decreased on day 1 (6.3 nmoles of NADPH per mg of protein per min versus 8.3 in the controls), but a significant increase was seen 1 hr after exposure. The cytoplasmic lactate dehydrogenase activity was increased on day 2 (685 nmoles of NADH per mg of protein per min versus 532 in the controls). Following repeated exposure, there were no significant changes in the cytoplasmic hexokinase activity, but the mitochondrial hexokinase activity was decreased 1 hr and 2 days after exposure (18.2 and 15.9 nmoles of NADH per mg of protein per min, respectively, versus 25.6 in the controls). The cytoplasmic glucose-6-phosphate dehydrogenase and mitochondrial cytochrome oxidase activities were also decreased significantly 1 hr and 2 days after exposure, and the malate dehydrogenase activity in the mitochondria was reduced 1 hr after exposure. The succinate dehydrogenase activity of the mitochondria was significantly decreased after 1 hr (1.49 U/10 mg of protein per min), and it increased significantly 14 days after exposure (2.28 U/10 mg of protein per min). The changes seen following single-time exposure were interpreted as the adaptive reaction of the body, while the changes following repeated exposure indicated disorders in the metabolic processes.

6041 PRACTICAL EXPERIENCE WITH INTERFERENCE-CURRENT THERAPY OF MEN WITH VEGETATIVE UROGENITAL COMPLAINTS. *(Ger.)* Leuthausel, W. (No affiliation given); Rugendorff, E. W. *Therapiewoche* 28(47): 9219-9221; 1978. (3 refs)

Forty-three men with vegetative urogenital syndrome received interference-current therapy on the inguinal region by means of a Nemectrodyn apparatus (90-100 Hz, 50% and then 100% of individual optimal current intensity, 8-12 min/session, 10 sessions). Therapeutic response was achieved in 90%. At the end of the treatment 50-60% of the patients were completely symptom-free, and another 30-40% achieved considerable improvement.

6042 CARDIOVASCULAR CHANGES IN RABBITS EXPOSED TO A STATIC MAGNETIC FIELD OF 600 Oe. *(Jpn.)* Nakagawa, M. (Dept. Public Health, Medical Sch. Nagoya City Univ., Nagoya, Japan). *Jpn J Ind Health* 20(2): 112-113; 1978. (5 refs)

Cardiovascular changes were investigated in domestic white rabbits (3-3.5 kg) following a 5-wk exposure to a static magnetic field of 600 Oe. The animals were exposed in a room at 24 ± 1 C, 60 ± 5% relative humidity that was lit from 0600-1800 hr. The 6 experimental and 4 control rabbits were injected intramuscularly with 1 mg/kg Reserpine 24 hr prior

to measurement of magnetic field effects to suppress reaction to external stimuli. Rabbits exposed to the magnetic field for a comparatively long period had an increased heart rate and peripheral blood volume compared with controls. The increase in blood volume was thought due to excitation of heart function and not vasodilation.

6043 DYNAMICS OF CHANGES OF THE CORTICAL-SUBCORTICAL CORRELATIONS IN EXPERIMENTAL ANIMALS EXPOSED TO ELECTROANALGESIC PULSED CURRENTS. *(Rus.)* Persianinov, L. S. (All-Union Scientific Res. Inst. Obstetrics and Gynecology, USSR Ministry of Public Health, Moscow, USSR); Tkachenko, N. M.; Dmitrieva, O. K.; Smetnik, V. P. *Akush Ginekol* (10): 29-34; 1978. (8 refs)

The effect of pulsed current (0.08-0.1 mA, 150-160 Hz, length of treatment about 1 hr with 2-5 min pauses at 10-15 min intervals) on the cortical and subcortical electrical activity was studied in 48 rabbits. Electrodes were implanted in the midbrain reticular formation, hippocampus, anterior and posterior hippothalamic nuclei, nonspecific thalamic nucleus, and in the sensorimotor, occipital, and parietal regions of the cerebral cortex. The stimulation of the hippocampus led to the activation of the thalamic structures, whose stimulation caused sleep. The pulsed-current stimulation of the hippocampus inhibited the ascending activating effect of the reticular formation, and this facilitated the manifestation of slow diencephalic rhythms. The current was found to directly inhibit the activating effect of the cortex and reticular formation alike, and, due to reciprocity, facilitated the expression of the inhibiting effect of the hippocampus. The findings suggest that all mechanisms are involved in the formation of the inhibiting activity under the effect of pulsed current, and that the predominant effect of each of these mechanisms is dependent on the functional status of the brain.

6044 STATUS OF OXIDATIVE PHOSPHORYLATION PROCESSES IN LIVER MITOCHONDRIA UNDER THE EFFECT OF ELECTRICAL FIELD. *(Rus.)* Koziarin, I. P. (A. A. Bogomolets Kiev Medical Inst., Kiev, USSR); Rudichenko, V. F. *Gig Sanit* (11): 26-29; 1978. (6 refs)

The effect of exposure to electrical field (1-15 kV/m, 50 Hz, 2 hr/day for 4 mo) on the copper and iron levels of the liver and on the oxidative phosphorylation processes in the liver mitochondria was studied in male albino rats with an initial body weight of 120 g. The exposure to the electrical field caused a field intensity-dependent, significant decrease in the hepatic copper and iron levels: the copper level decreased from 603 μg% in the group exposed to the 1 kV/m-field to 288.7 μg% in the group exposed to the 15 kV/m field, compared with 759.3 μg% in the non-exposed controls. The iron level dropped from 29.5 mg% in the group exposed to the 1 kV/m field to 10.9 mg% in the group exposed to 15 kV/m, compared with 39.8 mg% in the controls. Exposure to 1-4 kV/m fields caused no significant changes in the oxidative phosphorylation processes, but fields with higher intensities caused pathologic changes (dissociation of respiration and phosphorylation).

6045 ASSESSMENT OF THE POSSIBILITY OF PREDICTION OF INDIVIDUAL RADIOSENSITIVITY BY THE RESPONSE TO NON-RADIATION EFFECTS. *(Rus.)* Darenskaia, N. T. (No affiliation given); Kuznetsova, S. S.; Chekhonadskii, N. A. *Radiobiologiia* 18(6): 931-935; 1978. (14 refs)

Correlations were studied between the effect of stress factors (30-min hyperthermia at 40-50 C, 24-hr starvation, and 0.5 to 5-hr exposure to a 600-Oe constant magnetic field) and the sensitivity of 2- to 3-mo-old male mongrel and Wistar rats to ionizing radiation (telecobalt, single 600 R dose) in an attempt to predict the radiosensitivity from the response to the stress factors. Changes in the leukocyte count, ranging from a decrease by 5,600 to an increase by 15,450 cells, were seen only following 4- to 5-hr exposure to the magnetic field. The leukocyte count normalized in 20 hr. The changes in the erythrocyte count and Hb level ranged from -18% to +16% and the changes in the exhaled carbon dioxide ranged from -25% to +32%. The body weight decreased by up to 10%, but some animals showed almost no weight loss. Correlation was found between the response to the stress factor and the radiosensitivity in about 50% of the animals only.

6046 THERMORADIOTHERAPY IN AN ANIMAL EXPERIMENT: TUMOR GROWTH AND CURE. *(Ger.)* Dietzel, F. (Abteilung Nuklearmedizin, Klinikum der Justus-Liebig-Universitat, Friedrichstrasse 25, 63 Giessen, W. Germany); Linhart, G.; Kovacs, G. *Strahlentherapie* 154(12): 861-868; 1978. (36 refs)

The effects of single-time x-ray irradiation (tumor dose 2,000 R, dose rate 285 R/min), local hyperthermia (39-43 C, induced by electromagnetic field, 461.04 ± 0.20 MHz, 150 W, 1-4 min) and their combination on the 30-day tumor volume reduction, tumor growth retardation, mean survival time, and cure rate were studied in female albino NMRI mice with solid Ehrlich carcinomas implanted in the neck. The treatment was given about 10 days after tumor implantation, when the tumor size reached 1.0 ± 0.2 ml. The hyperthermic treatment was given before or after x-ray irradiation, with a 20-sec interval between the two treatments. Hyperthermia alone had no significant effect on the parameters investigated, but it enhanced the effect of x-ray treatment. The sequence of the two treatments was not important. The 30-day tumor reduction was 29.5% after x-ray irradiation alone, 49.9-52.5% after x-ray + 1-min hyperthermia, 64.4-71.6% after x-ray + 2-min hyperthermia, 71.3-71.8% after x-ray + 3-min hyperthermia, and 69.8-71.6% after x-ray + 4-min hyperthermia. The mean survival time was 22.2 days after x-ray treatment alone, 29.5-34.2 days after x-ray + 1-min hyperthermia, 38.4-39.9 days after x-ray + 2-min hyperthermia, 48.8-49.9 days after x-ray + 3-min hyperthermia, and 33.2-40.7

days after 4-min hyperthermia. The cure rate was 2.1% after x-ray alone, 5.1-12.5% after x-ray + 1-min hyperthermia, 17.5-20% after x-ray + 2-min hyperthermia, 23.1-33.3% after x-ray + 3-min hyperthermia, and 15.8-21% after x-ray + 4-min hyperthermia. The findings indicate the potentiating effect of hyperthermia, especially in moderate doses (2 and 3 min).

6047 EFFECT OF STRONG MAGNETIC FIELDS ON ACTIVE TRANSPORT IN THE CHOROID PLEXUS. *(Rus.)* Bresler, S. E. (B. P. Konstantinov Leningrad Inst. Nuclear Physics, USSR Acad. Sciences, Leningrad, USSR); Bresler, V. M.; Vasil'eva, N. N.; Kazbekov, E. N. *Dokl Akad Nauk SSSR* 242(2): 465-468; 1978. (6 refs)

The effect of a magnetic field (5-50 kOe) on the active transport of fluorescein (10^{-4} M) in the isolated choroid plexus of rabbits was studied. The choroid plexus was incubated in Ringer-Hanks solution for 15 min. At high calcium ion concentration (normal medium) in the incubating medium, the magnetic field increased the fluorescein transport by nearly 100%, but it inhibited the transport of fluorescein in a medium with low calcium ion concentration (0.12 mmole) compared with that found without magnetic field. The rate of inhibition increased with increasing field intensity up to about 40 kOe, after which the further increase in the field intensity caused no considerable further increase in the inhibition rate.

6048 SHORTWAVE DIATHERMY AND ULTRASOUND IN PHYSIOTHERAPY (LETTER TO EDITOR). *(Eng.)* Moth, B. (Dept. Physiotherapy, Groote Schuur Hosp., Observatory, Cape Town, South Africa). *S Afr Med J* 54(27): 1119; 1978. (1 ref)

A statement in a previous article contending that the bulk of patients with chronic aches and pains obtain no benefit from shortwave diathermy and ultrasound is refuted in a letter to the editor. It is suggested that the use of diathermy has stood the test of time and that numerous patients return time and again for the pain relief obtained. It is also suggested that ultrasonic treatment, correctly given with an apparatus that has been carefully maintained, has also stood the test of time.

6049 PERCUTANEOUS CENTRAL GRAY STIMULATION FOR CANCER PAIN. *(Eng.)* Meyerson, B. A. (Dept. Neurosurgery, Karolinska Sjukhuset, S-104 01 Stockholm, Sweden); Boethius, J.; Carlsson, A. M. *Appl Neurophysiol* 41(1/4): 57-65; 1978. (16 refs)

Intracerebral electrical stimulation of the periventricular and periaqueductal gray matter via percutaneous electrodes was used on nine cancer patients in an attempt to relieve pain with midline and bilateral distribution. The average follow-up time was about 3 mo, with the longest being 1 yr. There were no major surgical complications or any later signs of local infections or meningitis. Good pain relief was experienced by four patients, moderate pain relief by three patients, and no pain relief by two patients. No patient experienced total alleviation of pain as a result of electrical stimulation. In one patient, a 64-yr-old woman with uterine cancer who initially experienced very good pain relief, the efficiency of stimulation seemed to decrease after about 2 wk, and the poststimulatory period of pain reduction was successively shortened from about 6 hr to less than 2 hr. However, one patient still experienced good pain relief after having used the stimulation for more than 1 yr, and the duration of poststimulatory pain relief has remained unchanged. As a rule, stimulation was performed at a frequency of about 30 Hz and at a pulse duration of 0.2 msec. Stimulation generally had to be on for about 20 min for maximal pain relief and was performed at intervals of about 4 hr. The stimulus intensity was kept at a level subthreshold to subjective sensations. The pain relieving effect of stimulation was very dependent on the exact position of the electrode. In order to investigate the role of endorphin activation in pain relief, endorphins in lumbar cerebrospinal fluid were estimated in eight of the patients. Two of four patients with good pain relief showed a significant increase of endorphin content as a result of stimulation; however, in both patients the endorphin level was higher than normal also prior to stimulation. Since stimulation-produced analgesia in animals is readily reversed by opiate antagonists, such as, naxolone, this drug was given as slow intravenous injections shortly after the cessation of stimulation when patients reported maximal pain relief. In three of the patients who had good or moderate pain relief, there was an unequivocal reversal of the effect of stimulation, which occurred 5-10 min after the injection. The idea that pain relief with central gray stimulation is accomplished by the activation of an opiate receptor system was further supported by the fact that one patient who had become slightly dependent on a narcotic analgesic found that increasing the dose of the drug resulted in a decrease in the pain-relieving effect of electrical stimulation.

6050 MECHANISM OF INTERACTION OF ALTERNATING ELECTRICAL FIELD OF INDUSTRIAL FREQUENCY WITH THE HUMAN AND ANIMAL BODY. *(Rus.)* Kolesnikov, S. V. (No affiliation given); Chukhlovin, B. A. *Plazmi Zh Tekh Fiz* 4(15): 935-939; 1978. (3 refs)

The mechanism of action of alternating electrical fields of industrial frequency (50 Hz) on the human and animal body was studied in model experiments. The computations revealed that during exposure to an electric field of 100 kV/m intensity, the current flowing through the human body amounted to 1,230 μA. The corresponding current intensities found for rabbits, rats, and mice were 40, 5.4, and 1.03 μA, respectively. The experiments in rats revealed no changes in energy metabolism during exposure to a field of 300 kV/m and 50 Hz, but significant changes were found in energy metabolism during

exposure to 300 kV/m at 500 and 1,000 Hz. The findings indicate that the observed reaction of the body is elicited by the current flowing through the body, which is proportionate to the frequency, and not by the field intensity. Another experiment revealed that the current flowing through the human body during exposure to a body surface field intensity of 10 kV/m equaled that elicited by exposure to 117 kV/m in rabbits, to 123 kV/m in rats, and to 151 kV/m in mice.

6051 EVALUATION OF LENS TRANSPARENCY IN PERSONS EXPOSED TO ELECTROMAGNETIC RADIATION AT 27-30 MHz FREQUENCY. *(Pol.)* Smolarz-Dudarewicz, J. (Instytut Medycyny Pracy, Racjonalizatorow 5, m. 10, 91-837 Lodz, Poland). *Med Pracy* 29(4): 349-353; 1978. (14 refs)

The transparency of the crystalline lens of the eye was evaluated in 55 women (welders) (average 35.3 yr) who had been occupationally exposed to electromagnetic radiation with a frequency of 27-30 MHz for periods ranging from less than 2 yr to 19 yr (average 6.3 yr) and in 101 healthy unexposed controls. The field strength to which the welders were exposed ranged from 3.2 to 135 V/m. Considerable opacification of the lens was found in 10/55 welders (18.2%) and in 21/101 controls (20.8%). Moderate opacification was seen in 19/55 welders (34.6%) and in 33/101 controls (32.7%). The frequency of opacification increased with age in both groups, but there was no correlation between the incidence and the length of occupational exposure among the welders. The findings failed to show any significant effect of electromagnetic field exposure on lens opacification.

6052 INFLUENCE OF ALTERNATING MAGNETIC FIELDS OF INDUSTRIAL FREQUENCY ON THYROID GLAND FUNCTIONAL ACTIVITY AND ^{131}I-THYROXIN BINDING BY TISSUES OF ALBINO RAT ORGANS. *(Rus.)* Udintsev, N. A. (Dept. Biochemistry, Tomsk Medical Inst., Tomsk, USSR); Serebrov, V. Iu.; Tsyrov, G. I. *Biull Eksp Biol Med* 86(11): 544-546; 1978. (13 refs)

The effect of exposure to an alternating electromagnetic field (50 Hz, 200 Oe, single exposures of 0.25, 6.5, or 24 hr or multiple exposures of 6.5 hr/day for 5 days) on the uptake of ^{131}I (0.5 μCi, administered subcutaneously) by the thyroid gland, on the protein-bound iodine (PBI) level of the serum, and on the uptake of ^{131}I-thyroxin by the testes, adrenals, heart, liver, and spleen was studied in 280 adult albino rats. The uptake of ^{131}I by the thyroid gland was increased significantly 12 hr after irradiation for 5x6.5 hr (65.01% of the dose administered, versus 58.96% in the nonirradiated controls), but there were no significant differences from the controls in the single-exposure group animals. The PBI level was increased after 15-min irradiation (4.72 mg/ml versus 2.94 mg/ml in the controls), reduced after 6.5-hr irradiation (1.69 mg/ml versus 2.68 mg/ml) and after 24-hr exposure (0.245 mg/ml versus 0.475 mg/ml), and increased after 5x6.5-hr exposure (2.02 mg/ml versus 1.48 mg/ml), 24 hr after the exposure. The ^{131}I-thyroxin uptake was significantly reduced ($p<0.05$) in the liver and spleen after the single 6.5-hr exposure and in all organs after the 5x6.5-hr or 24-hr exposure. The findings indicate the considerable effect of exposure to a 50-Hz electromagnetic field of 200 Oe on thyroid function, and the influence of exposure duration.

6053 ELECTROMAGNETIC FIELDS IN THE VICINITY OF RADAR THERAPY EQUIPMENT. *(Ita.)* Grandolfo, M.; Ranghiasci, C. (Laboratorio delle Radioazioni, Istituto Superior di Sanita, Viale Regina Elena 299, 00161 Rome, Italy). pp. 31-35; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. N78-20765]. (3 refs)

The electromagnetic field intensities and their angular distribution were measured around a therapeutic radar equipment (Siemens Radiotherm 306, power output 0-200 W, frequency 2.45 GHz) with rectangular and circular-field emitters. Field intensities of 10 mW/cm^2 or higher were measured even at distances of 1 m or slightly greater. The 10 mW/cm^2 level has been adopted in the USA and many West European countries as a maximum permissible intensity in the human environment. The field intensities were in the same order of magnitude with the rectangular and circular-field emitters. The findings indicate the hazards of exposure to therapeutic radar equipment for radiation therapists.

6054 INFLUENCE OF THE AGE OF MICE ON THE EFFECTIVENESS OF STIMULATION OF THE IMMUNE SYSTEM BY ELECTROMAGNETIC RADIATION. *(Fre.)* Pautrizel, R. (Laboratoire d'Immunologie et de Biologie parasitaire, Universite Bordeaux-II, 146, rue Leo-Saignat, 33076 Bordeaux Cedex, France); Chateaureynaud-Duprat, P. *C R Acad Sci [D] (Paris)* 287(5): 575-578; 1978. (5 refs)

The effect of microwave stimulation of the immune system on the course of *Trypanosoma equiperdum* infection (1,000 cells/animal administered intraperitoneally) was studied in young female Swiss mice. The animals were infected at the age of 0-40 days, and irradiation began on the day of the infection with a modulated electromagnetic field (9.4 and 17 MHz, 1,200 G, 6 hr/day for 4 days). All animals that were infected at the age of 0-28 days developed considerable parasitemia (nearly 10^6 cells/mm^3 of blood) and died 82-96 hr after infection. Some of the animals infected at the age of 28-31 days became *Trypanosoma*-negative, and survived. All animals that were infected at the age of 35-40 days became *Trypanosoma*-negative and survived. The investigation of other nonirradiated subgroups, infected at the age of 0-40 days, demonstrated the development of the immune system, including the appearance of agglutinating antibodies, during that period. The findings indicate that a mature immune system is required for microwave stimulation to be effective.

6055 STUDIES ON ELECTROMAGNETIC-FIELD EXPOSURE IN THE COURSE OF HEAT TREATMENT OF METALS BY MEDIUM- AND HIGH-FREQUENCY CURRENTS. *(Rum.)* Herman, H. (Institutul de Cercetari Stiintifice pentru protectia Muncii, Bucharest, Rumania); Badescu, L.; Rafaila, E. *Rev Ig (Pneumoftiziol)* 27(2): 139-146; 1978. (10 refs)

Workers from 48 industrial plants, who had been occupationally exposed to electromagnetic fields (2,500-8,000 Hz or 200-450 MHz, maximum 5 A/m and maximum 12.4 V/m) in metal hardening, melting, and joining operations were examined for possible health effects. Compared with an unexposed control group, no particular changes were found in clinical, endocrinologic, biochemical, and hematologic parameters. No cumulative effect of the electromagnetic fields was seen.

6056 ASPECTS OF THE MECHANISM OF ACTION OF PULSED CURRENTS WITH RESPECT TO ELECTRO-ANALGESIA. *(Rus.)* Persianinov, L. S. (All-Union Scientific Res. Inst. Obstetrics and Gynecology, USSR Ministry of Public Health, Moscow, USSR); Tkachenko, N. M.; Smetnik, V. P. *Akush Ginekol (Mosk)* (8): 7-14; 1978. (21 refs)

Cortical and subcortical structures were stimulated by square waves (pulse duration 0.2-0.9 msec, frequency 8-10 and 100-300 Hz, 0.3-0.8 mA) in adult experimental animals (species not specified). Spikes (3-4/sec, amplitude 120-150 μV) were found in all areas of the cortex, including the occipital and sensorimotor regions, following short-term (5-6 sec) stimulation of the anterior hypothalamic nuclei. Continued stimulation caused progressive inhibition; the amplitude of the rhythmic oscillations rose to 150-180 μA, and their frequency decreased. There was also a change in the response to afferent stimuli; in response to a single light flash, the amplitude of the basic negative wave and the amplitude and duration of the secondary components of the evoked potential increased. The findings indicate that local stimulation of the anterior hypothalamus plays an active role in the formation of the inhibitory activity under the effect of pulsed-current stimulation.

6057 CHANGES IN CONDUCTIVITY OF ALAMETICIN-MODIFIED PHOSPHOLIPID MEMBRANES IRRADIATED BY A HIGH-FREQUENCY ELECTROMAGNETIC FIELD. *(Rus.)* Tiazhelov, V. V. (Inst. Biological Physics, USSR Acad. Sciences, Pushchino [Moscow Oblast], USSR); Alekseev, S. I.; Grigor'ev, P. A. *Biofizika* 23(4): 732-733; 1978. (1 ref)

The conductivity of lecithin membrane systems was studied under the effect of a high-frequency electromagnetic field (0.9 GHz, 1.6-8 W, maximum pulse duration 4 sec, minimum pulse interval 10 sec) in KCl and NaCl solutions (0.5-2 moles) in the presence of alameticin (0.8 μg/ml). The pulsed electromagnetic field caused a sharp and sudden reversible drop in the resistance (increase in the conductivity); the new conductivity value established itself in 0.2-0.4 sec at the beginning of the pulse, and reverted to the initial level just as rapidly. The observed effect may have been due to local heating of alameticin channels in the membrane by the high-frequency field.

6058 SUTURELESS ANASTOMOSIS IN GASTROINTESTINAL SURGERY WITH AND WITHOUT STEADY MAGNETIC FIELD--AN EXPERIMENTAL STUDY. *(Rus.)* Kanshin, N. N. (Third Surgical Clinic, N. V. Sklifosovskii Moscow Municipal Scientific Res. Inst. Emergency Aid, Moscow, USSR); Permiakov, N. K.; Dzhalagoniia, R. A.; Nikulin, B. I.; Kuznetsov, A. A. *Arkh Patol* 40(8): 56-61; 1978. (10 refs)

Sutureless gastroduodenal and cecojejunal side-to-side anastomoses were performed in 52 dogs by means of simple compressing devices with and without steady magnetic fields (field intensity not specified). The anastomosis formation was completed in 6-7 days after the operation, and the compressing elements were discharged spontaneously in 7-8 days in both variants, signifying that the steady magnetic field had no effect on the healing of the anastomosis.

6059 CHANGES IN MUSCULAR FORCE CAUSED BY ELECTRICAL STIMULATION IN ELDERLY SUBJECTS. *(Pol.)* Dobkowska, A. (Klinika Rehabilitacji AM, ul. Wierzejewskiego 12, 05-510 Konstancin k/W-wy, Poland); Gorski, W.; Wirski, J. *Pol Tyg Lek* 33(48): 1849-1852; 1978. (10 refs)

The effect of electrical stimulation of the tibia (1-msec stimuli, frequency 50-60 Hz in 2-sec volleys at 10-sec intervals, 15-20 min/day for 3 wk) on the force of the soleus muscle was studied in 20 women aged 60-85 yr with functional disorders of the lower extremities. The force of the soleus muscle increased in all patients during the treatment; the initial force was in the range of 9-86 kg, and 30-122 kg were measured at the end of the treatment. The increase was 300-350% in the patients with low initial values, and 50-200% in patients whose muscular force was not reduced excessively before the treatment. The increase was less than 50% in three cases only.

6060 STIMULATION WITH AUTOMATIC RADIOFREQUENCY SYNCHRONIZATION AND PACING IN THE LONG-TERM TREATMENT OF HYPERKINETIC ARRHYTHMIA. *(Fre.)* Critelli, G. (Istituto di Patologia Medica dell' Universita II, Policlinico, Via Pansini 5, 80131 Naples, Italy); Grassi, G.; Perticone, F.; Adinolfi, L.; Maione, S.; Condorelli, M. *Arch Mal Coeur* 71(11): 1279-1282; 1978. (19 refs)

A pacemaker using radio frequency signals for synchronization and pacing, and seeking automatically the phase of the cycle at which tachycardia may be interrupted, is described. There ia an electromagnetic coupling between the external unit that can be activated by the patient and the implanted unit by means of a loop antenna. The program of the

external transmitter, which scans nearly all R-R cycles of the tachycardia, can be preset to transmit one or two synchronized stimuli, with a progressive delay of 5 or 10 msec. If the tachycardia is interrupted, the pacing stops automatically. The implantable unit can be connected to a normal endocardial electrode, has no batteries, is of small size, and weighs only 33 g. The unit was used successfully in 4 patients with reciprocal junctional tachycardia (3 of these patients had Wolff-Parkinson-White syndrome), and in one case of chronic recurrent ventricular tachycardia. All patients had been refractory to conventional drug treatment.

6061 EFFECTS OF ELECTRICAL STIMULATION OF VAGAL NUCLEI IN ANESTHETIZED AND UNANESTHETIZED CATS. *(Eng.)* Dugin, S. F. (Dept. Physiology Man and Animals, Moscow State Univ., Moscow, USSR); Zakharov, S. I.; Samonina, G. E.; Udel'nov, M. G. *Neurosci Behav Physiol* 8(4): 317-320; 1978. (16 refs)

Changes in heart rate were studied during electrical stimulation (1.75-4.0 V, 30-70 Hz, 0.1 msec) of the effector nuclei of the vagus nerves in anesthetized and unanesthetized cats. Tungsten microelectrodes with a tip diameter of 10-25 micron were inserted into the dorsal vagal nucleus and into the nucleus ambiguus of the medulla of cats under pentobarbital anesthesia. In seven cats, seven points were investigated, four in the dorsal vagal nucleus and three in the nucleus ambiguus. Stimulation of these points in anesthetized animals caused a slowing of the heart beat after a relatively short latent period (1-2 sec), and the effect stopped virtually as soon as the stimulation ceased. Changes in heart rate and various types of motor responses were obtained by stimulation of the same points in unanesthetized cats. The motor responses consisted of slight twitching of the neck muscles, the tips of the ears, and the whiskers. In contrast with anesthetized cats, stimulation of the dorsal vagal nucleus or nucleus ambiguus in unanesthetized cats was usually accompanied by a quickening of the heart beat; in some cases quickening was followed by slowing. Just as with the bradycardia in the anesthetized cats, tachycardia developed after a short latent period (1-2 sec) and it ceased virtually immediately after stimulation was ended. The increase in the heart rate of unanesthetized cats after stimulation of the effector nuclei of the vagus nerves was not due to activation of the sympathetic nervous system as was demonstrated in experiments with Obsidan, a β-adrenoblocker. The injection of Obsidan never abolished the effect of tachycardia. This applied both to groups of neurons whose stimulation led to the development of tachycardia alone and to groups of neurons whose stimulation produced tachycardia accompanied by motor responses. It was concluded that the tachycardia arising in response to stimulation of the vagal nuclei is parasympathetic in nature. This conclusion was confirmed by the character of the tachycardia, i.e., its short latent period and the quick termination of the effect after stimulation ceased. Opposite effects were also obtained in anesthetized and unanesthetized cats during stimulation of the same group of neurons of the anterior hypothalamus (preoptic region). Bradycardia arising in anesthetized cats was replaced by tachycardia when stimulation was applied after the end of the anesthesia. This tachycardia also was parasympathetic since it remained after the administration of Inderal. In an animal in the normal state, stimulation of efferent neurons of the parasympathetic pathways is thus accompanied by an increase in the heart rate, suggesting that acceleratory influences are among the regulatory functions of the parasympathetic innervation of the heart. Dominance of the inhibitory effects on stimulation of the same efferent neurons in anesthetized animals suggests that the widely held view that the function of the vagal innervation of the heart is purely inhibitory is evidently based on the inadequate responses of the heart of anesthetized animals.

6062 PHANTOM LIMB PAIN TREATED BY ELECTRICAL STIMULATION. *(Eng.)* Miles, J. (Center for Pain Relief and Regional Dept. Medical and Surgical Neurology, Walton Hosp., Liverpool 9, England); Lipton, S. *Pain* 5(4): 373-382; 1978. (11 refs)

The suitability of using an electrical stimulator implant to the peripheral nerve or spinal cord for the treatment of phantom limb pain was assessed in 20 patients with this condition. Of 12 patients who were so treated, 7 obtained excellent relief of pain such that they required no analgesics. Three patients obtained only partial relief of pain and occasionally required simple analgesics. Three patients achieved such a satisfactory relief of pain on transcutaneous stimulation that they were maintained on this form of treatment; one continues to obtain excellent pain relief after 1 yr. Two patients obtained no pain relief, and both of these patients were subsequently recognized to have had evidence suggestive of ipsilateral cord injury. None of the patients responding to electrical stimulation had evidence of ipsilateral cord injury or even ptosis or myosis.

6063 MICROWAVE PROPERTIES OF CRYOPROTECTANTS. *(Eng.)* Macklis, J. D. (Cryogenic Engineering Lab., Massachusetts Inst. Technology, Cambridge, MA); Ketterer, F. D. *Cryobiology* 15(6): 627-635; 1978. (6 refs)

The temperature dependence of both the dielectric constant and loss tangent of three membrane-penetrating, hydrogen-bonding cryoprotectants commonly used in organ preservation, i.e., dimethylsulfoxide (DMSO), ethylene glycol (EG), and glycerol (GCL), was investigated to elucidate the process of microwave thawing of cryopreserved tissue. The tests were performed over a temperature range of +15 to -70 C. The microwave frequency used ranged from 1.45-1.55 GHz; this frequency range is about midway

between 0.915 and 2.45 GHz, frequencies for which commercial microwave heating equipment is available and which have been shown to be useful for organ thawing. The microwave signal was 100% square wave modulated external to the source. Although the data showed certain similarities in the general temperature dependencies of the microwave properties of DMSO, EG, and GCL, different characteristics were clearly present in each. At approximately 1.5 GHz, DMSO was by far the most electrically active, exhibiting a room temperature dielectric constant almost four times larger than that of EG and almost 10 times that of GLC. However, at low temperatures, the dielectric constant of DMSO was only approximately two times that of EG and GLC. A comparison of loss tangent versus temperature curves showed that all three cryoprotective agents have maximum loss tangent values of approximately the same magnitude. However, there was a great variation as to where in the temperature range the maxima occurred. The highest loss tangent for GLC was at approximately room temperature, with GLC rapidly losing its lossiness with declining temperature. In contrast, EG was quite lossy over a fairly wide temperature range; the loss tangent showed a modified plateau from approximately +5 C to about -10 C, and it gently decreased at both above and below this temperature range. The loss tangent of EG fell to an extremely low value below -60 C, a value that was less than one fourth as small as that for GLC's low temperature minimum. A wide temperature range of relatively high loss tangent values was exhibited by DMSO, but below the temperature of about -40 C this property fell off very rapidly with decreasing temperature. This decrease was about twice as fast as that for EG. From the above data it appears that, by properly designing a cryoprotective mixture, electrical property temperature dependence may be controlled. Due to the frequency dependence of both the dielectric constant and the loss tangent, the reported results are only truly valid for frequencies approximating 1.5 GHz.

6064 SOFT TISSUE STRETCHING WITH MAGNETS. *(Eng.)* Engel, J. (Chaim Sheba Medical Center, Tel Hashomer and Tel-Aviv Univ., Sackler Sch. Medicine, Israel); Dagan, J. *Hand* 10(3): 312-316; 1978. (2 refs)

The possibility of stretching soft tissues by magnetic force was tested in rabbits and dogs. A small ferromagnetic metallic sphere was implanted under the skin of the animal's amputated forearm, and a Samarium Cobalt permanent magnet (residual induction of 8,000 G and coercive force of 7,500 Oe) that was connected to a turnbuckle device was attached to the stump by means of two Kirschner wires. This device stretched the skin by pulling the implanted sphere toward the magnet. The goal was to elongate the stump by 2-3 cm. The device was activated once a day, achieving a stretch of 3-4 mm daily. Initially, experiments were performed on the amputated forearm of a rabbit, but these failed because the rabbit did not tolerate the bulky apparatus connected to the stump. A second series of experiments was performed on four mongrel dogs whose upper limbs were amputated through the forearm. A metallic disc was inserted, and the stump was closed. The turnbuckle device containing the magnets was mounted on the leg and transfixed to the forearm bone by means of two Kirschner wires proximal to the magnet at the stump. X-ray films demonstrated that the metallic disc tilted after application of the magnet, causing the skin wound to break down. Ten additional dogs were amputated in the same manner, but this time a metal sphere, rather than a disc, was implanted distal to the bone. The sphere was installed under the skin in five dogs. However, the metal sphere caused the skin to break in these dogs between days 2 and 5 after stretching was initiated. In another five dogs the sphere was covered by muscle and skin. In these dogs, migration of the metal sphere was much slower than in the first group of five dogs; however, elongation was achieved without skin necrosis or breakage. The optimal distance between the magnet and metal sphere was that which exerted maximal pull but did not cause the skin to blanch or become necrotic. Although no more than 700 g of pull could be exerted without the skin showing signs of impending necrosis, this pull was enough to create a gradual elongation in soft tissue that ranged from 2.4-2.7 mm/day in the mongrel dogs. Vessels and nerves were not affected in the test animals.

6065 SINGLE NEURON ANALYSIS OF THE HUMAN MIDBRAIN TEGMENTUM: ROSTRAL MESENCEPHALIC RETICULOTOMY FOR PAIN RELIEF. *(Eng.)* Amano, K. (Neurological Inst., Tokyo Women's Medical Coll., 10 Kawada-cho Shinjuku-ku, Tokyo, Japan); Tanikawa, T.; Iseki, H.; Kawabatake, H.; Notani, M.; Kawamura, H.; Kitamura, K. *Appl Neurophysiol* 41(1/4): 66-78; 1978. (19 refs)

Microelectrode recordings from nociceptive neurons in the human midbrain reticular formation (MRF) were made during rostral mesencephalic reticulotomy (RMR) for pain relief in four patients. The target area was in the MRF bordering the periaqueductal gray matter at the superior collocular level. The recording loci of single neuron discharge and stereotactic radio frequency lesion were 13-16 mm posterior to the midpoint of the AC-PC line and 508 mm below the AC-PC line. The laterality of the target was measured from the center of the aqueduct, ranging from 5-8 mm from the midline. Single neuron analysis of MRF investigated in four patients with intractible pain during RMR revealed the following: abrupt change of background noise on entering the reticular formation; firing of neurons mostly composed of small cells; bilateral projection from the periphery with wide receptive fields; and a predominance of delayed firing in response to peripheral pinprick stimulation. The unit latency of these nociceptive neurons was classified into three groups: in the range of less than 250 msec (early response type); in the range of 400-800 msec (intermediate type); and in the range of more than 1,000 msec (delayed response type). Electrical stimulation of MRF

(3-10 V, 60 Hz, 1 msec pulse width) produced pain sensation mainly in the face but also in the trunk and extremities contralateral to the side of stimulation. This sensory phenomenon by electrical stimulation was seen when the electrode was in the reticular formation, more than 5 mm off the midline of the aqueduct. When the stimulating electrode was more medial in the central gray matter, the patient expressed fear sensation and experienced a burning sensation of the entire body rather than pain. A small radio frequency lesion in the MRF (approximately 2 by 3 mm) produced marked relief of pain. The stereotactic lesion is considered to be in the rostral MRF, lateral to fasciculus Foreli dorsolateralis and dorsolateral to the central tegmental tract and medial longitudinal fasciculus. A small radio frequency lesion in MRF has therapeutic significance in the treatment of intractable pain by making stereotactic intervention in the dividing zone of the ascending extralemniscal system at the midbrain into two different pathways, one being the projection to the posterior thalamus as discriminative pain or pain as sensation and the other to the limbic emotional brain as motivational pain or pain as suffering.

6066 THE EFFECTS ON CARDIAC PACEMAKERS OF IONIZING RADIATION AND ELECTROMAGNETIC INTERFERENCE FROM RADIOTHERAPY MACHINES. *(Eng.)* Marbach, J. R. (Radiotherapy Service, Veterans Admin. Hosp., 2002 Holcombe Blvd., Houston, TX 77211); Meoz-Mendez, R. T.; Huffman, J. K.; Hudgins, P. T.; Almond, P. R. *Int J Radiat Oncol Biol Phys* 4(11/12): 1055-1058; 1978. (2 refs)

Four demand-type pacemakers were exposed to electromagnetic fields associated with two betatron units and three linear accelerators. The pacemakers tested were the medtronics Models 5944 and 5950, the Cardiac Pacemakers Model 0502 Minilith, and the Intermedics Model C-MOS I. To simulate patient implant conditions, the pacers were placed in a 0.2% saline bath and fastened loosely to a block of lucite with a rubber band. The water temperature was maintained between 31 and 37 C since pulse rates vary with temperature. In each instance, from 1-2.5 cm of saline covered the pacer. With the exception of the Medtronics 5950 unit, which appeared to function normally in a Siemens electron beam, all the pacers failed under both betatron units. Failure was due to either loss of inhibit function, which is believed to be caused by the magnetic field of the machine, or erratic output, which is believed to be caused by the electric field from the beam injector. All of the pacers functioned normally under exposure to the three linear accelerators with the exception of the Minilith 0502, which failed completely while under an ARCO 8 beam. It also failed when the pacer was located out of the beam toward the machine gantry. In each case where failure from electromagnetic interference was encountered, the pacers returned to normal function immediately after the electromagnetic fields were removed. It is concluded that the use of betatrons should be avoided in patients who have implanted cardiac pacemakers. When linear accelerators are used, each case should be considered individually since variations from one therapy unit to another can play a very important role in the type of interference exerted on the pacemaker.

6067 MICROWAVE INTERROGATION OF DIELECTRIC TARGETS. PART I: BY SCATTERING PARAMETERS. *(Eng.)* Larsen, L. E. (Dept. Microwave Res., Walter Reed Army Inst. Res., Washington, DC 20012); Jacobi, J. H. *Med Phys* 5(6): 500-508; 1978. (51 refs)

A system for the generation of microwave images from homogeneous and heterogeneous dielectric targets is described. The microwave imaging system is based on automatic microwave network analysis for scattering parameters using launched radiation. Small dielectric targets may be imaged in water-dominated environments with dielectrically loaded and matched transmitting and receiving antennas. Targets on the order of 1 cm may be imaged with radiation of free space wavelength on the order of 10 cm by this technique. Geometrical fidelity can be retained in the near field for simple targets when multipath is well controlled. Small physical apertures improve spatial resolution. The method is sensitive to changes of the innermost dielectric in multilayered targets. The method may be generalized to three-dimensional analysis, which does not require prior knowledge of propagators (in contrast with Fourier transform holography). The radiation levels necessary for such interrogation in biomedical targets are well below the present ANSI C95 advisory standard.

6068 MICROWAVE INTERROGATION OF DIELECTRIC TARGETS. PART II: BY MICROWAVE TIME DELAY SPECTROSCOPY. *(Eng.)* Jacobi, J. H. (Dept. Microwave Res., Walter Reed Army Inst. Res., Washington, DC 20012); Larsen, L. E. *Med Phys* 5(6): 509-513; 1978. (8 refs)

A microwave time delay spectrometry (MTDS) system that provides unambiguous information for a wide range of time delays and provides discrimination between multiple paths whose differential propagation time is quite small is described. The data from this MTDS system do not become ambiguous until the total propagation time is equivalent to that of over 1,400 miles in free space. This is clearly adequate for biologically relevant targets. Additionally, the system as it exists is capable of discriminating between two ray paths whose differential time delay is on the order of 100 picosec. This differential delay corresponds to a differential path length in the brain on the order of 6 mm. In muscle, this would correspond to about 4.5 mm. It has been further demonstrated that the success of such an imaging system depends critically on the physical aperture of the interrogating antennas. As aperture size increases, the inability of the target to occlude the direct ray path renders the system insensitive to small tar-

gets and is thus of diminished value. The water-loaded antennas do have small enough apertures that, when operating in the near field, propagation time may be measured over a region consistent with an imaging application. This approach offers promise for further development to allow later tomographic reconstruction by allowing multipath discrimination. It is clear that the MTDS system has much to offer in solving the temporal and spatial averaging problems encountered by the single-frequency continuous wave measurement systems.

6069 STEREOTACTIC RADIOFREQUENCY HYPOPHYSECTOMY. *(Eng.)* Zervas, N. T. (Dept. Neurological Surgery, Massachusetts General Hosp., Boston, MA 02114); Hamlin, H. *Appl Neurophysiol* 41(1/4): 219-222; 1978. (6 refs)

The use of stereotactic radio frequency (RF) hypophysectomy for the treatment of various disorders is discussed. The RF procedure uses the precise Todd-Wells cephalic instrument to direct a plastic-sheathed electrode (1.7 mm in diameter) containing a thermocouple within its tip intrasellar through either nasal cavity. The electrode slides inside a fitted cannula that has a side outlet at its active end that permits extrusion of a stainless steel spring into a 90 degree arc from its axis. The RF current is used to induce heat within a 4-6 mm length of tissue around a curved spring that ultimately forms a coalescent sequence of elipsoid destructions. The parameters of the RF procedure are a frequency of 1 Hz, a current of 100-300 mA, and a voltage of 20-50 V. Each heat spot is generated by maintaining the electrode tip at 80-85 C for 60-120 sec. The technical steps must be performed in sequence and with detail to provide safety while achieving maximal inactivation of the adenohypophysis. Among a recent series of 100 successive patients treated with the RF technique, cerebrospinal fluid leakage developed only once and was successfully countered by 6 days of regulated lumbar spinal drainage. There was no instance of visual or oculomotor deficit. Overall operative mortality was less than 1%. Among 116 cases of diabetic retinopathy treated by the RF technique, 80% achieved lasting improvement or stabilization of vision, and many have lived beyond 10 yr. The largest group of patients treated by the RF technique comprised metastatic breast cancer patients, with the usual candidate having skeletal and often multiorgan metastases as well as being postmenopausal, ovariectomized, estrogen-androgen responsive, and recently reactive to an estradiol receptor test. Success (1-3 yr survival) was obtained in approximately 55% of these patients. Many patients achieved rapid pain relief. The RF procedure has also been applied in several cases of active acromegaly due to small subdiaphragmatic tumors and also in a few craniopharyngiomas. Approximately 80-85% of all patients tested showed significantly diminished levels of growth hormone production. The RF procedure is not suitable for larger tumors or for isolated microadenoma, which is usually associated with persistent prolactic secretion.

6070 ELECTRICAL SPINAL CORD STIMULATION FOR SPASTIC MOVEMENT DISORDERS. *(Eng.)* Siegfried, J. (Dept. Neurology, Univ. Zurich, Zurich, Switzerland); Krainick, J.-U.; Haas, H.; Adorjani, C.; Meyer, M.; Thoden, U. *Appl Neurophysiol* 41 (1/4): 134-141; 1978. (12 refs)

The results of using electrical spinal cord stimulation for the treatment of 10 patients (8 men and 2 women; ages, 32-61 yr) with various spastic disorders are reported. The H reflex was conditioned by a dorsal column stimulus train (1-300 msec, 70 Hz and 0.2 msec impulse duration). In all patients stimulation of the cord elicited paresthesias in the implanted cervical or thoracic segment and, with higher intensities, in both legs or in all four extremities. Shortly after a few minutes of stimulation, the patients reported a decrease in the feeling of muscular stiffness. Neurologic examination confirmed this decrease of hypertonicity for periods ranging from 1-12 hr. The best results were observed in cases of multiple sclerosis (six patients). Two cases of spastic paraplegia as well as a case of vascular lesion of the cord were moderately improved. A post-traumatic patient with an almost complete interruption of the cord at the C_5 level showed very little improvement of a very severe tetraspasticity. The physiologic mechanisms of dorsal cord stimulation on spasticity are not yet determined since it is not known what is being stimulated.

6071 BEHAVIORAL EFFECTS OF MICROWAVE IRRADIATION ON SQUIRREL MONKEY *(SAIMIRI SCIUREUS)* PERFORMANCE OF A REPEATED ACQUISITION TASK. *(Eng.)* Nelson, T. D. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). 18 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD A055 953/4GA]. (9 refs)

The effects of pulsed microwave irradiation on the acquisition of new behaviors were studied in six individually caged male squirrel monkeys *(Saimiri sciureus)* using a repeated acquisition task. For 30-min periods the monkeys were repeatedly exposed to 5.62-GHz microwaves pulsed at a repetition rate of 600/sec. Pulse widths were 0.5 μsec at an average incident power density of 11 mW/cm^2 and 2 μsec at 43 and 53 mW/cm^2. A waveguide connected to a standard gain horn was used to irradiate the monkey's ventral surface while it was restrained in an upright seated position in a Styrofoam restraint chair. Response acquisition was impaired following 30 min of exposure to an incident power density of 53 mW/cm^2 but not to 11 or 43 mW/cm^2. A mean increase of 1.9 C in rectal temperature above control levels accompanied the behavioral effects observed in monkeys irradiated at a power density of 53 mW/cm^2. No such effects were observed without concomitant hyperthermia. These effects were transitory, and no evidence of irreversible impairment of learning ability was observed. The threshold power density necessary to significantly disrupt behavior under the conditions of this experiment was estimated to be be-

tween 45 and 50 mW/cm^2. This value compares to an estimated threshold for behavioral effects in the squirrel monkey of between 40 and 50 mW/cm^2 for 60 min of exposure to continuous wave 2,450-MHz microwaves. The results of this experiment were compatible with the hypothesis that behavioral changes were directly related to hyperthermia in the monkey.

6072 EFFECTS OF INTERSTITIAL IRRADIATION ALONE, OR IN COMBINATION WITH LOCALIZED HYPERTHERMIA ON THE RESPONSE OF A MOUSE MAMMARY TUMOR. *(Eng.)* Miller, R. C. (Div. Radiation Oncology, Dept. Radiology, Univ. Arizona Health Sciences Center, Tucson, AZ 85724); Leith, J. T.; Veomett, R. C.; Gerner, E. W. *J Radiat Res (Tokyo)* 19(3): 175-180; 1978. (20 refs)

The effects of interstitial irradiation (^{226}radium) alone or in combination with localized radio frequency (500 kHz) hyperthermia on the growth of a transplantable mammary sarcoma (EMT_6) in the mouse were investigated. For irradiation, tumors about 45 mm^3 in volume were implanted with two 3-cm long needles containing ^{226}radium; computerized dosimetry calculations indicated that the tumor was enclosed by an isodose curve of about 40 rad/hr at its periphery. For combined hyperthermic treatments, the implanted radium needles were used as electrodes for radio frequency heating (43 C for 1 hr). Localized hyperthermia in combination with interstitial irradiation resulted in a tumor volume reduction of more than 60% by 4 days after the initiation of treatment, whereas either hyperthermia or irradiation alone resulted in only a 20% reduction in tumor volume. Overall, there was a large killing effect on hypoxic and nutritionally deprived cells, leading to rapid cytolysis and a marked decrease in tumor volume that occurred as early as 1 day after combined hyperthermia and interstitial irradiation was initiated. Since the cell yield per milligram of tumor showed no difference for either treatment, while the tumor volume was reduced by up to 60% for the combined treatment, it is concluded that the actual cell survival must have been greatly reduced after combined treatment compared to irradiation alone. The implication is that a large percentage of hypoxic cells are preferentially removed by the combined modality treatment. It is concluded that these initial results provide a rationale for the use of hyperthermia combined with interstitial irradiation in the treatment of human cancers, particularly those of the head and neck.

6073 MICROWAVE-INDUCED INJURIOUS EFFECTS ON THE HUMAN-EMBRYO IN UTERO. *(Eng.)* Neelakantaswamy, P. S. (Electronics Section, Sch. Applied Sciences, Univ. Science Malaysia, Minden, Penang, Malaysia). *Biomed Tech* 23(11): 263-269; 1978. (17 refs)

A damage-risk criterion is established for the growing human-embryo in utero that is exposed to microwave radiation. Based on assumptions dealing with changes in oxygen consumption in the intrauterine region that is susceptible to microwave-induced damage, the relative time of failure for different stages of gestation is mathematically evaluated. It is evident that the risk of damage is more significant for the early stages of fetal growth. The dependency of oxygen consumption on microwave-induced thermal processes in the fetus is established and quantified in terms of a fatal factor. As a measure of the hazard involved, a term "lethality" is defined and evaluated in terms of deterministic parameters. Thus, the concepts of risk and damage are given concrete numeric expressions that can be extended to other susceptible parts of the body that are subjected to microwave irradiation.

6074 MICROWAVE DIELECTRIC RELAXATION OF AQUEOUS SOLUTIONS OF DEXTRAN. *(Eng.)* Delbos, G. (Laboratoire d'Optique Ultra-Hertzienne, Universite de Bordeaux 1, 351 cours de la Liberation, 33405 Talence Cedex, France); Bottreau, A.-M.; Marzat, C.; Salefran, J.-L. *J Microwave Power* 13(1): 69-75; 1978. (5 refs)

Microwave dielectric relaxation of aqueous solutions of T 110 dextran (average molecular weight of 1.1 x 10^5) was studied. Measurements were performed at the following frequencies: 3.624, 9.455, 15.350, and 35.250 GHz. A resonant cavity method was used at the first three frequencies, while an interferometric method was used at 35.250 GHz. The concentrations of the aqueous dextran solutions were 50, 100, 200, 300 and 400 g/l. Measurements were carried out at different temperatures between 10 and 60 C. A two "Debye" decomposition did not provide good agreement between experimental results and calculated values. However, good agreement between experimental results and calculated values was obtained using the Cole-Cole model with a distribution of relaxation times. The relaxation time distribution increased with concentration and temperature. It is concluded that the dielectric relaxation of dextran's aqueous solutions appears to be due only to the water, which is modified by dextran.

6075 SPINAL CORD STEREOTACTIC TECHNIQUES RE TRIGEMINAL NUCLEOTOMY AND EXTRALEMNISCAL MYELOTOMY. *(Eng.)* Schvarcz, J. R. (Inst. Neurosurgery, Sch. Medicine, Univ. Buenos Aires, Buenos Aires, Argentina). *Appl Neurophysiol* 41(1/4): 99-112; 1978. (53 refs)

The use of spinal cord stereotactic techniques for relieving various types of pain is reported. Radio frequency lesions were placed either at the spinal trigeminal nucleus (stereotactic trigeminal nucleotomy) or at the central cord region (stereotactic extralemniscal myelotomy) to interrupt preferentially multisynaptic nonspecific pathways. A total of 104 stereotactic trigeminal nucleotomies were performed on 100 patients. Among 48 patients with central pain from benign conditions, abolition of hyperpathia and marked reduction or disap-

pearance of deep background pain was achieved in 87.5% of those with postherpetic neuralgias, in 57% of those with anesthesiae dolorosa, and in 72% of those with dysesthesic conditions. The follow-up period ranged from 0.5-5.5 yr. Another 21 patients had idiopathic facial neuralgias; however, at this time, percutaneous thermocontrolled differential rhizotomy seems to be the procedure of choice for idiopathic trigeminal neuralgia. Among 31 patients with pain from malignancies, satisfactory pain relief was obtained in 83.8% of the cases after trigeminal nucleotomy, with the follow-up period ranging from 2-30 mo. A total of 76 myelotomies were performed on 75 patients. Among 14 patients with pain of central origin from benign conditions (4 causalgias, 4 postherpetic neuralgias, 3 brachial plexus avulsions, and 3 spinal cord lesions), abolition of hyperpathia and disappearance or marked reduction in deep background pain was achieved in 64% of the cases. The follow-up period ranged from 0.5-4 yr. Extralemniscal myelotomy was also performed in 61 patients with pain related to neoplasms; 42 had lower body, midline, and/or bilateral pain (mostly from rectal or cervical carcinomas) and 19 patients had unilateral upper body pain (mostly from lung carcinomas with respiratory inadequacy). Satisfactory pain relief was obtained in 78% of the cases. The follow-up time ranged from 0.5-24 mo, but 81% of the patients died within the first 6 mo. There were no lasting side effects associated with the stereotactic technique.

6076 IONIC FACTORS IN RELEASE OF $^{45}Ca^{2+}$ FROM CHICKEN CEREBRAL TISSUE BY ELECTROMAGNETIC FIELDS. *(Eng.)* Bawin, S. M. (Brain Res. Inst., Univ. California, Los Angeles, CA 90024); Adey, W. R.; Sabbot, I. M. *Proc Natl Acad Sci* 75(12): 6314-6318; 1978. (36 refs)

The effect of radio frequency stimulation (amplitude modulated at brain wave frequencies) on radiolabeled calcium^{+2} (Ca^{+2}) efflux from isolated chicken cerebral tissue was investigated. All irradiations were performed for 20 min in a 450-MHz horn radiator. The radio frequency generator was sinusoidally amplitude-modulated at 16 Hz. The incident field on the tissue was 0.75 mW/cm^2 in most cases. Radio frequency stimulation increased Ca^{+2} efflux from cerebral tissue, and the response was not sensitive to variations in the calcium concentration (0-4.16 mmolar [mM]) in the bathing solution. The radio frequency-induced Ca^{+2} efflux was inhibited in the absence of normal bicarbonate levels (2.4 mM). When the pH of the test solution was lowered from 7.6 to 6.8 by the addition of 0.108 mM hydrogen chloride, the radio frequency-induced Ca^{+2} efflux was enhanced. The presence of 0.5 mM lanthanum chloride in bicarbonate-free solution restored electrical responsiveness but the stimulus decreased (by 7%) rather than increased the efflux of Ca^{+2}; there was also a significant increase in the brain-to-efflux ratio (4.33 ± 0.17) in comparison with controls in bicarbonate-free medium (3.75 ± 0.12). The lanthanum-induced decreases in electrically stimulated Ca^{+2} efflux were of the same order of magnitude at lanthanum concentrations of either 0.5 or 2.0 mM. The results suggest that low-frequency, weak, extracellular electric gradients may be transduced in a specific class of extracellular negative binding sites normally occupied by Ca^{+2} and susceptible to competitive hydrogen ion binding.

6077 MICROWAVE-INDUCED HYPERTHERMIA IN CANCER TREATMENT: APPARATUS AND PRELIMINARY RESULTS. *(Eng.)* Mendecki, J. (Dept. Radiotherapy, Montefiore Hosp. and Medical Center, Bronx, NY 10467); Friedenthal, E.; Botstein, C. *Int J Radiat Oncol Biol Phys* 4(11/12): 1095-1103; 1978. (18 refs)

Experimental and clinical studies on the use of microwave radiation (915 or 2,450 MHz) for inducing hyperthermia (42.5-43 C) in cutaneous and subcutaneous tumors are described. Preliminary experiments were performed with various microwave applicators to determine the power required to raise the temperature of the irradiated volume to the desired threshold of approximately 42.5 C and then to maintain it at this level. In general, a power density of about 1 W/cm^2 of tumor surface area was necessary to operate the applicators effectively. In a pilot experiment using a waveguide applicator filled with a solid dielectric and prematched for muscle tissue, 54 mice with mammary adenocarcinoma received four hyperthermia treatments localized to the tumor site (43 C, 45 min, every other day), while 18 tumor-bearing mice served as controls. Complete eradication of tumors was achieved in all of the treated animals, and they showed no evidence of tumor recurrence over a 4-mo observation period. All of the 18 controls died within 4 wk after tumor inoculation. Clinical trials, which are still in progress, indicated that hyperthermia appears to be beneficial in the treatment of basal cell carcinoma, malignant melanoma, metastatic breast cancer, and local recurrence of breast adenocarcinoma following radical mastectomy. This appears to be especially true when hyperthermia is used in conjunction with ionizing radiation. Based on heat mapping experiments in both simulated body-cavity geometries and in vivo animal measurements, a coaxial applicator appears to have an important potential for the treatment of tumors contained in body cavities. The demonstration of directive heating using this type of applicator makes it particularly useful for the clinical treatment of human malignancies.

6078 FREE-SPACE ELECTRIC FIELD MAPPING OF MICROWAVE DIATHERMY APPLICATORS. *(Eng.)* Witters, D. M., Jr.; Kantor, G. (Div. Electronic Products, Bureau Radiological Health, Food and Drug Admin., Rockville, MD 20857). 25 pp.; 1978. [available through U.S. Dept. HEW, PHS, FDA, BRH, Rockville, MD 20857, HEW Publication (FDA) No. 79-8074]. (6 refs)

Free-space electric field maps are presented for various prototype and clinically used microwave

diathermy applicators that operate at a frequency of 2.45 GHz. Thermal maps describing energy deposition in planar phantoms of simulated tissue also are presented to further confirm the results of the field maps. It is shown that the transverse field induces virtually all of the heating in tissue and that the longitudinal or radial field does not contribute significantly to the heating effect of microwave diathermy. Parameters for the safety and thermal effectiveness of microwave diathermy applicators are also presented. Leakage of electromagnetic radiation from the applicators is higher for the older type B, C, and E free-space applicators than for the more recent Siemens and Transco applicators. The type B applicator is a hemispherical applicator (15.24 cm in diameter) with conical feed. Type C (12.7 cm by 11.43 cm) and the more recent type E (17.15 cm by 13.97 cm) applicators are corner reflectors with different T-shaped feeds. The Siemens applicator is circular (16.51 cm in diameter) with a helical feed. The Transco applicator (15.24 cm in diameter) is a direct contact applicator that is positioned directly on (or within 1 cm of) the tissue to be treated. The applicators' effectiveness was correlated with the ratio of the transverse field to the longitudinal field at the aperture center. Of the applicators mapped, the type B was by far the least effective because of the doughnut-shaped transverse field with a peaked radial field located over the doughnut's center (minimum). The type B applicator therefore has a small value for this ratio compared with the large value for the very effective Transco applicator. For clinical use, the Transco applicator seems to be the safest and most effective in terms of heating the prescribed tissue with low leakage.

6079 LEAKAGE IN THE PROXIMITY OF MICROWAVE DIATHERMY APPLICATORS USED ON HUMANS OR PHANTOM MODELS. *(Eng.)* Bassen, H. I.; Kantor, G.; Ruggera, P. S.; Witters, D. M., Jr. (Div. Electronic Products, Bureau Radiological Health, Food and Drug Admin., Rockville, MD 20857). 16 pp.; 1978. [available through U.S. Dept. HEW, PHS, FDA, BRH, Rockville, MD 20857, HEW Publication (FDA) No. 79-8073]. (4 refs)

Leakage radiation in the proximity of a 2,450-MHz contact microwave diathermy applicator developed for BRH by Transco Products, Incorporated was measured using various human anatomic models (phantoms) and two human volunteers. The objective of the study was to evaluate the practicality of using phantoms to predict leakage that would occur during actual clinical treatment procedures. The human volunteers were minimally exposed over 1-min intervals to low power (1-1.5 W of net power) simulated treatments, while leakage fields were mapped over the entire applicator/body interface surface. From typical diathermy treatments using the applicator on phantoms or humans at low power levels, the leakage at 5 cm from the surface of the applicator/tissue interface was extrapolated to effective treatment conditions (235 W/kg delivered to the phantom muscle material). The leakage levels for the human back, thigh, and elbow treatments were computed to be less than 5 mW/cm^2 under full-power conditions. The leakage for the forearm under full-power conditions was computed to be less than 10 mW/cm^2, while for the upper arm a maximum of 11.9 mW/cm^2 was obtained. These results suggest that the Transco contact applicator is generally appropriate for low-leakage back and thigh treatments. In addition, there was good agreement (within a factor of 2) between virtually all actual leakage data (human) and simulated (phantom) treatments provided that the appropriate phantoms were used. These results can be applied to the proposed BRH microwave diathermy standard, which intentionally omits the use of human subjects for diathermy equipment performance testing. It is concluded that leakage testing with appropriate phantoms is a reasonable means for minimizing unnecessary microwave leakage in clinical conditions. Phantom data on leakage and energy deposition for conventional, non-contact applicators (types B and E) revealed that high leakage (35.5 and 44.0 mW/cm^2) would have occurred under identical effective treatment conditions.

6080 ASSAY OF NOREPINEPHRINE AND DOPAMINE IN THE RAT BRAIN AFTER MICROWAVE IRRADIATION. *(Eng.)* Maruyama, Y. (Section Biochemical Pharmacology, Japan Upjohn Res. Lab., Takasaki, Gunma 370, Japan); Kusaka, M. *Life Sci* 23(15): 1603-1608; 1978. (26 refs)

Regional levels of norepinephrine (NE) and dopamine (DM) were measured by high performance liquid chromatography after rat brain enzyme inactivation by microwave irradiation. These levels were compared with those in brains from rats that were decapitated. Half of the rats sacrificed by microwave irradiation were exposed to 1.3 kW of 2.45-GHz radiation for 5.0 sec (low power), while the rest were exposed to 5 kW of 2.46-GHz radiation for 1.5 sec (high power). Using 350-450 g rats, the brain temperature was elevated to 80 C within 5 sec at 1.3 kW and within 1.5 sec at 5 kW. The order of NE regional levels after microwave irradiation was in accord with that obtained by decapitation. However, higher levels of NE (ng/g) were found in the cerebellum (257 ± 11) and the cortex (307 ± 11) after high power irradiation than after decapitation (214 ± 15 and 264 ± 4, respectively). After low power irradiation, NE levels were reduced in the medulla-pons (387 ± 11) and in the midbrain-thalamus (372 ± 12) in comparison with levels after decapitation (522 ± 20 and 506 ± 29, respectively). The level of DM was significantly increased in at least four regions of the brain after microwave irradiation in comparison with the DM level after decapitation. After high power irradiation the DM levels in the medulla-pons, corpus striatum, hippocampus, and cortex (ng/g) were 42 ± 7, 7,087 ± 286, 77 ± 18, and 473 ± 51, respectively, compared with levels of 25 ± 2, 5,565 ± 222, 25 ± 3, and 207 ± 29, respectively, after decapitation. After low power irradiation, DM levels were significantly increased in the cerebellum, medulla-pons, hippocampus, and cortex in

comparison with levels for decapitated specimens. These results indicate the importance of rapid inactivation of brain enzymes in the study of regional levels of NE and DM in the rat brain.

6081 CHRONIC PALEOCEREBELLAR STIMULATION FOR THE TREATMENT OF NEUROMUSCULAR DISORDERS: FOUR CASE REPORT. *(Eng.)* Manrique, M. (Dept. Neurosurgery, Clinica Puerta de Hierro, Madrid, Spain); Oya, S.; Vaquero, J.; Lozano, A. P.; Herrero, J.; Bravo, G. *Appl Neurophysiol* 41(1/4): 237-247; 1978. (20 refs)

Chronic paleocerebellar electrical stimulation was used to treat two patients with cerebral palsy, one patient with paraplegic spasticity, and one with familial cerebellospinal atrophic disease. Paleocerebellar stimulation was performed through a plate silicone-coated mesh, with four pairs of platinum-disc electrodes affixed, placed anteriorly over the cerebellum through small suboccipital craniectomies. Electrode implantation was performed bilaterally in two patients and on the right side in two patients. Stimulation potentials ranging from 6-10 V at a pulse repetition rate of 20-180 Hz were applied on a 15-min on, 15-min off schedule over periods ranging from 90 min to 7 hr daily. Some improvement was noted in three patients treated with high frequency stimulation (180 Hz); however, one of these suffered seizures after 3 mo of chronic stimulation. In two patients posterior fossa explorations revealed marked meningeal proliferation surrounding the electrodes. Light and electron microscopic examinations of biopsies showed loss of Purkinje cells and gliofibrillar reaction. One patient with spastic dystonia was treated with chronic low frequency stimulation (20 Hz) and showed negligible improvement after 9 mo of stimulation. The results indicate that chronic cerebellar stimulation can improve disturbances of posture and muscle tone in some patients. However, the present results seem less successful than those reported by others. Also, such stimulation techniques should be applied cautiously until more is known about their effects on the cerebellum.

6082 THE POSTEROMEDIAL HYPOTHALAMUS AND PAIN, BEHAVIOR, WITH SPECIAL REFERENCE TO ENDOCRINOLOGICAL FINDINGS. *(Eng.)* Mayanagi, Y. (Dept. Neurosurgery, Univ. Tokyo, Tokyo, Japan); Hori, T.; Sano, K. *Appl Neurophysiol* 41(1/4): 223-231; 1978. (12 refs)

The results of using posteromedial hypothalamotomy for the treatment of patients with aggressive behavioral disorders and patients with intractable pain are reported. After demonstration of the third venticle, a fine concentric bipolar electrode (0.8 mm in outer diameter with an interpolar distance of 0.5 mm) was stereotactically inserted through a frontal burr hole into the target point, which was 2 mm below the midcommissural point and 2 mm lateral from the wall of the third ventricle. High frequency stimulation (50-100 Hz, 10-20 V) with square wave pulses of 1 msec in width usually caused marked sympathetic responses, such as, mydriasis, elevation of blood pressure, increase in pulse rate, or short respiratory arrest followed by hyperpnea or tachypnea. During weak stimulation, (10-20 Hz, 5-10 V), patients often noticed a decrease in pain. When good sympathetic responses were obtained, electrocoagulation with high frequency current was performed using the same electrode. No neurologic deficit was found postoperatively. Among 38 evaluable patients with aggressive behavioral disorders, the procedure was considered to have been effective in 95% of the cases, with satisfactory results being obtained in 84%. Among 20 patients with intractable pain, complete or almost complete pain relief was achieved in 60%, partial relief in 35%, and no relief in 5%. From an endocrinologic viewpoint, the procedure appeared to activate the hypothalamic-hypophyseal axis only temporarily, without causing any serious dysfunction.

6083 TREATMENT OF SPASMODIC TORTICOLLIS BY DORSAL COLUMN STIMULATION. *(Eng.)* Gildenberg, P. L. (Dept. Surgery, Div. Neurosurgery, Univ. Texas Medical Sch., 6400 W. Cullen St., Houston, TX 77030). *Appl Neurophysiol* 41(1/4): 113-121; 1978. (17 refs)

The results of using an implanted dorsal column stimulator at the C_{1-2} level or transcutaneous stimulation for the treatment of 20 patients with spasmodic torticollis and 2 patients with dystonia musculorum deformans are reported. Initially the response to transcutaneous stimulation was evaluated. This involved the application of two electrodes to the skin of the neck, with the stimulation being controlled by the patient. A standard transcutaneous stimulating unit was employed; the Medtronic NeuroMod Stimulator, the StimTech EPC Personal Stimulator, and the Medgeneral miniCeptor proved satisfactory. Three of the torticollic patients responded satisfactorily enough to transcutaneous stimulation to be treated by this method alone. The remaining patients were evaluated with percutaneous electrodes with a wide range of stimulation frequencies. A consistent pattern was found in which patients reported the typical projection of sensation to the body at frequencies less than 800 Hz. As the stimulation was gradually increased from 800 to 1,100 Hz at a constant voltage, the sensation gradually diminished despite an increase in the total stimulus intensity. At frequencies above 1,100 Hz there was usually no sensation at the same voltage that caused a sensation at lower frequencies. Optimal benefit was found at frequencies of 1,100-1,400 Hz even though the patient had no sensation at that stimulus rate. Six patients with spasmodic torticollis and one patient with dystonia musculorum deformans who were evaluated with transcutaneous and percutaneous dorsal column stimulation had permanently surgically implanted dorsal column stimulators employed for the treatment of their disease. Of these, one patient achieved an excellent response, three a good response, one a fair response, and one

a poor response based on improvement of head positioning, comfort, and decrease in disability. The patient with dystonia musculorum deformans had considerable improvement with dorsal column stimulation but remained disabled. Most patients found it necessary to apply the stimulus for 5-15 min before obtaining relief, but the relief frequently outlasted the stimulus for many hours.

6084 RADIOLOGICAL HEALTH ATTITUDES OF COLLEGE STUDENTS. *(Eng.)* Weinstein, R. D. (Program of Radiologic Technology Education, Sch. Allied Health Sciences, Univ. Texas Health Science Center, Houston, TX 77025). *Radiol Technol* 50(3): 259-263; 1978. (3 refs)

Radiologic health attitudes were surveyed among 622 undergraduate college students using the Radiological Health Attitude Inventory. The study sample comprised 90% freshmen, 7% sophomores, and 3% juniors and seniors attending Texas A&M University in the spring of 1976. The leakage of hazardous levels of radiation from color television sets was considered a problem by 41% of the sample, although 54% disagreed that radar installations are sources of harmful radiation. With respect to attitudes on consumer products, 32% of the sample felt that microwave ovens leak harmful levels of radiation, while 49% disagreed and 18% were undecided. The results of this study indicated that misconceptions toward radiologic health hazards existed in the study sample.

6085 ELECTRICAL STIMULATION FOR VOIDING DYSFUNCTION AFTER SPINAL CORD INJURY. *(Eng.)* Godec, C. (Urology Services, Hennepin County Medical Center, St. Paul, MN); Cass, A. S. *J Urol* 121(1): 73-75; 1979. (25 refs)

The use of electrical stimulation of the anal sphincter in the management of incontinence and/or frequency of voiding in spinal cord injury patients is reported. Urinary incontinence was present in 15 of 18 patients studied, and frequency of voiding was present in more than half of the patients in whom it could be recorded. The criteria for selection of patients with spinal cord injury for treatment with electrical stimulation of the pelvic floor muscles were hyperreflexic bladder function and/or pelvic floor weakness with some innervation of the pelvic floor muscles and an anal sphincter pressure increase of greater than 15 cm of water with electrical stimulation of 15 V maximum. Treatment was either chronic or acute maximal functional electrical stimulation. Chronic stimulation was applied via an anal plug using a continuous train of stimuli. The parameters of stimulation were a pulse duration of 1 msec, a frequency of 20 Hz, and an amplitude of 3-8.5 V (10-15 mA). The patients were instructed to use the stimulator continuously except for voiding and a pause every 2 hr to pass flatus. Acute maximal stimulation was applied via an anal plug and stimulating needle electrodes inserted into the levator ani muscle to increase the input of electrical stimulation. The amplitude of stimulation was 47-50 V (100-150 mA). The duration of each acute maximal application was 15-20 min, and the applications were repeated 4-10 times with 2-3 days between applications. Of 11 patients who were treated with functional electrical stimulation, 9 showed either relief or improvement in their symptoms. Four patients experienced relief after periods of up to 20 mo after stimulation, and another four improved after follow-up periods of up to 10 mo. One patient is still on the device and is improving. An increase in anal sphincter pressure with functional electrical stimulation proved to be a more reliable criterion than an increase in maximum urethral pressure in the selection of patients for the procedure.

6086 COAGULATIVE PROPERTIES OF BLOOD AND TISSUES OF THE CARDIOVASCULAR SYSTEM IN EXPOSURE TO ELECTROMAGNETIC FIELD. *(Eng.)* Kuksinskiy, V. Y. (Dept. Normal Physiology, Chitinskiy Medical Inst., Chita, USSR). 7 pp.; 1978. Translated from Russian--*Kardiologiya* (3): 107-110; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. HC A04/MF A01]. (29 refs)

The effects of an electromagnetic field on the coagulative properties of blood and tissues of the cardiovascular system were examined by exposing 50 albino rats for 20 min/day to a low frequency (1,000 Hz) electromagnetic field of 30 V/cm intensity for periods of either 8 or 20 days. After the 8-day exposure, the coagulation activity of the cardiovascular tissues was drastically reduced. This was expressed in a lengthening of the recalcification time, a drop in the tolerance of plasma for heparin, and a decrease in the consumption of prothrombin under the influence of tissue extracts. A rise in the thromboplastic and fibrinolytic activity of the blood was also observed after an 8-day exposure. After the 20-day exposure, an even greater inactivation of both tissue and plasma factors in coagulation and fibrinolysis was noted.

6087 POSSIBILITY OF ATTENUATING THE ECOLOGICAL EFFECTS OF ALTERNATING CURRENT POWER LINES AS A RESULT OF NEW DESIGNS AND CIRCUIT CHANGES. *(Eng.)* Postolatiy, V. M.; Putyatin, S. P. (No affiliation given). pp. 13-22; 1978. Translated from Russian--*Izv Akad Nauk Mold SSR, Ser Fiz Tekh Mat Nauk* (1): 73-79; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. HC A04/MF A01]. (7 refs)

The possibility of reducing the ecologic effects of single- and double-circuit alternating current electric power lines (EPL) by means of approximating phases is theoretically examined in reference to the proposed use of ultrahigh voltage EPL (1,150 V or more) in the USSR. With respect to multicircuit EPL, reduction of interphase and intercircuit distances is discussed along with a change in the phase shift of triple-phase voltage systems applied to the circuits. It is shown that the intensity of the electric field generated by an alternating

current EPL near the ground surface can be reduced without altering the clearance distance by 10-15% for single-circuit, triple-phase EPL by approximating the phases to the minimum permissible distance with due consideration of interphase overvoltages; the intensity of the electric field near the ground surface can be reduced by 16-46% when the EPL are constructed in the form of controllable self-compensating lines.

6088 ELECTRIC AND MAGNETIC FIELD CALCULATIONS IN SUPPORT OF BIRD MIGRATION STUDIES AT THE WISCONSIN TEST FACILITY. *(Eng.)* Lanera, D. (IIT Res. Inst., 10 West 35th St., Chicago, IL 60616). 19 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD-A057 412]. (4 refs)

Calculations of extremely low frequency (ELF) electric and magnetic fields along specific line paths of birds at the Navy's Wisconsin Test Facility (WTF) are presented in support of studies on the possible effect of ELF fields on bird migration. The WTF consists of two antenna elements installed in a cross-shaped pattern. Each antenna element is approximately 14 miles long and is composed of a cable suspended from poles at an average height of 30 feet above the ground. The antenna elements terminate in grounding electrodes that consist of bare, horizontal, buried wires. The antenna current may be as high as 300 A and is modulated in the frequency band of 72-80 Hz. The two antenna elements can be operated independently or together in any phase relationship: Calculations are presented for the case of a north-south antenna operating alone at a current of 300 A and a frequency of 76 Hz. The results of the calculations are as expected and show field magnitudes that are highest over the antenna and then decrease as the distance increases. A few kilometers away and beyond, no difference is observable among the fields at various altitudes.

6089 HIGH-VOLTAGE POWER LINES AND HUMAN HEALTH. *(Eng.)* Sulpor, B. (Electric Power Res. Inst., 3412 Hillview Ave., P.O. Box 10412, Palo Alto, CA 94303). *Public Util Fortn* 103(1): 11-15; 1979. (0 refs)

Studies on the biologic effects of high-voltage power lines are reviewed. Although Soviet studies have reported such effects as listlessness, excitability, headache, loss of sex drive, drowsiness, and fatigue among electrical switchyard workers, other studies on substation and transmission line workers in Canada, England, France, West Germany, Italy, and the United States have failed to demonstrate these effects. Animal studies at the Veterans Administration Hospital in Syracuse, New York have shown that rats exposed for 30 days to an electric field experienced a response similar to that undergone by an animal or human suffering from stress. It was also found that mice exposed to a vertical electric field for three successive generations were stunted. However, tests under way at Battelle on mice, rats, and swine as well as tests completed recently at the University of Utah on rats have failed to confirm the above results. The only biologically significant and confirmed observation of nearly 500 tests made thus far at Battelle is that rats, when given a choice, spend more time out of the electric field than in it when field strengths are greater than 15 kV/m. Other studies have demonstrated that some plants are slightly damaged by electric fields. Field tests involving the placement of shielded and unshielded beehives between two 765-kV transmission towers demonstrated that less honey was produced in unshielded metal hives and that bees from these hives weighed less than controls. It was also noticed that honeybees on the outside of nonmetal unshielded hives stung one another. This aggression was attributed to an electric current buildup on these particular hives, which contained polyethylene and were nonconductive. The investigators in these experiments state that it is still too early to determine the significance of these results.

6090 PRELIMINARY CLINICAL TRIALS OF ELECTROPHORETIC IONIZATION IN THE TREATMENT OF MALIGNANT TUMORS. *(Eng.)* Nordenstrom, B. (Dept. Diagnostic Radiology, Karolinska sjukhuset, S-104 01 Stockholm 60, Sweden). *IRCS Med Sci: Cancer* 6(12): 537; 1978. (2 refs)

Local electrophoretic ionization was used to treat seven inoperable lung metastases in five patients (ages, 20-68 yr). Teflon insulated platinum electrodes (0.2 mm thick) with the distal 20 mm free from insulation were implanted percutaneously under local anesthesia. One electrode was placed in the tumor and one in the surrounding tissue or in a vessel supplying the tumor. A 10- to 15-V direct current was then applied, with the tumor being electropositive. An initial current of 5-10 mA was then increased gradually to 30-40 mA, producing intensive tissue ionization. The electropositive tumor tissue turned into a dry gangrene surrounded by diapedetic bleeding, thrombosis, and intensive leukocyte attraction. The tissue around the electronegative electrode became edematous by field-induced electro-osmosis with some minor tissue destruction and mainly vascular contractions. No serious complications resulted from treatment, and temporary production of pneumothorax was easily managed. Six of the tumors showed a gradual decrease in size at various times after treatment. Although this form of treatment seems promising, the long-term effects cannot yet be evaluated.

6091 THE EFFECT OF HYPERTHERMIA ON SURVIVAL IN TRANSPLANTED LYMPHOSARCOMA. *(Eng.)* Malangoni, M. A. (Section Pediatric Surgery, Dept. Surgery, Indiana Univ. Sch. Medicine, Indianapolis, IN); Grosfeld, J. L.; Cakmak, O.; Ballantine, T. V. *J Pediatr Surg* 13(6D): 740-745; 1978. (28 refs)

The effect of 2,450-MHz microwave-induced hyper-

thermia on the survival of C3H mice bearing transplanted Gardner lymphosarcoma was investigated. On day 7 after 73 mice received subcutaneous injections of 1.2 x 10^6 tumor cells, the animals were randomly assigned to one of four treatment groups. Group I animals served as controls and received no treatment. Group II mice were given a single intraperitoneal injection of cyclophosphamide (CP) at a dose of 50 mg/kg. Group III mice received a single dose of microwave irradiation. Group IV mice were treated with both CP and microwaves at the same doses that were administered to Groups II and III. Microwave treatment was given for 4 min at a power of 40 W. The tumor temperature averaged 41.5 C in both Group III and IV animals. Control animals (Group I) and mice receiving microwave therapy alone (Group III) did not survive the 21-day experimental period. Group II mice treated with CP only had a survival rate of 45% (9/20 animals). The survival rate of mice treated with both CP and microwaves was 79% (15/19 animals); this was significantly better than the survival rate of Group II mice treated with CP only. Histologic evaluation at 21 days showed areas of central tumor necrosis surrounded by normal tumor. There was evidence of vascular degeneration and thrombosis in the more central tumor regions. Tumor size was decreased similarly in both Groups II and IV mice. These data demonstrate a synergistic effect of CP and microwave-induced hyperthermia in this highly lethal transplanted lymphosarcoma. It is concluded that the concomitant use of hyperthermia and chemotherapy may be of value in the treatment of certain neoplastic diseases.

6092 NONTHERMAL BIOEFFECTS SUGGESTED AT 2450 MHZ. *(Eng.)* Anonymous. (No affiliation given). *Microwaves* 17(12): 16, 19, 28; 1978. (0 refs)

The effects of 2,450-MHz microwave radiation on the behavior and blood chemistry of rats were studied at the University of Washington in Seattle to replicate research conducted at the Kiev Institute of Industrial Hygiene in the Soviet Union. Eight rats (with eight control animals) were exposed to continuous wave radiation for 7 hr/day. The average absorbed energy was 0.5 W/kg, which was measured by monitoring input and reflected and transmitted power with a twin-well calorimeter. After 3 mo of irradiation, behavior effects involving sensory, physical, and learning responses were observed. Adverse effects were also observed in rat blood content. After 1 mo of exposure, irradiated rats showed a 10-15% decrease in some blood enzymes. However, during mo 2 and 3, enzyme levels were normal. Perhaps the most quantitative change noticed was an imbalance of sodium and potassium in the rats' blood. During the 3 mo of irradiation, sodium levels increased and potassium levels dropped. Sodium and potassium concentrations are controlled by the adrenal glands, and microscopic observation of adrenal cells showed that they were swollen, which is a symptom of excessive sodium production and sloughing of potassium. At the power level used in these experiments (0.5 mW/cm^2), temperature changes were too small to measure as the animal's cooling system dissipates heat before a change can be measured. The researchers in this study are not yet totally willing to say that the above effects are nonthermal, however.

6093 EXACT ANALYSIS FOR CALCULATING HEMODYNAMIC PARAMETERS IN UNSTEADY BLOOD FLOW IN ARTERIES IN PRESENCE OF STATIC MAGNETIC FIELD. *(Eng.)* Kumar, V. (Old E-9 Residences, Regional Engineering Coll., Kurushetra, Haryana, Pin 132119, India). *Stud Biophys* 72(1): 43-50; 1978. (7 refs)

An exact analytic solution in the closed form for calculating hemodynamic parameters in unsteady laminar blood flow through a straight, rigid, circular artery under the influence of a static transverse magnetic field of arbitrary strength is presented. The blood was assumed to be a conducting and incompressible Newtonian liquid. Using the method of separation of variables, the governing equation in dimensionless form was split into two ordinary differential equations, one being of first order and the other being a second order nonhomogeneous differential equation. The first-order differential equation was solved directly, while the second was solved using the infinite fourier series. The other hemodynamic parameters were also derived analytically (from the axial velocity distribution) in the closed form without using any approximation. Numeric data were calculated for a human femoral artery. It is concluded that the quantity of blood flowing and also the shear stress are reduced with increasing magnetic fields in the transverse direction for a given oscillation. It is also concluded that with higher pulsation the total quantity of flow as well as the shear stress are decreased for a given transverse magnetic field.

6094 DIELECTRIC RELAXATION OF COLLAGEN IN AQUEOUS SOLUTIONS. *(Eng.)* Umemura, S. (Applied Physics, Faculty Engineering, Univ. Tokyo, Bunkyo-ku, Tokyo 113, Japan); Sakamoto, M.; Hayakawa, R.; Wada, Y. *Biopolymers* 18(1): 25-34; 1979. (20 refs)

The dielectric relaxation of collagen in aqueous solutions was studied. The complex dielectric constant of collagen in aqueous solutions at a polymer concentration (Cp) of 0.02-0.2% was measured at a temperature of 10 C in the frequency range of 3 Hz-30 kHz. The dielectric loss peak for a Cp of 0.02% was located at 90 Hz, and the dielectric relaxation time (DRT) was estimated to be 1.8 ± 0.3 msec. This DRT agreed well with the rotational relaxation time estimated from the reduced viscosity, and the relaxation was ascribed to the end-over-end rotation of the molecule. The Cp dependence of DRT and the dielectric increment (DI) were interpreted in terms of the aggregation of molecules. The dipole moment of a molecule, obtained from DI at a Cp of 0.02% and a pH of 6.5 was calculated to be equal to 5.2 ± 0.2 x 10^4 times the rotational dif-

fusion constant. This was explained by the asymmetrical distribution of the ionized side chains of the molecule.

6095 CEREBELLAR STIMULATION FOR EPILEPSY AND CEREBRAL PALSY. *(Eng.)* Anonymous. (No affiliation given). *Lancet* 2(8103): 1290; 1978. (2 refs)

The use of chronic cerebellar stimulation (CCS) for the treatment of epilepsy and cerebral palsy is discussed. The usual procedure is to place silicon-mesh plates, bearing platinum electrodes, bilaterally on the anterior and posterior lobes of the cerebellum. The operation is done under general anesthesia via 3-cm (diameter) craniectomies; subcutaneous leads pass to a subcutaneously implanted receiver that is activated by a radio frequency signal from a power pack carried by the patient. The best position and number of electrodes and the best type of pulse have still to be determined. Also, the current required to elicit neurophysiologic evidence of inhibition varies between patients, and too much current may worsen symptoms. Data on 32 patients (ages, 14-56 yr) with epilepsy (length of illness, 3-49 yr) who were followed up for 13-53 mo after treatment with CCS indicate that 18 patients had a good clinical response (at least 50% reduction of seizures). Nine patients were therapeutic failures, but none was made neurologically worse by the procedure. Experience with CCS in 141 patients with cerebral palsy (ages, 7-55 yr) indicated moderate to marked overall improvement in 46% and mild improvement in 39%. Cerebellar biopsy specimens were taken at operation from 30 of the 173 patients comprising both of the above groups, and 3 patients were autopsied. As in animals, the stimulating electrode produced a limited lesion without fibrosis; however, there was no evidence of serious harm from CCS. It is concluded that electrical stimulation of the cerebellum or spinal cord is the only really promising approach in patients with cerebral palsy. In cases of epilepsy, it is possible that cerebellar stimulation will now save some patients from ablative surgery.

6096 AUTO-ELECTROTHERAPY IN NERVE LESIONS. *(Eng.)* Cugola, L. (Orthopedic Clinic, Univ. Verona, Verona, Italy); Tarolli, G. *Rand* 10(3): 279-282; 1978. (0 refs)

A portable auto-electrotherapy generator designed for the treatment of upper limb nerve injuries is described. The device is battery operated and automatically generates impulses at 3-60 sec intervals. The intensity of the electrical impulses can be varied from 1-10 mA, and the impulse duration is about 30 msec. The device can be used with either a brush stimulator, which the patient applies to pre-established points, for providing selective therapy to muscles requiring intensive treatment or with a glove embedded with electrodes for the simultaneous stimulation of many muscles or muscle groups. Three possible patterns of stimulation can be achieved. The first involves stimulation of the intrinsic muscles (using two plates, one in the palm for the lumbricals and the other on the back of the hand for the interossei and thumb adductor) plus stimulation of the thenar and hypothenar muscles by plates on the respective eminences. The second stimulation pattern involves stimulation of the extensors using three plates. One is placed on the proximal third of the forearm for the radial extensors of the wrist and the common digital extensors. A second is placed on the middle third for the ulnar extensors, and a third is placed over the distal third for the thumb abductors and extensors. The third stimulation pattern involves stimulation of the wrist and hand flexors. Three plates are used; one for the brachioradialis, a second for the radial wrist flexors, pronator teres, and flexor carpi ulnaris (both placed in the proximal third of the front of the forearm), and a third plate in the distal third for the flexor pollicis longus and digital flexors. The device can be used either for nerve injuries using a reduced number of plates or for multiple injuries when the maximum number of plates is used.

6097 ARE MICROWAVES HARMLESS? *(Ger.)* Anonymous. (No affiliation given). *Schweiz Rundschau* 96(50): 982-983; 1978. (0 refs)

Studies concerning the thermal and non-thermal biologic effects of microwaves on microorganisms conducted at the Max-Planck Institute of Solids Research are reported. The microwave energy absorbed by microorganisms and their components is being measured using highly sophisticated methods. The effects of microwave radiation on 10 consecutive generations of yeast cell cultures are being studied. There is as yet no scientific evidence of the non-thermal effect of microwaves.

6098 THE RADIATION SAFETY OF MICROWAVE OVENS. *(Dut.)* Anonymous. (No affiliation given). *Ned Tijdschr Geneeskd* 122(50): 1978; 1978. (0 refs)

The radiation leakage from microwave ovens is generally not hazardous. The maximum permissible leakage radiation intensity, measured at 5 cm distance, is set at 5 mW/cm^2 in the Netherlands, but new ovens with a radiation intensity exceeding 1 mW/cm^2 cannot be sold because the radiation intensity is believed to increase during the use of the oven.

6099 PROTECTION OF SUBSCRIBERS AND WIRED RADIO-RELAY INSTALLATIONS FROM DANGEROUS VOLTAGES AND CURRENTS OCCURRING ON RADIO-RELAY NETWORK LINES. *(Eng.)* USSR Central Scientific Res. Inst. Communications. (No affiliation given). 18 pp.; 1977. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD-A052550]. (0 refs)

Standards for the protection of subscribers and wired radio-relay installations from dangerous vol-

tages and currents occurring on radio-relay network (RRN) lines in the USSR are presented. These standards were promulgated by decree of the Committee on Standards, Measures, and Measuring Instruments of the Council of Ministers USSR on July 25, 1969. The period of the introduction of these standards is established from January 1, 1970. Specific standards are provided for the following: the protection of radio-relay equipment connected to feeder lines of more than 360 V; the protection of equipment with connected RRN feeder lines of up to 360 V; the protection of subscribers and equipment on 15- and 30-V subscriber lines; the protection of cable inserts and loading coils of RRN overhead lines; the protection of apparatus at receiving antenna inlets; and the protection at intersections of RRN lines with transmission lines or with contact wires of electric-powered ground transportation systems.

6100 HIGH-TENSION ELECTRICAL INJURY. *(Eng.)* Anonymous. (No affiliation given). *Lancet* 2(8097): 978; 1978. (5 refs)

The effects of high-tension electrical shock (usually 11,000 V or more) are discussed. Tissue damage is largely due to the conversion of electrical energy to thermal energy. According to Joule's law, when a current passes through a conductor the power (heat) is proportional to the amperage squared times resistance; thus, bone and skin, which are poor conductors of high resistance, will very efficiently convert electrical energy to thermal energy. This accounts for the severe damage to periosseous muscles beneath viable tissue. When the current in a high-tension accident arcs, commonly from the palm to the volar aspect of the wrist, there is a voltage drop absorbing much of the electrical energy as the air particles become ionized. The temperature in such an arc can reach 4000 C, with burning of tissue and ignition of clothing. Thus, tissue damage can result from both the heat of the electric arc and the flow of current. Particular attention must be paid to the tissue damage at the site of contact. Immediate decompression by escharotomy and fasciotomy must be followed by debridement of dead tissue. Any progressive necrosis of muscle results from infection and hypoxia and is prevented by thorough debridement of all dead muscle, especially around bone. Nerves and tendons, even if apparently not viable, should be spared since some regeneration is possible if good cover is provided early with a skin flap.

6101 STUDIES ON THE INTERACTION OF MICROWAVE RADIATION WITH CHOLINESTERASE. *(Eng.)* Olcerst, R. B. (Inst. Environmental Medicine, New York Univ. Medical Center, 550 First Ave., New York, NY 10016). Rabinowitz, J. R. *Radiat Environ Biophys* 15(3): 289-295; 1978. (15 refs)

The effect of 2.45-GHz microwave irradiation on the enzymatic activity of the stereospecific protein acetylcholinesterase in aqueous solution and in defibrinated rabbit blood was studied. At power densities of up to 100 mW/cm^2 for uncooled exposures of 30 min and for a large number of 3-hr cooled exposures at 25 mW/cm^2, there was no significant difference between irradiated samples of the purified enzyme in aqueous solution and control samples. A 30-min uncooled exposure at a power density of 125 mW/cm^2 caused a significant drop in the initial velocity of the enzyme. However, in this experiment, the temperature was allowed to rise during irradiation and was 60 C after 30 min. At this temperature, thermal denaturation would cause irreversible changes in the enzyme structure. Microwave radiation of defibrinated rabbit blood had no effect on the total cholinesterase activity at levels of 21, 35, and 64 mW/cm^2 for both continuous wave and square wave modulated irradiation (pulse width, 0.75 msec and 0.71 pulses/msec). In this series of experiments, the heat exchange system maintained a temperature of 37 ± 0.5 C in both controls and irradiated samples. Since changes in enzyme activity could be affected in the in vivo calcium and magnesium in the serum, a similar irradiation procedure was used to investigate the release of bound calcium and magnesium from rabbit red blood cells. No change in the levels of magnesium and calcium in cell-free serum was found after 3 hr of irradiation of defibrinated rabbit blood in a temperature controlled system. Overall, these studies showed no direct effect of microwave radiation on acetylcholinesterase activity.

6102 EFFECTS OF RADIO-FREQUENCY RADIATION ON INFLAMMATION. *(Eng.)* Liburdy, R. P. (Radiation Sciences Div., USAF Sch. Aerospace Medicine, Brooks Air Force Base, TX 78235). *Radio Sci* 12(2): 179-183; 1977. (19 refs)

The effect of pretreatment with continuous wave 26-MHz radio frequency (RF) radiation was compared with that of warm air heating (79 C) on inflammatory responses that were induced in rats by a subcutaneous injection of sheep red blood cells (SRBC) into footpads and in mice by tail vein trauma due to sequential bleeding. Both RF radiation (4-7 min) and warm air (8-12 min) exposures were matched to induce an increase of body temperature between 2 and 4 C. At 4 hr after the injection of SRBC into footpads of rats, animals that were pretreated with RF radiation showed an averaged thickness of footpad that was 33.0% and 45.6% less, respectively, than those of warm air-treated and sham-exposed animals. Thus, RF radiation pretreatment protected significantly against the development of SRBC-induced inflammation. The white blood cell counts in RF pretreated tail vein traumatized mice remained constant in contrast to a leukocytosis (7,000 cells/cm^3 increasing to 15,000 cells/cm^3 at 12 hr) for warm air and sham-treated mice. Moreover, the inflammatory response in RF-pretreated mice was accompanied by a well defined, transient refractory state in the circulating white blood cell population that was characterized by a fourfold decrease of lymphocytes and a concomitant fourfold increase in neutrophils. The refractory lymphopenia contrasts with the monotonic panleukocytosis that was observed in warm air- and sham-exposed mice. The fact that RF pre-

treatment of mice resulted in a fourfold increase of neutrophils at 3-6 hr after exposure serves to explain the twofold difference in footpad swelling that was observed at 4 hr postexposure between RF- and sham-exposed rats that were inoculated with SRBC. The results indicate that RF radiation can attenuate an inflammatory reaction. This inhibitory property may have relevance to immunocompetency of cell-mediated immunity (CMI) since CMI responses invoke nonspecific inflammatory reactions.

6103 TESTS FOR HUMAN PERCEPTION OF 60 Hz MODERATE STRENGTH MAGNETIC FIELDS. *(Eng.)* Tucker, R. D. (Biophysics Group, 200 T.N.C.E., Electrical Engineering, Univ. Minnesota, Minneapolis, MN 55455); Schmitt, O. H. *IEEE Trans Biomed Eng* BME-25(6): 509-518; 1978. (13 refs)

Human subjects were exposed to 60-Hz magnetic fields varying in field strength from 7.5-15 G (root mean square) to determine if they could detect or learn to detect by biofeedback training the presence of a moderate magnetic field. Preliminary experiments revealed that some very perceptive individuals unintentionally used subtle auxiliary clues to develop impressive records of apparent magnetic field detection. A tightly sealed subject chamber was developed to provide extreme isolation against these clues, and a large number of individuals were tested in this system with computer randomized sequences of 150 trials per individual. An analysis of the whole experimental series showed that each successive improvement in isolation from field associated clues resulted in lowered perception, until not even biofeedback learning could produce significant perception. Neither gradient fields nor higher strength fields concentrated about the subject's head showed significant perception. The results appear to establish that these fields are not normally sensed. Magnetic headaches that were experienced by subjects in placebo experiments where the fields were never turned on suggest that many of these reported discomforts may be iatrogenic, technogenic, or produced by simple fear of the unknown.

6104 INTRACELLULAR HYPERTHERMIA: SELECTIVE CANCER CELL DESTRUCTION BY THE BIOPHYSICAL ALTERATION OF INTRACELLULAR PROPERTIES. *(Eng.)* Gordon, R. T. (4936 W. Estes, Skokie, IL 60077); Hines, J. R.; Gordon, D. *IRCS Med Sci: Cancer* 6 (10): 425-426; 1978. (10 refs)

The use of electromagnetic field-induced intracellular hyperthermia for the selective destruction of cancer cells is described. Using induced heat energy after tumor phagocytosis of magnetically excitable submicron particles, the cancer cell membrane (composed of lipids and proteins), which is an excellent thermal barrier and a very poor thermal conductor, is utilized to contain the energy within the cancer cell, resulting in the selective thermal destruction of cancer cells. Any magnetic or electric dipole contained, introduced, or capable of being produced by an external field can be used. This new approach uses a frequency sufficiently low (450 kHz) so that there is virtually no tissue heating and no damage to normal cells; the heating is generated intracellularly, i.e., within the cell, itself. Sprague Dawley rats with spontaneous mammary tumors (adenocarcinomas and fibroadenomas) were injected in the tail vein on 3 successive days with 2 cm^3 of a solution that contained iron-containing particles. The entire animal was exposed to a 450-kHz electromagnetic field (30 kW) for 12 min, beginning 48 hr after the last injection. Electron microscopy and light microscopy confirmed the destruction of cancer cells. In animals where the tumor cells were destroyed, all normal tissues were histologically unchanged including those containing particles. In animals where the tail injections were subcutaneous instead of intravenous such that the animal did not receive any particles intravenously, the same exposure to the electromagnetic field had no effect on the tumor cells or on the normal cells and tissues. The selectivity of the particles for the cancer cells in this method may be enhanced using particles bound with antibodies or radioisotopes, and localized magnetic fields may be applied to concentrate more particles in the tumor. It is concluded that the described method represents a new effective treatment of cancer by intracellular alteration of biophysical properties resulting in the selective destruction of cancer cells without affecting normal cells and tissues.

6105 A COMPARATIVE STUDY OF THE EFFECTS OF MICROWAVE RADIATION AND CONVENTIONAL HEATING ON THE REPRODUCTIVE CAPACITY OF *DROSOPHILA MELANOGASTER*. *(Eng.)* Pay, T. L. (U.S. Dept. Health, Education, and Welfare, Public Health Service, Food and Drug Admin., Bureau Radiological Health, 5600 Fishers Lane, Rockville, MD 20857); Andersen, F. A.; Jessup, G. L., Jr. *Radiat Res.* 76(2): 271-282; 1978. (10 refs)

The effects of continuous wave 2,450-MHz microwave radiation (dose level, 0.644 W/g for 10 min) and conventional water-bath heating (44 C) on the egg-laying pattern of female fruit flies *(Drosophila melanogaster)* and on the viability of eggs produced were investigated. The temperature of 44 C was chosen to obtain the same percentage kill as in the microwave-exposed group. The egg production of females exposed to heat and females exposed to microwave radiation was significantly reduced when compared with their respective sham groups. However, there were no significant differences in egg production between females exposed to microwave irradiation and those exposed to conventional heating. There was a significant difference in the survival of eggs laid by both the heat-exposed and the microwave-irradiated females when compared to their respective sham groups. In the heat-exposed group, the survival was significantly greater than that of their shams, whereas in the microwave-irradiated group, a significant decrease in survival was seen in comparison with the respective sham group. The difference in the survival of eggs laid by heat-exposed and microwave-irradiated females was statistically significant ($p<0.01$). Both the mean number of eggs produced and the mean percentage survival of eggs laid by normal

females mated to treated males was not significantly different from their respective sham groups regardless of whether the males were exposed to heat or irradiated with microwaves. It is concluded that the two treatments used do not produce results consistent with identical mechanisms of action, although heating may be involved in each case. It remains to be seen if the reduced survival of eggs produced by microwave-irradiated females is due to a damage mechanism that is completely separate from that which caused the increased survival of eggs produced by females exposed to conventional heating.

6106 TEMPERATURE UNIFORMITY IN HYPERTHERMAL TUMOR THERAPY. *(Eng.)* Harrison, G. H.; Robinson, J. E.; Samaras, G. M. *In: Hyperthermia as an Antineoplastic Treatment Modality. Proceedings of a Symposium Sponsored by Langley Res. Center, Hampton, VA, and Eastern Virginia Medical Sch., Norfolk, VA, January 28, 1978.* NASA Conference Publication No. 2051. pp. 27-32; 1978. (6 refs)

The temperature uniformity of mouse mammary tumors transplanted in the flank or hind leg of C3H mice was measured during water bath- or microwave-induced hyperthermia. Tumors implanted on the mouse flank were easily heated to uniformities within 0.1 C by using water baths. However, when the same tumors were implanted on the hind leg, cold spots were observed during water bath heating. Two thermal profiles taken through a leg tumor are illustrated. The tumor was roughly ellipsoidal in shape and measured 15 by 12 by 8.5 mm along the three orthogonal major axes. The water bath in which it was immersed was maintained at 42.9 C. One profile was taken along a line near the leg bone, but well within the tumor. The second was taken about one-third of the way into the tumor on the side away from the bone. The profile showed marked temperature variations, with temperatures measured being as low as 41.6 and 42.2 C for the thermal scans near and away from the bone. To overcome this cold spot problem, heating was performed with combined 2,450-MHz microwaves and a temperature-controlled liquid bolus (80% by weight of isotonic and saline and 20% by weight of ethanol). The tumor was surrounded with the liquid bolus in plane-parallel-slab geometry and was irradiated with parallel-opposed microwave beams. The liquid bolus was maintained at 42.9 C, and the tumor with bolus was irradiated with a microwave power of 22 W. Heating with combined microwaves and temperature-controlled liquid bolus significantly improved the thermal uniformity within the tumor. The cold spots observed during water bath hyperthermia were attributed to cooling of the tumor by major blood vessels near the tumor. The above observations might have some bearing on the discrepancies in biologic hyperthermia data for different tumors subjected to apparently similar thermal treatments. It is suggested that careful thermal studies are even more important to thermobiology than good radiation dosimetry is to conventional radiobiology.

6107 THE COMBINED EFFECTS OF PULSED RADIATION (DIAPULSE) AND CHEMOTHERAPY ON TUMOR BEARING MICE. THE MEASUREMENT OF RODENT PALATAL EXPLANTS AS A DEVICE FOR MEASUREMENT OF THE BIOLOGIC EFFECTS OF NONIONIC RADIATION (EMR). *(Eng.)* Regelson, W.; West, B.; DePaola, D. P. *In: Hyperthermia as an Antineoplastic Treatment Modality. Proceedings of a Symposium Sponsored by Langley Res. Center, Hampton, VA, and Eastern Virginia Medical Sch., Norfolk, VA, January 28, 1978.* NASA Conference Publication No. 2051. pp. 54-66; 1978. (17 refs)

The combined effects of pulsed radiowave (diapulse) irradiation and chemotherapy on the lifespan of BDF_1 mice injected subcutaneously with 10^6 Lewis lung carcinoma cells in the flank were investigated. The diapulse generator operated at a carrier frequency of 27.12 MHz, which was pulse modulated over a frequency range of 80-600 cps. At maximum settings, the treatment unit supplied 974 W of instantaneous power with a 3.9%-duty cycle; the pulse duration of 65 μsec. This yielded a highest average power output of 38 W. Experiments were also performed at a low mean power of 4 W. Mice receiving cancer chemotherapy alone in the form of hydroxyurea (HU) had an increased lifespan (ILS) of 22.1% over untreated controls. Mice receiving HU plus low-power irradiation (mean, 4 W) had an ILS of 5.1% over controls. Mice receiving HU plus high-power irradiation (mean, 38 W) had an ILS of 101.9% over controls. Mice receiving chemotherapy alone in the form of Cytoxan (CTX) had an ILS of 64.1% over controls. Mice receiving CTX plus high-power irradiation had a 74.1% ILS, and those receiving CTX plus low-power irradiation had a 106.6% ILS in comparison with controls. Mice receiving a combination of HU and CTX showed a 41.2% decrease in lifespan compared with untreated controls. Mice receiving a combination of HU and CTX plus low-power irradiation had an ILS of 38% over untreated controls, and mice receiving HU and CTX plus high-power irradiation had an ILS of only 1.7% over untreated controls. Overall, simultaneous treatment with pulsed radiowave radiation and chemotherapy significantly extended the lifespan of tumor-bearing mice. For example, in comparison with non-treated controls, the combination of HU and whole body radiation produced a differential enhancement of longevity depending on the power output. The combination of HU and high-power irradiation produced a mean extension of life that was 67% greater than that for mice treated with HU alone. Since the stress involved in confining mice to holders and subjecting them to nonionic radiation and chemotherapy produced significant variability in tumor growth, an in vitro system of quantifying the biologic effects of radiation was investigated. Palatal explants from 14-day-old mouse embryos suspended in tissue culture were studied as the radiation target. However, technical problems related to timing of mouse pregnancy and palatal harvest suggested that this method of biologic assay currently has variables equal to those of tumor growth studies in the living mouse.

6108 FOCUSSED MICROWAVE RADIATION THERAPY FOR DEEP TUMORS. *(Eng.)* Samaras, G. M.; Robinson, J. E.; Cheung, A. Y.; Weinmann, S. F. *In: Hyperthermia as an Antineoplastic Treatment Modality. Proceedings of a Symposium by Langley*

Res. Center, Hampton, VA, and Eastern Virginia Medical Sch., Norfolk, VA, January 28, 1978. NASA Conference Publication No. 2051. pp. 67-70; 1978. (8 refs)

Systems designed to focus microwave radiation for the heating of deep tumors are described that are based on the concept of superposition of separate radiation beams. The application of this multiple-beam paradigm to microwave diathermy offers the potential of generation and control of spatio-temporally complex thermal fields deep within the body. A prototype system consisting of two parallel-opposed simulated TEM applicators operating at 2,450 MHz with power time-multiplexed either between the treatment beams or off to an air-cooled load has been developed. Using this system it has been found that the central axis tissue temperature profile is parabolic as would be predicted by superposition of energy deposition in tissue. In tumor regrowth studies with C3H murine mammary carcinomas transplanted to the flank of mice, it was found that the delay in tumor regrowth following microwave treatment compares favorably with the results obtained in previous water bath studies. Currently a programmable system (microprocessor controlled) is under evaluation and software development. The system is capable of supporting 16 miniature applicators and controlling the output power of each applicator while monitoring forward and reflected power, temperature, and physiologic parameters. While currently being operated at 915 MHz, the control system is frequency-independent and will be operated at a lower frequency when clinical trials commence. The programmable system is currently being used to study the efficacy of focussed heating in a feline brain through the measurement of electric and resultant thermal fields. The major limitation of microwave diathermy in cancer thermotherapy is the equipment's ability to heat deep tumors and at the same time spare the intervening tissue. With the development of technology for focussing the heat to the tumor site, the utility of localized microwave-induced hyperthermia as an adjunct to radiotherapy and chemotherapy in the clinical management of some cancers should be improved, especially in cases involving malignant brain tumors.

6109 GENERAL STATEMENT ON HYPERFREQUENCIES AND THEIR BIOLOGICAL EFFECTS. *(Fre.)* Servantie, B. M. (Hopital d'Instruction des Armees Sainte-Anne, 83800 Toulon Naval, France); Klein, M. J. *In: Effets Biologiques des Rayonnements Non Ionisants--Utilisation et Risques Associes.* Proceedings of the Ninth International Congress of the Societe Francaise de Radioprotection. (Nainville-les-Roches, France): pp. 215-253; 1978. (102 refs)

Literature on the biologic effects of microwaves published since 1958 is reviewed. An analysis of data in about fifty papers indicates that the terminology "thermal" and "nonthermal" or "specific" fails to accurately describe or differentiate between the effects of microwave activity. Effects appear to be related rather to the power density (mW/cm^2) absorbed by the irradiated biologic unit. Methods of calculating the absorption of electromagnetic energy from a microwave source are discussed. Biologic effects at the cellular level, on the central nervous system, and on the blood-brain barrier of experimental animals, and on humans are reviewed. The thermal effects of microwave radiation on biologic tissue have led to efforts to devise therapeutic applications particularly for cancer. Problems of focusing the radiation on the pathologic tissue are not yet resolved. Finally, the problem of defining safe microwave exposure levels for both the population at large and workers is considered. Dangerous levels have been defined as less than 1 $\mu W/cm^2$, less than 0.1 mW/cm^2, and about 10 mW/cm^2 by various national agencies. It is concluded that an ideal system for defining dangerous exposure levels has not yet been devised. Further research and public awareness are crucial.

6110 EFFECT OF MICROWAVES ON DEVELOPMENT OF GONADS AND ADRENAL GLANDS IN THE NEWBORN RAT. *(Fre.)* Maniey, J. (Laboratoire de Physiologie des Regulations, Universite de Rennes, Rennes, France); Le Ruz, P.; Plurien, G. *In: Effets Biologiques des Rayonnements Non Ionisants--Utilisation et Risques Associes.* Proceedings of the Ninth International Congress of the Societe Francaise de Radioprotection. (Nainville-les-Roches, France): pp. 257-264; 1978. (0 refs)

The effect of exposure of newborn rats for 15 consecutive days to radiation from a radar emitter (pulsed beam of 3 GHz with a horizontal repetition frequency of 500 Hz; power density of 5-10 mW/cm^2) on gonadal and adrenal development was studied. White Sherman rats born and raised in laboratory cages maintained at a temperature of 22 ± 2 C and exposed to 12 hr of artificial light per 24 hr were utilized. Animals were weaned at 21 days and then fed on a standard diet. After sacrifice at age 60, 90, or 140 days, testes or ovaries and adrenal glands were weighed and examined histologically. No effects were observed in rats killed at age 60 days. Irradiated rats killed at 90 days had testes that were reduced in weight as compared to controls (2.65 ± 0.15 g compared to 3.00 ± 0.13 g) as well as smaller ovaries (79.60 ± 4.06 mg compared to 88.45 ± 4.04 mg). Exposed rats killed at 140 days also had smaller testes (2.79 ± 0.15 g compared to 3.05 ± 0.07 g) and ovaries (71.22 ± 6.8 mg compared to 88.38 ± 10.35 mg). Histologic examination of irradiated rats revealed closed seminiferous tubes and blocked spermatogenesis in testes and reduced oocyte formation in ovaries. Adrenal glands were smaller in irradiated female rats killed at 140 days (48.08 ± 3.45 mg compared to 56 ± 5.70 mg), but not in irradiated males. Blood corticosteroids, measured after subjecting rats to stress (3 min of isolation under small glass bell), were increased in rats killed at 90 days (males: 33.23 ± 3.49 µg versus 2.87 ± 2.9 µg; females: 82.34 ± 7.64 µg compared to 60.96 ± 9.58 µg). The position of the cage in relation to the radiation source had a significant effect on the reduction in the weight of the glands.

6111 EFFECT OF MICROWAVE RADIATION (2,450 MHz) ON THE PITUITARY-TESTICULAR AXIS IN THE WHITE RAT. *(Fre.)* Dechaux, P. (Laboratoire de Physiologie Cellulaire, Universite Claude Bernard, 69621 Villeurbanne, France); Pelissier, J. P.; Santini, R.; Fontanges, R. *In: Effets Biologiques des Rayonnements Non Ionisants--Utilisation et Risques Associes.* Proceedings of the Ninth International Congress of the Societe Francaise de Radioprotection. (Nainville-les-Roches, France): pp. 265-269; 1978. (2 refs)

The effect of exposure for 24 hr to microwaves (2,450 MHz; industrial band, 10 mW/cm^2) on pituitary and gonad gland function of Sprague-Dawley rats was investigated. Rats, aged 60 days at time of irradiation, were decapitated 10 min, 3, 8, and 15 days after irradiation. Plasma levels of testosterone and luteinizing hormone (LH) were measured by radioimmunoassay in blood from killed animals. LH increased (83 ± 3.2 ng/ml compared to 70 ± 5.0 ng/ml; $p<0.01$) 10 min after irradiation, was the same as controls 3 days after irradiation (73 ± 2.5 ng/ml) and fell to less than control levels (52 ± 1.2 ng/ml compared to 65 ± 3.0 ng/ml; $p\leq0.1$) after 8 days. Plasma levels of testosterone were significantly increased 3 and 8 days after irradiation (285 ± 30 ng/100 ml compared to 180 ± 10 ng/100 ml; $p\leq0.05$ at 3 days: 630 ± 100 ng/100 ml compared to 350 ± 65; $p\leq0.1$ at 8 days). The pituitary gland was apparently affected by irradiation directly since LH levels rose within 10 min; testosterone levels then rose by feed-back mechanism. Normal hormonal equilibrium was reestablished 15 days after irradiation.

6112 COMPARISON OF THE EFFECT OF MICROWAVES ON THE LIPID METABOLISM OF SEVERAL MOUSE STRAINS. *(Fre.)* Dumas, J. C. (Laboratoire de Physiologie, Faculte de Pharmacie, 31 allees Jules-Guesde, 31400 Toulouse, France); Laurens, S.; Plurien, G. *In: Effets Biologiques des Rayonnements Non Ionisants--Utilisation et Risques Associes.* Proceedings of the Ninth International Congress of the Societe Francaise de Radioprotection. (Nainville-les-Roches, France): pp. 271-276; 1978. (4 refs)

A comparison was made of the levels of triglycerides (TRG) in three types of mice, C57B1, DBA, and Swiss, exposed to microwaves at a frequency of 2,450 MHz for 59 hr consecutively. Mice were irradiated in anechoic chambers measuring 2.50 x 1.50 x 1.50 m in which the air was constantly renewed. All measurements were made on male mice weighing 23 ± 2 g. Control C57B1 mice had TRG levels of 1.46 ± 0.06 g/l, control DBA mice had TRG levels of 1.98 ± 0.09 g/l, and control Swiss mice, TRG levels of 1.30 ± 0.11 g/l. At a power density of 12 mW/cm^2, only the C57B1 (2.35 ± 0.11 g/l; 62% increase) and DBA mice (2.95 ± 0.15 g/l; 49% increase) experienced significant ($p<0.001$) increases in TRG levels. The percentage of C57B1 mice with TRG levels higher than the upper limit of the controls was 70%; the corresponding percentage for the DBA mice was 67%. At a power density of 3 mW/cm^2, a significant increase in serum TRG levels was observed only for the C57B1 mice (2.95 ± 0.15 g/l; 43% increase). The percentage of irradiated mice with TRG levels higher than the upper limit of the controls was 65% for the C57B1 mice. It is concluded that, with respect to elevation of TRG levels, different strains of mice vary in their sensitivity to microwaves, and individuals within the strain may also vary in sensitivity.

6113 EFFECT OF MICROWAVES ON BACTERIA, YEAST, AND *DROSOPHILA*. *(Fre.)* Dardalhon, M. (Fondation Curie, Institut du Radium, Section de Biologie, 26, rue d'Ulm, 75005 Paris, France); Averbeck, D. *In: Effets Biologiques des Rayonnements Non Ionisants--Utilisation et Risques Associes.* Proceedings of the Ninth International Congress of the Societe Francaise de Radioprotection. (Nainville-les-Roches, France): pp. 279-299; 1978. (25 refs)

The effect of microwaves on the growth, survival, and mutation frequency of various cultures of *Escherichia coli* and *Saccharomyces cerevisiae* and on the survival, fertility, and appearance of mutations and malformations of wild-type and melanoma tumor-bearing mutant *Drosophila* was investigated. Survival in four types of *E. coli* (wild type, recombinant, and Uvr) and two types of *S. cerevisiae* (wild type and rad) was not affected by exposure to 70-75 GHz (power density, 60 mW/cm^2) or 17 GHz (50 mW/cm^2) for 30 min. A decrease in the growth rate varying from 6-30% was observed in the *E. coli* after 3 hr of irradiation of 70.5 GHz or 73 GHz. Mutation frequency as measured by reversal of tryptophan dependency in *E. coli* and by petite colony formation in *S. cerevisiae* was not increased in colonies subjected to 70-75 GHz for 30-40 min compared with controls; induction of mitotic recombination in *S. cerevisiae* also was not changed in yeast exposed to 17 GHz for 1-24 hr. *S. cerevisiae* showed a slight increase in petite colony mutation after exposure to a combination of 1 hr of 17 GHz microwave radiation and 30 krad of x-radiation. The *Drosophila* experiment included irradiation of eggs, larvae, pupae, and adults. After treatment with 17 GHz, 60 mW/cm^2 for 2-3 hr or 73 GHz, 100 mW/cm^2 for 2 hr, eggs, larvae, and pupae demonstrated only a slight decrease in survival, which was not statistically significant. No mutagenic or teratogenic effects were observed. There was a slight decrease in the number of tumors observed in the mutants (2.66-7.19%). When female *Drosophila*, irradiated for 16 hr or 21 hr with 17 GHz, were crossed with nonirradiated males, a significant increase (30%) in the number of eggs produced was observed. Comparable results were obtained when nonirradiated females were crossed with irradiated males.

6114 A SPECIFIC EFFECT OF THE BIOLOGICAL IMPACT OF MICROWAVES. *(Fre.)* Tchao, Y. H. (Laboratoire d'Opto-Acousto-Electronique de Valenciennes, Laboratoire associe au CNRS 59326 Valenciennes, France); Radziszewski, E.; Sauzin-Monnot, M. J.; Briancon, C.; Wikgren, M. *In: Effets Bio-*

logiques des Rayonnements Non Ionisants--Utilisation et Risques Associes. Proceedings of the Ninth International Congress of the Societe Francaise de Radioprotection. (Nainville-les-Roches, France): pp. 301-313; 1978. (11 refs)

The biologic effects of microwaves (9,300 MHz) from either a continuous power source of 10 W or from a pulsating generator (NARDA model 18 500 B) on the planaria *Dugesia gonocephala* were studied. The planaria were weighed individually and classed in three groups: 3.5-4.4 mg; 4.5-5.4 mg; 5.5-6.4 mg. They were anesthetized with 2.5% chloretone and placed on individual Plexiglas supports. Each planaria was irradiated individually, and 10 planaria were irradiated for each aspect of the experiment. The density of absorbed energy (DAE) was 24 mW/mg for planaria exposed for 1 min to continuous wave microwaves. It was apparent that the electrical field was responsible for the deleterious effects rather than the magnetic field since planaria irradiated parallel to the electrical field experienced almost 100% mortality at 24 hr; mortality was approximately 10% for planaria placed parallel to the magnetic field. Planaria were exposed to a continuous or pulsating wave with DAE of 1-20 mW/mg for periods of 10, 20, and 40 sec, and the head was then severed. For both continuous and pulsating radiation exposure, at all three exposure periods, mortality was greater for head segments than for body segments indicating the higher sensitivity of nervous tissue to microwaves. Planaria regeneration was studied in planaria decapitated and then irradiated 1-7 days later with continuous wave microwaves (DAE of 5.5 mW/mg for 20 sec). Mortality measured at 24 hr and at 7 days showed a relationship to duration of time between decapitation and irradiation with maximum mortality at 4 days. Cells undergoing differentiation were more radiosensitive than undifferentiated cells.

6115 PRELIMINARY RESULTS ON THE STUDY OF EFFECTS OF MICROWAVES ON THE CENTRAL NERVOUS SYSTEM OF A PRIMATE (*MACACA MULATTA*). (*Fre.*) Klein, M. J. (Centre de Recherches de Medecine Aeronautique, 26 Boulevard Victor, 75996 Paris Armees, France); Milhaud, C. L. *In: Effets Biologiques des Rayonnements Non Ionisants--Utilisation et Risques Associes*. Proceedings of the Ninth International Congress of the Societe Francaise de Radioprotection. (Nainville-les-Roches, France): pp. 315-336; 1978. (47 refs)

Thirteen adult or young adult Macaque Rhesus monkeys were studied for effects on the central nervous system and behavior following exposure to microwave irradiation, either whole-body or localized, of varying power density (1.1 mW/cm^2; 3-5 mW/cm^2; 15 mW/cm^2), of different types (9.4 GHz from a pulsating source; 2.45 GHz from a continuous source) and of varying duration (3-25 days). Monkeys were exposed in an anechoic chamber (2 x 2 x 1.8 m) that was ventilated, maintained at temperatures of 20-24 C, and lighted 12 out of 24 hr. The animals were exposed to two different sources of radiation: (1) 9.4 GHz modulated by 1 μsec impulses with a repetition frequency of 570 Hz delivered by a 250-kW generator from an overhead source; and (2) 2.45 GHz from a continuous wave 1.5-kW generator. Radiation reached the animals via a waveguide in the ceiling of the chamber. Six monkeys were subjected to whole-body 9.4 GHz pulsed radiation for 230 hr and to 2.45 GHz continuous wave radiation for 25 days. Two monkeys were irradiated on the head only for 75 hr. One monkey was subjected to discontinuous irradiation of 10 min/day before and after which cerebral temperature measurements were made. Five of this group of monkeys had epidural electrodes implanted prior to radiation. Visual and statistical analysis of electroencephalograms taken daily during a 1-hr stoppage of the generators failed to show any evidence of abnormalities. Cerebral temperature rose 0.5 C maximum in the monkey irradiated intermittently, which was attributed to the thermoresistance of the implanted electrodes. Spontaneous and operant conditioning behavior studies were performed on four monkeys irradiated with 2.45 GHz for 400 hr after a conditioning period of 4 mo. Only one monkey showed changes in spontaneous behavior with development of clonic type uncontrolled motor movements of 2-3 sec, which occurred about 10x/day after the animal had been irradiated for 90 hr. No changes in conditioned behavior occurred (20 tests). No changes in psychologic parameters, triglycerides, or rectal temperature were observed following irradiation.

6116 NONIONIZING RADIATIONAL INJURY OF HUMANS. (*Eng.*) Zaret, M. M. (Zaret Foundation, P.O. Box 388 M, Scarsdale, NY 10583). *In: Effets Biologiques des Rayonnements Non Ionisants--Utilisation et Risques Associes*. Proceedings of the Ninth International Congress of the Societe Francaise de Radioprotection. (Nainville-les-Roches, France): pp. 337-356; 1978. (0 refs)

Clinical and experimental data on nonionizing radiation injury are reviewed with particular emphasis on the inadequacies of existing health standards. For both the visible and invisible portions of the nonionizing radiation spectrum, the vast majority of experimental data on which regulations have been based were derived from acute animal research. However, safety must be determined from different criteria, such as, delayed effects following chronic exposure. Regarding the microwave portion of the nonionizing radiation spectrum, there is clinical evidence to imply that field intensities of about 1 mW/cm^2 can be cataractogenic in man. It has also been shown that microwaves can produce premature or abnormal aging. Other conditions related to microwave exposure include interference with cardiac pacemaker function, hypogonadism, angiitis, adverse transfusion reactions (including death) due to hemolysis of blood warmed by microwaves immediately prior to its use, and injury of the fingers and fingernails among food-preparation employees operating microwave ovens. Weak magnetic fields produced by extremely low frequency signal generators have been associated with elevated serum triglyceride levels and with measurable mentation

deficits. There are also a large number of reports relating immunologic, teratogenic, and carcinogenic effects to the microwave portion of the nonionizing radiation spectrum. Finally, it has been hypothesized that aberrant electronic smog is an etiologic or contributory factor in sudden-infant-death syndrome.

6117 RADIOFREQUENCIES AND HYPERFREQUENCIES: APPLICATIONS AND RISKS. *(Fre.)* Vautrin. (No affiliation given); Caluzade; Cavelier. *In: Effets Biologiques des Rayonnements Non Ionisants--Utilisation et Risques Associes.* Proceedings of the Ninth International Congress of the Societe Francaise de Radioprotection. (Nainville-les-Roches, France): pp. 357-363; 1978. (0 refs)

The potentially harmful effects of exposure to electromagnetic radiation in the high or hyperfrequency range are reviewed in addition to the theoretic aspects of electromagnetic waves. Practical applications are tabulated, giving frequency in MHz and power in kW. Sources of high or hyperfrequency electromagnetic waves already widely in use are radio and television transmitters, radar, industrial and medical machinery, and microwave ovens; under development are methods and machinery for repairing roads, disinfecting water, milk and foodstuffs, and exploding rocks and concrete. Malfunctioning computers can be a source of microwave radiation. Due to a lack of knowledge concerning the nonthermal biologic effects of high and hyperfrequency electromagnetic radiation, internationally acceptable standards for regulation of radiation have not yet been established. A table compares dangerous levels of exposure as defined by the United States, the USSR, and France for workers and the population at large. Methods used to monitor electromagnetic radiation in France are described; the mW/cm^2 after 1 hr of exposure to 18 different industrial and domestic sources of radiation is graphed. Limitation of exposure to radiation under 10 mW/cm^2 is recommended, and methods for reducing exposure, such as, shielding machinery or personnel, are described.

6118 MAGNETIC FIELD EXPOSURE GUIDELINES. *(Eng.)* Alpen, E. L. (Donner Lab., Lawrence Berkeley Lab., Berkeley, CA 94720). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 19-26; 1978. (3 refs)

Sources of occupational magnetic field exposure and guidelines for such exposures are reviewed. Magnetic fields of up to 1,000 G, which are accessible to operators, are associated with such old technologies as induction welding, electronic heat-sealing of plastic devices, spot welding, induction furnaces, and other induction-type devices. Among the newer technologies that involve possible hazards from magnetic fields is the superconducting magnet energy storage system. The maximum fields that will be accessible to operators of these systems will be on the order of 200-500 G. Data on the maximum possible exposure to persons who will be in maintenance and operating spaces outside the control room of prototype fusion reactors indicate that the magnetic fields can rise as high as 10 kG with very large gradients; the duration can be quite long (about 30 sec). In the new technology of accelerator operations, bubble chambers involve particularly large magnetic fields; operating personnel could be exposed to anywhere from 6-15 kG for approximately 8-10 min, Currently there are no official magnetic field exposure criteria extant anywhere in the world. Unofficial standards recommended in the USSR for homogeneous fields (direct current) are 300 G (whole body) and 700 G (hands) and for gradient fields (direct current) 500-2,000 G/m (whole body) and 1,000-2,000 G/m (hands). Magnetic field exposure standards are currently in use at two laboratories in the United States. At the National Accelerator Laboratory, the exposure standard is 100 G to 5 kG when work in the area is minimized. A standard of 5-10 kG is set for whole body exposure for up to 1 hr; this can be exceeded with permission of the Senior Radiation Officer. An individual who will be exposed to a field exceeding 10 kG must have the approval of the Senior Radiation Officer. At the Stanford Linear Accelerator facility, the standards for exposure to direct current fields for extended periods are 200 G for the whole body or head and 2,000 G for the arms and hands. For short periods (minutes), the respective standards for whole body or head and arms and hands are 2,000 G and 20,000 G. Although the current unofficial standards contain a wide range of numbers, they differ only by about an order of magnitude.

6119 EXPERIMENT AND THEORY IN LONG RANGE INTERACTIONS OF ELECTROMAGNETIC FIELDS AT BRAIN CELL SURFACES. *(Eng.)* Adey, W. R. (Res. Service 151, Jerry L. Pettis Memorial Veterans Admin. Hosp., Loma Linda, CA 92357). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 53-78; 1978. (24 refs)

Experiments and theoretic models dealing with long-range interactions of electromagnetic fields at brain cell surfaces are reviewed. Experiments with animals have indicated that behavior can be modified by the presence of radio signals that are made to resemble, to some degree, the brain's own signaling system. For example, in training and extinction trials with cats exposed to 147-MHz radiowaves (0.8 mW/cm^2) that were amplitude modulated at a frequency of an electroencephalogram rhythm burst in the particular brain structure, the presence of the modulated radio frequency field greatly prolonged the extinction of a learned response. Experiments with isolated neonatal chick forebrain have demonstrated significantly increased calcium efflux under exposure to 450-MHz fields amplitude modulated at 16 Hz when the incident field intensities were in the range of 0.1-1.0 mW/cm^2. Theoretic models that address the question of cooperativity at cell membrane surfaces in relation to the sensing

of weak fields are reviewed. One of the models examined suggests that the membrane surface may be acting as a low pass filter for the transfer of thermal noise. It is suggested that if one looks at the surface of the membrane in the counter-ion layer (within 20-50 A of the surface) it may indeed be functioning as a low pass filter. In both theoretic models and in actual tests, it has been shown that there is a dielectric dispersion with an apparent dielectric constant in excess of 10^6 at frequencies of less than 1.0 kHz in the counter-ion layer, indicating that it is almost an ideal low pass filter. Taking these data and a specific resistance of 300 ohms/cm for the brain, it is calculated that in order to displace ions along the surface, the transfer function for the bulk of thermal noise would be 10^{-8} V/cm. This is exactly the figure that has been indicated as the biologic sensitivity in marine vertebrates. This figure is also within an order of magnitude of the sensitivity observed for the mammalian central nervous system in extremely low frequency experiments, both chemically and behaviorally. Overall, it is concluded that there are special structural organizations in the central nervous system of all vertebrates, and particularly the mammal, that may make them susceptible in subtle ways to environmental electric fields, electromagnetic fields, and to the intrinsic fields in brain tissue.

MEETING ABSTRACTS

6120 FERROMAGNETIC ORIENTATION IN BACTERIA (MEETING ABSTRACT). *(Eng.)* Blakemore, R. (Dept. Microbiology, Univ. New Hampshire, Durham, NH 03824). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 6-7; 1978. (3 refs)

Studies of ferromagnetic orientation in bacteria are reviewed. Bacteria that orient and swim in a preferred direction in magnetic fields have been observed in diverse aquatic environments. Electron microscopy of marine and freshwater magnetic bacteria has revealed the presence of intracytoplasmic granules or crystals arranged in clusters or chains and contained within triple-layered membranes. Energy dispersive x-ray analysis revealed iron as the predominant elemental constituent of these particles. A species of magnetic bacterium recently isolated from a swamp retained its magnetism upon repeated transfer in laboratory culture media. Cells of this species contained chains of electron-dense crystals previously described as constituents of magnetic bacteria from mud. Remagnetization of swimming magnetic bacteria has been studied using a critically damped electric circuit capable of producing a magnetic field strength of 0-600 G in the center of two Helmholtz coils. Bacteria were made to swim in a constant, uniform magnetic field ranging from zero to four times that of the local geomagnetic field. The application of a magnetic pulse of sufficient intensity and antiparallel to the direction in which the bacteria were swimming caused the cells to turn around and swim in the opposite direction. To affect turning of 50% of a population of the predominant type from a freshwater swamp, 375-400 G was required. To remagnetize 50% of the predominant form from a marine marsh, 525-550 G was required. Tracks of swimming bacteria have been photographed using timed exposures; the radius of the U-turn resulting from reversing the ambient (orienting) field was essentially the same as that resulting from remagnetizing the bacteria. Moreover, at the intensity required to remagnetize 50% of the population, no cells in the population remained completely depolarized. These results suggest that the bacteria orient through ferromagnetism and exhibit properties characteristic of single magnetic domains. No experimental evidence is presently available to explain why the cell's magnetic movement favors northward and downward motion in the geomagnetic field.

6121 ELECTROMAGNETIC GUIDANCE SYSTEMS IN FISHES (MEETING ABSTRACT). *(Eng.)* Kalmijn, A. J. (Dept. Biology, Woods Hole Oceanographic Inst., Woods Hole, MA 02543). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 8-10; 1978. (12 refs)

Electromagnetic guidance systems in fish are discussed. Marine sharks, skates, and rays are extremely sensitive to weak electric fields in their seawater environment. Operating in the frequency range of 0 (direct current) to about 8 Hz, they exhibit biologically meaningful responses to voltage gradients as low as 0.01 μV/cm. These low-level electric fields are detected by the ampullae of Lorenzini, which comprise a delicate sensory system in the protruding snout of the elasmobranch fish. Freshwater stingrays, lower bony fish, catfish, and weakly electric fish also have ampullary receptors, though of much smaller size, which render them sensitive to direct current and low-frequency voltage gradients of 1 μV/cm or slightly less. The ampullary receptors of both marine and freshwater electrosensitive fish have been shown to play an important role in the detection of prey and in spatial orientation. When actively swimming through the earth's magnetic field, sharks, skates, and rays also induce local electric fields of which the voltage gradients depend on the fish's compass heading. Since these fields are strong enough to be detected at swimming speeds of only a few cm/sec, the elasmobranches could very well be endowed with an electromagnetic compass sense. Sharks and rays have been observed to react to non-uniformities in the geomagnetic field, to rest in areas predetermined by the magnetic field direction, and during training experiments to secure food from an enclosure in the east but not to enter a similar enclosure in the west of their tank.

6122 EFFECTS OF MAGNETIC FIELDS ON AVIAN ORIENTATION (MEETING ABSTRACT). *(Eng.)* Keeton, W. T. (Section Neurobiology and Behavior, Cornell Univ., Ithaca, NY 14853). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 11-13; 1978. (14 refs)

Studies on the effects of magnetic fields on avian and insect orientation are reviewed. Bar magnets were found capable of disrupting the orientation of mature birds under overcast skies, though not under the sun. The magnets were also observed to disorient first-flight birds even when the sun was visible. The orientation of pigeons was changed (not merely disrupted) under overcast skies by attaching Helmholtz coils around the birds' heads. A rotated orientation of migratory restlessness in birds exposed to turned magnetic fields in circular test cages has also been reported. The birds' sensitivity was limited to a narrow range of field strengths approximately equal to the geomagnetic field. The birds paid no attention to field polarity but read north as that direction where the magnetic and gravity vectors formed the most acute angle. Evidence that birds use the earth's magnetic field to calibrate the star compass has also been obtained. The dance of scout honeybees has been reported to be influenced by even minor natural fluctuations in the earth's magnetic field, suggesting a sensitivity to changes of less than 10^{-3} G and perhaps less than 10^{-5} G. Similar sensitivity has been reported for gull chicks and for free-flying migrants. Pigeons also are influenced by natural magnetic fluctuations and must have a similar sensitivity. Migrants have been found to be influenced by the weak low-frequency alternating fields produced by the test antenna for the Navy's proposed Project Seafarer. There is now abundant evidence that both birds and insects are very sensitive to magnetic stimuli when they are orienting. Whether they are responsive to such stimuli under other circumstances is not yet clear.

6123 EFFECTS OF 60 HZ ELECTROMAGNETIC FIELDS ON BEES AND SOIL ARTHROPODS (MEETING ABSTRACT). *(Eng.)* Greenberg, B. (Dept. Biological Sciences, Univ. Illinois at Chicago Circle, Chicago, IL 60680). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): p. 14; 1978. (1 ref)

Experiments on the effects of 60-Hz electromagnetic fields on soil arthropods and honeybees are reported. Population curves and predator-prey proportions of soil arthropods exposed to the Navy's Wisconsin test facility antenna fields (0.1-2.5 V/m; less than 0.9 G), which were monitored annually since 1969, did not show any significant departures from normal fluctuations observed in control populations. Also, no significant sustained differences in metabolic rate measurements were noted between several species of soil-dwelling animals (earthworm, slug, wood louse, and redbacked salamander) that were collected from sites near the antenna and control populations. A comparison of metabolic rates for the summer and fall months revealed no seasonally-linked change in sensitivity to the electromagnetic fields. Experiments with honeybees in conventional metal-containing hives under a 765-kV transmission line (7 kV/m; 10^{-3} G) showed the following effects not observed in shielded counterparts under the line or in a control area (10 V/m; 10^{-4} G): hives failed to increase in weight; individual bees weighed less; fewer pupae were produced; moisture content of honey was less; and propolization of hive entrances was extensive. Unshielded metal-free hives under the transmission line were normal except for some propolization of hive entrances, possibly higher hemocyte counts, and possibly higher overwintering mortality.

6124 TESTS IN THE PLANT *TRADESCANTIA* FOR MUTAGENIC EFFECTS OF STRONG MAGNETIC FIELDS (MEETING ABSTRACT). *(Eng.)* Baum, J. W. (Safety and Environmental Protection Div., Brookhaven Natl. Lab., Upton, NY 11973); Schairer, L. A.; Lindahl, K. L. *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 15-17; 1978. (4 refs)

Possible mutagenic effects of strong magnetic fields (20-37,000 G) on the plant *Tradescantia* were investigated. The endpoints for mutagenicity included pink stamen hair mutation, pollen abortion, and micronuclei formation in the tetrad stages of pollen production. Results were obtained in eight separate trials. For each of the three endpoints studied, no increase in mutation rate was observed for exposed compared to control plants over exposure periods varying from 0.9 to 6 days. The pooled data indicated that a small but not highly significant increase of $2.7 \pm 2.3 \times 10^{-4}$ pink mutations per hair resulted from these magnetic field exposures. These data were used to estimate a possible mutation increase of 8×10^{-5}% for exposures to 200 G for 8 hr (a conventional limit for whole-body exposure at several laboratories). In comparison, mutation increases of 0.015% would be produced in this system by a permissible daily dose of 20 milli roentgen equivalents (mrem) of ionizing radiation. Assuming that linear relations hold between field strength, exposure time, and the observed effect, then these results suggest that an 8 hr/day exposure to a 40-kG field would be necessary to produce the same (or probably lower) mutation frequency as a 20-mrem x-ray exposure.

6125 MAGNETIC FIELD INTERACTIONS IN MAN AND OTHER MAMMALS: AN OVERVIEW (MEETING ABSTRACT). *(Eng.)* Sheppard, A. R. (Jerry L. Pettis Memorial Veterans Hosp., Loma Linda, CA 92357). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 28-31; 1978. (29 refs)

Magnetic field interactions in man and other animals are reviewed. Reports of magnetic field effects

cluster about effects on blood composition, alterations in normal physiologic parameters of growth and activity, effects on the immune system, altered neural function, and altered animal behavior. Interest in possible effects on the central nervous system by weak fields is stimulated by evidence that birds possess a magnetic compass, by several findings concerning bird orientation in very weak electromagnetic fields, and by the extraordinary electric field sensitivity of certain fish. The effect of weak low frequency electric fields on calcium binding in neural tissue provides a possible neurochemical basis for these influences. It is clear that humans in a strong magnetic field (greater than 100 G) experience excitation of the visual pathway (magnetic phosphene) in the form of the sensation of flickering, shimmering light patterns. Swedish scientists have observed spike trains in retinal ganglion cells following exposure to a magnetic field, and they have characterized a frequency dependent threshold for phosphenes in humans. When phosphenes are produced under certain ambient light conditions, the threshold above 30 Hz differs in subjects with abnormal color vision, although the localization of phosphenes in the peripheral visual field suggests little involvement for the color-sensitive cone receptors of the foveal region.

6126 EFFECTS OF MAGNETIC FIELDS ON BEHAVIOR IN NONHUMAN PRIMATES (MEETING ABSTRACT). *(Eng.)* de Lorge, J. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 32-33; 1978. (5 refs)

Studies of magnetic field effects on the behavior of nonhuman primates are reported. In one study three squirrel monkeys (*Saimiri sciureus*) were conditioned to respond on a visual vigilance task and were subsequently exposed to a direct current magnetic field in the core of a water-cooled Bitter magnet. Responding was greatly suppressed by fields of 70 kG or more, and a threshold seemed to exist between 46 and 70 kG. A second experiment in a superconducting magnet in which eight squirrel monkeys were trained on several operant tasks revealed similar suppressive effects at magnetic field strengths of up to 97 kG. In addition, two of the monkeys regurgitated when exposed to the higher fields. All of these effects were reproducible. Recent studies using rhesus (*Macaca mulatta*) and squirrel monkeys have revealed no behavioral effects of extremely low frequency electromagnetic fields. Magnetic fields ranging from 3-10 G and electric fields from 1-29 V/m (root mean square) at frequencies of 7, 10, 15, 45, 60, and 75 Hz were used. No consistent effects, other than one unreplicated effect on general activity, were observed. It is concluded that reported effects of low magnetic fields on behavior are probably related to other uncontrolled environmental variables.

6127 MAGNETIC FIELD EFFECTS ON RODENTS (MEETING ABSTRACT). *(Eng.)* Nahas, G. G. (Dept. Anesthesiology and Pathology, Coll. Physicians and Surgeons, Columbia Univ., New York, NY 10032). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 34-35; 1978. (1 ref)

Possible vascular or histopathologic effects in rats exposed to homogeneous magnetic fields produced by permanent magnets were investigated. Capillary circulation in the mesoappendix was observed by an in vivo microscopic technique after exposure to 500 G for 6, 12, and 30 days. Rats exposed to 200-1,200 G for 29-32 days were sacrificed for analysis of blood chemistry, body and organ weights, and histopathologic examination of vascular tissues and 10 selected organs. The in vivo capillary circulation study and histopathologic results indicated no hemodynamic alterations or intravascular thrombosis associated with magnetic field exposure. Hematology revealed no changes in hematocrit, white blood cell count, hemoglobin level, or coagulation time in exposed rats. Except for nonpathologic congestion of the spleen, no histopathologic effects were noted in any organs following magnetic field exposure. Body and organ weights of young rats exposed to magnetic fields were increased relative to matched controls; however, the number of animals studied was small, and further studies are required to determine the significance of this observation.

6128 STUDIES ON BIOMAGNETIC EFFECTS IN MICE (MEETING ABSTRACT). *(Eng.)* Biggs, M. W. (Dept. Industrial Medicine, Lawrence Livermore Lab., Livermore, CA 94550). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): p. 36; 1978. (3 refs)

The possible effects of magnetic fields ranging in strength from 8,800-14,400 G on murine growth rate and hematologic parameters and on in vivo tumor growth were investigated. In two separate experiments, the growth rate of young male mice weighing 12 g at the start of the experiment was unaffected by a continuous 15-day exposure to the magnetic field; no growth effects were observed following termination of the exposure. In adult mice, no alterations were observed relative to matched controls in body weight, white blood cell count, differential blood count, hematocrit, red blood cell count, or liver and spleen weights following magnetic field exposures for periods of 16-23 days. The effect of the magnetic field on the growth of Ehrlich ascites tumor was not statistically significant both in terms of tumor growth rate and mean survival time of tumor-bearing hosts.

6129 MECHANISMS OF MAGNETIC FIELD INTERACTIONS WITH RETINAL RODS (MEETING ABSTRACT). *(Eng.)* Hong, F. T. (Dept. Physiology, Wayne State Univ. Sch. Medicine, Detroit, MI 48201). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. Cali-

fornia, Berkeley, CA (LBL-7452): pp. 38-40; 1978. (11 refs)

Mechanisms of magnetic field interactions with retinal rods are discussed. It has been reported that isolated frog rod outer segments in aqueous suspension can be oriented by a homogeneous magnetic field of 10 kG. The equilibrium orientation is parallel to the applied field, and the two ends of a rod appear equivalent in a magnetic field. Among the possible mechanisms considered responsible for this orientation effect is magnetic anisotropy. Numeric estimation based on the mechanism of magnetic anisotropy indicates that it is impossible to orient individual molecules in a rod with a field strength of 10 kG. However, two major molecular constituents, visual pigment rhodopsin and phospholipid, are oriented along the axial direction in a rod. If either molecule possesses a small anisotropy, the anisotropy will be additively summed in a rod and increased by a factor of 3×10^9 (rhodopsin) or 10^{13} (phospholipid). The crucial parameter is the summed anisotropy, which is the sum of the anisotropy of all the individual oriented anisotropic molecules. An elementary calculation using classical magnetic theory leads to expressions that correctly describe the time course of orientation. Other investigators have confirmed the effect and have shown that the anisotropy is due mainly to the protein moiety of rhodopsin (possibly an alpha-helical region) rather than phospholipid or the chromophore retinal. The magneto-orientation effect is a manifestation of the extraordinary order in the rod membrane structure and has been utilized as an experimental tool in obtaining oriented biologic samples for x-ray crystallography and neutron diffraction studies in addition to fluorescence depolarization and linear dichroism studies. Similar magnetic orientation mechanisms might play a physiologic role in other systems. For example, accumulating evidence has shown that some birds use the terrestrial magnetic field as a cue in orientation and navigation. Experiments with European robins have suggested that the magnetic compass of the bird can only detect the axial direction of the magnetic field and cannot differentiate north from south. Thus, birds trained in the northern hemisphere will perhaps be confused in the southern hemisphere. If this turns out to be the case, then ordered biologic structures (such as *pecten oculi*) instead of ferromagnetic particles should be examined in the search for the biologic compass.

6130 ORIENTATION OF BIOLOGICAL MEMBRANES AND CELLS IN MAGNETIC FIELDS (MEETING ABSTRACT). *(Eng.)* Geacintov, N. E. (Chemistry Dept., New York Univ., New York, NY 10003). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 41-43; 1978. (3 refs)

A theoretic analysis of the orientation of biologic membranes and cells in magnetic fields is presented. The observation of magnetic orientation effects depends critically on the product of the volume of the domains of oriented molecules and the anisotropy; this product is found to be 10^{-20} cm^3 for whole *Chlorella* cells. The smaller the anisotropy, the larger the size of the domain containing the oriented molecules that is necessary to achieve an observable orientation. Using magnetic fields of 10-20 kG, it has been found that the minimum size of the biologic particles that can be oriented by magnetic fields is of the order of 1 μ. However, smaller particles, such as, small protein complexes can be readily oriented by electric fields. Also, while a magnetic field of 15 kG is necessary to completely orient spinach chloroplasts, these particles are easily oriented in the presence of weak alternating electric fields (60 Hz) as low as 20-30 V/cm. It is therefore evident that the orienting magnetic forces are much weaker for normally available magnetic fields than for commonly available electric fields. It is concluded that orientation forces in biologic systems must be considered when assessing possible biologic effects of magnetic fields.

6131 ENZYME-SUBSTRATE REACTIONS IN HIGH MAGNETIC FIELDS (MEETING ABSTRACT). *(Eng.)* Weissbluth, M. (Stanford Univ., Stanford, CA 94305). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 44-45; 1978. (4 refs)

Three sets of experiments investigating the possible effects of high-strength magnetic fields on enzyme-substrate reaction rates are reported. The experiments were performed at a temperature close to 25 C, with temperature variation generally being limited to within 0.5 C. In the first series, the systems ribonucleic acid (RNA)-ribonuclease and succinate-cytochrome c reductase were investigated in magnetic fields of up to 48 kG over exposure periods of 5-6 min. The second series of experiments consisted of exposing the following systems to 85 to 170 kG magnetic fields over periods of 2-20 min: RNA-ribonuclease, horseradish peroxidase (which catalyzes the oxidation of *o*-dianisidine by hydrogen peroxide), tyrosinase-L-tyrosine, and aldolase-fructose 1,6-diphosphate. The peroxidase was additionally placed in the fringe field at 85 kG to provide a field gradient with a variation of about 30% over the sample volume. In the final series of experiments, trypsin-BAPA was exposed to 220 kG for 9 min; finally, the enzyme alone was pretreated for 65-220 min at 208 kG. In all cases the reaction rates were independent of the magnetic field. A survey of the literature indicated that positive results have been obtained in some instances, e.g., a magnetic field of 3,200 G resulted in a 30% increase in the reaction rate of deoxyribonuclease.

6132 EFFECTS ON CELL FUNCTION RESULTING FROM EXPOSURE TO STRONG MAGNETIC FIELDS AT 4°K (MEETING ABSTRACT). *(Eng.)* Malinin, G. I. (Physics Dept., Georgetown Univ., Washington, DC 20057); Gregory, W. D.; Morelli, L.; Ebert, P. S. *In: Proceedings of the Biomagnetic Effects Workshop,*

April 6-7, 1978. Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 46-47; 1978. (1 ref)

Various cell types were exposed to magnetic fields at a temperature of 4 Kelvin (K), thus transforming a fluid cellular target into a solid state system, in an effort to overcome the ambiguous quantitative results of magnetic field effects on cellular functions observed at ambient temperature. In all experiments, target cells were frozen to 4 K in the presence of an appropriate cryoprotective agent, exposed to a given magnetic field for a predetermined time, thawed rapidly, and allowed to resume metabolism under optimal growth conditions. Murine heteroploid L-929 and human diploid WI-38 fibroblasts exposed to a 5-kG magnetic field at 4 K subsequently developed morphologically distinct cell types that could be propagated from generation to generation. Deoxyribonucleic acid synthesis in spleen-derived murine lymphocytes was measured by tritiated thymidine (^{3}H-TdR); ^{3}H-TdR incorporation in concanavalin A-stimulated lymphocytes previously exposed to a 40-kG field at 4 K was drastically reduced compared to controls. Hemoglobin synthesis in murine erythroleukemia cells could not be induced with butyrate following exposure of the cells to a 40-kG field at 4 K. In this series of experiments, control cultures showed a normal response to butyrate induction as measured with the benzidine assay. These data seem to indicate that the exposure of target cells to strong magnetic fields at 4 K results in reproducible and measurable alterations of cellular metabolic indicators. Preliminary measurements of this magnetization of cells with a superconducting SQUID magnetometer indicated a possible difference in cell magnetization between control and target cells.

6133 EFFECTS OF A TRANSVERSE MAGNETIC FIELD ON THE DOSE DISTRIBUTION OF HIGH ENERGY ELECTRONS AND ON THE RESPONSES OF MAMMALIAN CELLS IN VITRO TO X-RAYS (MEETING ABSTRACT). *(Eng.)* Nath, R. (Dept. Therapeutic Radiology, Yale Univ. Sch. Medicine, New Haven, CT 06510); Rockwell, S.; Bongiorni, P.; Schulz, R. J. *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978*. Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 48-49; 1978. (2 refs)

Possible changes in the viability of radiation responses of mammalian cells in vitro exposed to high magnetic fields were investigated in connection with potential complications of using transverse magnetic fields for enhancing the dose of high-energy electron beams in clinical radiotherapy. The exposure of unirradiated EMT6 mouse mammary tumor cells to an almost uniform magnetic field of 1,400 G for up to 48 hr did not alter the proliferation or viability of the cells. Exposure of the cells to this magnetic field during irradiation with 120-kV x-rays did not alter the repair of sublethal damage. Exposure of plateau phase cultures to the magnetic field after irradiation for times up to 24 hr did not alter the repair of potentially lethal damage. An almost uniform magnetic field of 5,700 G did not alter the repair of sublethal or potentially lethal damage of x-irradiated EMT6 cells and did not alter the viability of unirradiated cells during exposures of up to 6 hr. More recent experiments with DON Chinese hamster cells and higher field strengths have indicated that the exposure of these cells to an almost uniform field of 20.5 kG or to a nonuniform field of 17.4 kG with a gradient of 2,300 G/cm for 2 hr did not alter their viability. The survival curves for cells exposed to 30-MV x-rays delivered in a single treatment or in two treatments separated by an incubation period of 2 hr outside the magnetic field were not affected by the almost uniform 20.5-kG magnetic field. Thus far, no significant changes in the viability of radiation responses of mammalian cells in vitro have been observed in cells exposed to high magnetic fields.

6134 EFFECT OF MAGNETIC FIELDS ON THE DRUG-INDUCED CONTRACTILITY OF THE CILIATE SPIROSTOMUM (MEETING ABSTRACT). *(Eng.)* Ettienne, E. (Univ. Massachusetts Medical Sch., Worcester, MA 01065); Ripamonti, A.; Frankel, R. B. *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978*. Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 50-52; 1978. (4 refs)

The effect of a homogeneous magnetic field on drug-induced contractility of the ciliate *Spirostomum ambiguum* was investigated. Ciliate contraction was induced by the addition of 10 µmol of 2,2'-dipyridyldisulfide (PDS). *Spirostomum* were exposed to a 9,200-G magnetic field, and the number of PDS-induced contractions per minute was monitored over a 20-min interval in populations of cells exhibiting synchronous contractions. At 7, 10, 13, and 16 min following incubation in PDS, the values for peak contraction frequencies were depressed in the exposed samples relative to controls by 50, 37, 33, and 33%, respectively; all of these differences were significant ($p<0.001$). The duration of the relaxation phase in the magnetic field was observed to be extended over that of controls. A significant decrease in cell survival over the entire incubation period for cells exposed to magnetic fields of either 5,000 or 9,200 G also was observed. Based on the known physiology of *Spirostomum*, the above observations suggest that the presence of a magnetic field serves to decrease the enzymatic transport of calcium ion out of the cytoplasm following contraction.

6135 ANALYSIS OF STATIONARY MAGNETIC FIELD EFFECTS ON IONIC DIFFUSION AND NERVE ACTION POTENTIALS (MEETING ABSTRACT). *(Eng.)* Liboff, R. L. (Sch. Applied Physics and Electrical Engineering, Cornell Univ., Ithaca, NY 14853). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978*. Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 80-81; 1978. (6 refs)

Studies of magnetic field effects on ionic diffusion

and nerve action potentials are reported. Magnetically-induced changes in ion diffusion rates were studied by measuring the conductivity of cesium chloride solutions in the presence and absence of a magnetic field. An alternating current bridge circuit was employed in which the frequency was about 10^3 times lower than the Larmor frequency (about 10^7 Hz at 1 kG). A null-point conductivity measurement was made to detect any imbalance of the bridge circuit resulting from the application of the magnetic field, thus signifying an influence of the field on the ionic diffusion coefficient. No imbalance of the bridge circuit was observed following the application of fields of up to 1 kG. A possible inductive interaction between a steady magnetic field and a nerve action potential was also analyzed. An action potential propagating along a squid axon with a velocity of about 10^3 cm/sec was assumed to enter a region with a steady magnetic field directed transverse to the axis of the axon. The analysis indicated that magnetic field effects tend to be nullified because of the rotational symmetry of the current loops in the action potential. Previous experimental studies indicated that no magnetic effects on the action potential of the frog sciatic nerve occurred at fields of up to 100 kG distributed over 0.5 cm. The possibility of current distortion of the action potential due to a magnetic field was also investigated; the extent of such distortion was evaluated by comparing the Hall electric field (E_H) to the electric field associated with the current flow of the action potential (E_a). For parameters appropriate to the squid axon, the ratio of E_H/E_a remained less than unity for magnetic fields less than about 1 kG.

6136 MECHANISMS OF BIOMAGNETIC EFFECTS (MEETING ABSTRACT). *(Eng.)* Mahlum, D. D. (Biology Dept., Pacific Northwest Lab., Richland, WA 99352). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 82-83; 1978. (0 refs)

Studies conducted by the Pacific Northwest Laboratories on the mechanisms of biomagnetic effects in both warm- and cold-blooded animals are described. Studies with mice are being performed using a replicate experimental design that permits prolonged exposures of mice in different stages of gestation to static homogeneous (10,000 G), static gradient (260 G/cm), or cyclic gradient (250 G/cm, approximately 0.6 cycles/min) magnetic fields. Some animals are examined prenatally for morphologic effects, while others are evaluated postnatally for functional changes. In other studies with trout, eggs are fertilized and permitted to develop in the magnetic field for 21 days (approximately 7 days before hatching). The eggs are then removed from the field and allowed to hatch in a flow-through incubator. Several endpoints including morphologic alterations, hatching efficiency, and survival are used to assess the effects of exposure. These studies should provide an integrated assessment of biomagnetic effects that is independent of the level at which the effect occurs and that is independent of the mechanism. In addition, a number of simpler in vitro systems are being investigated. These include changes in permeability characteristics of artificial and natural membranes, changes in gelation temperatures of macromolecules, effects on growth and morphologic and functional characteristics of cells in tissue culture, and the effects on neuromuscular function. Studies of possible genetic effects using microbial and animal systems are also in progress. Current speculation suggests that alterations in macromolecular or membrane conformation could result in biochemical and physiologic changes that would serve to amplify small effects produced by the interaction of magnetic fields with biologic material. Singer's fluid mosaic model of membrane structure may provide a tool for exploring the validity of these speculations if reproducible effects can be identified.

6137 MAGNETIC FIELD COUPLING WITH LIQUID CRYSTALLINE STRUCTURES (MEETING ABSTRACT). *(Eng.)* Labes, M. M. (Dept. Chemistry, Temple Univ., Philadelphia, PA 19122). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 84-85; 1978. (4 refs)

A model for magnetic field coupling with liquid crystalline structures is proposed. In a magnetic field, arrays of diamagnetic rods adopt a position that minimizes their free energy. If the diamagnetic anisotropy (X_a) is greater than 0, then the long molecular axis aligns in the field. The free energy perturbation $(F_m) = -1/2\ X_a\ (nH)^2$, where n is the director of the liquid crystal and H is the magnetic field strength. The critical magnetic field to produce reorientation of the director in a thin sample (about 0.1 mm in depth) is typically 10^3-10^4 Oe, depending on the magnitude of X_a. Subcritical fields perturb cholesteric liquid crystals by changing the pitch of the cholesteric helix. Transport processes are known to be anisotropic in liquid crystals; e.g., diffusion coefficients are typically twice as large parallel to the long axis as compared to the perpendicular direction. The proposed model for biomagnetic effects consists therefore of the perturbation of a transport process through a liquid crystalline membrane. The perturbation can be expected to influence the rate of transport by a factor of 2 for magnetic fields of 10^3-10^4 Oe. Measurements of magnetic field effects on diffusion in liquid crystals and on the anisotropy of diffusion confirm several aspects of the above model of biomagnetic effects.

6138 SUPERCONDUCTIVE JOSEPHSON JUNCTIONS--A POSSIBLE MECHANISM FOR DETECTION OF WEAK MAGNETIC FIELDS AND OF MICROWAVES BY LIVING ORGANISMS (MEETING ABSTRACT). *(Eng.)* Cope, F. W. (Biochemistry Lab., Naval Air Development Center, Warminster, PA 18974). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 86-87; 1978. (7 refs)

Biological Effects of Nonionizing Electromagnetic Radiation III(4), June 1979

The phenomenon of superconductive Josephson junctions is considered as a possible mechanism for the detection of very weak magnetic fields (0.1-5 G) and microwaves by living organisms. Although no direct evidence for this phenomenon has been obtained in vivo, various model chemical systems have been examined for the presence of superconductive transitions and Josephson junctions at temperatures in the physiologic range. For example, experimental evidence indicates probable superconductive transitions in the cholates at near room temperature. Also, weak magnetic field effects on probable Josephson junctions have been observed in carbon films at 25 C. Electron tunneling through these junctions responds to very small magnetic fields as evidenced by the fact that superconducting Josephson junctions have been fabricated that exhibit sensitivity to fields as small as 10^{-11} G. Josephson junctions between superconductive microregions in living systems may therefore provide a possible physical mechanism with more than enough sensitivity to explain the observed responses of organisms to weak magnetic fields. Microwave effects observed on probable room temperature Josephson junctions in carbon films suggest that nonthermal effects of microwaves in biologic systems may occur with high sensitivity by the same mechanism.

6139 THEORETICAL REMARKS ON LOW MAGNETIC FIELD INTERACTIONS WITH BIOLOGICAL SYSTEMS (MEETING ABSTRACT). *(Eng.)* Swenberg, C. E. (Dept. Physics, Univ. Puerto Rico, Rio Piedras, PR 00931). *In: Proceedings of the Biomagnetic Effects Workshop, April 6-7, 1978.* Lawrence Berkeley Lab., Univ. California, Berkeley, CA (LBL-7452): pp. 88-90; 1978. (8 refs)

The theory of low magnetic field interactions with biologic systems is discussed, with particular emphasis on examples of biomagnetic hyperfine interactions. One such example is provided by the photochemical properties of the bacterium *Rhodopseudimonas sphaeroides*. In this system, if the photochemical electron transfer to the iron-ubiquinone complex is blocked by chemical reduction, the lifetime of the radical pair intermediate ($P870^{+}I^{-}$) formed by a flash excitation will increase from 0.2 to 10 nsec. Under this condition, a magnetic field effect on the spin state of the intermediate can be observed as a change in the absorption spectrum of the carotenoid receptor. The saturation field is approximately 100 G, and the maximum magnetic field effect on the absorption is about 30%. Other examples of biomagnetic hyperfine interactions may arise in systems where a photoisomerization is coupled to an exothermic transfer reaction. It has been proposed that the sensitivity of certain migratory birds to the geomagnetic field may originate from an anisotropic hyperfine tunneling mechanism that serves as an internal compass. In cases where light is necessary for the detection of both the presence and direction of the earth's field, small fluctuations are predicted to occur in the plasma membrane current of retinal photoreceptor cells when they have different spatial orientations relative to the field.

6140 THE APPLICATION OF TRANSMISSION MICROWAVE TECHNOLOGY TO LUNG WATER MEASUREMENTS (MEETING ABSTRACT). *(Eng.)* Bragg, D. G. (Dept. Radiology, Coll. Medicine, Univ. Utah, Salt Lake City, UT); Durney, C. H.; Iskander, M. F. *Invest Radiol* 13(5): 373; 1978. (1 ref)

A pulmonary edema animal model was developed to test the transmission microwave monitoring method. The method employs a transmission microwave applicator and detector system and appears to have good power coupling to the tissue, with minimal external radiation. The open strip transmission line has been tested in animal models and appears to satisfy the requirements of small size and the ability to be conveniently attached to the chest wall. In the present study, the amplitude and phase of the transmitted microwave signal was constantly monitored during the induction and reversal of pulmonary edema. The animals were simultaneously evaluated with serial chest radiographs, together with a constant monitoring of systemic arterial pressures, mean pulmonary arterial and venous pressure, and cardiac output. The microwave transmission technique appears to be the most sensitive and specific method available to detect changes in total lung water content. Future research will be directed toward improvements in system design to eliminate problems of maintaining the opposing applicator reference position and reducing the sensitivity of the technique in response to geometric and motion artifacts.

6141 LOCALIZED RADIOFREQUENCY HYPERTHERMIA (LRFHT) OF THYROID GLAND (WORK IN PROGRESS) (MEETING ABSTRACT). *(Eng.)* Kotlyarov, E. V. (Univ. Nebraska Medical Center, Omaha, NB 68105); Washburn, J. H.; Baltaxe, H. A. *Invest Radiol* 13(5): 425; 1978. (0 refs)

The possibility of utilizing localized radio frequency hyperthermia (LRFHT) (alone or with radioactive iodine) in the treatment of euthyroid goiter and possibly in primary or secondary thyroid cancer was investigated. Initial studies of the effect of LRFHT on the uptake of ^{131}I and ^{99m}Tc-pertechnetate and the pathologic effects of LRFHT on the thyroid gland are presented. The initial parameter of localized hyperthermia was determined by direct implantation of a thermoprobe into one of the thyroid lobes of six rabbits (1.5-2 kg) (both sexes). A triport 222 three-channel radio frequency generator transmitting at 13.56 MHz was utilized to induce localized hyperthermia. Eliptical copper electrodes measuring 6 cm^2 were used, and a mean power of 10-12 W was applied to the electrodes to produce localized hyperthermia with an average applied power of 1.8-2.2 W/cm^2. Power was pulsed through the electrodes and an intrathyroid temperature of 41.5 ± 0.5 C was maintained for 60 min. In a second study, the effect of LRFHT on 2-hr ^{99m}Tc-pertechnetate and 2, 24, 48, and 72-hr ^{131}I thyroid uptake was investigated. The discharge of incorporated ^{131}I from the thyroid due to different time (30-60 min) of hyperthermia during 1 wk daily was studied. The thyroid (neck) uptake was obtained in vivo after intravenous injection of 20 µCi of ^{99m}Tc-pertechnetate and 3 µCi of ^{131}I. Radiometry was performed by

scintillation detection placed on the skin in front of maximal radioactivity on the neck. The results indicate a significant decreased thyroid function (trapping and organification) as well as a significant discharge of organified iodine compounds from the thyroid gland.

6142 UNIFORM THAWING OF CANINE KIDNEYS USING SINGLE-FREQUENCY ELECTROMAGNETIC ENERGY (MEETING ABSTRACT). *(Eng.)* Burdette, E. C. (Engineering Experiment Station, Georgia Inst. Technology, Atlanta, GA 30332); Karow, A. M., Jr. *Cryobiology* 15(6): 725; 1978. (0 refs)

Uniform thawing of canine kidneys was investigated using kidneys from dogs perfused with a K^+,Mg^{++}-rich perfusate containing one of several dimethylsulfoxide (Me_2SO) concentrations, frozen to -80 C, and thawed using 918-MHz electromagnetic (EM) energy. A special dielectric-loaded horn illuminator was designed to accomodate the kidney geometry and provide a uniform field incident upon the kidney. The thawed kidneys were evaluated by anatomic (macroscopic and microscopic) and physiologic observations. Temperature and thawing uniformity were measured by monitoring the power reflected back to the EM source during thermal phase change and by using high-resistivity thermistors during and immediately following thawing. Temperature uniformity was maintained to within 4 C throughout the entire kidney with thawing rates of 30 to 45 C/min. Histologic evaluation revealed little difference between frozen-EM-thawed renal tissue and controls.

6143 RECENT DEVELOPMENTS IN MICROWAVE HEATING (MEETING ABSTRACT). *(Eng.)* Hand, J. W. (Medical Res. Council Cyclotron Unit, Hammersmith Hosp., Du Cane Rd., London W12 OHS, England). *Br J Radiol* 51(611): 934; 1978. (0 refs)

Recent developments in microwave heating are discussed with emphasis on microwave applicators that are likely to be useful for hyperthermia application. In particular, a waveguide applicator partially loaded with dielectric slabs in order to produce a uniform microwave field across part of the aperture is described. Heating patterns produced by such an applicator are of greater uniformity than those produced by direct contact microwave applicators operated in the TE_{10} mode. This new type of applicator could be used in treating patients with superficial lesions. Microwave applicators made from micro-miniature coaxial waveguide also are reviewed. These applicators may be inserted into tissue via a catheter or as interstitial implants and are capable of producing localized hyperthermia deep in tissue. Small applicators of coaxial geometry could prove useful in the treatment of areas, such as, bladder, rectum, esophagus, and cervix. An experimental technique for inducing hyperthermia in a loop of exteriorized mouse intestine is described. The organ is immersed in a liquid that is both biologically compatible with and dielectrically similar to this tissue. This technique improves the efficiency of coupling the microwaves into the tissue and avoids the effects of shape and size on the absorption characteristics of the irregularly shaped mouse jejunum. A multi-sensor thermistor probe produced by thick film technology for temperature measurements in the presence of electromagnetic fields also is discussed.

6144 A TECHNIQUE FOR PRODUCING LOCALIZED MEASURABLE HYPERTHERMIA IN SUPERFICIAL RAT TUMOURS USING RADIO-FREQUENCY CURRENTS (MEETING ABSTRACT). *(Eng.)* Dunscombe, P. B. (Dept. Medical Physics and Radiotherapy, Charing Cross Hosp., London W6 8RF, England); Backhouse, B. M. *Br J Radiol* 51(611): 934; 1978. (0 refs)

Currents at 433 MHz were passed through superficial tumors of rats by means of a waveguide and aerial system to produce localized hyperthermia. It was demonstrated that this hyperthermia technique resulted in higher rates of heat production in fat and in the regions near the electrodes. Both the tumor and rectal temperatures were monitored during heating using thermocouple probes. The tumor probe was housed in a steel needle to facilitate insertion into the tissue. By maintaining the metallic components of the probes normal to the electric vector of the field it was possible to reduce pick up of the electromagnetic field to an acceptably low level. Thermographic studies performed on tissue-equivalent gels indicated a high degree of localization of heat production (full width at half maximum height of the temperature distribution was 1.5 cm) and surface heating. Similar studies failed to show any perturbation of the temperature distribution due to the presence of a thermocouple probe. A series of anesthetized rats carrying tumors on the flank was subjected to the heating system. The mean rate of rise of temperature in the tumors was 3.3 ± 2.2 C/min at 37 C corresponding to a power absorption of 270 ± 190 W/kg.

6145 MEASUREMENT OF THE ELECTRICAL PROPERTIES OF MATERIALS OF BIOLOGICAL INTEREST (MEETING ABSTRACT). *(Eng.)* Sheppard, R. J. (Dept. Physics, Queen Elizabeth Coll., London, England). *Br J Radiol* 51(611): 934; 1978. (0 refs)

Complex permittivity and conductivity is briefly defined and explained with particular reference to biologic materials. The reasons why such parameters and in particular their variation with frequency need to be known are discussed and apparatus required for such measurements is described. Frequency domain techniques are outlined, and alternating current bridges (10 kHz-100 MHz), coaxial lines (50 MHz-12 GHz), and waveguides that can operate over narrow frequency bands up to about 100 GHz are discussed. In addition, the new method of time domain spectroscopy (TDS), which enables data to be taken in the time domain, is explained. These data are Fourier transformed to give permittivity as a function of frequency. The advantages of TDS are that it has a wide frequency response and can

measure small (less than 1 ml) conductive samples. The technique is also ideally suited to measure tissue as well as solutions. Recent data on the lens of rabbit's eyes also are presented.

6146 HEAT TRANSFER AND CONDUCTION IN RADIO-FREQUENCY HEATING (MEETING ABSTRACT). *(Eng.)* Strang, R. (West of Scotland Health Boards, Dept. Clinical Physics and Bioengineering, 11 W. Graham St., Glasgow G4 9LF, Scotland); Patterson, J. *Br J Radiol* 51(611): 934; 1978. (0 refs)

Radio frequency hyperthermia is discussed with respect to heat transfer and conduction. In this heating modality the tissue to be heated is placed between two electrodes and a high-frequency alternating current is passed between them. The main advantage of this type of heating over other techniques is that it is possible to achieve heating at depth. Several factors affect the distribution of temperature produced by this technique, including differences in electrical impedance and specific heat, conduction of heat out of the heated volume and the transfer of heat by blood flow. Differences in electrical impedance and specific heat give rise to preferential heating in some tissues. In particular, if the tissues are in series, the relative temperature rise in fat and bone is much greater than in muscle (18:1 fat, 27:1 bone). After heat is deposited in a tissue there are processes that modify the resulting temperature distribution. One such process is the flow of blood through the tissue. Blood flow has two main effects: (1) for a given rate of production of heat in a tissue the temperature produced is limited to a certain value dependent on the blood flow; and (2) the temperature subsequently produced in normal tissues varies widely due to the large range of blood flows encountered.

6147 ATHERMAL EFFECTS OF MICROWAVES AT THE CELLULAR LEVEL (MEETING ABSTRACT). *(Eng.)* Ramsey, N. W. (Medical Physics Dept., Charing Cross Hosp., London W6 8RF, England). *Br J Radiol* 51(611): 935; 1978. (5 refs)

Investigations concerning the athermal effects of microwaves at the cellular level are reviewed. Cataract formation was induced in the lens of rabbit eyes by exposure to 12.2 cm wavelength radiation. A roughly reciprocal relationship was found between incident power and exposure time required, but at less than 40 mW/cm^2 incident power, virtually unlimited exposure could be tolerated. Using 1.25 cm wavelength it was found that an exposure of 5 min duration was sufficient to impair production of testosterone in the rat testes even though histologic examination revealed no obvious damage. This treatment produced a slight temperature rise but a comparable temperature rise induced by exposure to infrared radiation did not impair testosterone production. The absorbed power was less than 250 mW/cm^2. Embryonic chick hearts exposed to 1.25 cm wavelength radiation at an incident power of 74 mW/cm^2 and for durations up to 3 min showed gross changes in the electrocardiographic pattern. Evoked potentials were recorded from an electrode in the brain stem of a cat exposed to pulsed radiation at 20 cm to 25 cm wavelength, and peak power level of 60 mW/cm^2. The effect of 12.2 cm radiation on the intercellular reaction between mouse macrophages and a suspension of human erythrocytes was to depress phagocytosis. The effect was found to be transient, recovery taking place when the irradiation ceased. The incident power level was 50 mW/cm^2 with exposures lasting up to 30 min. Erythrocytes from rabbit venous blood and granulocytes isolated from the peritoneal cavity of the rabbit, following exposure to 10 cm wavelength radiation in vitro showed evidence of damage. An incident power of less than 10 mW/cm^2 for a period of 1 hr was sufficient to produce a loss of potassium from erythrocytes, indicating interference with the sodium-potassium pump. Hemoglobin loss from the erythrocytes occurred at an incident power of less than 10 mW/cm^2, and the osmotic resistance of the lymphocytes indicated some degree of cell damage for a similar exposure. Incident powers as low as 5 mW/cm^2 for periods of less than 1 hr were sufficient to kill a proportion of granulocytes, as demonstrated by nigrosin staining. If cells in the blood are readily damaged by such low power levels, the implications could be far reaching in that however radiation may be applied to the body, some fraction of the blood will always be irradiated. It is concluded that carefully quantitated data on the athermal effects of ultra high frequency (UHF) radiation on intact animals is an essential prerequisite to the use of UHF heating for the production of hyperthermia in humans.

6148 EVALUATION OF THE PERTH EXPERIENCE IN TREATING WITH IONIZING RADIATIONS AND VHF (434 MHz) RADIATIONS (MEETING ABSTRACT). *(Eng.)* Caldwell, W. L. (Div. Radiation Oncology, Dept. Human Oncology, Univ. Wisconsin Center for Health Sciences, Madison, WI 53706). *Int J Radiat Oncol Biol Phys* 4(Suppl. 2): 120-121; 1978. (1 ref)

The results of a series of 52 patients with advanced head and neck cancer treated with ionizing radiation in combination with 434 MHz very high frequency (VHF) radiation are reported. Included were cancers of the tonsil (8), pharynx (5), anterior tongue (5), floor of the mouth (4), soft palate (4), supraglottic larynx (4), larynx (4), maxilla (3), and other sites (15). The patients were administered doses of irradiation that were consistently lower than those used conventionally. The doses for the 18 patients with extensive disease who survived ranged from 4,000 rad/6 wk to 6,300 rad/7 wk (one patient was administered 2,500 rad/4 wk) with three patients having gold grain implant boosts; only six patients had doses in excess of 5,500 rad/6 to 7 wk. The doses in the 19 patients who died within 2 or more yr of completion of treatment were slightly lower, with only two patients being irradiated above 5,500 rad/6 to 7 wk. The treatment approach was not consistent; the site and extent of disease at the time of treatment varied sufficiently that individualization of treatment was felt unnecessary. Most of the pa-

tients were exposed to 434 MHz radiation in a Tronado unit (three rings of 434 MHz diathermy units, each ring composed of four units) for 20 to 30 min before treatment with ionizing radiation. Six to 18 exposures to VHF radiation were used, but generally these were expected to be between 39 C and 40.5 C. At this temperature for 20 min there is no cell kill from the heat, but there is sensitization to ionizing radiation. Normal tissue tolerance was excellent.

6149 THERMAL DISTRIBUTIONS FOR CLINICAL MICROWAVE HYPERTHERMIA (MEETING ABSTRACT). *(Eng.)* Kopecky, W. J. (Div. Radiation Oncology, Mallinckrodt Inst. Radiology, Washington Univ. Sch. Medicine, 510 S. Kingshighway, St. Louis, MO 63110); Perez, C. A. *Int J Radiat Oncol Biol Phys* 4(Suppl. 2): 119; 1978. (0 refs)

A saline-filled bath was used to determine the thermal distribution for several clinically useful waveguide applicators used in microwave hyperthermia. The system utilized a saline-filled compartment placed within a temperature-controlled water bath set to 37.5 C. Thermal distributions were taken with a hypodermic thermistor probe placed perpendicular to the electric field. In this way longitudinal and transverse cross sections of the heat deposition due to microwave interaction with the saline bath could be elicited. A similar arrangement was carried out to determine the thermal distribution from these waveguides in a tissue phantom. Results using these techniques are compared with thermographic camera data on central axis, and cross sectional distributions. Additionally, the clinical significance of these results are discussed.

6150 CLINICAL HYPERTHERMIA AND RADIATION (MEETING ABSTRACT). *(Eng.)* Johnson, R. J. R. (Dept. Radiation Medicine, Roswell Park Memorial Inst., 666 Elm St., Buffalo, NY 14263); Bicher, H. I.; Clubb, B. S.; Sandhu, T. S.; Hetzel, F. W.; Kowal, H. S.; *et al.* *Int J Radiat Oncol Biol Phys* 4(Suppl. 2): 119-120; 1978. (0 refs)

The potential application of hyperthermia in combination with x-irradiation was investigated using 2,450, 915, and 434 MHz microwaves for local tumor heating and whole-body hyperthermia for deep tumors. Local hyperthermia to 42.5 C will only produce tumor differential heating when the normal tissue perfusion rate exceeds that of the tumor. Hyperthermia at 42.5 C, applied immediately after x-irradiation, will cause a thermal enhancement ratio of 1.3:1.6 for both normal and tumor tissue. An improvement in the therapeutic ratio will result if the normal tissue can be maintained below 41 C. A pilot program using whole-body hyperthermia induced and controlled by a NASA environmental suit was used to assess the clinical feasibility of whole-body hyperthermia and x-irradiation and also to determine changes in distribution of regional and tumor blood flow, tumor PO_2 and pH. The relevance of these findings in relation to the potential use of whole-body hyperthermia and radiotherapy are discussed.

6151 MICROWAVE-INDUCED LOCAL HYPERTHERMIA IN COMBINATION WITH RADIOTHERAPY OF HUMAN MALIGNANT TUMORS (MEETING ABSTRACT). *(Eng.)* U, R. (Dept. Radiology, Duke Univ. Medical Center, Durham, NC 27710); Noell, K. T.; Woodward, K. T.; Worde, B. T.; Fishburn, R. I.; Miller, L. S. *Int J Radiat Oncol Biol Phys* 4(Suppl. 2): 122; 1978. (0 refs)

A pilot study using microwave hyperthermia immediately following administration of ionizing radiation was undertaken to evaluate the response of normal tissues, the regression of cutaneous or subcutaneous tumors, and the practical feasibility of such combined modalities in therapeutic radiology. Ionizing radiation in individual fractions of 200-700 rad was used 2-5 times per week to total doses of 1,400-6,000 rad in 5-30 fractions. Microwave hyperthermia (42-43.5 C) was applied 2-3 times per week, maximum 14 sessions in 5 wk. The 20 patients treated had squamous cell carcinoma, adenocarcinoma, malignant melanoma, plasmacytoma, epithelioid sarcoma, and undifferentiated carcinoma. After over 150 microwave hyperthermia sessions, it was found that: (1) local hyperthermia with microwave alone or in combination with ionizing radiation can be used with excellent normal tissue tolerance provided local tissue temperatures are carefully monitored and controlled; (2) a significantly higher level of preferential heat induction into tumor tissue occurs as compared to surrounding normal tissues; and (3) repeated microwave hyperthermia at 42-43.5 C for 45 min/session immediately following photon irradiation yields a favorable therapeutic ratio, often with dramatic results. It is concluded that microwave hyperthermia in combination with radiotherapy has significant potential in clinical cancer therapy, whether of curative or palliative intent.

6152 MICROWAVE HEATING AND THERMAL SENSITIVITY OF MICROWAVE HEATED MOUSE MAMMARY TUMORS (MEETING ABSTRACT). *(Eng.)* Robinson, J. E. (Div. Radiation Res., Univ. Maryland Sch. Medicine, Baltimore, MD 21201); Cheung, A. Y.; Harrison, G. H.; Samaras, G. *Int J Radiat Oncol Biol Phys* 4(Suppl. 2): 122; 1978. (0 refs)

Microwave heating techniques designed to heat tumors uniformly in mice are described. The technique employed tissue equivalent bolusing to minimize size and shape dependence of microwave absorption, and parallel opposed microwave beams to improve uniformity of energy deposition within the tumor. The techniques were used to quantitate the effects of microwave heating on mammary carcinomas in C3H mice under three conditions: tumors implanted on the flank and immersed in semi-solid gel, and flank tumors and leg tumors immersed in liquid bolus. All microwave irradiation was at a frequency of 2.45 GHz, and treatment temperatures ranged from 37.5 C to 44.0 C. Data from tumors heated in the semi-solid bolus yielded plots of tumor-volume-redoubling time versus treatment time that were shallower and had larger intercepts than data from tumors heated in water baths, which implied thermal non-uniformity of the microwave

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heated tumors. Plots of thermal sensitivity versus treatment temperature were parallel to, but displaced upward from those obtained with water bath heating. The displacement suggested that at least some part of the microwave-heated tumors was about 1 C lower in temperature than the target temperature. To obviate thermal gradients, tumors were microwave heated in a well-stirred liquid bolus (20% ethanol in saline) maintained 0.1 C below the target temperature. Tumor regrowth curves determined with this heating technique were consistent with uniform tumor temperature. Plots of thermal sensitivity versus target temperature indicated that all parts of the tumor were at or slightly above those heated with water baths at the same target temperature. Prior to microwave heating, the thermal uniformity of leg tumors immersed in the liquid bolus but not microwave heated was studied. Temperatures in the interior of the tumor and adjacent to large blood vessels were 1 C or more below water bath temperature. Microwave heating markedly improved the temperature uniformity. Tumor regrowth curves were consistent with good thermal uniformity. Because of the marked thermal heterogeneity of these leg tumors without microwave heating, it was not useful to do regrowth studies by water bath heating. Therefore, it was not possible to directly compare the effects of microwave and water bath heating with the leg tumors. However, plots of thermal sensitivity of the microwave-heated leg tumors suggested a lower inherent thermal sensitivity or lower temperatures than with the waterbath heated flank tumors with the same target temperature.

6153 REOXYGENATION INDUCED BY LOCALIZED MICROWAVE HYPERTHERMIA AS AN ADJUVANT TO RADIATION THERAPY (MEETING ABSTRACT). *(Eng.)* Bicher, H. I. (Dept. Radiation Medicine, Roswell Park Memorial Inst., 666 Elm St., Buffalo, NY 14263); Hetzel, F. W.; Johnson, R. J.; Mitagvaria, N.; O'Hara, M. *Int J Radiat Oncol Biol Phys* 4(Suppl. 2): 145; 1978. (0 refs)

Tissue oxygen levels (TPO_2) and local blood flow were determined on subcutaneous tumors in patients and in implanted leg tumors in mice, using a 100 μ tip floating oxygen microelectrode and a local hydrogen generation method. TPO_2 and response to 100% O_2 breathing were recorded on a Grass Model 7 polygraph, as well as temperature changes both on tissue surface and in-depth, as measured with needle thermocouples. Hyperthermia was induced with microwave irradiation at the frequency of 2,450 MHz. Tumor temperature was maintained below 40 C for 2 hr. There was an increase in TPO_2 that paralleled the rise in tumor temperature, which was sustained throughout the test period. The elevation in TPO_2 may also have been potentiated in some locations by the hyperthermia-induced increased local blood flow. In a separate group of mice, the temperature was elevated to 46 C in tissue and it was found that the TPO_2 decreased. These findings suggest an increased tumor blood flow, depending on the temperature changes up to 40 C, with a decrease in tumor blood flow above that temperature. The results in human tumors paralleled those obtained in animals. The possible influence of concomitant metabolic changes remains to be investigated. The influence of microwave-induced tumor oxygenation on the TCD_{50} and regrowth times of mouse leg tumors treated with x-irradiation was tested on four groups of 120 mice at 10 different dose levels. One control group received x-irradiation alone. The second, x-irradiation and hyperthermia (40 C), the third, x-irradiation with hyperthermia and O_2 breathing, and the fourth, x-irradiation and O_2 breathing alone. Preliminary results suggested that moderate hyperthermia may cause tumor reoxygenation.

6154 RADIOFREQUENCY INDUCED HYPERTHERMIA IN AFTERLOADING IRIDIUM 192 IMPLANTATION (MEETING ABSTRACT). *(Eng.)* Mantik, D. (Univ. Southern California Sch. Medicine, Dept. Radiation Medicine, Los Angeles, CA 90033); Puffer, H. W.; Astrahan, M. A.; Norman, A.; Roseboro, J. A.; Syed, A. M. N.; *et al. Int J Radiat Oncol Biol Phys* 4(Suppl. 2): 225; 1978. (0 refs)

A system for radio frequency current induced hyperthermic fields using afterloading needle guides as electrodes was developed for use in afterloading ^{192}Iridium therapy to achieve hyperthermic radiosensitization. Radio frequency current patterns and isothermal distributions were mapped. In vivo oxygen levels were measured using teflon-encased hydron-coated gold tissue electrodes, and point by point temperature mapping was performed. Initial results confirmed a rapid decline in temperature with distance from the electrodes, but the predicted rapid diffusion of heat from the implanted area was not encountered, and consistent maintenance of desired thermal levels was accomplished with a temperature regulation system using an implanted thermistor at the geographic center of the volume defined by the needle electrodes. This technique is effective in producing and monitoring homogeneous hyperthermic fields at depth without overheating more superficial tissues. In addition, monitoring of oxygen values is facilitated. The invasive nature of the technique is not an adverse consideration when used with afterloading ^{192}Iridium implantation. Extending the system to external radiotherapy applications, however, requires special indications. The technique and methods, phantom, animal, and human pilot studies are described.

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