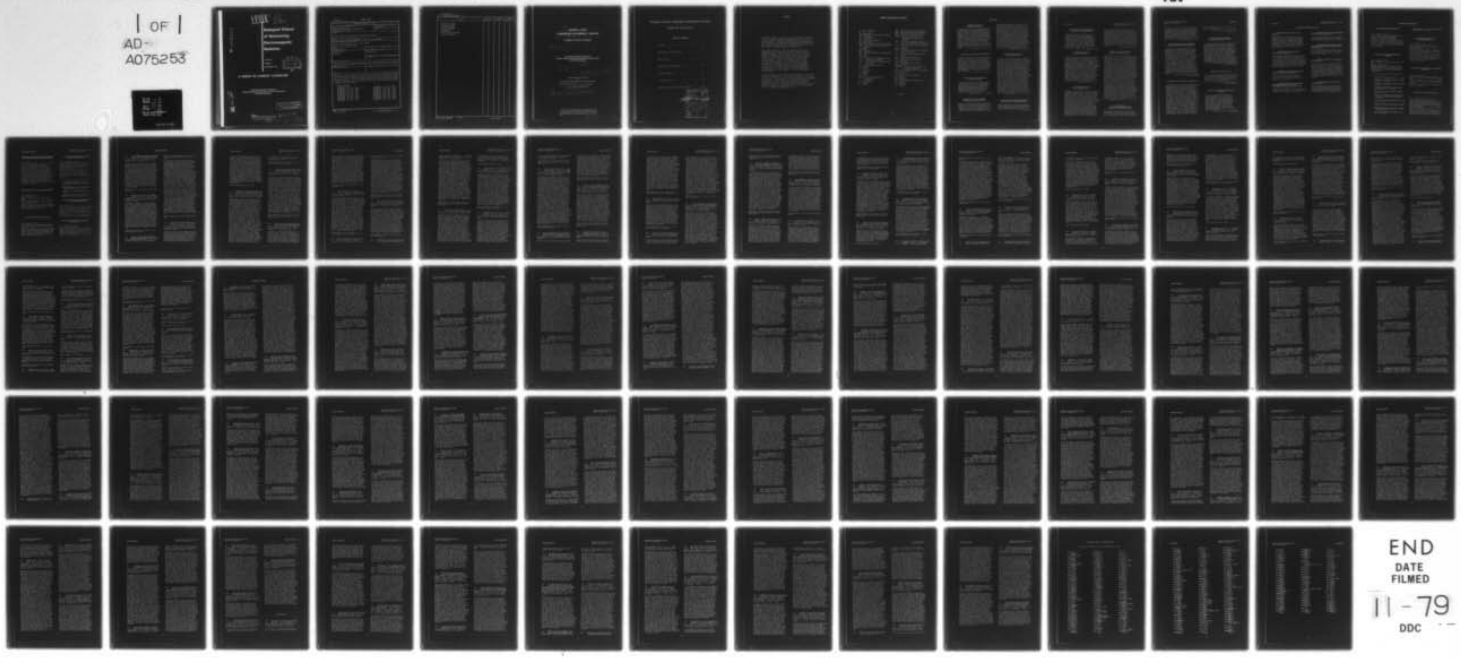
AD-A075 253 FRANKLIN RESEARCH CENTER PHILADELPHIA PA SCIENCE INF--ETC F/G 6/18
BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION. VO--ETC(U)
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Biological Effects of Nonionizing Electromagnetic Radiation

VOLUME IV

NUMBER 1

SEPTEMBER, 1979

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A DIGEST OF CURRENT LITERATURE

V3 n1 A-59870

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

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FRANKLIN RESEARCH CENTER
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410 886

79 10 09 073

Unclassified

ERRATA SHEET

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Franklin Research Center Science Information Services Organization Philadelphia, PA 19103	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE:

Biological Effects of Nonionizing Electromagnetic Radiation

4. DESCRIPTIVE NOTES (Type of report and inclusive dates):
Quarterly Report: June, 1979-September, 1979 (Volume IV, Number 1)

5. AUTHOR(S) (First name, middle initial, last name)
Bruce H. Kleinstein, Ph.D., J.D., Project Manager
Sheryl A. Dyner, Managing Editor

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO OF REFS
September, 1979	61	

8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
HO-A01-78-1157 b. PROJECT NO c. d.	80G-C5003-01 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
Previous issues of the digest can be obtained from the National Technical Information Service (NTIS), Springfield, Virginia 22161. The accession numbers for these issues are listed below.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

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

Accession Numbers

AD-A034926 I(1-2): June-Sept., 1974
AD-A034423 I(3): Dec., 1974
AD-A034893 II(1): Mar., 1975
AD-A034426 II(2): Jun., 1975
AD-A034429 II(3): Sep., 1975
AD-A034430 II(4): Dec., 1975
AD-A034166 I(1): Oct., 1976
AD-A034895 I(2): Jan., 1977
AD-A039956 I(3): Apr., 1977
AD-A040681 I(4): Jun., 1977
AD-A043458 II(1): Sep., 1977
AD-A047647 II(2): Dec., 1977
AD-A052779 II(3): Mar., 1978
AD-A055569 II(4): Jun., 1978
AD-A059870 III(1): Sep., 1978
AD-A061947 III(2): Dec., 1978
AD-A065989 III(3): Mar., 1979
AD-A070242 III(4): Jun., 1979

DD FORM 1473 (PAGE 1)
S/N 0102-014-6700

Unclassified
Security Classification

Unclassified

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
biologic effects						
electric fields						
electromagnetic						
magnetic field						
microwaves						
nonionizing radiation						
radio frequency						

(6)

BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION.

Volume II, Number 1.

A Digest of Current Literature

(9) Quarterly rept. Jun–Sep 79,

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

(12) 68

(11) Sep 79

(15) HO-A01-78-1157

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

(10) Bruce H. Kleinstein, Ph.D., J.D., Project Manager
Sheryl A. Dyner, Managing Editor

(14) 8QG-C50Q3-01-VOL-4-1

"The views and conclusions contained in this documentation are those of the author and should not be interpreted as necessarily representing the officials' policies, either expressed or implied, of the National Telecommunications and Information Administration or of the U.S. Navy."

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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

September, 1979 Volume IV, Number 1

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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 IV, 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--

NEWS ITEMS

GERMANS STUDY EFFECTS OF MICROWAVES ON LIVING CELLS

In response to the growing use of microwave ovens in the Federal Republic of Germany and the lack of information about possible nonthermal effects of microwaves, scientists at the Max Planck Institute of Research into Solid State Physics in Stuttgart and the Radiation and Environmental Research Association in Neuherberg plan to study the effect of electromagnetic millimeter waves on living cells. In the project, promoted by the German Research Association, yeast cells will be bombarded with microwaves of varying lengths and the effects on cell colony growth and individual cell behavior will be analyzed. Extremely sensitive instruments are now being developed at the Max Planck Institute to measure these effects.

Dtsch Forschungsdienst 17(12): 6; 1978.

PIGEONS SENSE CHANGES IN EARTH'S MAGNETIC FIELD

Pigeons have recently been found to have the ability to sense minute changes in the Earth's magnetic field or in the barometric pressure, according to Cornell biologist Timothy Larkin and his associate William Keeton, in experiments conducted on pigeon homing behavior over the last 4 yr. The scientists have also discovered that the birds can detect low frequency sounds at hundreds of kilometers, can see light waves that are invisible to man, and can detect the moon's position and then use it to set their flight paths.

Bioscience 29(4): 263; 1979.

ATTENDANCE HIGH AT 1979 INTERNATIONAL MICROWAVES SYMPOSIUM

The 1979 International Microwave Symposium was held in Orlando, Florida from April 30 through May 2, 1979. The theme of this year's conference was "The World of Microwaves--What's Next?". The technical highlights featured new semiconductor developments and miniaturizations. Several awards were presented to those who made outstanding contributions in the field.

Microwaves 18(4): 10, 11, 13; 1979.

MASSACHUSETTS ACTIVISTS SUE TO PREVENT MICROWAVE TEST RANGE INSTALLATION

Residents of two Massachusetts' towns, Wayland and Stow, have filed suit against two electronic firms, Raytheon Co. of Lexington and Radant Systems, Inc. of Wayland to prevent the installation of two microwave test ranges in their communities. The citizens are concerned that the ranges, used to map an antenna's beam pattern, may be hazardous to the residents by exposing them to microwaves. The major concern, according to a Wayland English teacher, George W. Faison, "is that there are few standards for exposure, and those that exist differ and are arbitrary." In response to the citizens' concern, Richard H. Park, president of Radant Systems, Inc. demonstrated that on a road directly in front of and 2,000 feet away from the test range's antenna, the exposure would be about 0.1 $\mu W/cm^2$ and at a sidelobe, would be only about 0.003 $\mu W/cm^2$. He insists that the power densities generated by his company's range in Stow would be only about one-ninth those measured by the EPA in the heart of Boston. Park's response has not assuaged the citizens' concern and he feels that the information on any long-term effects of microwave exposure on peoples' health must come from the medical profession and that could "take upwards to 10 years."

Electronics 52(8): 48-49; 1979.

RESEARCHERS LINK HEART ATTACKS WITH GEOMAGNETIC ACTIVITY

A significant relationship between the frequency of heart attacks and the earth's magnetism has been found by S. R. C. Malin of the Institute of Geological Sciences in Edinburgh, Scotland and B. J. Srivastava of the National Geophysical Research Institute in Hyderabad, India. Data on cardiac emergencies occurring in Hyderabad and Secunderabad, India from 1967 to 1972 was obtained from hospitals and compared on a day-by-day basis with measurements of the earth's geomagnetic activity. Even allowing for possible seasonal effects of weather or diet on heart attack occurrence, the correlation between geomagnetic activity and cardiac emergencies was statistically significant. The results do not agree with those from a similar study made in the United States from 1962 to 1966 by B. J. Lipa and associates. Drs. Malin and Srivastava suggest that the discrepancy may be due to the artificial magnetic disturbances of cars, industry, and appliances, which are common in the United States, that may mask the underlying statistical relation between geomagnetic activity and the incidence of heart attacks. The scientists have no clinical explanation for their findings, however, they suggest there may be some other cause, possibly of solar origin, that is responsible for both the magnetic and medical phenomena.

New York Times, p. C5; April 24, 1979.

RADIO SCIENCE TO PUBLISH SPECIAL SUPPLEMENT ON BIOLOGIC EFFECTS OF ELECTROMAGNETIC WAVES

A Special Supplement to *Radio Science* containing selected papers from the 1977 Airlie Symposium on the "Biological Effects of Electromagnetic Waves" will be published in December 1979.

IMPI News Release

PATENT ISSUED FOR A RF THERMOGRAPHY DEVICE THAT IMPROVES FIELD INTENSIFICATION

A patent was issued for a device that will increase the intensity of the electromagnetic field used in radio frequency thermography. An inductance element that is part of the circuit tuned to the frequency of the electromagnetic field being applied to the tumor is implanted in the vicinity of the tumor, thereby increasing the intensity of the field near the tumor without causing any significant damage to the adjacent normal tissue. The device bears U.S. patent number 4,154,246.

Official Gazette 982(3): 887; 1979.

BRH APPROVES MICROWAVE OVEN CORRECTIVE ACTION PLAN

The BRH has approved corrective plans for 2,394 Roper and 251 Sears Kenmore free-standing common cavity microwave/conventional ovens, marketed after July 12, 1976 that failed to meet safety standards established in the Radiation Control for Health and Safety Act of 1968. The ovens (Roper units 2356W00, 2356A00, 2356C00, 2356H00, 2356W10, 2356A10, 2356C10, and 2356H10 and Sears models 103.9547615, 103.9547625, 103.9547645, and 103.9547665) have a primary interlock system that may fail to meet the standard's definition of a safety interlock under certain operational conditions. Corrections will be performed free of charge by the dealer, distributor, and factory and will include replacement of the lock box with a new box containing the handle, door hook assembly, primary interlock switch, and secondary interlock; replacement of the thermofuse with a 15-A fuse; and securing to the modified oven a new wiring diagram depicting the modifications.

BRH Bulletin 12(7): 5-6; 1979.

LOW-LEVEL MICROWAVES AFFECT RATS' RESPONSE TO LIBRIUM

Researchers at the Naval Medical Research Institute in Bethesda, MD have found that low-level microwaves change the response of laboratory rats to the tranquilizer Librium. The Navy is interested in these effects on Librium's action since the drug is commonly prescribed to relieve tension on board ship. John R. Thomas, working with Linda S. Burch and Stephen S. Yeandle, determined that rats worked harder (i.e., pushing a button to receive food pellets at a faster rate) when exposed to as little as 1 mW/cm^2 of pulsed power. This power level, at 2.45 GHz, is typical of that found near radar equipment aboard ship. The microwaves were emitted from a standard-gain horn antenna oriented so that the electrical field was vertically polarized around the rats and the animals were kept 3.75 wavelengths from the antenna so that near-field conditions applied. The tests were structured so that the responses of the rats depended only on whether the microwave radiation was turned on, thereby eliminating changes caused by other variables. The researchers have not yet determined how microwaves and Librium interact with each other, but they are fairly certain that the behavioral change was not due to heating effects. Thomas plans to work with other major drugs that affect the central nervous system to see if their action is also affected by microwaves. He stresses, however, that the results of his experiments cannot yet be applied to human beings and that there is a big difference between exposing a biologic system to radiation and the amount of radiation actually absorbed.

Electronics 52(9): 46; 1979.

SMOKESTACK ANTI-POLLUTION DEVICES GENERATE ELECTROMAGNETIC FIELDS

Government scientists have discovered that a new type of pollution, invisible thunderstorms of highly charged electrical particles, is being generated by anti-pollution devices installed in smokestacks to clean the air. The scientists speculate that increased airborne electricity may affect the amount of rainfall, and they are concerned because little is known about the effect of electrical charges in the air on plant and animal life. According to the study conducted by William Cobb, Billy Caldwell, and Dennis Wellman of the National Oceanic and Atmospheric Administration (NOAA), Atmospheric Physics and Chemistry Laboratory in Boulder, Colorado, these devices, which effectively reduce the fly ash from the smokestacks, create plumes of highly negatively charged particles that escape from the anti-pollution devices and are transported downwind where they add their charge to the normal atmospheric electrical condition. Measurements taken from an aircraft about 800 feet downwind from the smokestacks of coal-fired power plants near Emery, Utah; Farmington, New Mexico; and Colstrip, Montana have recorded atmospheric electrical charge equivalent to that in a thunderstorm. The scientists report that it would take about 250 smokestacks with these devices to equal the electrical charge of one thunderstorm and that "the possibility exists that the increasing production of electrical charge in the atmosphere may at some point affect the global circuit current." The scientists indicate that further research on the effects of these invisible thunderstorms on plant and animal life is necessary since it seems unlikely that organisms living beneath these areas would not be affected in some way.

Philadelphia Inquirer, p. 5-A: June 22, 1979.

ITALIAN JOURNAL *ALTA FREQUENZA* PLANS SPECIAL ISSUE ON NONIONIZING ELECTROMAGNETIC RADIATION

Alta Frequenza plans to publish a special issue (March 1980) on "Electromagnetic Non-ionizing Radiations: Biological Effects and Relevant Measurements. Electromagnetic Compatibility and Relevant

Measurements." Papers to be included in the issue will deal with the biologic effects of nonionizing electromagnetic fields, the evaluation of radiation hazards and criteria for determining and defining safety standards, therapeutic and diagnostic applications, electromagnetic compatibility, instrumentation and international calibration cycles, the generation of uniform field intensity in a restricted space, and ways to lower radiation levels.

Alta Frequenza 48(2): 42-2E; 1979.

MICROWAVE-INDUCED LOCAL TUMOR HYPERTHERMIA ENHANCES CHEMOTHERAPY OF LUNG TUMORS

Researchers at the National Cancer Institute in Bethesda have used microwave-induced local tumor hyperthermia (LTH) and specially formulated heat-labile liposomes to enhance methotrexate (MTX) accumulation in Lewis lung carcinomas in mice. Microwave power at 2,450 MHz was used to maintain a constant temperature of 42 ± 0.1 C in the center of each heated tumor, while liposomes containing ^{3}H-MTX were injected into the tail vein of the mice. The heating period was maintained for 60 min. Microwave LTH doubled the rate at which liposome encapsulated ^{3}H-MTX was removed from the blood and enhanced accumulation in the heated tumors 4.3 times that in the untreated controls at 4 hr after injection. Enhanced clearance or accumulation was not found when local hyperthermia was used. The researchers findings lead them to suggest that the accumulated MTX was intracellular and bound to its target enzyme dihydrofolate reductase.

Bioelectromagnetics Society Newsletter, (6): 1, April 1979.

A NEW JOURNAL, *BIOELECTROMAGNETICS*, IS ANNOUNCED

A new journal, *Bioelectromagnetics*, sponsored by the Bioelectromagnetics Society has been announced. The journal will be a quarterly and Volume 1 is scheduled for publication by Alan R. Liss, Inc., New York in 1980. This journal will be devoted to research on the interaction of electromagnetic fields with biologic systems. The electromagnetic spectrum from constant fields to visible light will be covered. *Bioelectromagnetics* will consider for publication articles reporting complete findings of original research. The major areas of interest will include: responses of biologic systems to electromagnetic environments, mechanisms of electromagnetic field and biologic process interaction, absorption and distribution of electromagnetic energy within biologic systems, and diagnostic and therapeutic uses of electromagnetic radiation or fields. Concise critical reviews of current research developments will also be published. Manuscripts and editorial correspondence should be addressed to the editor: Dr. Elliot Postow, *Bioelectromagnetics*, Building 142, National Naval Medical Center, Bethesda, MD 20014. Instructions for contributions can be obtained from either the editor or the publisher.

Bioelectromagnetics Society Newsletter, (6): 3, April 1979.

USSR ACADEMY OF SCIENCES ORGANIZES A NEW BIOELECTROMAGNETICS SECTION

A new bioelectromagnetics section of the USSR Academy of Sciences has recently been organized by the Scientific Counsels for Biophysics and Radiobiology. Professor I. G. Akoev will head the section and will coordinate investigations on the biologic effects of high frequency electromagnetic fields (from the radio frequency range through millimeter waves) and static and low frequency magnetic and electric fields. The research will be conducted as part of an overall program dealing with problems of the physical environment and investigations will include studies of the mechanisms and interaction of biologic systems and different environmental factors (electromagnetic and acoustic waves, vibration, acceleration, and temperature).

Bioelectromagnetics Society Newsletter, (6): 4; April 1979.

GHANDI ELECTED FELLOW OF THE IEEE

Dr. O. P. Ghandi was elected Fellow of the Institute of Electrical and Electronics Engineers "for contributions to the understanding of nonionizing radiation effects, to the development of electron devices and to engineering education."

Utah Bioengineering Newsletter, Spring Issue, 1979.

NEW NTIA TASK FORCE ON NONIONIZING RADIATION ANNOUNCED

A federal interagency task force has been established to develop a coordinated plan for all government sponsored research on the biologic effects of nonionizing electromagnetic radiation. The announcement was made by Henry Geller, the Assistant Secretary of Commerce for Communication and Information and the head of the NTIA. NTIA will serve as the leading agency for the task force. Additional information on the new task force may be obtained from NTIA, 1800 G Street, N.W., Washington, DC 20504.

Bioelectromagnetics Society Newsletter, (7): 1; 1979.

ITEMS FROM THE COMMERCE BUSINESS DAILY

☐ **MICROWAVE INTERACTION WITH NERVE CELL MEMBRANES.**

The Environmental Protection Agency, Contracts Management Div., Office of Administration, Research Triangle Park, NC 27711 is negotiating with Duke University, Department of Biomedical Engineering, Durham, NC 27706 for a study to measure neonatal transmembrane currents that are induced by microwave fields and to determine whether such currents are attributable to a membrane detection process. (April 24, 1979)

☐ **IDENTIFICATION OF SITES IN BRAIN TISSUE AFFECTED BY NON-IONIZING EMR.**

The Environmental Protection Agency, Contracts Division, Office of Administration, Research Triangle Park, NC 27711 is negotiating with the Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709 for this study concerning identification of sites in brain tissue that can be affected by electromagnetic radiation using the 2-deoxyglucose method as the primary means to identify sites of altered brain/metabolic activity. (May 4, 1979)

☐ **RESEARCH ON THE EFFECTS OF ELECTROMAGNETIC ENERGY ON THE IMMUNE SYSTEM OF MAMMALS.**

The Office of Naval Research, 800 Quincy St., Arlington, VA 22217 has contracted with the University of Illinois, Urbana, IL 61801 for the above study. (May 22, 1979)

☐ **CONTINUED RESEARCH AIMED AT MORE PRECISELY IDENTIFYING AND PREDICTING THE EFFECTS OF ELECTROMAGNETIC ENERGY UPON THE NERVOUS SYSTEM.**

The Office of Naval Research, Arlington, VA 22217 is negotiating with Randomline, Inc., Huntingdon Valley, PA 19006 for the above study. (May 29, 1979)

☐ **DETERMINATION OF ELECTROMAGNETIC PARAMETERS THAT AFFECT THE BRAIN AND BEHAVIOR.**

The Office of Naval Research, Arlington, VA 22217 is negotiating with Randomline, Inc., Huntingdon Valley, PA 19006 for the above study. (June 4, 1979)

☐ **DETERMINATION AND IDENTIFICATION OF EVOKED MAGNETIC FIELDS OF THE HUMAN BRAIN ASSOCIATED WITH AUDITORY STIMULATION.**

The Office of Naval Research, Arlington, VA 22217 has contracted with the University of Colorado Medical Center, Denver, CO 80220 for the above study. (June 6, 1979)

☐ **CEREBELLAR HISTOGENESIS IN RATS EXPOSED TO 2450 MHz RADIATION.**

Microwaves are suspected of causing delay in the gross body weight of rodents and also of subtle morphologic changes in the central nervous system (CNS). This project is designed to determine if the gross body weight decreases are associated with maturational delays in CNS structure. The EPA, Contracts Management Division (MD-33) Office of Administration, Research Triangle Park, NC 27711 is negotiating with George Washington University, Washington, DC 20007 for the above study. (June 20, 1979)

☐ **THE EFFECTS OF MICROWAVE RADIATION ON CEREBRAL METABOLISM.**

The Environmental Protection Agency, Office of Adminstration, Research Triangle Park, NC 27111 has contracted with the Duke University Medical Center, Department of Radiology, Durham, NC 27706 for the above study. (June 29, 1979)

MEETINGS AND CONFERENCES

NINTH EUROPEAN MICROWAVE CONFERENCE

Date: September 17-21, 1979
Place: Brighton, England: The Brighton Centre
Sponsor: Inst. of Electrical Engineers, Inst. 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

PRACTICAL APPLICATIONS OF MICROWAVE ENERGY SYMPOSIUM

Date: September 28, 1979
Place: Manhattan, KS: K-State Union, Kansas State Univ.
Sponsor: Kansas State Univ.
Requests for Information: Dr. D. Y. C. Fung, Chairman, Kansas State Univ., Manhattan, KS 66506
Content: Topics will cover the practical aspects of microwave energy related to the welfare of the general public

Selected Bibliography of Papers to be Presented:

PRINCIPLES OF MICROWAVE RADIATION. B. Curnutte

A REVIEW OF THE BIOLOGICAL HAZARDS OF MICROWAVE RADIATION. J. P. Lambert

EFFECTS OF MICROWAVES ON MICROORGANISMS IN FOODS: A REVIEW. D. Y. C. Fung

INFLUENCE OF MICROWAVE RADIATION ON PSYCHROTROPIC BACTERIA. F. E. Cunningham

DESIGN AND UTILIZATION OF DOMESTIC MICROWAVE OVEN. P. J. Annis

WHAT DOES THE FUTURE HOLD FOR MICROWAVE ENERGY IN RELATION TO CONSUMERS AND THE INDUSTRY? R. F. Schiffmann

EFFECTS OF MICROWAVE COOKING ON QUALITY OF FOODS. D. L. Harrison

EFFECTS OF MICROWAVE COOKING ON CEREAL PRODUCTS. C. C. Tsen

TECHNICAL ADVANCEMENTS ON THE USE OF MICROWAVES AS AN ANALYTICAL TOOL. M. Collins

APPLICATIONS AND EFFECTS OF MICROWAVES ON TEXTILES. B. M. Reagan

APPLICATION OF MICROWAVE ENERGY IN MEAT PROCESSING RESEARCH. D. H. Kropf

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; and standards and regulations

1979 IEEE INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY

Date: October 9-11, 1979
Place: San Diego, CA: Town & Country Hotel
Sponsor: Inst. of Electrical & Electronics Engineers (IEEE)
Requests for Information: F. J. Nichols, LectroMagnetics, Inc., 6056 W. Jefferson Blvd., Los Angeles, CA 90016
Content: Will include sessions on biomedical areas, hazards, and standards

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

NTERNATIONAL RADIATION PROTECTION ASSOCIATION: SECOND ASIAN REGIONAL CONFERENCE ON RADIATION PROTECTION

Date: November 5-9, 1979
Place: Manila, Philippines: Philippine Plaza Hotel
Sponsor: Philippine Assoc. 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

NATIONAL TELECOMMUNICATIONS CONFERENCE

Date: November 27-29, 1979
Place: Washington, DC: Shoreham-Americana Hotel
Sponsor: IEEE--Communications Society and Washington Section
Requests for Information: J. N. Birch, Dept. of Defense, 3311 Marlborough Way, College Park, MD 20740
Content: Topics will include electromagnetic compatibility, frequency standards and utilization, government regulation, microwave theory and techniques, and radio communication

FOURTH INTERNATIONAL CONFERENCE IN INFRARED AND NEAR-MILLIMETER WAVES

Date: December 10-15, 1979
Place: Miami Beach, FL: Americana Hotel
Sponsor: IEEE Society on Microwave Theory and Techniques, IEEE Quantum Electronics and Applications Society, International Union of Radio Science (URSI)
Requests for Information: K. J. Button, MIT Natl. Magnet Lab., Cambridge, MA 02139

Content: Topics will cover work concerned with near-millimeter wave and infrared theory, techniques, devices, systems, spectroscopy, and applications

Selected Bibliography of Papers to be Presented:

THE LOW FREQUENCY NORMAL MODES OF NUCLEIC ACIDS AND RELATED COMPOUNDS. G. Ascarelli, E. Prohovsky

NONTHERMAL RESONANT BIOLOGICAL RESPONSE TO MICROWAVE IRRADIATION. F. Kellmann

LATTICE MODES OF HYDROGEN-BONDED CRYSTALS. A. Novak

RESONANCE RAMAN SEPCTROSCOPY OF BIOLOGICAL MOLECULES. A. Mayer, W. Dreybrodt

INTERNATIONAL RADIATION PROTECTION ASSOCIATION: FIFTH INTERNATIONAL CONGRESS

Date: March 9-14, 1980
Place: Jerusalem, Israel: Jerusalen Convention Center
Sponsor: Israel Health Physics Society; International 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

5TH INTERNATIONAL CONFERENCE ON INFRARED AND MILLIMETER WAVES

Date: December 8-12, 1980
Place: Wurzburg, West Germany
Sponsor: Inst. of Electrical & Electronics Engineers (IEEE)--Microwave Theory & Techniques Society
Requests for Information: K. J. Button, MIT Natl. Magnet Lab., Cambridge, MA 02139
Content: Will include session on biologic effects of electromagnetic radiation

0470 NAVY ENVIRONMENT: MECHANISMS OF MICROWAVE-INDUCED BLOOD-BRAIN BARRIER ALTERATIONS. Lin, J. C.; Noonan, S. M. (Wayne State Univ., Sch. Engineering, Dept. Electrical 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.

0471 MICROWAVE EFFECTS ON EXCITABLE MEMBRANE SYSTEMS. Cleary, S. F.; Liu, L. (Virginia Commonwealth Univ., Sch. Basic Sciences & Graduate Studies, Dept. Biophysics, 901 W. Franklin St., Richmond, VA 23284).

The excitable internodal cell of the algae *Chara australis* will be exposed to S-band microwave radiation in a temperature-controlled exposure chamber to investigate effects upon the resting potential, amplitude, duration, and propagation velocity of the action potential and the excitation threshold. The independent variables investigated will include microwave frequency, pulse-modulation parameters, field intensity, exposure duration, and temperature. The electrical properties will be measured by the insertion of microelectrodes into the cell external to the waveguide exposure chamber thus eliminating artifacts due to field pick-up or interference. The primary objective of the research is to compare the effects of continuous wave versus pulse-modulated fields on the electrical activity of an excitable cell model of a neuron. The role of field-induced and nonfield-induced temperature increases will also be determined. (funding period 2/78-1/80)

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

0472 MORTALITY, REPRODUCTIVE AND INDUSTRIAL HYGIENE STUDY OF WORKERS EXPOSED TO MICROWAVES/RADIOFREQUENCY ENERGY. Egan, B.; Cox, C. (U.S. Dept. HEW, PHS, Center for Disease Control, NIOSH, Div. Surveillance Hazard Evaluations & Field Studies, 4676 Columbia Parkway, Cincinnati, OH 45266).

Radio frequency/microwave (RF/MW) radiation has been implicated in a variety of biologic phenomena including altered transmembrane potentials, increased membrane permeability, hyperthermia, hormonal imbalance, chromosomal anomalies, and mutagenesis. Although their exact roles are unknown, similar phenomena have been implicated in carcinogenesis. In addition, several unconfirmed allegations have been made associating exposure to microwave radiation with pancreatic cancer in radar repair workers, brain cancer in electronic workers, and leukemia in the Moscow Embassy employees. Unfortunately, the size of the population potentially at risk in most of these case reports was too small for scientific evaluation. More recent research has indicated that exposure to RF/MW radiation can affect incidence of infertility and teratogenesis among exposed study groups. Further research is required to critically assess both the potential carcinogenic hazards and reproductive hazards of RF/MW radiation. NIOSH has identified a cohort of radar repair workers that may be suitable for inclusion in an epidemiologic mortality study. This population would consist of all persons enrolled in the Electronic Apprenticeship Training Program, which has been sponsored by the Naval Air Reworks Facility since the early 1950's. However, since this study population will only consist of about 1,000 individuals and it may be difficult to obtain complete employment histories on all workers, additional walk-through surveys and record assessments will be conducted in plants having microwave heat sealing, drying, or baking operations before a final cohort is selected. If possible, a cohort will be selected that includes a large number of female employees so that a retrospective cohort mortality study and a reproductive study can be conducted on the same population. If a cohort with a large enough number of female workers cannot be identified, then the wives of male workers will be interviewed for a reproductive history. (funding period 10/77-9/81)

Supporting Agency:HEW, PHS, Center Disease Control, NIOSH

0473 ACCELERATION OF FRACTURE HEALING BY ELECTRICAL FIELDS. Brigton, C. T.; Friedenberg, Z. B.; Black, J.; Pollack, S.; Heppenstall, R. B. (Univ. Pennsylvania, Sch. Medicine, Dept. of Orthopedic Surgery, 36th & Hamilton Walk, Philadelphia, PA 19104).

Investigation of the effects of applied electrical fields on the acceleration of fracture healing in laboratory animals will be continued. The proposed research is designed to determine: (1) the optimum parameters of applied (exogenous) electricity for accelerating fracture healing; (2) the role of stress generated (endogenous) electricity in fracture healing; and (3) the mechanism of elec-

trically induced osteogenesis at the cell level. Methods to be used include the comparison of the osteogenic response of in vitro fetal rat tibia and in vivo healing rabbit fibula to constant direct current, various pulsed unidirectional electric fields, and various electromagnetic fields. Osteogenesis and bone healing will be evaluated by incorporation of tritiated thymidine, ^{45}Ca, and $^{35}SO_4$, as well as maximum resistance to bending as determined by an Instron Testing Machine. Stress generated potentials will be measured in fracture calluses. Origin of stress generated potentials will be evaluated by altering tendon collagen biochemically. The mechanism of action of electrically induced osteogenesis will be sought by determining (1) pO_2 and pH changes in the vicinity of a cathode, (2) changes in surface of cell membrane, (3) mitochondria release of calcium, (4) cellular proliferation and migration, and (5) collagen and proteoglycan biosynthesis and processing. (funding period 8/78-7/79)

Supporting Agency:HEW, PHS, NIH, NIAMDD

0474 COMPARISON OF THEORETICAL AND EXPERIMENTAL ABSORPTION OF RADIOFREQUENCY POWER. Johnson, C. C.; Durney, C. (Utah Higher Education System, Univ. Utah, Sch. Engineering, Dept. Electrical Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

Methodology for quantitating electromagnetic radiation (EMR) energy distribution and measurement will be developed. Methods and data are critically needed to extrapolate (via appropriate scaling factors) animal data to man to establish more realistic personnel safety exposure guidelines for Air Force operations. The specific objectives of this study are (1) to define adequate models, (2) to extend theoretic radio frequency (RF) power absorption data to assess consequences of human exposure to 10 kHz to 1.5 GHz RF radiation fields, and (3) to develop methods, accounting for size and orientation effects, to extrapolate animal exposures to equivalent human exposures. Twenty phantoms will be constructed to simulate 3.5 kg monkeys. Absorbed power will be calculated utilizing this monkey model for exposures in free space, near field, and on a ground plane. Experiments will be conducted to measure power absorbed in the phantom and in actual monkeys for six exposure orientations. The best model for man, monkey, rat and mouse will be developed and calculations will be performed to determine power density to which these animals should be exposed to produce the same average absorbed power as man when exposed to 10 mW/cm^2 at the same frequency. The exposure frequency for animals subjected to the same power density as man to accomplish equivalent average power absorption will also be calculated. These data will be used to compile a handbook (Researcher's Guide) for use in selecting appropriate exposure parameters (frequency and power density) for animal studies to simulate bioeffects in man. Power absorption calculations for man and animals will be extended to 1.5 GHz using wave solution, numeric techniques, or other applicable methods. (funding period 1/75-6/80)

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks AFB

0475 MICROWAVE EXPOSURE EFFECTS ON BEHAVIORAL ACTIONS OF PHARMACOLOGICAL AGENTS. Thomas, J. R. (U.S. Dept. Defense: Navy, Naval Medical Res. Inst., Behavioral Sciences Dept., Bethesda, MD 20014).

This research will determine if exposure to microwave radiation modifies the effects of pharmacologic compounds on behavior. It is important to determine if microwave radiation interacts with other agents, which may produce potential hazards by changing the efficacy and safety of drugs, medication, and compounds commonly used by military personnel. Initial studies will evaluate how microwave radiation can affect the manner in which organisms react to pharmacologic agents. The research techniques involve the development of complex patterns of behavior in animals. The developed behavioral baselines will be used to assess the effects of both acute and chronic drug regimens under both normal and radiation conditions. Assessment of irradiation effects with low-level microwave energy (near and below 10 mW/cm^2) will be emphasized. Dose-response functions will be determined for a range of radiation intensities for a variety of parameters (frequency, pulse repetition rate, pulse versus continuous wave, acute versus chronic exposure). Using this methodology, modifications in behavior due to interactions between drugs and microwave exposures will be empirically determined. Based on such determinations, re-evaluation of exposure limits for Navy personnel and specific recommendations for drug and medication usage in a microwave environment can be made. (funding period 10/76-10/81)

Supporting Agency:U.S. Dept. Defense: Navy, Naval Medical Res. & Development Command, Natl. Naval Medical Center

0476 A NEW TECHNIQUE FOR ELIMINATION OF CELLS CAUSING DEATH IN BONE MARROW TRANSPLANT PATIENTS. Kessler, S.; Scher, I. (U.S. Dept. Defense: Navy, Naval Medical Res. Inst., Immunopathology Div., Bethesda, MD 20014).

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

bone marrow transplantation in lethally-irradiated military personnel. The development of these isolation procedures will allow for the depletion of subpopulations of cells involved in graft rejection, without influencing other cellular populations necessary for successful engraftment. Uniform-sized latex (acrylic) microspheres containing colloidal iron will be synthesized. The chemical composition of these microspheres is such that they can be easily complexed with molecules such as specific immunoglobulins and/or fluorescent dyes. Initial studies will be designed to test the overall feasibility of this approach by separation of B- from T-lymphocytes using anti-Ig as the functional probe of the microspheres. A powerful magnetic field will then be used to separate lymphocytes with microspheres attached (B-cells) from unassociated lymphocytes (T-cells). Later studies will utilize reagents prepared to isolate lymphocyte subpopulations known to influence graft rejection. (funding period 10/77-9/79)

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

0477 RADIOFREQUENCY RADIATION MECHANISMS. Smith, G. (Georgia Inst. Technology, Sch. Engineering, Dept. Electrical Engineering, 225 North Ave., N.W., Atlanta, GA 30332).

The mechanisms of radio frequency radiation interaction with living tissue will be studied. A series of mathematical models will be developed describing the physical interaction of electromagnetic fields with tissue structures. The work will involve four levels of complexity in living tissues: (A) molecular physics, (B) details of biomolecular chemical reactions, (C) biomembrane phenomena, and (D) total tissue metabolism. The models will define the frequency dependence of the bioeffects under study, and for a given frequency, the models will suggest whether there is an amplitude threshold and/or window for the effect. For each of the above interactions, presently available models will be critically examined in the light of current theory and experimental data. The critical examination of each model will include a thorough treatment of the underlying physical theories and detailed evaluations of all assumptions. For each interaction, the most promising model(s) will be extended. The extensions can synthesize elements from several models or focus on one model. Available models might be rejected in favor of a new model(s). Various calculations will be performed with particular attention paid to the physical units. (funding period 7/78-12/79)

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks AFB

0478 ANALYTIC AND CALORIMETRIC MICROWAVE DOSIMETRY IN THE FAR-FIELD. Olsen, R. G.; Grissett, J. D. (U.S. Dept. Defense: Navy, Naval Aerospace Medical Res. Lab., Medical Science Dept., Pensacola, FL 32508).

The amount and distribution of electromagnetic energy deposited in the human body for a given far-field irradiation intensity at microwave frequencies of particular interest to the Navy will be ascertained. The physical parameters (beam polarization, body posture, and/or ground plane orientation) that produce the worst case energy absorption in the human body will be investigated. Three independent methods will be used in determining microwave absorption. The methods will involve far-field irradiation conditions at or near the frequencies of L-band (1.27 GHz), S-band (2.88 GHz), and C-band (5.67 GHz). First, vector E-fields external to an irradiated phantom will be measured to calculate the net microwave energy absorbed by the target using the difference between incident and scattered energy distributions. Second, a calorimetric dosimetry study will be conducted using nonperturbing temperature probes implanted in man-size and primate phantoms. The phantoms will contain simulated muscle and brain tissue and simulated versions of the major bones of the body. Third, infrared scanning techniques will be used to record surface temperature distributions of live animals and phantom models. (funding period 7/75-9/82)

Supporting Agency:U.S. Dept. Defense: Navy, Naval Medical Res. & Development Command, Natl. Naval Medical Center

0479 LASER EYE MEASUREMENT AND EVALUATION SYSTEM. Bruckner, A. P.; Auth, D. C. (Univ. Washington, Sch. Engineering, Dept. Aeronautics & Astronautics, 206 Guggenheim Hall, Seattle, WA 98105).

This project will develop a system to quantitate eye abnormalities for radio frequency radiation personnel hazard assessment. Specifically, a portable device(s) capable of both holographic recording and short pulse scattering measurements in the eye will be developed. The device is required to quantitate and study radio frequency radiation-induced eye opacities. Previous research resulted in the development of two promising techniques for noninvasive optical evaluation of radio frequency-induced cataracts in the eye in vivo. The first uses short pulse laser rangegating and scattering measurements to determine the thickness of ocular layers. The second records holographically the three-dimensional internal structure of the eye including microcataracts. These techniques will be incorporated into a system that can be used to quantitate eye changes and provide permanent records of such changes. (funding period 9/74-9/79)

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine

0480 SLOW CHANGES IN BLOOD BRAIN BARRIER IN THE RAT FOLLOWING EXPOSURE TO MICROWAVE RADI-

ATION. Gruenau, S. P.; Rapoport, S. I. (U.S. Dept. Defense: Navy, Naval Medical Res. Inst., Behavioral Sciences Dept., Bethesda, MD 20014).

Techniques are being developed at National Institutes of Health for measuring subtle changes in blood-brain-barrier (BBB) permeability in local regions of the brain with a time resolution of 0.5 hr. An absolute sensitivity of 10^{-9} cm/sec, and a standard error of about 20%. This technique has been used to measure BBB permeabilities of glycerol, mannitol, sucrose, and inulin, independent of variations of cerebral blood flow. The technique has demonstrated how long and to what extent microwave radiation induces changes in the BBB. Rats will be exposed to 2,450 MHz pulsed microwave radiation, pulse repetition rate 500 Hz, and 2 μsec pulse duration for a period of 0.5 hr at power densities ≤15 mW/cm^2. At various times following the irradiation, the BBB permeability to ^{14}C sucrose in different parts of the brain will be assayed by the above-described technique. Because animal sacrifice is required for the measurement, different animals will be used for different times. Animals subjected to both sham and experimental radiation will be studied. The time course over days of microwave-induced changes in the BBB permeability will be determined. Future plans include searching for long-lasting BBB changes in animals chronically exposed to about 100 mW/cm^2 at various pulse repetition rates and pulse widths. Irradiation values that cause BBB changes will provide guidelines for the formulation of safe human exposure levels for naval personnel. (funding period 10/77-9/79)

Supporting Agency:U.S. Dept. Defense: Navy, Naval Medical Res. & Development Command, Natl. Naval Medical Center

0481 LOCALIZED ELECTRO-MAGNETIC HEATING. Jones, R. C. (Univ. Arizona, Sch. Medicine, Dept. Radiology, 1501 N. Campbell Ave., Tucson, AZ 85721).

This project is part of a broader program to determine the efficacy of hyperthermia, either used alone or as an adjuvant to radiation or chemotherapy, as a therapeutic modality in the treatment of human malignancies. The proposed research involves a multidisciplinary effort, including biological, physical, and clinical scientists. Specific projects within this program will study a broad-range of the biologic effects of hyperthermia, spanning molecular and biochemical, cellular and organized tissue systems, including both tumor and normal tissues. Other projects will focus on techniques to produce elevated temperature distributions in biologic systems and measure the temperature patterns. The experimental studies will provide the required biologic and physical information required for the initial studies employing hyperthermia in the treatment of human neoplasms. The basic science projects also will further develop the rationale for, and the understanding of, the clinical potential of hyperthermia. The clinical projects will initiate studies to explore the clinical efficacy of hyperthermia, both as a local and systemic modality, combined with radiation or chemotherapy. (funding period 7/78-6/79)

Supporting Agency:HEW, PHS, NIH, NCI

0482 RADIOFREQUENCY RADIATION BIOEFFECTS MATH MODELS. Bell, E. L.; Cohoon, D. K. (U.S. Dept. Defense, Air Force Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Mathematic/computer research adjunctive to laboratory experimentation will be performed to determine the effects of radio frequency radiation on living tissue. The objectives of this research are: (1) to define how radar energy is distributed in the human body and to calculate resultant temperature rises, (2) to quantify acoustic wave generation by pulsed radar and estimate tissue compression responses, and (3) to develop equations describing radio frequency effects on biochemical events including chemical reactions, metabolite diffusion in tissue, and living cell membrane effects. The results will enable prediction of the effects of radio frequency radar on human beings and will improve the quality of Air Force radio frequency radiation safety standards. The use of mathematic/computer formulations will provide estimates of effects presently unavailable through experimentation or direct measurement, improve utilization of available data, and indicate needed critical laboratory tests. To accomplish objectives 1 and 2, the relevant partial differential equations will be solved for specific model living tissues. (funding period 2/78-6/80)

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks AFB

0483 NEUROENDOCRINE EFFECT OF PULSED MICROWAVE RADIATION. Lotz, W. G.; Cook, L. L. (U.S. Dept. Defense: Navy, Naval Aerospace Medical Res. Lab., Medical Sciences Dept., Pensacola, FL 32508).

Quantitative measurements of neuroendocrine perturbations induced by microwave radiation will be provided, and the physiologic significance of the neuroendocrine response will be assessed. Neuroendocrine parameters will be measured on rhesus monkeys for both single and chronically repeated exposures. For single exposures the animals will be exposed for 8 hr during a 24-hr period. Hourly blood samples will be drawn by indwelling jugular catheters. Several power levels of exposure will be used to estimate a possible threshold level of exposure required to cause neuroendocrine changes at a particular frequency. When a response has been characterized, the responsive neuroendocrine parameters will be studied during chronically repeated microwave exposures to determine the physiologic significance of the response at a par-

ticular set of field conditions. These experiments will be repeated using different frequencies. (funding period 7/75-9/82)

Supporting Agency:U.S. Dept. Defense: Navy, Naval Medical Res. & Development Command, Natl. Naval Medical Center

0484 VESTIBULO-COCHLEAR EFFECTS OF UHF-MICROWAVE RADIATION. Lebovitz, R. M.; Seaman, R. L. (Univ. Texas, Health Science Center at Dallas, Dept. Physiology, Southwestern Medical Sch., 5323 Harry Hines Blvd., Dallas, TX 75230).

This research will document the effects of microwave radiation (MWR) on the nervous system by examining single unit discharge in sensory systems that are responsive to continuous wave or pulse-modulated MWR. Previous work confirmed that single units in the vestibular pathway and single units in the auditory pathway show an acute response to continuous wave and pulse MWR, respectively. This project will derive a more complete quantitative understanding of these interactions, investigate the underlying physical mechanisms, and evaluate the general biologic significance of these MWR effects in cats. Similar studies using laboratory primates will then follow. The response of single vestibular units and of single auditory units to appropriate physiologic stimuli will be recorded via glass micropipette located in the eighth nerve and in brain stem vestibular and cochlear nuclei. Once functionally identified, the subsequent response of the units of MWR (915 and 2,450 MHz) applied to the head will be noted. For vestibular units, the emphasis will be on their response to physiologic angular acceleration of the head as compared with their response to exposure to near field continuous wave MWR. For auditory unit the emphasis will be on their response to physiologic acoustic stimuli (tone bursts and clicks) as compared with their response to pulse-modulated MWR. The capability of pulsed MWR to mask acoustic stimuli will also be examined. Calibration of the MWR dose will be in terms of regional absorbed energy density. Recording sites will be marked and verified by histologic examination. These data will be applied to the analysis of the biologic hazards of pulsed MWR and of the biomedical utility of MWR interaction with the central nervous system. (funding period 1/78-12/79)

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

0485 BEHAVIORAL CHARACTERISTICS OF MONKEYS AND RATS IRRADIATED WITH MICROWAVES. Delorge, J. O.; Grissett, J. D. (U.S. Dept. Defense: Navy, Naval Health Res. Center, Biomedical Div., Pensacola, FL 32512).

The effects of low power density microwave radiation on animals will be investigated by measuring ongoing operant behavior in monkeys and rats. Rhesus monkeys, squirrel monkeys, and rats trained on various operant tasks will be exposed for 30 to 60 min periods repeatedly to microwave radiation at low power levels, pulsed at selected frequencies. The animals, while working, will be exposed to far-field radiation at 1.27, 2.45, and 5.64 GHz to demonstrate differential effects of both power density and frequency. Animals will be irradiated in essentially non-reflective restraint devices. In addition, the animals, chosen for body size differences, will perform on similar tasks thereby permitting a comparison of animal size and microwave parameters utilizing operant behavior as the dependent variable. (funding period 7/75-10/82)

Supporting Agency:U.S. Dept. Defense: Navy, Naval Medical Res. & Development Command, Natl. Naval Medical Center

0486 EFFECTS OF ACUTE ELECTROMAGNETIC RADIATION ON THE CENTRAL NERVOUS SYSTEM: MORPHOLOGICAL STUDY OF HYPOTHALAMIC AND SUBTHALAMIC REGIONS. McKee, A. E.; Dorsey, C. H. (U.S. Dept. Defense: Navy, Naval Medical Res. Inst., Experimental Pathology Dept., Bethesda, MD 20014).

The effects of microwave irradiation on the central nervous system (CNS) will be investigated. Morphologic studies of the CNS will be conducted to evaluate and characterize histologic alterations. Efforts will be made to establish thresholds relative to time and power densities and to determine whether morphologic changes are reversible or permanent. Morphologic changes in the CNS of Chinese hamsters due to exposure to acute continuous wave microwave irradiation will be evaluated by light and transmission electron microscopy. Two groups of Chinese hamsters, each divided into two subgroups, will be used in this study. The first group will be irradiated at a frequency of 1.7 GHz and at power densities of 10 and 25 mW/cm^2. The second group will be irradiated at a frequency of 2.45 GHz and at power densities of 10 and 25 mW/cm^2. The exposure time will range from 30, 60, and 120 min. Animals from each group will be sacrificed either immediately after exposure or after a recovery period of 15 days. (funding period 10/77-9/80)

Supporting Agency:U.S. Dept. Defense: Navy, Naval Medical Res. & Development Command, Natl. Naval Medical Center

0487 MICROWAVE-INDUCED DAMAGE IN THE MAMMALIAN BRAIN. Catravas, G. N.; Takenaga, J. (U.S. Dept. Defense, Defense Nuclear Agency, Armed Forces Radiobiology Res. Inst., Bethesda, MD 20014).

Changes in levels of neurotransmitters and activities of enzymes involved in neurotransmitter metab-

olism in the central nervous system of microwave-irradiated animals will be determined. Eastern European studies have indicated that microwave irradiation at low, nonthermal levels results in a number of neurologic and behavioral effects in animals and humans. To substantiate Russian data, a systematic study will be conducted to determine if and to what extent neurochemical mechanisms in mammalian brain are affected by exposure to low level microwave radiation. Groups of rats will be exposed to continuous low-level microwave radiation of 2,450 MHz and approximately 10 mW/cm^2. At various postirradiation time intervals, levels of acetylcholine, norepinephrine, dopamine, and serotonin will be determined in discrete brain areas of experimental animals and sham-irradiated controls. Radiation-induced changes in activity of brain enzymes, choline acetyltransferase, acetylcholinesterase, tyrosine hydroxylase, tryptophan hydroxylase and monoamine oxidase, which are involved in neurotransmitter metabolism, will also be determined. In another series of experiments the effect of microwave radiation on adenylcyclase-cyclic adenosine monophosphate and prostaglandin system will be determined. (funding period 10/76-9/80).

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

0488 MICROWAVE EFFECTS. Tredici, T. J. (U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

A detailed initial ophthalmologic evaluation and follow-up will be provided for Air Force personnel who have suffered a microwave overexposure, i.e., exposure greater than twice the permissible exposure limit. Attention will be focused on the presence or absence of lenticular lesions and the possible causal relation of microwave exposure. Patients will be evaluated in the ophthalmology branch, clinical sciences division, School of Aerospace Medicine at Brooks Air Force Base following standard patient evaluation protocols. Follow-up will be established on an individual basis and reports will be made to the referring physician and medical facility. When sufficient data have been accumulated, the material will be published. (funding period 10/76-12/79)

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks AFB

0489 MICROWAVE RADIATION AND THERMOREGULATION. Adair, E. R. (John B. Pierce Foundation of Connecticut, 290 Congress Ave., New Haven, CT 06519).

In recent years, the U.S. research effort in dealing with the biologic effects of nonionizing radiation has increasingly been directed toward the effects produced by low levels of irradiation. These levels have been characterized as having no obvious thermal biologic consequences. This research emphasis has been generated partly by the discrepancy between permitted exposure levels in this country and the Soviet Union and partly by reports from several eastern European countries regarding central nervous system (CNS) malfunctions resulting from prolonged low-level microwave irradiation. If such CNS malfunction could be rigorously demonstrated at any level (from cellular organization to complex behavioral patterns), definitive grounds for reconsideration of the U.S. maximum permissible exposure levels would be provided. The primary goal of this project is to learn whether low levels of microwave radiation can influence or interfere with normal responses, both physiologic and behavioral, that regulate body temperature. The ultimate goal is to evaluate the impact of such disturbances on the human thermoregulatory system with reference to current maximum permissible exposure standards. The research proposed will expose restrained squirrel monkeys to specific durations and intensities of microwave irradiation during ongoing behavioral thermoregulation and during measurement of autonomic responses of heat production and heat loss at a variety of discrete ambient temperatures. (funding period 9/77-9/79)

Supporting Agency:U.S. Dept. Defense: Air Force, Office Scientific Res.

0490 USE OF SYNAPTOSOMES AS AN EXPERIMENTAL MODEL FOR EVALUATING THE EFFECT OF ELECTROMAGNETIC RADIATION (EMR) ON NEURAL MEMBRANE FUNCTION. Millar, D. B.; Christopher, J. P. (U.S. Dept. Defense: Navy, Naval Medical Res. Inst., Biochemistry Div., Bethesda, MD 20014).

Synaptosomes will be used as a neural membrane model to evaluate the potential hazard that electromagnetic radiation (EMR) poses to military personnel during performance of critical, defense-related tasks. Synaptosomes will be prepared from guinea pig brains and purified by density gradient centrifugation. Neural membrane function will be reflected by changes in the permeability of isolated synaptosomes. Permeability will be monitored by the uptake of radiolabeled choline, release of radiolabeled calcium, and by the measurement of internal membrane viscosity with appropriate fluorescent probes. The results will serve as baseline values for permeability in the absence of EMR. Synaptosomes will then be exposed to radiation of various doses with a frequency of 2.8 GHz (radar). Power levels will be determined as specific absorption rates, and proper thermal controls will be employed in each case. Threshold values for EMR-neural membrane interaction will be determined in this manner. Neuropharmacologic drugs will then be screened for those that minimize the effect of EMR on the stability of synaptosomes. (funding period 10/77-9/82)

Supporting Agency:U.S. Dept. Defense: Navy, Naval Medical Res. & Development Command, Natl. Naval Medical Center

0491 EFFECTS OF MICROWAVE RADIATION ON THE BEHAVIORAL DEVELOPMENT OF LEARNING PROCESSES: ACUTE AND CHRONIC EXPOSURE. Maitland, G.; Thomas, J. R. (U.S. Dept. Defense: Navy, Naval Medical Res. Inst., Behavioral Sciences Dept., Bethesda, MD 20014).

The overall objective of this research is to determine whether acute and chronic exposures to low power levels of microwave radiation produce effects on the acquisition of new behaviors. It is important to determine whether the learning process is modified by microwave radiation levels similar to those produced by the electromagnetic emitting equipment operated by naval, surveillance, and communication systems. Acquired behavior is weaker and more susceptible to environmental influences than maintained well-established behavior. Established effects of low-level radiation on the development of behavior can be used to aid in specification of permissible levels of exposure across a range of frequencies for military personnel under functionally similar conditions. The methodology involves several new behavioral techniques that have been developed for studying repeated acquisition of behavioral chains with individual subjects. These techniques, which have proved to be extremely sensitive to the effects of a range of environmental variables, will be used to measure low-level radiation effects on behavior acquisition in animals as modified by several important radiation parameters. Frequency (initially 1 to 3 GHz), modulation values, and exposure time will be explored. Acute exposures as well as continuous exposures under chronic conditions (up to 90 days) will be emphasized. (funding period 10/77-10/82)

Supporting Agency:U.S. Dept. Defense: Navy, Naval Medical Res. & Development Command, Natl. Naval Medical Center

0492 LOW LEVEL MICROWAVE RADIATION EFFECTS ON BEHAVIOR. Thomas, J. R.; Yeandle, S. (U.S. Dept. Defense: Navy, Naval Medical Res. Inst., Behavioral Sciences Dept., Bethesda, MD 20014).

The effects of low-level microwave radiation on behavior will be determined. Behavioral changes produced by radiation will be used to establish threshold power levels and may be used both in determining low-limit permissible levels for naval personnel exposure and in reevaluating acceptable exposure limits. Operant conditioning techniques will be used to develop complex timing, counting, and perceptual-motor behaviors in animal subjects. Such baselines will be used to assess irradiation effects with low-level microwave energy (near 10 mW/cm^2). Lower-limit threshold radiation values that cause detectable behavioral changes will be established by assessing a range of frequencies and modulation parameters. As specific behavioral effects are established, additional studies will investigate concurrent effects and interactions of microwave irradiation on behavioral changes. Long-term chronic exposures will be conducted to determine any possible cumulative behavioral effects. The irradiation values that cause any specific behavioral changes may be used for studies to establish lower-limit permissible values for human exposure. (funding period 7/74-10/80)

Supporting Agency:U.S. Dept. Defense: Navy, Naval Medical Res. & Development Command, Natl. Naval Medical Center

0493 NAVY ENVIRONMENT: MICROWAVE DISPERSION AND ABSORPTION IN TISSUE: MOLECULAR MECHANISMS. Foster, K. R. (Univ. Pennsylvania, Sch. Engineering & Applied Sciences, Dept. Bioengineering, 4001 Spruce St., Philadelphia, PA 19104).

This research is part of the Navy's ongoing program to elucidate the basis for alterations in biologic tissue resulting from microwaves and other electromagnetic fields. This research specifically seeks to increase the data base relating to the dielectric permittivity of tissue on a macroscopic and microscopic level. The dielectric properties of various tissues over the frequency range of 0.1 to 18 GHz will be examined. Measurements will be made by confining the sample in a coaxial line or waveguide section that is terminated in a known impedance. Using a slotted line, the standing wave pattern in front of the sample will be measured allowing calculation of the dielectric properties of the material. Special emphasis will be placed on bound and free water. Molecular mechanisms that result in microwave absorption will be studied as functions of frequency and temperature. (funding period 4/78-cont.)

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

0494 ELECTROMAGNETIC BLOOD WARMING. Silva, J.; Bentley, B. K. (U.S. Dept. Defense: Navy, Naval Ocean Systems Center, Systems & Technology Dept., San Diego, CA 92152).

The feasibility of using electromagnetic energy to thaw frozen blood products for clinical use in the Navy will be determined. The use of energy at different frequencies from approximately 30 to 3,000 MHz will be explored to determine the optimum wavelength for this application. Initial tests will be performed using materials with dielectric properties similar to those of frozen blood. Heat transfer properties and temperature elevation profiles, as functions of frequency and energy level, will be determined. Subsequently, tests using genuine frozen blood products will

be performed. Finally, a test protocol for handling electromagnetically thawed blood will be prepared and followed to establish the value of the method of heating as a means of restoring frozen blood to its clinically useful form. (funding period 10/76-10/79)

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

0495 BIOLOGICAL EFFECTS OF LOCALIZED ELECTRIC AND MAGNETIC MICROWAVE FIELDS. Olsen, R. G.; Grissett, J. D. (U.S. Dept. Defense: Navy, Naval Aerospace Medical Res. Lab., Medical Sciences Dept., Pensacola, FL 32508).

The effects of individual microwave fields on small biologic systems will be studied. Both the E-field and H-field exist in a traveling plane wave; however, when such a wave is reflected from a flat conducting surface, a standing wave pattern is formed creating regions of predominantly one field quantity or the other. Since standing waves are found on board ship because of reflections from bulkheads, other conducting structures, and equipment, it is important to determine whether there are specific biologic effects of exposure to one field quantity or the other. A two-dimensional standing wave pattern will be generated at 5.95 GHz by wave reflection from a metal plate at normal incidence. Pupae of the darkling beetle, *Tenebrio molitor*, will be placed in regions of the standing wave that contain predominantly only one field component. Microwave energy that has been deposited in the pupae will be measured calorimetrically using both miniature temperature probes during irradiation and post-irradiation cooling curves. Infrared scanning techniques will be used to determine the spatial distribution of the absorbed microwave energy. (funding period 5/75-9/81)

Supporting Agency:U.S. Dept. Defense: Navy, Naval Medical Res. & Development Command, Natl. Naval Medical Center

0496 COMPUTER STUDIES OF DOSE DISTRIBUTION IN BIOLOGICAL MODELS EXPOSED TO ELECTROMAGNETIC RADIATION. Meijer, P. H. (Catholic Univ. America, Sch. Arts & Sciences, Dept. Physics, 620 Michigan Ave., N.E., Washington, DC 20017).

Theoretic dose distribution calculations for man exposed to nonionizing electromagnetic radiation will be performed utilizing newly-developed computer programs. Theory and programs have been perfected using finite element numeric approximation techniques for the calculation of induced fields and power deposition in biologic tissue of two-dimensional geometry and irregular cross sections. (funding period 9/77-4/79)

Supporting Agency:HEW, PHS, FDA, BRH

0497 RADIOFREQUENCY RADIATION INTERFERENCE (RFI) OF MEDICAL PROSTHETIC DEVICES. Mitchell, J. C.; Hardy, K. A. (U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

A biomedical data base on the interaction of Air Force radio frequency (RF) radiation emitters and medical prosthetic devices will be established, and a state-of-the-art technology watch on cardiac pacemaker interference will be maintained. Manufacturers' progress in developing pacemakers to operate properly in pulsed RF fields of 200 root mean square V/m will be assessed, and the data will be applied to operational situations in accordance with Air Force regulation (AFR) 161-42. New state-of-technology pacemakers will be accepted on loan from manufacturers and evaluated under a variety of RF emission sources in the USAFSAM laboratory. Sources will include radio frequencies between 50-500 MHz. Field tests will also be conducted using a high frequency transmission system. Additional field tests will be conducted in support of specific operational problems as provided by AFR 161-42. (funding period 7/74-6/79)

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks AFB

0498 RADIOFREQUENCY RADIATION EFFECTS ON BIOCHEMICAL SYSTEMS IN THE CENTRAL NERVOUS SYSTEM. Merritt, J. H.; Frazer, J. W. (U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

The Department of Defense Triservice Electromagnetic Radiation (EMR) Bioeffects Research Program describes the central nervous system (CNS) as the "singularly most important area where there is evidence that EMR interacts with biological systems." The objective of this effort is to quantitate the radio frequency (RF) EMR effects on biochemical events subserving nerve transmission in the CNS. The information obtained will be applied to establish more appropriate safety standards for personnel working in close proximity to Air Force RF emitters. The effects of RF radiation on the CNS, specifically on a specialized function of the neuron, namely synaptic transmission, will be studied. This effort will attempt to quantify changes produced by RF energy in these chemical switching systems, determine thresholds for frequency and power density, and interpret these changes in terms of the expected effect on man in Air Force operational environments. (funding period 9/74-8/79)

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks AFB

0499 FLUID SHEAR OF MAGNETIC ALIGNMENT OF BLOOD COMPONENTS. Gardner, R. A. (Washington Univ., Sch. Engineering & Applied Science, Dept.

Mechanical Engineering, 4559 Scott Ave., St. Louis, MO 63130).

The objective of this project is to quantitatively identify field mechanisms of interaction in blood due to either fluid flow (rate-of-shear) or externally applied fields (electric or magnetic). Two effects, which have been recently documented are the delay of in vitro thrombus formation due to either increasing rate-of-shear in the flow or the application of an external magnetic field. The results of this research may validate the hypothesis that the mechanism that results in these effects is the preferential alignment of one or more of the macromolecular participants in the in vitro thrombus-formation process. Fresh whole blood (wb) or platelet-rich-plasma (prp) from fasted normal donors will be used to produce coagula under the controlled in vitro flow conditions of a modified Chandler rotating loop system. The effects to be studied include: (a) the dependence of thrombus-formation time in prp and wb on field strength and rate-of-shear, and (b) the dependence of thrombus structure in wb and prp on field strength and rate-of-shear. The reduced sedimentation of erythrocytes in whole blood or single protein solutions in a transverse field will be examined theoretically and experimentally to identify orientation effects. Solutions of single blood proteins will be examined using the optical techniques of spectrophotometry, spectropolarimetry, and birefringence to quantify their orientation in a transverse magnetic field. (funding period 6/77-11/79)

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

0500 EFFECTS OF MICROWAVE RADIATION ON NEURAL RESPONSE AND THE CENTRAL NERVOUS SYSTEM. McRee, D. I. (Natl. Inst. Environmental Health Sciences, NIH, PHS, HEW, P.O. Box 12233, Research Triangle Park, NC 27709).

Isolated nerve preparations will be exposed to different microwave frequencies, intensities, and modulations to determine whether microwave radiation has a direct effect on nerve function. One possible site of interaction may be the neuronal membrane since it plays an important role in maintaining the ionic gradients that are necessary for the propagation of electrical impulses. Preliminary experiments have shown that microwave irradiation causes a faster rundown of nerves that are continuously stimulated. These experiments will be continued to determine whether microwaves have a direct effect on membrane permeability to cations. (funding period n/a)

Supporting Agency:EPA, Office of Energy, Minerals, and Industry

0501 EFFECTS OF 2450 MHz MICROWAVES ON THE EMBRYONIC DEVELOPMENT, IMMUNOLOGY AND FERTILITY OF JAPANESE QUAIL. McRee, D. I. (Microwave Res. Section, Natl. Inst. Environmental Health Sciences, NIH, PHS, HEW, P.O. Box 12233, Research Triangle Park, NC 27709).

The effects of microwave radiation on embryonic development, immunology, and fertility of the mature quail were studied in quail exposed to microwaves during their development. Fertilized Japanese quail eggs were exposed to 2,450 MHz microwave radiation at 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 exactly the same way except for the microwave exposure. At hatch the quail were checked for deformities. 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 had reduced sperm numbers and reduced sperm motility, and there was 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 n/a)

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

0502 BIOMEDICAL EFFECTS OF MAGNETIC FIELDS. Rubias, C. A. (Lawrence Livermore Lab., Univ. California, P.O. Box 808, Livermore, CA 94550).

A variety of magnetic exposure devices will be developed for exposure of biologic materials and humans to controlled field distribution with other environmental variables under rigid control. Basic effects on cells and molecules will then be measured. Certain types of suspected effects, especially visual and nervous system effects, will be investigated in mammals and man. These devices should permit the establishment of a basic relation between field intensity, spatial and temporal variations, and biologic effects; remove the existing controversial and confusing information that exists; and permit recommendations for safe operation of future power systems. Initial assessment of effects should be available by July 1979. (funding period n/a)

Supporting Agency:U.S. Dept. Energy, Div. Biomedical and Environmental Res.

0503 ELECTROMAGNETIC RADIATION PRODUCT INVESTIGATION AT RADIO-FREQUENCIES. Ruggera, P.

S. (Electronic Products Div., BRH, HEW, 5600 Fishers Lane, Rockville, MD 20852).

Three classes of radio frequency (RF) emitting products, investigated in light of their potential for significant impact on public health through direct radiation emission or through interference to critical life support equipment are currently being studied. The electric and magnetic strengths from industrial RF sealers, citizen-band radios, and electrosurgical units have been quantified utilizing state-of-the-art instrumentation developed by BRH in previous years. Preliminary investigations have confirmed that under typical use conditions, these products can exceed the applicable safety exposure standards set by the American National Standards Institute, and/or could severely affect the function of critical equipment through electromagnetic interference. Through cooperation with other involved governmental agencies and manufacturers, BRH will define and attempt to minimize the potential hazard through technical and regulatory activities. (funding period n/a)

Supporting Agency:HEW, PHS, FDA, BRH

0504 BIOPSYCHOLOGICAL STUDIES OF MICROWAVE IRRADIATION. Justesen, D. R. (Dept. Psychiatry, Sch. Medicine, Univ. Kansas, 39th St. and Rainbow Blvd., Kansas City, KS 66103).

A behavior-development-longevity study of C3H mice that were sham radiated or microwave radiated in utero (3 exposures between days 9 and 15 of gestation: 2.45 GHz at 60 Hz sine modulation, 43 mW/g whole-body dose rate for 20 min in multimode cavity, dams' $LD_{\%}$=10) is in progress. In the first 12 mo, the following observations were made: (1) mortality of radiated pups of surviving dams was higher than that of controls, but there was little difference in death rates of weaned animals; and (2) indices of development (e.g., eye-opening latency, growth of pelt, and body mass) were essentially the same for radiated and control animals. Of particular interest in the coming months will be differences of longevity of animals and of rate of development of spontaneous tumors. (funding period n/a)

Supporting Agency:HEW, PHS, FDA, BRH

0505 BIOPSYCHOLOGICAL STUDIES OF MICROWAVE IRRADIATION. Justesen, D. R. (Neuropsychology Res. Lab., VA Hosp., 4801 Linwood Blvd., Kansas City, MO 64128).

Ongoing studies of longevity and development of tumor-prone mice, whose dams were subjected to LD_{10} radiation, are entering the second yr. To date, little has been found behaviorally to distinguish radiated from control mice. The incidence of spontaneous tumors is nil in both groups, but close monitoring will be continued. Nearing completion is a study in which rats are being observed for evidence of escape learning during trials in an intense 918-MHz field. While marked behavioral and physiologic signs of overheating are observed, there is no evidence of purposive escape. Diffuse whole-body heating, lack of directional cueing, is believed responsible. (funding period n/a)

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

0506 BOSE-EINSTEIN CONDENSATION IN BIOLOGICAL SYSTEMS. Wu, T. (State Univ. New York, Binghamton Campus, Sch. Science & Mathematics, Dept. Physics, Vestal Parkway East, Binghamton, NY 13901).

Frohlich's model suggests that energy applied above a critical rate to the branch or branches of biologic systems that contain dipolar elements capable of oscillation causes Bose-Einstein condensation into the lowest energy state. Several recent Soviet experiments, involving microwave irradiation of living organisms, provide strong support for Frohlich's theory. A criticism of Frohlich's theoretic model will be analyzed, and an alternative microscopic approach using perturbation theory will be examined. This research project will involve the Green's function method. By this theoretic technique the lifetime of the collective excitations in the biologic system will be calculated and will yield an approximate value for the time representing the onset of the coherent oscillation of the dipole elements in certain biologic systems. Finally, the research will deal with model studies where at first simple, specific biologic systems will be analyzed. The interplay of theory and experiment will yield better physical models and closer correlation between theoretic predictions and experimental measurements. (funding period 2/78-2/80)

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

0507 RADIOFREQUENCY ELECTROMAGNETIC ENVIRONMENT SIMULATION AND MEASUREMENT. Allen, S. J. (Sch. Aerospace Medicine, U.S. Dept. Defense, Brooks Air Force Base, San Antonio, TX 78235).

The equipment and methodology necessary to define radio frequency (RF) energy transfer to animals and man will be developed. The results of these experiments will provide the basis for modifying the personnel exposure criteria for Air Force RF operations. Instrumentation will be developed to monitor incident fields and absorbed power for biologic systems exposed to RF fields in the range of operational Air Force systems, 10 MHz-10 GHz. The present power absorption techniques are usable from 10 to 50 MHz.

Methodology will be developed to measure power absorption in the 50 MHz-10 GHz frequency range. The modeling of animals will continue until a suitable model for the theoretic analysis necessary to predict power absorption over the specified frequency range is found. (funding period n/a)

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks AFB

0508 IONIZING AND NON-IONIZING RADIATION BIOLOGY. Appleby, A. (Agricultural Experiment Station, New Brunswick Campus, Rutgers--State Univ. New Jersey, Old Queens Bldg., New Brunswick, NJ 08903).

An understanding of the biologic and chemical processes involved in the interaction of radiation with organisms will be sought to enable the development of ways to inhibit, neutralize, or reverse the biologic damage caused by radiation. The relative radiation sensitivity of experimental animals with or without treatment by radiated gas will be determined by standard procedures. A 2,450 MHz microwave oven was calibrated by colorimetry as a specimen irradiator, and its effects on mouse thyroid function were examined. Preliminary results showed no significant changes in thyroid function following single or multiple exposures at various power levels. The effects of chronic low level microwave exposures on cataract formation of the anterior lens of mammals of various ages will also be evaluated. The mitotic index of the chosen species will be measured by tritiated-thymidine autoradiography in different age groups after various exposure periods, and followed by observing cataract producing doses. (funding period 7/71-6/81)

Supporting Agency:New Jersey State Government

0509 MEASUREMENT OF MUSCULATURE BLOOD FLOW INDUCED BY MICROWAVE DIATHERMY. Lehmann, J. F. (Medical Rehabilitation Res. and Training Center, Univ. Washington, 15th Ave. N.E., Seattle, WA 98105).

To ascertain the quantitative relation between microwave diathermy and deep musculature blood flow increases and rate changes, a ^{133}Xe-washout technique of the human thigh will be utilized. Prior to the actual isotope wash-out experiments, however, subjects will be familiarized with the general experimental procedures and X-rays of both thighs from the lateral aspect will be taken to determine the anatomic dimensions relevant to the thigh diathermy problem (i.e., thickness of the anterior fat layer, location of the femur relative to the anterior thigh surface, and the distortion of the thigh profile). The geometric dispersion of the injected ^{133}Xe depot will be imaged by means of a gamma ray camera interfaced with an on-line computer having disk memory allowing replay of the depot clearance event and separate analysis of different regions in time and space. The thigh blood perfusion rate will be quantitated by coupling the wash-out image with the ^{133}Xe clearance measurement by means of a scintillation counter. In addition, the microwave diathermy process, comprising both the absorbed energy distribution and the responding blood flow field, will be modeled with a finite element digital computer thermal analyzer to define the range of most probable models describing the physiologic response of the thigh. This computer model will consolidate information from (a) previous and ongoing tissue substitute model energy deposition experiments, (b) transient human thigh temperature data obtained in vivo during diathermy application, (c) anatomic details regarding the thigh's geometric distortion under the weight of the direct contact diathermy applicator (obtained from cadaver specimens), and (d) the ^{133}Xe blood clearance experiments. (funding period 8/76-8/80)

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

0510 IMMUNOLOGICAL ASPECTS OF HYPERTHERMIA CANCER THERAPY. Cain, C. A.; Tompkins, W. A.; Dunn, F. (Univ. Illinois, Urbana Champaign Campus, Sch. Engineering, Dept. Electrical Engineering, 2527 Hydrosystems Lab., Urbana, IL 61801).

The effects of hyperthermia, ultrasound, and microwave treatment of tumor cells on different parameters of the immune response will be evaluated using a syngeneic hamster tumor system. Research could lead to the development of techniques that render tumor cells more immunogenic and/or antigenic, perhaps resulting in enhancement of tumor rejection mechanisms. The proposed work will include: (1) in vitro experiments that will result in a quantitative description of changes in sensitivity of tumor cells to immune lysis following treatment and (2) in vivo tests to determine the immunologic effects of treatment of growing tumors by hyperthermia induced by ultrasound or microwave radiation. Immunologic reactivity in vitro will be correlated with observed tumor regressions in vivo. Available sensitive assays to quantitate immune responses to tumor antigens will be employed. (funding period 4/79-3/80)

Supporting Agency:HEW, PHS, NIH, NCI

0511 CHROMOSOMAL EFFECTS OF 2.45 GHz MICROWAVE NON-THERMAL EXPOSURE. Yao, K. (Genetic Studies Section, BRH, HEW, 5600 Fishers Lane, Rockville, MD 20852).

A specially designed chamber for nonthermal microwave exposure will be used to investigate microwave effects on chromosomes of cultivated cells. The chamber disperses heat quickly into a waterbath, which has a controllable temperature. Cells will

be irradiated at G_2 and M stages, the two stages most sensitive to irradiation. Temperature of the waterbath will be 25 C, 37 C, and 42 C. (funding period n/a)

Supporting Agency:HEW, PHS, FDA, BRH

0512 EFFECTS OF MICROWAVES ON NEURAL RESPONSE. McRee, D. I. (Microwave Res. Section, Natl. Environmental Health Sciences, NIH, PHS, HEW, P.O. Box 12233, Research Triangle Park, NC 27709).

The effect of microwave radiation on neurologic response will be analyzed in isolated neurons, such as the abdominal ganglion of the *Aplysia*, the sciatic nerves of frogs, and the saphenous nerves of cats exposed to continuous wave, pulsed and modulated microwave radiation in the power density range of 1-10 mW/cm^2. The effects of the microwave radiation on the strength-duration of a stimulus to produce an action potential, amplitude of the response, and conduction velocity will be investigated. The fatique 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 W/kg, 50 W/kg, 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 refraction of the exposed nerve were seen in comparison to the control nerve. The vitality of the nerves was affected and was greater for the higher dose rates. (funding period n/a)

Supporting Agnecy:HEW, PHS, NIH, Natl. Inst. Environmental Health Science

0513 EPIDEMIOLOGY OF MAGNETIC EFFECTS ON HUMANS. Budinger, T. F. (Lawrence Livermore Lab., Univ. California, P.O. Box 808, Livermore, CA 94550).

An epidemiologic study of 2,000 scientists and technicians who have been exposed to high magnetic fields for substantial cumulative exposures will be conducted, and a previously completed study of 1,500 workers who had ill effects from magnetic field exposures will be analyzed. Medical data on at least 500 exposed subjects, 500 matched controls, and 2,000 case histories of cyclotron workers and high energy researchers will be included in a data base. A potential data base for high tension linemen, power station operators, and European scientists will be investigated. (funding period n/a)

Supporting Agency:U.S. Dept. Energy, Div. Biomedical and Environmental Res.

0514 IDENTIFICATION OF PERIPHERAL AND CENTRAL RECEPTORS MEDIATING THE EFFECTS OF MICROWAVE RADIATION ON BRAIN ACTIVITY. Wilson, R. (Res. Triangle Inst., P.O. Box 12194, Research Triangle Park, NC 27709).

The effect of pulsed microwave radiation on auditory nerve activity will be studied with an electrophysiologic technique that involves recording the response of single units in auditory nerve and cochlear nucleus to microwave and acoustic stimuli. The ^{14}C-2-deoxyglutathione method will also be used in some instances to corroborate and complement the results. An additional set of experiments using the ^{14}C-2-deoxyglutathione method is proposed to detect effects of nonionizing radiation on the activity of brain structures other than nuclei of the auditory system. With this method the effects of nonionizing radiation 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 also 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 n/a)

Supporting Agency:EPA, Office of Energy, Minerals, and Industry

0515 DETRIMENTAL BIOLOGICAL EFFECTS OF MAGNETIC FIELDS. Baum, J. W. (Brookhaven Natl. Lab., U.S. Dept. Energy, Upton, NY 11973).

A study of somatic, genetic, and developmental effects using mutations in *Tradescantia* stamen hairs (somatic tests) and *Drosophila* (genetic and developmental effects) is planned. *Tradescantia* cuttings will be exposed for periods from 1 to 20 days in fields of intensity from 1 to 100,000 Oe. *Drosophila* will be exposed continuously for several generations in preliminary screening studies. Later, genetic and developmental effects will be separated by exposing flies only before mating for a 12-hr period. Effects of field intensity, field gradient, and exposure time will be explored. Results will be compared to previous findings involving ionizing radiation and various chemical mutagens. Implications for exposure to man will be considered in terms of appropriate permissible exposure standards for workers and the general public. (funding period n/a)

Supporting Agency:U.S. Dept. Energy, Div. Biomedical and Environmental Res.

0516 MICROWAVE EXPOSURE SYSTEMS AND MICROWAVE DOSIMETRY. McRee, D. L. (Microwave Res.

Section, Natl. Inst. Environmental Health Sciences, NIH, PHS, HEW, P.O. Box 12233, Research Triangle Park, NC 27709).

Exposure systems for bioeffects research and test techniques for measuring energy absorption will be developed. The waveguide system for exposing isolated neurons to 2,450 MHz microwave radiation has been modified so that longer survival times and constant nerve temperatures during exposure could be achieved. Small thermistor probes have been used to measure deep colonic temperatures in pregnant mice during exposures to 2,450 MHz microwave radiation. Average absorption rates, calculated from the temperature profiles of the sacrificed mice, agreed with both calculated and measured whole-body absorption reported in the literature. A system for exposing 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 n/a)

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

0517 PROGRAM ON THE QUANTITATION OF THE EFFECTS OF ELECTROMAGNETIC ENERGY ON HUMAN TISSUE. Guy, A. W. (Medical Rehabilitation Res. and Training Center, 15th Ave. N.E., Seattle, WA 98105).

The electromagnetic (EM) field patterns due to external sources of energy in and around human and test animal tissues will be measured with thermographic and thermocouple techniques to elucidate the effects of EM radiation on the body and to provide realistic guidelines for safety standards of human exposure (with respect to the source, configuration, frequency, and location). Test animals will be exposed to various continuous wave and modulated EM sources at both thermal and nonthermal power levels and the physiologic characteristics and behavior of the animals before, during, and after exposure to EM radiation will be monitored. In addition, the time and power density thresholds for cataract production in animals exposed to microwave radiation will be studied. Theoretic analysis will involve solution of Maxwell's equation for absorbed power by biologic systems for a variety of geometries. In experiments conducted to date, all observed changes in the central nervous system of animals exposed to EM fields were thermal in nature. The most pronounced effects appeared to be latency changes in evoked brain potentials in cats exposed to EM fields. An experiment of chronic exposure with rats demonstrated the auditory nature of microwave behavior control, and provided cogent evidence that microwave pulses activate only the auditory sensory modality at the incident power densities employed. No significant differences were found between four irradiated and four normal animals with respect to the cataractogenic effects of microwaves. Additional experiments concerning the effect of microwaves on lymphocytes and the amounts of microwave power that might be absorbed by women and children have been conducted. (funding period 1/70-6/80)

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

0518 MICROWAVE HYPERTHERMIA SYSTEMS FOR CANCER TREATMENT. Cheung, A. Y.; Taylor, L. S.; Scott, R.; Robinson, J. E.; Harrison, G. H. (Sch. Medicine, Baltimore Professional Sch., Div. Radiation Therapy, Univ. Maryland, 1420 N. Charles St., Baltimore, MD 21201).

The design, construction, and preclinical testing of advanced microwave applicators for hyperthermia treatment of deep-lying cancers will be studied theoretically and experimentally in a special "phantom" facility. The design will be optimized to evaluate and calibrate the deep-heating performance of the systems in in vivo animal experiments. In preliminary studies, applicators for internal introduction of microwave heating fields via electromagnetic syringes or catheters, such as stomach tubes, were shown to be feasible. External systems, employing conformal microstrip antennas or arrays of miniature waveguide applicators and bolus techniques to focus the fields, were also found to be useful for establishing microwave heating fields. (funding period 9/78-7/79)

Supporting Agency:HEW, PHS, NIH, NCI

0519 EFFECTS OF CHRONIC EXPOSURE TO EMR ON IMMUNE DEFENSE MECHANISMS OF ANIMALS. Smialowicz, R. J. (Health Effects Res. Lab., EPA, Durham, NC 27711).

The effects of long-term exposure of rats in utero and/or during early life to electromagnetic radiation at a forward power of 500 W at 100 MHz on lymphocyte function will be investigated. In addition, the effect of 915 MHz for 20 hr/day for 1-2 mo on the immune function of adult rats will also be investigated. 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 also be compared. Rats were exposed in utero and will be exposed through 90 days of age in the chronic study. Data from rats sacrificed at 22 and 42 days of age show no difference in the hematologic and immunologic indices measured between sham- and microwave-exposed rats. Exposure of rats to 915 MHz is anticipated to begin in a few months. (funding period n/a)

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

0520 MORTALITY, INDUSTRIAL HYGIENE STUDY OF WORKERS EXPOSED TO MICROWAVE AND RADIO

FREQUENCY ENERGY. Egan, E. (Survey Hazard Evaluation, Field Study Div., NIOSH, HEW, 4676 Columbia Parkway, Cincinnati, OH 45226).

NIOSH plans to conduct a retrospective mortality study to further investigate the health effects resulting from long-term, low-level exposure to electromagnetic radiation. Recent evidence indicates that the development of cancer at certain sites may be associated with exposure to electromagnetic radiation. At a naval air station at Quonset Point, Rhode Island, three civilian employees among a group of eight technicians who were engaged in the overhaul and repair of Tactical Airborne Navigation Equipment either have developed cancer or died of it since 1970. Two of the men, 31 and 35 yr of age, developed pancreatic cancer, a rare occurrence, since 99% of all reported cases of pancreatic cancer occur in persons over 40 yr of age. (funding period n/a)

Supporting Agency:HEW, PHS, Center Disease Control, NIOSH

0521 RADIO FREQUENCY/MICROWAVE TERATOGENIC EFFECTS STUDY. Conover, D. (Biomedical and Behavioral Sciences Div., Natl. Inst. Occupational Safety and Health, HEW, 4676 Columbia Parkway, Cincinnati, OH 45226).

A pilot study will be initiated to determine the types of effects produced following radio frequency (RF) irradiation of rats during gestation. Groups of animals will be irradiated at high power levels at 27.12 MHz on days 1, 3, 5, 7, 9, 11, 13, and 15 after conception. The study will include evaluation of preimplantation and resorption losses and skeletal and gross malformations. Follow-up studies will determine the threshold level for these effects. Work in progress under an interagency agreement with NBS will lead to the development of a total power absorption analyzer system. The system will be employed to noninvasively determine the distribution and magnitude of absorbed RF power to aid in extrapolating the results of the animal studies to humans. (funding period n/a)

Supporting Agency:HEW, PHS, Center Disease Control, NIOSH

0522 TERATOGENIC EFFECTS OF 915 MHz IN RATS. Berman, E. (Health Effects Res. Lab., Office Res. and Development, EPA, Research Triangle Park, NC 27711).

The teratogenicity of a daily exposure of 915 MHz microwaves in gestating rats will be investigated by examining the fetuses. Circularly polarized exposure units have been assembled. (funding period n/a)

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

0523 MICROWAVE DOSIMETRY IN BIOLOGICAL SYSTEMS. Tripathi, V. K. (Sch. Engineering, Oregon State Higher Educational System, 200 Covell Hall, Corvallis, OR 97331).

A simplified model of prolate spheroid shape and incident frequencies near resonance (incident wavelength and object size of comparable magnitude) was used to find mathematical solutions to help explain the interaction of electromagnetic energy with biologic systems. (funding period n/a)

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

0524 EFFECTS OF MICROWAVE EXPOSURE ON INFECTIOUS AGENTS IN LABORATORY ANIMALS. Liddle, C. G. (Developmental Biology Branch, Health Effects Res. Lab., EPA, Durham, NC 27711).

Animals will be infected with type III *Streptococcus pneumoniae* and exposed to various frequencies and power densities of microwaves to determine if the radiation alters the course of disease in animals exposed to an infectious agent. The results should provide information on whether microwave exposure is deleterious to sick or debilitated individuals, which may be useful in setting population exposure standards. The first group of mice was infected and exposed to 2,450 MHz microwaves at an incident power density of 10 mW/cm^2 for 5 hr/day for 6 days. Preliminary results indicate that at this frequency and power density there is no difference in acute mortality between the exposed animals and the sham-irradiated controls. (funding period n/a)

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

0525 BIOLOGICAL EFFECTS OF MAGNETIC FIELDS. Mahlum, D. D. (Battelle Pacific N.W. Lab., U.S. Dept. Energy, P.O. Box 999, Richland, WA 99352).

Pregnant mice will be exposed at varied times after conception to magnetic fields ranging up to 5,000 G, and the frequency and type of abnormalities in the offspring will be observed. Changes in litter size, behavioral activity, and growth will also be determined. The potential biologic impact of magnetic fields will be determined over the range where human exposure may occur in a proposed nuclear fusion plant. (funding period n/a)

Supporting Agency:U.S. Dept. Energy

0526 PRIMATE TRACKING PERFORMANCE DURING MODULATED 1.2 GHz EXPOSURES. Scholl, D. M. (Sch. Aerospace Medicine, U.S. Air Force, Brooks Air Force Base, San Antonio, TX 78235).

Nonhuman primates will perform a compensatory visual task under 2-hr long radio frequency (RF) exposures that meet or exceed current safety criteria to explore the possible behavioral effects of RF exposure and to respond to literature reports of low-power level RF effects. The task will require

considerable vigilance as it is believed that factors disrupting the emotional state may influence primate performance. Selection of RF parameters was based on known energy deposition and wave penetration factors, and on reports of emotional, behavioral, and neurophysiologic effects to low-power level RF exposures at specific frequencies and modulations. Tracking performance under RF will be contrasted with stable pre- and postexposure data. (funding period n/a)

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks AFB

0527 NAVY ENVIRONMENT: EFFECTS OF PULSED MICROWAVE RADIATION FROM NAVY RADAR ON MAMMALIAN BLOOD CELLS. Cleary, S. F. (Virginia Commonwealth Univ., Medical Coll. Virginia, Dept. Biophysics, 1200 E. Broad St., Richmond, VA 23298).

Much recent research has shown that pulse-modulated microwave fields can produce alterations in biologic systems. The mechanisms of the interactions that cause these alterations are not generally understood. As a major producer of such fields from radar and other equipment, the Navy is conducting a program to determine the extent of hazard to its personnel and the public. This study is aimed at elucidating the mechanisms at the membrane level. Pulsed x-band microwave fields will be used to expose cell model systems consisting of human, dog, and rabbit blood cells. Studies will be made of effects on membrane permeability and cellular metabolism. The effects of the fields on membrane ion (Na^+ and K^+) fluxes will be studied to distinguish between active and passive transport alterations. In vitro studies will be carried out on the following mammalian cell lines: lymphocytes, thymocytes, polymorphonuclear leukocytes, and thrombocytes. In addition, osmotic fragility, intracellular proteins, oxygen consumption rates, and cell viability will be studied. Other studies will be carried out with the microwave field parameters as independent variables. (funding period 3/78-cont.)

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

0528 ELECTROMAGNETIC RADIATION AND BIOLOGICAL SYSTEMS. Adey, W. R.; Bawin, S. M.; Sheppard, A.; Sagan, P. M. (U.S. Veterans Admin., Dept. Medicine & Surgery, Medical Center, 11201 Benton St., Loma Linda, CA 92357).

The interactions between weak ultra-high-frequency (450 MHz) electromagnetic fields and the central nervous system will be studied. The investigation will continue research that has disclosed power windows and modulation frequency windows for these interactions. Studies of interactions between weak electromagnetic fields and calcium ion binding in the central nervous system will be continued and will serve as reference for experiments involving amino acids and other putative neurotransmitters. Chick and cat cerebral tissues will be compared in their response to field stimulation. Performances of neonate chicks and ducklings exposed to 450 MHz fields will be compared in a series of behavioral measurements ranging from free behavior to sophisticated behavioral tasks, including variation of an interresponse time schedule. Schedule-controlled behavior in monkeys will be tested under similar field conditions. There will be continued collaboration with the Bureau of Radiological Health in measurements of field gradients in tissue as correlates of neurochemical responses. Recent developments in theoretic physics will be applied in modeling non-linear responses of the central nervous system to weak perturbations of the extracellular environment. (funding period 10/78-n/a)

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

0529 ELECTROMAGNETIC RADIATION AND BIOLOGICAL SYSTEMS. Adey, W. R.; Bawin, S. M.; Sheppard, A. R.; Sagan, P. M.; LinLiu, S. (U.S. VA, Dept. Medicine & Surgery, Medical Center, 11201 Benton St., Loma Linda, CA 92357).

See Current Research 0528 for description of this research. (funding period 3/78-2/80)

Supporting Agency:HEW, PHS, FDA, BRH

0530 BIOLOGIC CONSEQUENCES OF PULSED VERSUS CONTINUOUS WAVE RADIOFREQUENCY RADIATION (RFR). Caln, F. (Georgia Tech Res. Inst., Atlanta GA 30332).

There is some uncertainty regarding the relative abilities of continuous wave (CW) and pulsed (P) radio frequency radiation (RFR) to produce biologic effects. There is some controversy as to whether the rapid rise and fall of electric and magnetic fields of P RFR are more stressful than CW RFR. This project will attempt to answer some of the questions involved in this controversy. Test animals will be exposed in both P and CW RFR fields to establish relative biologic effects. Effects will be characterized as to frequency, incident power, absorbed power, pulse and modulation characteristics, tissue temperature, and duration of exposure. This is a multi-source contract. (funding period 7/77-6/79).

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks AFB

0531 BIOLOGIC CONSEQUENCES OF PULSED VERSUS CONTINUOUS WAVE RADIOFREQUENCY RADIATION (RFR). Guy, A. W. (Rehabilitation Medicine, Sch. Medicine, Univ. Washington, 500 17th Ave., Seattle, WA 98122).

See Current Research 0530 for description of this research. (funding period n/a)

Supporting Agency:U.S. Dept. Defense: Air Force, Sch. Aerospace Medicine, Brooks AFB

6155 MEASUREMENTS OF THE DENSITY OF THE MICROWAVE POWER FLUX. *(Pol.)* Bogucki, J. (No affiliation given). *Ochr Pracy* 32(12): 12-13; 1978. (0 refs)

Problems associated with the examination of the amount of microwave energy emitted accidentally from high-power generators are discussed. So-called secondary sources of microwave energy can cause uncontrollable emission of microwave energy in the vicinity of a generator and therefore frequent examination of the density of the microwave power flux is needed to safeguard employee health. The measurements should be performed using an apparatus consisting of an antenna, a waveguide, and a meter. The device should be able to measure the density of the microwave power flux in the range of 5×10^{-2}-100 W/m^2. The functioning of an American-made device for such measurements is discussed.

6156 MICROWAVE HAZARDS. *(Eng.)* Goldwag, H. (No affiliation given); Justesen, D. R. *IEEE Spectrum* 16(5): 66-68; 1979. (3 refs)

The adequacy of United States standards for safe exposure levels of microwave and radio frequency radiation is discussed. The American limit of 10 mW/cm^2 is based on the concept of a no-damage threshold and on data from controlled laboratory studies. In contrast, the Soviet standard of 10 μW/cm^2 is based on a no-effects philosophy and on data largely from epidemiologic studies. Although Eastern European data appear to refute the simplistic thesis of gross thermal damage that underlies the American standard, a consensus on the validity of the data has not been reached in the United States. Biologic effects that have been reported in certain frequency windows include insect teratogenesis, efflux of calcium ions from cortical neurons, altered heart rates, transformation of mammalian cells in vivo, break down of the blood-brain barrier, and disruption of innate and learned behavior. Enhanced cell transformation and calcium ion efflux from isolated chick brains are confirmed effects, while others such as insect teratogenesis are believed to be due, at least in large part, to other factors. Measurement artifacts are believed to be responsible for reports of altered blood-brain barrier permeability. Reported alterations of learned behavior in experimental animals involve exposures to field strengths much higher than the current American standard of 10 mW/cm^2. The effects of continuous ultralong-term exposure to weak microwave fields are uncertain at present.

6157 INTERACTION OF RADIOFREQUENCY AND MICROWAVE RADIATION WITH LIVING SYSTEMS: A REVIEW OF MECHANISMS. *(Eng.)* Stuchly, M. A. (Nonionizing Radiation Section, Radiation Protection Bureau, Environmental Health Centre, Health and Welfare, Ottawa, Ontario, K1A 0L2, Canada). *Radiat Environ Biophys* 16(1): 1-14; 1979. (69 refs)

The interaction of radio frequency (RF) and microwave radiation (10 MHz to 300 GHz) with living systems on the molecular, cellular, and macroscopic level is reviewed. There appears to be no adequate basis for establishing frequency specific molecular interactions at electromagnetic field intensities that do not result in an increase of tissue temperature. Data on changes in calcium ion efflux in isolated cerebral tissue of neonatal chicks due to exposure to low frequency fields (5-25 Hz) or RF fields modulated at frequencies of 5-25 Hz suggest a possible interaction on the cellular level. Further progress in understanding the basic mechanisms of neural processes might lead to an explanation of some effects (e.g., calcium ion efflux) that cannot directly be explained by a thermal interaction mechanism. On the macroscopic level involving phenomena that can be described in terms of classical electrodynamics (i.e., Maxwell's equations), the interaction between RF and microwave radiation and living organisms can be defined in terms of absorbed power, which in turn is determined by electric permittivity, magnetic permeability, and internal field intensity. An analysis of human phantoms indicates that an adult man absorbs 50-200% of the power that is calculated as the incident power density times surface area (one side) of a man. The average specific absorption rate can be substantially higher at resonant frequencies, however. The total power absorbed and its spatial distribution within a human body are functions of electromagnetic field frequency, field polarization, body-to-radiation source configuration, exposure environment, and tissue dielectric constant and conductivity. Nonuniform heating resulting from exposure to RF or microwave radiation may cause a variety of secondary interactions. For example, preferential heating of the hypothalamus may affect thermoregulation and elicit aberrant neurophysiologic responses even at relatively low power density levels, which are not accompanied by increase in whole body temperature. One of the most prominent thermally induced effects where temperature increases are very small is the microwave hearing effect. The proposed mechanism for this effect is as follows: electromagnetic radiation causes a rapid temperature increase that generates thermal expansion pressure in the brain matter which then launches the acoustic wave of pressure that is detected by the cochlea. The cochlear microphonic frequency is independent from the microwave frequency and the absorption pattern.

6158 SOME PERSPECTIVES ON RESEARCH INTO THE BIOLOGICAL RESPONSE TO NON-IONIZING ELECTROMAGNETIC RADIATION. *(Eng.)* Sharp, J. C. (NASA, Ames Res. Center, Moffett Field, CA 94035). *Radio Sci* 14(1): 5-10; 1979. (0 refs)

Trends in research on the biologic effects of nonionizing electromagnetic radiation over the last three decades are reviewed, with particular reference to the proposed solar energy space power station (SPS). As a result of the advent of radar in World War II, research on the biologic effects of

radio frequency radiation reached a peak in the late 1950s and early 1960s. This was followed by a nadir in research activity, and in 1965 not a single federal agency was supporting research in this area. A resurgence of research has occurred in the past decade, with 13 federal agencies or departments now annually supporting a multi-million dollar effort. One project associated with research on the biologic effects of nonionizing radiation is the proposed solar energy SPS. When fully implemented, approximately 100 satellites would be placed in orbit with solar collectors. Energy would be relayed to any desired location on earth via a carefully controlled microwave beam. Under optimal conditions, the power density at the center of the collecting antenna array would probably be no greater than 25 mW/cm^2 (continuous wave) at a frequency of 2.45 GHz. The environmental and ecologic impacts of such a system are unknown at present, including the effects from the microwaves beamed to earth. It is suggested that a new pragmatism and conservatism have evolved in the United States with regard to such research and that there would be wide opposition to implementing the SPS system if it were initiated today.

6159 A PHYSIOLOGICALLY COMPATIBLE TISSUE-EQUIVALENT LIQUID BOLUS FOR MICROWAVE HEATING OF TISSUES. *(Eng.)* Hand, J. W. (MRC Cyclotron Unit, Hammersmith Hosp., Ducane Road, London W12 OHS, England); Robinson, J. E.; Szwarnowski, S.; Sheppard, R. J.; Grant, E. H. *Phys Med Biol* 24(2): 426-431; 1979. (12 refs)

A physiologically compatible and microwave tissue-equivalent liquid bolus system consisting of dextran in Krebs-Ringer solution was used to provide efficient microwave coupling to irregularly shaped mouse tissue without adversely affecting this tissue. Complex permittivity was measured at frequencies of 915 MHz and 2,450 MHz for Krebs-Ringer solution and for solutions of dextran in Krebs-Ringer solution at concentrations of 200, 300, and 400 g/l. It was estimated that less than 1% of the incident microwave power should be reflected from tissue immersed in the bolus solutions compared with 10-20% for tissue immersed in Krebs-Ringer solution only and more than 50% for an air-tissue interface. In an experiment without a loop of exteriorized mouse intestine present in the bolus cell, the microwave applicator was tuned such that 2 ± 0.2 mW of reflected power was present at a forward power level of 40 W. When a loop of intestine was introduced into the bolus, the reflected power remained virtually unchanged. Tests with mouse leg and mouse tail in the bolus showed that heating rate exhibited little dependence on orientation or position of the sample with respect to the microwave field. It is concluded that the above approach should be useful in developing uniform heating of small laboratory animals. Furthermore, the liquid bolus could be used in direct contact with the skin in treatments involving microwave heating of superficial lesions in human patients and would allow the transformation of the complex shapes of treated areas into ones of simple plane geometry.

6160 A NON-INVASIVE, PARTIAL-BODY EXPOSURE METHOD FOR MEASURING THE COMPLEX PERMITTIVITY OF BIOLOGICAL SUBSTANCES AT MICROWAVE FREQUENCIES. *(Eng.)* Neelakantaswamy, P. S. (Dept. Electrical Engineering, Indian Inst. Technology, Madras 600036, India); Gupta, K. K.; Basavaraju, K. *Med Biol Eng Comput* 16(4): 419-424; 1978. (10 refs)

A non-invasive, partial-body exposure method for measuring the complex permittivity of slab-like dielectric materials at microwave frequencies is described. A Gaussian beam launcher is used to irradiate selectively the test material at the particular position of interest, and an X-band reflectometric bridge arrangement is used to measure the amplitude and phase of the reflected beam wave. The real and imaginary parts of the permittivity are computed using the measured data and the theoretically formulated expression for the reflection coefficient. Measurements at X-band frequencies were performed for dielectric materials, such as, acrylic plastic, bakelite hylam, human skullbone (in vitro measurements), and the midportion of the palm (in vivo measurement). The real parts of the dielectric constants of the test materials measured by the present method agreed closely with the results using von Hippel's method. However, there were deviations in the results for the loss tangents. For the external surface of the human skull, in particular, the real part of the permittivity agreed closely with the nominal value, but the loss tangent indicated deviations that can be attributed mainly to the surface irregularity of the interior base of the skull. Results obtained for the occipital region of the skull were in close agreement with the nominal value owing to the fact that the occipital region is fairly thick and, for the test skull used in this experiment, the external protuberance and crest at the occipit were not geometrically significant. For in vivo measurements on the midportion of the palm, the values of both the real part of the permittivity and the loss tangent agreed closely with the respective nominal values. It is concluded that this noncontact and nondestructive approach to measuring complex permittivity is suitable for in vivo or in vitro measurements in biologic experiments involving radiation dosimetry.

6161 MAPPING OF THE NEAR-FIELD PATTERN IN SIMULATED BIOLOGICAL TISSUES. *(Eng.)* Gajda, G. (Dept. Electrical Engineering, Univ. Ottawa, Ottawa, Ontario, Canada); Stuchly, M. A.; Stuchly, S. S. *Electronics Lett* 15(4): 120-121; 1979. (9 refs)

A simple system for mapping the electric-field pattern in a simulated tissue is described and its performance evaluated. The basic components include a microwave generator, a test applicator, a container with liquid-tissue phantoms, an electric-field probe, a detector, an amplifier, and an X-Y recorder. The system's short probe is sensitive to the E-field in one direction, which is driven along a selected path by the X-scan of the X-Y recorder, while the intensity of the field measured by the

diode detector is recorded simultaneously along the *Y*-coordinate of the recorder. To evaluate the system's performance the probe was inserted into a section of the waveguide terminated by an absorbing mat. The probe penetrated the mat and was arranged in the center of the waveguide parallel to the direction of propagation. The directional response of the probe was found by monitoring the transmitted signal against the angular position of the probe. The coupling coefficient (S_{21}) was found to be -33 ± 1 dB, and the directivity (the ratio of coupling coefficient in two orthogonal directions) was approximately 20 dB. Near-field patterns in simulated muscle tissue (a mixture of water and glycerol), the squared value of the electric field strength at 2 mm from the aperture of an applicator operating at 2.45 GHz, and the patterns of the electric field across the symmetry line of the applicator at distances ranging from 0 to 25 mm from the aperture of the applicator were obtained. The system provides a viable complementary or alternative technique to the thermographic-camera method in evaluating the performance of microwave applicators for local hyperthermia.

6162 CHARACTERISTICS OF THE BIOLOGIC ACTION OF MILLIMETER-RANGE RADIOWAVES AND THEIR POSSIBLE MEDICAL APPLICATIONS. *(Rus.)* Sevast'ianova, L. A. (Oncology Res. Center, USSR Acad. Medical Sciences, Moscow, USSR). *Vestn Akad Med Nauk SSSR* (2): 65-68; 1979. (21 refs)

Studies on the biologic effects of millimeter-range radiowaves and their possible medical applications are reviewed. Millimeter waves do not have any serious injurious effect on microorganisms. They increase the mitotic activity of yeast cells, the number of colicin-synthesizing *Escherichia coli* cells, have an inhibiting effect on adenovirus, and increase the nucleic acid levels in the cells. Millimeter waves cause no mutagenic changes in bacteria. They enhance the antitumor effect of previous x-ray treatment of chemotherapy, and they protect the erythroid cell line of the bone marrow from the harmful effects of x-rays and cytostatic drugs. Millimeter waves may inhibit tumor growth, and no stimulation of tumor growth has been observed. The biologic effects are strongly frequency-dependent.

6163 ELECTROMAGNETIC FIELDS AND POWER DEPOSITION IN BODY-OF-REVOLUTION MODELS OF MAN. *(Eng.)* Wu, T-K. (Lockheed Missiles and Space Co., Inc., Sunnyvale, CA 94086). *IEEE Trans Microwave Theory Tech* MTT-27(3): 279-283; 1979. (15 refs)

The feasibility of using the surface integral equation (SIE) technique to analyze the electromagnetic fields and power deposition in a homogeneous dielectric body of revolution of biologic tissue is demonstrated. The method also applies to any arbitrarily shaped body-of-revolution models of man and animals. Although the illuminating sources considered here are plane waves for near zone sources such as manpack radio antennas, direct-contact aperture sources, and corner reflectors, the technique still applies. Numeric results for electromagnetic fields and power deposition in a body-of-revolution model of a human torso with a height of 1.78 m were evaluated for frequencies of 30, 80, and 300 MHz. It was found that the strongest power deposition in the torso model occurred for fields polarized along the longest dimension and for frequencies near the first resonance (80 MHz) of the torso body. Hot spots were also observed in the neck region of the torso body. The SIE method may be generalized to analyze inhomogeneous bodies by employing the invariant imbedding technique, and the method applies over a wide range of dielectric parameters, with the dielectric constant ranging from 1.1 to 10^2 and the conductivity ranging from $0\text{-}10^3$ mhos/m. Because of the versatility of the moment method of solutions to changes in geometry with the present technique, a myriad of body configurations may also become tractable, e.g., a human torso with outstretched arms and legs or even a torso carrying a manpack transceiver.

6164 INTERDISCIPLINARY AND INTERNATIONAL CONTRIBUTIONS TO RESEARCH ON BIOLOGICAL EFFECTS OF ELECTROMAGNETIC WAVES: PAST PERFORMANCES AND FUTURE CHALLENGES. *(Eng.)* Johnson, C. C. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112). *Radio Sci* 14(1): 1-4; 1979. (0 refs)

Progress in research on the biologic effects of electromagnetic radiation is reviewed. The Eastern European countries have made significant attempts to understand the nervous and behavioral response to electromagnetic waves, to gauge the response of the blood-forming and immune systems, and to establish standards that protect the health of occupationally exposed personnel. The Western countries have achieved significant progress in perfecting instrumentation and measurements, in developing dosimetry, and in investigating the potential of electromagnetic radiation in medical applications, especially in the treatment of cancer. Significant accomplishments have also been made in the development of improved equipment for irradiation of biologic specimens and in the development of instrumentation for making nonperturbing measurements of temperature in electromagnetic fields. However, despite these accomplishments, there is no consensus as to the hazards of electromagnetic radiation or to the mechanisms of its effects.

6165 THE ELECTRIC-FIELD PROBE NEAR A MATERIAL INTERFACE WITH APPLICATION TO THE PROBING OF FIELDS IN BIOLOGICAL BODIES. *(Eng.)* Smith, G. S. (Sch. Electrical Engineering, Georgia Inst. Technology, Atlanta, GA 30332). *IEEE Trans Microwave Theory Tech* MTT-27(3): 270-278; 1979. (10 refs)

A worst case analysis was formulated to determine the effect of a nearby interface on the response of an electric field probe. The results of the analysis showed that the interaction between the

electrically short probe and the interface had the following properties. The interaction (error in response) is decreased if the radius or the length of the probe is reduced. A low value for the load admittance at the terminals of the probe will produce less interaction than a high value of the load admittance. An increase in the dissipation in the medium surrounding the probe will decrease the interaction at a distance from the interface but can increase the interaction when the probe is very close to the interface. The use of a probe with a concentric cylindrical insulation of a permittivity ratio much greater than 1 can reduce the interaction to the level that is obtained with an open-circuited bare probe with the same dimensions; the interaction for the insulated probe, unlike that for the bare probe, will be independent of the value of the load admittance used. For electrically short bare probes that are thin, the error in the response for either low or high values of load admittance is found to be less than 5% when the distance from the interface is greater than the half-length of the probe. The addition of an insulating sheath with a permittivity ratio much greater than 1 reduces the error to less than 5% for spacings where the distance from the interface is greater than one-third the half-length of the probe. A simple approximate analysis indicates that the response of all electrically short insulated dipole probes will exhibit a behavior similar to that for the probe with a concentric cylindrical insulation when the insulation is not very thin and the permittivity ratio is much greater than 1. An analysis of data measured for the electric field near an interface using an electric field probe developed by the BRH indicates that the measured results are in general agreement with the theory.

6166 ELECTROMAGNETIC RADIATION EMITTED FROM VIDEO COMPUTER TERMINALS. *(Eng.)* Weiss, M. M. (Bell Telephone Lab., Inc., Murray Hill, NJ 07974); Petersen, R. C. *Am Ind Hyg Assoc J* 40(4): 300-309; 1979. (6 refs)

Electromagnetic radiation (EMR) emissions from typical video terminals (CRT) used by the Bell System were measured. Electric field strength and/or power density measurements were made over the frequency range of 10 kHz to 18 GHz. With the exception of a digital graphics terminal and a Tektronix display unit, measurable levels occurred at frequencies extending only up to a maximum of about 150 MHz. For the above exceptions, a number of small signals in the hundreds of MHz region were detectable; however, these signals were due to computers and other peripheral equipment. In all cases the values of the total root mean square (RMS) electric field strength were well below the most stringent exposure standard used anywhere in the world. The maximum total RMS electric field strength of all measured frequency components for each CRT was about 0.01 V/m and resulted primarily from emissions associated with the sweep circuitry (below 1 MHz including all measurable harmonics). Irradiance measurements indicated that UV exposure levels were well below the recommended levels in the NIOSH criteria document. There is no experimental or epidemiologic evidence presently available to indicate that the above levels of EMR could have any detrimental effects on the health of personnel using CRT devices like the ones examined in this study.

6167 INDUSTRIAL, SCIENTIFIC, AND MEDICAL MICROWAVES: SOME FACTS, SOME FINANCES, SOME FEARS, AND THE FUTURE. *(Eng.)* Herbaugh, R. E. (No affiliation given). *Microwaves* 18(3): 43-45, 48, 49, 52; 1979. (6 refs)

Industrial, medical, and scientific applications of microwave radiation are discussed. Industrial heating systems are available that operate at frequencies of 915 and 2,450 MHz. Output powers vary from about 500 W for some domestic microwave ovens into the 90-kW region for some industrial heaters. In a recent report to Congress (December, 1978), NIOSH noted that 75% of the workers using radio frequency sealing and heating equipment were exposed to radiation levels in excess of the present occupational exposure guidelines. In addition to the assessment of the potential hazards of microwaves, this technology is currently being investigated for the detection and treatment of cancer. One of the standard industrial, scientific, and medical frequencies, 2,450 MHz, is being used at the University of Miami School of Medicine to treat malignant brain tumors that have been implanted in mice. At the University of Utah, researchers are studying the millimeter-wave properties of tissues to try to determine whether some European and Soviet theories are valid. Some U.S. scientists feel there are specific frequency effects on tissues in the millimeter ranges. Also, Utah scientists are studying the water content of the lungs via microwaves. Microwaves have also been used to thaw frozen blood. Georgia Institute of Technology researchers are using microwaves for the uniform heating of frozen animal kidneys. Once perfected, the technique may be used to thaw human organs that are stored in tissue banks.

6168 RADIO AND TELEVISION TRANSMITTERS AND THE LIVING ENVIRONMENT. *(Cze.)* Musil, J. (Institut hygieny a epidemiologie, Srobarova 48, 100 42 Prague 10, Czechoslovakia). *Cesk Hyg* 23(10): 504-508; 1978. (10 refs)

Studies on the possible health hazards of the electromagnetic radiation emitted by radio and television transmitters are reviewed, and typical radiation levels measured in different countries are presented. Hygienic standards are recommended for the general population exposed to electromagnetic radiation generated by radio and television transmitters; the exposure should be limited to 5 V/m in the frequency range of 0.03-30 MHz, 1 V/m in the range of 30-300 MHz, and 2.5 μ/cm^2 above 300 MHz.

6169 A STUDY OF THE HEALTH STATUS OF RADAR WORKERS. *(Eng.)* Djordjevic, Z. (Inst. Aviation Medicine, Zemun, Yugoslavia); Kolak, A.; Stojkovic, M.; Rankovic, N.; Ristic, P. *Aviat Space Environ Med* 50(4): 396-398; 1979.

The health status of 322 radar workers (ages, 25-40 yr) occupationally exposed to pulsed microwaves of various frequencies for 5-10 yr was compared with that of 220 nonexposed controls matched with respect to age, work regimen, and social and living conditions. The intensity of microwave exposure was generally less than 5 mW/cm^2. Clinical examinations of the workers included detailed internal, neurologic, ophthalmologic, otologic, hematologic, and biochemical investigations. There were no statistically significant differences in clinical or laboratory findings between exposed and control workers. However, general subjective complaints such as headache, fatigue, and irritability were observed more frequently in the exposed workers than in controls. These subjective complaints can not be ascribed only to microwave exposure because the workers were also exposed to uncomfortable occupational conditions such as inadequate air temperature, poor lighting, high noise level, and the necessity of paying attention to radar screens. Harmful effects from microwave exposure are concluded to be unlikely in radar workers working under normal conditions.

6170 ELECTROMAGNETIC POWER ABSORPTION IN CYLINDRICAL TISSUE MODELS EXCITED BY A LOOP ANTENNA. *(Eng.)* Yoneyama, T. (Res. Inst. Electrical Communication, Tohoku Univ., Sendai 980, Japan); Suzuki, T.; Nishida, S. *Electron Lett* 15(4): 125-127; 1979. (6 refs)

A cylindrical homogeneous tissue model in the field of a loop antenna located coaxially is proposed to measure electromagnetic power absorption in biologic tissues. Simple computations are derived for the electromagnetic power absorption based on the assumption that the wavelength is large compared to the radius of the cylindrical tissues. The power absorption coefficient for cylindrical tissues (the ratio of the absorbed power in the tissue to the total radiated power in the loop) increases as the radii of the loop and cylindrical tissue approach each other. Although the coaxial arrangement of the loop antenna and the cylindrical tissue is a rather idealized model of the real physical structure, the results may be useful for determining total absorbed power estimates in real tissues. The derived equations are simple and may be computed with a pocket calculator if a table of Bessel functions for complex arguments is available.

6171 MECHANISM OF LETHAL ACTION OF 2,450-MHz RADIATION ON MICROORGANISMS. *(Eng.)* Vela, G. R. (Dept. Biological Sciences, North Texas State Univ., Denton, TX 76203); Wu, J. F. *Appl Environ Microbiol* 37(3): 550-553; 1979. (18 refs)

The mechanism of lethal action of microwave radiation on microorganisms was investigated using various bacteria, actinomycetes, fungi, and bacteriophages exposed in the presence and absence of water. All irradiations were performed in a specially constructed stainless steel cavity coupled to a magnetron tube capable of emitting 1.5 kW of forward power at 2,450 ± 20 MHz. Energy output was a flux of 1 kW (1,000 J/sec) at the sample locations. To examine the thermal component of the bactericidal properties of microwaves, a series of experiments was performed in which the rate of inactivation of viable microorganisms was compared with the temperature of the suspending medium. The system of choice was considered one in which microorganisms could exist in either the presence or absence of water. It was found that inactivation of soil *Azotobacter* depended on the presence or absence of water. It was found that inactivation of soil *Azotobacter* depended on the presence or absence of water and/or on the temperature of the specimen after irradiation. The experiments were repeated eight times with different soil samples, and the results were essentially identical. In 14 other experiments in which the total soil population (heterotrophic, aerobic, mesophilic) was counted, the results were essentially the same as those for *Azotobacter*. The results were interpreted as showing that, in the presence of water, the temperature of the suspending medium and bacterial inactivation are dependent functions of the total amount of radiation delivered into the cavity by the magnetron tube and, also, that temperature increase in the sample depends on the presence of water. Since the loss factor (dielectric constant x loss tangent) of water at 2,450 MHz is much greater than that of soil or that of the glass beakers, it was assumed that the major part (<98%) of microwave energy was absorbed in the soil. Results of experiments in which diverse microbial populations were monitored showed that bacteria, actinomycetes, and fungi were inactivated as a function of the moisture content of the soil. These results proved that the bactericidal effect of microwaves was due to the total amount of water in the soil sample. In more than 70 repetitions of this experiment, the results showed that there was a distinct loss of microbicidal activity as the moisture content of the sample approached zero. To circumvent the problem of energy absorption by water and soil, lyophilized organisms were irradiated in the dry condition and, for comparison, after moistening. The results also showed that cell killing is a function of moisture content; lyophilized yeast cells were inactivated in the presence of water but survived large doses of radiation in the dry state. It is concluded that microbial cells are not inactivated by large amounts of microwave radiation. Furthermore, it is clear that microwaves kill microorganisms only by thermal effect and that, if there is a nonthermal effect, it is not a bactericidal one, although the possibility exists that water may be necessary to potentiate the nonthermal effect.

6172 SEARCH FOR MILLIMETER MICROWAVE EFFECTS ON ENZYME OR PROTEIN FUNCTIONS. *(Eng.)*

Tuengler, P. (Seaver Chemistry Lab., Pomona Coll., Claremont, CA 91711); Keilmann, F.; Genzel, L. *Z Naturforsch [C]* 34c(1/2): 60-63; 1979. (12 refs)

The effects of millimeter microwaves (MMW) on in vitro enzyme and protein functions was investigated. The effect of MMW on an enzyme system was studied in the reduction of ethanol by alcohol dehydrogenase (molecular wt 144,000) in a constant-flow technique. Fresh samples, each with a 1 x 1 cm^2 surface area, were irradiated with MMW of 10 mW/cm^2 intensity; the frequency was varied from 40 to 115 GHz with a resolution of a few MHz. Microwaves had no significant influence, having less than a 1.0% effect on alcohol dehydrogenase turnover rate. The effect of MMW on protein functions was analyzed in the cooperative binding of oxygen and hemoglobin (molecular wt 67,000). Fresh samples, each with a 2 x 2 cm^2 cross section (4 times the sample area of the alcohol dehydrogenase system), were irradiated with MMW of 10 mW/cm^2 intensity in the same manner as the alcohol dehydrogenase system. The irradiation had less than 0.4% effect on the equilibrium oxygen constant of half-oxygenated hemoglobin. Since the amount of possible nonlinear amplification necessary to observe changes in protein and hemoglobin function in vivo is unknown, it cannot be concluded that MMW has no effect on the function of the alcohol dehydrogenase system and on the function of hemoglobin in oxygen transport.

6173 PATHOGENESIS OF INSULIN DEFICIENCY INDUCED BY ALTERNATING MAGNETIC FIELD OF INDUSTRIAL FREQUENCY. *(Rus.)* Kolesova, N. I. (Dept. Biochemistry, Medical Inst., Tomsk, USSR); Voloshina, E. I.; Udintsev, N. A. *Patol Fiziol Eksp Ter* (6): 71-73; 1978. (6 refs)

The effect of exposure to alternating magnetic field (200 Oe, 50 Hz, 1 x 24 hr or 6.5 hr/day for 5 consecutive days) on the overall serum insulin activity, free insulin level, hepatic glycogen, and blood glucose levels was studied in 200 male rats. Single-time exposure caused a significant increase in the overall serum insulin activity (4.1 mg/g/3 hr 1 hr after exposure and 5.1 mg/g/3 hr 48 hr after exposure, compared with 2.5 mg/g/3 hr in the controls); the normalization of this parameter on day 7 after exposure was followed by another increase. The free insulin level was decreased significantly 24-48 hr after exposure, and increased significantly 7-14 days after exposure. The hepatic glycogen level was decreased significantly during the first 24 hr after exposure, and was normal thereafter. The blood glucose level showed no significant change. These findings indicate the development of relative insulin deficiency after single-time exposure. Following repeated exposure, both the overall serum insulin activity and the free insulin level and the liver glycogen level were decreased significantly, and the blood glucose level was increased significantly; these findings are indicative of absolute insulin deficiency. The considerable increase in the insulin activity following single-time exposure was interpreted as an important component of the adaptive reaction of the body to compensate for the neuroendocrine and metabolic shifts observed. The more deep-going changes seen following repeated exposure were closely linked to the derangement of carbohydrate and energy metabolism.

6174 COMPARATIVE ASSESSMENT OF THE EFFICACY OF SEDUXEN AND CYCLODOL, AND THEIR COMBINATION WITH ELECTROPULSE TREATMENT FOR INCREASING THE RESISTANCE TO EXPERIMENTALLY INDUCED MOTION SICKNESS. *(Rus.)* Matsnev, E. I. (Inst. Medical Biologic Problems, USSR Ministry of Public Health, USSR); Zakharova, L. N.; Polevoi, L. G. *Vestn Otorinolaringol* (2): 27-32; 1979. (29 refs)

The effects of sexuden (0.01 and 0.005 mg), cyclodol (0.004 mg), combined seduxen (0.01 mg) and cyclodol (0.004 mg), and of 1-hr electropulse treatment (500-750 Hz, current intensity 0.3-2.5 mA, galvanic component 25-30%) or its combination with seduxen (0.005 mg) or cyclodol (0.004 mg) on resistance to motion sickness induced experimentally by Coriolis acceleration were studied in 30 normal men aged 24-36 yr. Preliminary experiments had demonstrated that electropulse treatment inhibited caloric nystagmus. Only when the two drugs were administered in combination was there a significant increase in the resistance to motion sickness. The effect of the drugs was enhanced by electropulse treatment. The effect of the electropulse treatment can be explained by the stimulation of the hypothalamus and limbic structures.

6175 IMMUNOLOGIC EFFECT OF MICROWAVES. *(Rus.)* Shandala, M. G. (A. N. Marzeev Kiev Scientific Res. Inst. General and Communal Hygiene, Kiev, USSR); Vinogradov, G. I. *Gig Sanit* (10): 34-38; 1978. (5 refs)

Recent studies performed in the USSR on the immunologic effects of super high frequency (SHF) radiation in experimental animals are reviewed. The effect of 30-day exposure to SHF fields (1-50 $\mu W/cm^2$) on the phagocytic reaction of the neutrophils and on the serum complement titer was studied in guinea pigs. The microwaves were found to stimulate phagocytosis, especially in animals exposed to low doses. The serum complement titer was increased significantly even 4 wk after the end of the treatment, especially in the groups treated with low doses. The exposure of albino rats and guinea pigs to a 50 $\mu W/cm^2$ SHF field caused significant increases in the number of plaque-forming cells, basophil degranulation, and in the percentage of damaged neutrophils. Studies on the joint effects of microwaves and environmental pollutants (formaldehyde, carbon monoxide) showed that in the presence of a non-allergenic chemical substance, the end effect is determined by the intensity of the microwave exposure (no autoallergenic effect is seen at low intensity), while the irradiation of animals pretreated with chemical allergens leads to a suppression of the immune

reactivity and of allergic reactions. Low-intensity irradiation does not eliminate the effect of chemical allergens.

6176 MICROWAVE RADIATION AND CHLORDIAZEPOXIDE: SYNERGISTIC EFFECTS ON FIXED-INTERVAL BEHAVIOR. *(Eng.)* Thomas, J. R. (Behavioral Sciences Dept., Naval Medical Res. Inst., Bethesda, MD 20014); Burch, L. S.; Yeandle, S. S. *Science* 203 (4387): 1357-1358; 1979. (7 refs)

The effect of low intensity (1 mW/cm^2) pulsed microwave radiation (2.45 GHz, 2-μsec pulse width, 500-Hz pulse repetition frequency) on chlordiazepoxide-modified fixed-interval behavior was studied in four male Long-Evans hooded rats. The animals were exposed to microwave radiation immediately after drug administration for a 30-min period. Behavioral effects were measured during the 1st hr after termination of the 30-min radiation exposure. All exposures were conducted under near-field conditions with the subjects located 3.75 wavelengths from the antenna. Microwave irradiation potentiated the response-rate increasing effects of chlordiazepoxide, while the general shape of the drug dose-effect functions remained relatively constant under microwave irradiation. These results indicate that brief exposure to low-intensity pulsed microwave radiation can act synergistically with another agent in affecting the behavior of an organism, although the mechanism of interaction is not clear.

6177 RADIOFREQUENCY RADIATION ALTERS THE IMMUNE SYSTEM: MODULATION OF T- AND B-LYMPHOCYTE LEVELS AND CELL-MEDIATED IMMUNOCOMPETENCE BY HYPERTHERMIC RADIATION. *(Eng.)* Liburdy, R. P. (Radiation Sciences Div., U.S. Air Force Sch. Aerospace Medicine, Brooks Air Force Base, TX 78235). *Radiat Res* 77(1): 34-46; 1979. (25 refs)

The time course of radio frequency radiation (RFR, 26 MHz)-induced lymphopenia in C57BL/6 ($H\text{-}2^b$) and Balb/c ($H\text{-}2^d$) mice was characterized for single and multiple RFR exposures. In addition, the effects of RFR on thymus-dependent and -independent lymphocyte frequency in the spleen and on cell-mediated immunity were investigated. Whole-body exposure of RFR (26 MHz, 800 MW/cm^2, 5.6 W/kg, raising core temperature by 2 C) induced lymphopenia and neutrophilia that persisted for 12 hr. Maximal lymphopenia, obtained in mice given three hyperthermic RFR exposures, persisted for >15 hr after treatment. Mice exposed to a single RFR dose recovered in 6 hr as compared to 12 hr for mice receiving multiple doses. RFR-induced lymphopenia was accompanied by an increase in splenic T- and B-lymphocytes that was more pronounced after three RFR exposures given at 3-hr intervals. Multiple RFR exposures also led to a significant decrease in thymic weight and thymic and splenic cell density and to suppressed cell-mediated immunity (measured by in vivo local delayed-type hypersensitivity). Warm air exposure (41 C to produce a 2 C core temperature rise in 15 min) increased B-lymphocyte levels, but produced no change in local delayed-type hypersensitivity. To quantitate the degree of stress associated with RFR treatments, plasma corticoid levels and thymus and spleen weight and cell density were measured immediately following thermogenic RFR. Plasma corticoid levels in animals given single or chronic (20 times) RFR exposure were increased by threefold and thymic weight and splenic and thymic cell density in chronically exposed mice were markedly reduced compared to warm air or sham controls. To determine if the steroid-induced effect was qualitatively similar to that observed with RFR, 4 mg/kg methyl prednisolone sodium succinate was injected intraperitoneally. Lymphopenia, increased splenic B- and T-lymphocyte frequency, and thymic involution were observed along with reductions in thymic weight and splenic and thymic cell density after 2 days. The results demonstrate that hyperthermic RFR produces significant alterations in lymphocyte distribution and function. The RFR effect on cell-mediated immunity may be mediated indirectly through steroid-associated actions.

6178 ELECTRICAL WIRING CONFIGURATIONS AND CHILDHOOD CANCER. *(Eng.)* Wertheimer, N. (Dept. Preventive Medicine and Community Health, Box C-245, Univ. Colorado Medical Center, 4200 E. Ninth Ave., Denver, CO 80262); Leeper, E. *Am J Epidemiol* 109(3): 273-284; 1979. (19 refs)

The relationship of excess wiring configurations suggestive of high-current flow to the childhood cancer mortality rate of the greater Denver, Colorado area was analyzed. Cancer data were collected for 344 children who died before 19 yr of age between 1946-1973 and who either remained at the same address for life (109 children) or moved, but whose birth and death addresses were known (147), and for those with only birth (16) or death (72) addresses available. Maps of the addresses denoting the electrical wires and transformers in the vicinity were drawn. The most striking difference between the cases and controls (children from homes not near high-current flow) occurred for children spending their entire life at one address; the effect appeared to be dose-related. The greater the exposure to the current, the greater the excess of cancer in comparison to controls that was observed: substations with very high expected current showed 100% with cancer; other high current configurations (HCC) with high expected current, 63.1%; low current configurations (LCC) with low expected current, 47.1%; and end poles with very low expected current, 30.8%. An excess of cancer cases compared to controls with respect to HCC was noted for several types of cancer (e.g., leukemia, lymphoma, and nervous system tumors), suggesting that HCC may hinder the body's general ability to resist cancer. There was a significant excess of cancer among men with a lower current configuration for the birth than the death address and among men from stable (i.e., lifetime) addresses who developed cancer after at least 1 yr of postnatal life at a residence near primary wires. The HCC-cancer relationship was demonstrated in both younger and older subjects and was largely attributed to the HCC residence near

the time of cancer onset. Neighborhood, street congestion, social class, or family structure had no significant effect on the HCC-cancer mortality rates. Although the reason for the correlation between HCC and childhood cancer is unknown, it is suggested that the current in water pipes or the alternating current of magnetic fields may have hazardous physiologic effects.

6179 MICROWAVE DIATHERMY: THE INVISIBLE HEALER. *(Eng.)* Greene, J. (Food and Drug Admin., Office Public Affairs, Rockville, MD 20857). *FDA Consumer* 13(1): 7-11; 1979. (0 refs)

The medical use of heat produced by microwave radiation (microwave diathermy) is reviewed. Microwave diathermy can induce a deep-heating effect in muscles as much as 2 inches below the skin and can raise the temperature of the area treated to as much as 42 C. Microwave diathermy is used in the treatment of muscle pulls and strains, bursitis, tendonitis, and arthritis. The FDA estimates that about 10,000 such units are being used in the United States by chiropractors, physical therapists, family physicians, and various medical technicians. However, the FDA cautions consumers to check with qualified medical experts before undergoing any microwave diathermy treatment. Radiation from these applicators has been known to cause cataracts in patients being treated for sinus conditions. The possibility also exists that a patient being treated for a neck or shoulder injury could be subjected inadvertently to stray radiation in the eyes. In addition, painful and even severe burns of the skin and underlying tissue can occur if too much radiation is delivered to the area being treated or if the exposure duration is too long. The FDA plans in 1979 to publish a proposed regulation establishing a performance standard for microwave diathermy units that is based on the Agency's overall investigation of these medical devices. The standard will cover four important use areas that the FDA thinks will improve their safety and effectiveness. The areas are minimum therapeutic heating, maximum microwave radiation leakage, product interlocks and controls, and user information. The maximum microwave radiation leakage provision would ban applicators that generate large amounts of stray radiation outside the intended treatment area but would permit a nominal amount of leakage about 2 inches from the outer edge of the various applicators when used on phantoms. Once the standard is published, manufacturers will have 1 yr to comply with its technical specifications and labeling requirements. The FDA can take legal action to remove from the market microwave diathermy units currently in use or manufactured before the standard if they are found to pose a significant health hazard under the Agency's Medical Device Amendments of 1976.

6180 CURRENT STATUS OF MICROWAVE THERMOGRAPHY FOR MEDICAL APPLICATIONS. *(Eng.)* Schultz, S. (Dept. Physics, Univ. California, San Diego, La Jolla, CA 92093). *IEEE Trans Nucl Sci* NS-26(2, part 2): 2722-2723; 1979. (4 refs)

The physical processes involved in microwave thermography of the human body are described and the problems associated with the determination of the volume temperature of the body are discussed. In addition, some possible biomedical uses of microwave thermography are presented. Microwave thermography of the human body is based on the measurement of infrared radiation emitted by the human body over a continuous frequency, from which the absolute temperature may be inferred. The electromagnetic absorption properties of water determine the absorption length (or penetration depth) of the body's thermal radiation. Since the penetration depth is less than 1 mm at infrared frequencies, conventional thermography can only determine the surface or skin temperature. A technique that uses much lower frequencies, 1-10 GHz, to determine the body's radiation temperature has recently been implemented. Since penetration depth increases significantly with lower frequencies, temperature "hot spots" or anomalies may be detected in regions several centimeters below the skin. However, technical problems, such as impedance matching and receiver sensitivity, and spatial resolution of temperature mapping must be solved before microwave thermography will be useful for determining the thermal radiation from a specific region of the human body. Microwave thermography has been used under clinical conditions to screen approximately 3,000 women for breast anomalies at 3.3 GHz and 1,000 women at 1.3 GHz. Anomalies were determined by comparing the magnitude of the temperature asymmetry between corresponding locations on the right and left breast. With an asymmetry threshold of 1.3 C at 1.3 GHz, the true positive and the true negative probabilities were 0.76 and 0.63, respectively; these results are comparable to those obtained with infrared thermography. Microwave thermography is a noninvasive technique that does not expose the patient to any radiation or harmful effects. Other medical problems may benefit from the noninvasive determination of volume temperature, such as, vascular congestion, internal infection, hypothermia as applied in cancer treatments, and energy deposition monitoring.

6181 THRESHOLDS FOR PHYSIOLOGICAL EFFECTS DUE TO RF AND MAGNETIC FIELDS USED IN NMR IMAGING. *(Eng.)* Budinger, T. F. (Donner Lab., Univ. California, Berkeley, CA 94720). *IEEE Trans Nucl Sci* NS-26(2, part 2): 2821-2825; 1979. (52 refs)

The biologic effects of radio frequency (RF) heating, static magnetic fields, and electric current induction due to rapid changes (dB/dt) induced by nuclear magnetic resonance (NMR) body imaging were investigated. Heating, the major effect of RF fields on the body, is not associated with any serious health hazards provided the average power densities do not exceed 10 mW/cm^2 for 30 min. The safety level established by OSHA of 10 mW/cm^2 for 10 MHz-100 GHz averaged over 6 min is based on the concept that the electro-

magnetic heat load should not exceed man's basal metabolic rate. However, Russia and Eastern European countries have lower limits for safety that are based on central nervous system and behavioral responses. Static fields below 0.5 tesla (T) should be tolerated without ill effects. However, this standard has not been confirmed and no well-defined epidemiologic study with a sufficiently large population of exposed individuals showing the integrated effects of magnetic field exposure of levels >0.5 T has been undertaken. Current densities of 3 $\mu A/cm^2$, produced by rapid changes in magnetic fields of 3 T/sec, should not cause any biologic effects. However, wave form, energy, dose rates, and time intervals must also be considered when assessing the physical stimulation of biologic systems by electric current induction, particularly if a dB/dt of >3 T/sec is applied. Safe NMR imaging is possible if time varying fields such as 1.5 mT (15 G) at 60 Hz are used. In conclusion, NMR imaging should not produce health hazards if RF power densities are less than 10 mW/cm^2, static magnetic fields are less than 0.5 T, and the temporal variation of fields is less than 3 T/sec.

6182 RF USED TO FIGHT CANCER. *(Eng.)* Brinton, J. B. (No affiliation given). *Electronics* 52(9): 88-90; 1979. (0 refs)

The use of radio frequency (RF) hyperthermia in experimental cancer therapy is reported. The technique is based on the fact that normal tissue is capable of dissipating more heat than tumor tissue; the heat generated in cancer cells causes changes in cellular pH and other factors that can kill the cancer cells. In one clinical trial 27.12-MHz RF heating (42.2 C) was used for 30 min just prior to radiation therapy (RT) for the treatment of malignant melanoma, a tumor resistant to ionizing radiation. At 6 mo after this combined therapy, 16 of 18 tumors in 9 patients had completely responded in contrast to only 1 of 8 tumors in patients treated with radiation only. Two factors inhibiting the development of RF hyperthermia in cancer therapy are a lack of firm research results based on well-controlled experiments and a paucity of RF hyperthermic equipment. A system especially developed for RF hyperthermia research has recently been introduced that uses a microprocessor-controlled RF generator that operates over a frequency range from 10-2,500 MHz. Temperature is measured in the tumor with nonmetallic thermistors whose output is fed to a microprocessor that in turn controls RF output. Temperature is controlled to within ±0.1 C.

6183 HYPERTHERMIA - 'HOTTEST NEWS IN CANCER THERAPY.' *(Eng.)* Leff, D. N. (No affiliation given). *Med World News* 20(10): 52-53, 57-58, 60, 65, 69; 1979. (0 refs)

The use of microwave and shortwave radio hyperthermia for cancer therapy is reported. Based on the fact that cancer cells are more sensitive to heat than normal cells, hyperthermia is being used to selectively destroy tumors. In one case, a 54-yr-old woman with three surface nodules that grew at the scar site 6 yr after a radical mastectomy was treated with 10 40-min applications of 2,450-MHz microwave energy. Tumor temperatures reached 43-45 C. At the end of her twice-weekly hyperthermia sessions, the nodules had disappeared; however, 4 wk later all three recurred, though only at the margins. Central areas of necrosis were healed. At least a 90%-plus response to treatment was observed in another patient who was treated with hyperthermia in combination with drugs and ionizing radiation for a bleeding vaginal leiomyosarcoma. In general, microwave hyperthermia is used only for small skin surface or subcutaneous tumors because of the inability of microwaves to penetrate more deeply into the body. However, tests with shortwave radio hyperthermia at a frequency of 13.56 MHz indicate that this modality is capable of elevating the temperature of a tumor of any size and anywhere in the body to 50 C. Radio frequency hyperthermia appears to be theoretically ideal for large sarcomas that keep growing despite surgery, irradiation, and chemotherapy. To date, 75 malignancies in 64 patients with large sarcomas, melanomas, and other diseases that had failed standard therapy have been treated with radio frequency hyperthermia; marked tumor necrosis has been observed in about half of these patients, and there have been a few remarkable remissions.

6184 MICROWAVES HELP DETECT TUMORS. *(Eng.)* Hindin, H. J. (No affiliation given). *Electronics* 52(8): 85-86; 1979. (0 refs)

The use of microwave radiometers for the detection of breast cancer is discussed. Cancerous tissue is usually accompanied by an increase in local temperature of a few degrees. This radiation can travel through human tissue for distances up to several centimeters, and it can also escape from the body if its source is close enough to the surface. Once out, the radiation is readily detected by present-day microwave radiometric receivers. Thus, noninvasive scanning of a patient's natural microwave emissions can be used to locate possible cancerous hot spots. Microwave detection at frequencies of 1.3 and 3.3 GHz has been used in clinical tests, and it has been demonstrated that microwave scanning in combination with infrared thermography can detect as many cancers as X-rays alone and has the same true negative rate. Both the 1.3- and 3.3-GHz radiometers are comparison-type superheterodyne receivers with a 100-MHz intermediate frequency bandwidth centered at 60 MHz. The input to the first-stage tunnel-diode amplifier is switched at an 8-Hz rate between the antenna that picks up the human body radiation and a matched load whose temperature is controlled by a thermoelectric refrigerator. Tests funded by the NIH are being conducted on the properties of millimeter microwave thermography (11 and 30 GHz), and clinical trials of millimeter systems combined with conventional infrared and mammograms are being conducted at Denver's Swedish Hospital. In Europe, a group from Phillips GmbH in Hamburg, West Germany is performing 2-GHz examinations at a breast cancer detection

clinic in Strassburg, France. Their system features real-time compensation for variable antenna-skin interface energy reflections.

6185 A HISTOPATHOLOGIC STUDY ON THE EFFECTS OF RADIOFREQUENCY THERMOTHERAPY ON MALIGNANT TUMORS OF THE LUNG. *(Eng.)* Sugaar, S. (Dept. Surgery, State Univ. New York, Downstate Medical Center, Brooklyn, NY); LeVeen, H. H. *Cancer* 43 (2): 767-783; 1979. (42 refs)

Histologic alterations of malignant lung tumors in three patients treated by repeated local radio frequency (RF) heating are reported. All patients were heated by the dielectric method using 13.56-MHZ RF radiation. Short bursts of power were sequentially switched to different electrode pairs that continuously heated the cancer but avoided overheating the skin. In addition to expected tumor cell degeneration, changes in the tumor's stroma were also observed after RF heating. Stromal blood capillary walls were massively infiltrated with round cells and underwent degenerative changes leading to necrosis and obliteration of the tumor's vascular supply. Extensive infiltration of the stroma with the host's round cells also occurred. Following focal necrosis and rupture of the stroma, pools of lymphocytes established direct contact with heat damaged malignant cells, leading to further destruction of persisting tumor. The histologic evidence of widespread necrotic changes of all histologic elements of the tumor's stroma and a reduction and widespread destruction of still recognizable but obviously nonviable nests of tumor alveoles was best seen in the most central area of the large tumor mass. The histopathologic changes induced in solid tumors by local RF thermotherapy appeared to be similar to histologic changes occurring in acute allograft rejection. This similarity has not been noted following other treatment modalities in cases of spontaneous human or animal malignant tumors.

6186 THE USE OF 2450 MEGAHERTZ OF MICROWAVE IN CANCER THERAPY. *(Eng.)* Luk, K. H. (Dept. Radiation Oncology, Claire Zellerbach Saroni Tumor Inst., Mount Zion Hosp. and Medical Center, P.O. Box 7921, San Francisco, CA 94120); Baker, D. G.; Purser, P.; Castro, J. R.; Manuel, F. *Phys Ther* 59(4): 405-408; 1979. (9 refs)

Preliminary results of a pilot study on microwave-induced hyperthermia (average 42.5 C) for the treatment of 26 patients with superficial tumors are reported. Local tissue hyperthermia was induced using a microwave unit operating at 2,450 MHz with a maximum power of 125 W. From December 1976 to June 1977, 28 courses of hyperthermia were given. Ten of these courses were hyperthermia treatment alone; 18 were combined with radiation therapy. The entire procedure of tissue hyperthermia normally lasted about 90 min. Generally, the induction phase of the heating occurred within 5 min, with the temperature rising from 36.0 C to 41.7 C. The treatment was then given for another 60 min. Minor fluctuations in the recorded temperature ranged from 41.7 C to 43.5 C. At the end of the treatment course, the thermal washout was recorded for 3 min and the temperature dropped from 43.5 C to 38.6 C. Whole body temperature was not significantly elevated (<1 C), as measured by an oral mercury thermometer placed under the tongue for 5 min before and after hyperthermia treatments. When the applicator of the microwave unit was directed over major blood vessels, the potential for the temperature to rise was greater. Twenty-six courses of treatment were evaluated. Local tumors showed an improved response rate to the tissue hyperthermia alone, as well as to tissue hyperthermia combined with radiation therapy. There were 7 complete responses, 11 partial responses, 5 minimal responses, and 3 with no response. In addition to objective evaluation of tumor responses, 70% of the patients reported palliation of pain, decreased or controlled bleeding, reduction of oozing and crust formation, and decreased foul odors concurrent with tumor regression. Blistering occurred in seven patients; two of these patients suffered third-degree burns in the fat layer, which required debridement of eschar and frequent dressing change. These burns resulted from transient rise in temperature to more than 44 C for more than 10 min. One patient developed a cellulitis, which was treated successfully with oral antibiotics. Two patients had massive tumor necrosis, leaving large open ulcers that required a long time to heal. The occurrence of such complications underlines the necessity of medical team care for patients receiving hyperthermia treatment.

6187 THE CAUSE OF CANCER: BIOCHEMICAL DEFECTS IN THE CANCER CELL DEMONSTRATED BY THE EFFECTS OF ELECTROMAGNETIC RADIATION, GLUCOSE AND OXYGEN. *(Eng.)* Holt, J. A. (190 Cambridge St., Wembley, Perth 6014, West Australia, Australia). *Med Hypotheses* 5(1): 109-143; 1979. (17 refs)

Studies of the effects of very-high-frequency (VHF) radiation on cancer patients are discussed in relation to the mechanism of carcinogenesis. High intensity VHF (over 50 mW/cm^2) can cause cancer cells to die from thermal and/or nonthermal effects. Low intensity VHF (below 10 mW/cm^2) can stimulate the rate of growth of many common cancers and alter the microscopic appearances of the cancer. During and shortly after such irradiation, the cancer cells produce progeny that reveal a more primitive, less differentiated form with suppression of whatever sophisticated somatic characteristics their ancestors may have formerly exhibited. Normal adult cells are not macroscopically or microscopically altered by VHF at any intensity up to 150 mW/cm^2, making VHF a unique tool to show the differences between cancer cells and histologically similar normal cells. Studies on the effects of applying 434-MHz VHF radiation to cancers and normal tissues while they were normo- or hypoglycemic and simultaneously oxygenated or anoxic demonstrate that each human cell contains at least two separate respiratory pathways that can convert glucose to

energy. The first pathway produces energy by an anaerobic mechanism and it can be demonstrated that this energy is used for cell replication. The second pathway(s) produces energy from glucose by aerobic oxidative processes that can be shown to energize other cellular functions, including that of controlling cell division. Release of the anaerobic system from supervisory control of the aerobic system permits unlimited cell division, which is characteristic of cancer. Circumstantial evidence suggests that this is not the result of nuclear or chromosomal defects or mutations but is due to direct irreversible sublethal damage to the cellular aerobic glucose metabolic system while the anaerobic system remains intact.

6188 SELECTIVE OCCLUSION OF TUMOR TISSUE CAPILLARIES BY HYPERTHERMIA SHOCK DURING HYPERGLYCEMIA. *(Ger.)* von Ardenne, M. (Forschungsinstitut Manfred von Ardenne, Zeppelinstr. 7, DDR-8051 Dresden, E. Germany). *Dtsch Gesundheitsw* 33(45): 2158-2159; 1978. (14 refs)

The effect of local hyperthermia on erythrocytes was studied in capillaries of DS carcinomas of 20 rats in connection with investigations on the effects of hyperthermia and hyperacidification of tumor tissue by glucose infusion in cancer multistep therapy. The tumor pH was adjusted to 6.1. A 8-kW high-frequency generator with moving applicator (CMT Selectotherm unit) was used to generate hyperthermia (41 C). Due to the highly homogeneous energy supply, it was possible to induce hyperthermia shocks by 2-4 C at a rise time of 3-6 min. The temperature peak was maintained for 5-15 min. Hyperglycemia caused a total loss of flexibility of the erythrocyte membrane, which, combined with the local hyperthermia, led to a total stoppage of microcirculation at the venous capillary end in the carcinosarcoma. The terminal section of the tumor capillaries was found to be more sensitive to hyperthermia and hyperacidification than the tumor cells supplied by the capillary network.

6189 INTRACELLULAR HYPERTHERMIA: A BIOPHYSICAL APPROACH TO CANCER TREATMENT VIA INTRACELLULAR TEMPERATURE AND BIOPHYSICAL ALTERATIONS. *(Eng.)* Gordon, R. T. (4936 W. Estes, Skokie, IL 60077); Hines, J. R.; Gordon, D. *Med Hypotheses* 5(1): 83-102; 1979. (21 refs)

The use of intracellular hyperthermia for the destruction of cancer cells is described. Submicron particles were colloidally suspended, injected intravenously, and were phagocytized by cancer cells. Application of an external high frequency or pulsed electromagnetic field then raised the particles' temperature, thus generating intracellular heat in precise increments and resulting in selective thermal destruction of the cancer cells with little effect on normal cells. Sprague Dawley rats bearing spontaneous mammary tumors were given intravenous injections of iron-containing particles and 48 hr after the last injection were exposed to a 450-kHz electromagnetic field for 12 min. Tumor necrosis was seen in 11 of 12 animals treated in this manner. In the animals where tumor cells were destroyed, normal tissues were histologically unchanged, even when particles were found in these tissues. There was no uptake of particles in the bone marrow, and the treatment had no effect on either bone marrow or on surrounding connective tissue. It is suggested that the sensitivity and affinity of cancer cells for these particles may be increased by the use of specific radioisotopes or tumor specific antibodies bound to such particles or to chemotherapeutic microspheres.

6190 BIOLOGIC EFFECT OF PERMANENT MAGNETIC FIELD ON THE HEMATOPOIETIC SYSTEM OF INTACT AND TUMOR-BEARING ANIMALS. *(Rus.)* Savchik, A. B. (Lvov Inst. Hematology and Blood Transfusion, Lvov, USSR); Savchuk, L. F.; Ivasivka, S. V.; Savchik, B. A. *Probl Gematol Pereliv Krovi* 24(3): 58-60; 1979. (6 refs)

The effect of exposure to a permanent electromagnetic field (16 kA/m, 1 hr/day on 2 consecutive days) on the hematopoietic system was studied in intact male albino mice and mice with transplanted subcutaneous solid Ehrlich's carcinoma and intramuscular lymphoma NK/Ly. A total of 132 animals was used in the experiments. The hematologic changes were studied on the day after the second exposure. In the intact controls, the irradiation caused significant decreases in the Hb level, erythrocyte and thrombocyte counts, and a significant increase in the reticulocyte count. In the animals with NK/Ly, the Hb level decreased from 12.6 g% before exposure to 8.7 g% ($p<0.001$), the erythrocyte count from 9,300,000/µl to 6,800,000/µl ($p<0.01$), the leukocyte count from 27,000 to 13,600/µl ($p<0.05$), and the thrombocyte count from 278,400 to 81,200/µl ($p<0.001$). In the mice with Ehrlich's carcinoma, the Hb level decreased from 13.98 g% to 8.97 g% ($p<0.001$), the erythrocyte count from 9,830,000/µl to 7,710,000/µl ($p<0.05$), and the thrombocyte count from 453,400 to 159,700/µl ($p<0.001$), and the reticulocyte count increased from 4.918% to 11.24% ($p<0.001$). The leukocytes of the controls as well as those of the animals with Ehrlich's carcinoma were not affected by the exposure.

6191 INVESTIGATIONS OF THE SHAPE TRANSITIONS OF HUMAN ERYTHROCYTES IN AN OUTER MAGNETIC FIELD. INFLUENCE OF TEMPERATURE AND ALBUMIN. *(Eng.)* Leitmannova, A. (Sektion Biologie, Bereich Biophysik, Humboldt Universitat, Hessische Str. 3/4, 104 Berlin, E. Germany); Bilke, C.; Lerche, D.; Stoesser, R.; Glaser, R. *Stud Biophys* 72(2): 85-90; 1978. (13 refs)

The influence of temperature, human serum albumin (HSA), and magnetic field on human erythrocyte shape transition was studied. For temperature studies, ACD blood (1- to 2-day old; A, Rh+) was diluted to a 0.1% hematocrit with Krebs Ringer solution and subjected to temperatures from 20 to 48 C for up to

10 min while the magnetic field strength was varied from 1 to 11.0 kOe. For albumin studies, the blood was diluted to a 0.1% hematocrit with phosphate-buffered sodium chloride solution (PBS) and HSA while the temperature and magnetic field strength were maintained at 37 C and 1 kOe, respectively. Only the shape transition of echinocytes adhering to the surface of the glass chamber into discocytes and stomatocytes was observed. Neither discocytes nor stomatocytes underwent any transition under a magnetic field of 1.0-11.1 kOe. No significant dependence of shape transition on magnetic field strength was observed from 20-35 C. Shape transitions occurred above 35 C; however, at temperatures >35 C, thermally-induced shape transition accounted for some of the increased transition. At 37 C, there was no significant difference between Ringer solution and PBS incubations with respect to shape transition. HSA-incubated PBS-diluted cells showed increased shape transitions in comparison with control blood diluted with PBS only. The results demonstrate that both temperature and HSA affect the membrane structure or cell interior, which leads to echinocyte shape transition. Both of these effects are amplified by exposure to an outer magnetic field.

6192 EFFECT OF A HOMOGENEOUS MAGNETIC FIELD ON RED BLOOD CELLS: A CELL ELECTROPHORETIC STUDY. *(Fre.)* Bellossi, A. (Service de Physique Medicale, U.E.R. Clinique et Therapeutique Medicales, avenue du Pr L. Bernard, 35043 Rennes, France); de Certaines, J. *Biol Cell* 33(3): 263-264; 1978. (11 refs)

The effect of a 2-hr exposure to a homogeneous magnetic field (5,000 G) generated by an electromagnet on the electrophoretic mobility of erythrocytes was studied in 92 blood samples from 92 healthy blood donors (68 men and 24 women, average age 44 yr). Thirty-five donors were blood group O, 34 blood group A, 5 blood group B, and 5 blood group AB. The blood group was not determined in 13 cases. Fifty-six donors were Rh-positive, 18 Rh-negative; the others were not identified. The exposure increased the electrophoretic mobility of the erythrocytes in 41 cases, and decreased it in 41. An increase in electrophoretic mobility was seen in 24/68 men, 17/24 women, 10/35 donors of blood group O, and in 22/34 donors of blood group A. The electrophoretic mobility was reduced by 65% in the men and increased by 71% in the women, and it was reduced by 71% in the donors of blood group O and increased by 65% in blood group A donors. The differences between men and women and those in blood groups O and A were statistically significant ($p<0.01$) as to the extent of the change, but there were no significant differences in the distribution of increase and decrease as to age, sex, blood group, and Rh factor.

6193 PHENOMENON OF MIGRATION AND SEDIMENTATION OF ERYTHROCYTES INDUCED BY MAGNETIC FIELDS. *(Eng.)* Porath-Furedi, A. (Dept. Biological Chemistry, The Hebrew Univ., Jerusalem, Israel); Yanai, P. *J Histochem Cytochem* 27(1): 371-374; 1979. (2 refs)

Suspended erythrocytes were exposed to static and to moving nonhomogeneous magnetic fields to investigate the effect of such fields on erythrocyte migration and sedimentation. In experiments with static weak magnetic fields, erythrocytes became more concentrated along the edges of the magnetic poles than in the rest of the container. The sedimentation was affected by the chemical state of the hemoglobin and by the geometry of the field. In an experimental system in which the erythrocytes had been previously oxygenated, the cells sedimented on the bottom of the container homogeneously; in a system in which the erythrocytes were deoxygenated, the sediment layer became dense closest to the edges of the magnetic poles beneath. In several different experiments in which the shape of the magnetic poles was different, the applied magnetic field resulted in a sedimentation pattern in which the density of the sedimented cells was highest at the points of greatest magnetic field density. Another series of experiments was carried out in which the induction of electric currents was based, not on the Brownian motion of the erythrocytes in a stationary magnetic field but rather on the effect of a magnetic field rotating rapidly. As this treatment separated the suspended cells while the suspension was moving in the direction of the inducing field, it was concluded that the moving magnetic field is able to cause or to direct motion of the cells in suspension. The disappearance of the phenomenon at a lowered but constant temperature showed that induced temperature rise is a prerequisite of the separation and directive cell motion. Added grains of dye revealed streaming in the system in the direction of the motion of the magnetic field, whereas in a cell-free system no such streaming was detected. In both the stationary magnetic field and in the moving magnetic field systems, the directing factor was the anisotropic Brownian motion caused by induced electric currents. In the stationary system, this restricts the particles to oscillations along the field, aided by the very weak magnetic attraction and by the force of gravity, bringing them to the magnetic poles. In the system with the magnetic field in motion, the cells are repelled from the magnetic poles to the farthest possible point. During this process, cell fractionation occurs, leaving above cells that are smaller than those in the bulk; at the same time, the force of gravity reduces by sedimentation the number of cells still in suspension.

6194 CHANGES IN THE BLOOD COUNT OF GROWING RATS IRRADIATED WITH A MICROWAVE PULSE FIELD. *(Eng.)* Pazderova-Vejlupkova, J. (Klinika nemoci z povolani, Vysehradska 49, 128 21 Praha 2, Czechoslovakia); Josifko, M. *Arch Environ Health* 34(1): 44-50; 1979. (12 refs)

Changes in the blood count of growing rats were investigated in 20 male rats *(Rattus norvegicus,* f. albus, Wistar strain, Konarovice breed) irradiated for 7 wk (5 days/wk, 4 hr/day) with an electromag-

netic pulse field of the following parameters: working frequency 2,736.5 MHz; repeated frequency 395 Hz; pulse width 2.6 μsec; vertical polarization; mean power density 24.4 mW/cm^2; accuracy of measurement ±6%. During irradiation the animals were placed singly in perforated Plexiglas boxes situated above each other according to equal power density planes. A group of 20 control rats was also placed singly in Plexiglas boxes in the irradiation room but outside the electromagnetic field. The rectal temperature was measured in a selected group of rats before exposure and at 1-hr intervals during irradiation. Blood samples were taken before the onset of irradiation, and others were collected at the end of wk 1, 3, 5, and 7 of irradiation and at the end of wk 1, 2, 6, and 10 after termination of the exposure. Rectal temperatures rose during irradiation, with a maximum after 3 hr. The mean temperature rise was 0.3 C, the maximum increase was 0.5 C, as compared with the initial level. Prior to irradiation, experimental animals had a higher mean body weight than did controls. This statistically insignificant difference disappeared in wk 3 of irradiation, and the body weight increase of the controls began to consistently exceed that of the experimental animals. The difference attained a significant level in wk 1 after the termination of exposure. The mean hematocrit value of the experimental animals was somewhat higher before irradiation than that of the controls. Beginning with wk 3 of irradiation, experimental animals exhibited a statistically significant reduction of hematocrit values that persisted even after termination of irradiation and finally disappeared in the last sampling, i.e., 10 wk after irradiation. The mean number of leukocytes was insignificantly lower in experimental rats than in controls. Beginning in wk 3 of irradiation this difference disappeared, but a significant decrease in the leukocyte count of irradiated animals occurred from wk 5 of irradiation on. This significantly lower leukocyte count persisted even after irradiation and disappeared only after 10 wk. The mean value of the absolute count of neutrophil leukocytes in irradiated animals was lowered only in the last week of irradiation. Statistical evaluation revealed no significant differences in the percentage proportion of the individual elements of the white blood count. Alkaline phosphatase activity showed a statistically significant transient increase at the end of wk 1 of irradiation and a transient drop immediately after irradiation. The results indicate that a microwave pulse field of given intensity affects both the white and red blood count in peripheral blood in its volume component. However, it is not clear if the growing organism is more sensitive to microwave radiation than the adult one since no analogous experiment has been done on adult rats under identical conditions. Whether the observed changes in the peripheral blood count were caused by the thermal effect of microwaves or by other effects remains to be determined.

6195 COAGULATION PROPERTIES OF PLATELETS IN CONSTANT MAGNETIC FIELD. *(Rus.)* Rusiaev, V. F. (Dept. Physics, Poltava Inst. Stomatology, Poltava, USSR). *Probl Gematol Pereliv Krovi* 24(2): 19-23; 1979. (21 refs)

The effect of a constant magnetic field (1,200 Oe) on the coagulation characteristics of platelets was studied in blood taken from exposed dogs, and on the bleeding time in 19 human volunteers. Exposure of dogs to a constant magnetic field decreased the recalcification time from 130 sec in the controls to 113 sec ($p<0.01$), the plasma tolerance to heparin from 309 sec to 284 sec ($p<0.01$), the thrombin time from 30 sec to 29 sec ($p<0.01$), the factor XIII activity from 51 sec to 44 sec ($p<0.01$), and increased the fibrinolysis time from 29 min to 35 min ($p<0.01$), and the prothrombin consumption rate from 85 to 92 sec ($p<0.01$). The exposure also reduced the sorption of fluorochrome by the platelets and the accumulation of acridine orange, and stimulated the aggregation in the presence of adenosine diphosphate. The bleeding time of a punctured finger was reduced significantly in the volunteers from 135 sec before exposure to 108 sec. The findings indicate that the constant magnetic field caused a considerable alteration in the morphologic and functional properties of the platelet membranes.

6196 A NEW OPERATIVE PROCEDURE OF HEPATIC SURGERY USING A MICROWAVE TISSUE COAGULATOR. *(Eng.)* Tabuse, K. (Dept. Gastroenterological Surgery, Wakayama Medical Coll., 7 Bancho, Wakayama-shi, Wakayama, Japan). *Arch Jpn Chir* 48(2): 160-172; 1979. (22 refs)

Partial resection (average, 30%) of 52 liver lobes was performed on 26 rabbits with the aid of a microwave tissue coagulator in an attempt to control bleeding and bile leakage. The output power of the 2,450-MHz microwave coagulator varied from 25-65 W for 20 sec; a monopolar antenna was inserted into each parenchyma several times causing a coagulated beltlike area 10 mm in width on the parenchyma surface, with the depth determined by the length of each insertion. Transection of parenchyma was performed with a surgical knife. Complete control of bleeding and bile leakage was achieved. Autopsy performed 1 day to 6 mo postoperatively revealed satisfactory healing without infection in all animals except one. Portoangiography indicated that veins up to 3 mm in diameter could be sealed. Temperature measurements indicated that the extent of thermal damage caused by microwave energy was less than 10 mm wide from the center of the coagulated tissue. Biochemical analysis and histologic studies indicated that liver cell damage was transient and that adverse systemic effects can be avoided by proper coagulation-necrosis of liver tissue by microwave energy.

6197 RESPONSE OF STRESS-SUSCEPTIBLE AND STRESS-RESISTANT HAMPSHIRE PIGS TO ELECTRICAL STRESS. I. PHYSIOLOGICAL AND BIOCHEMICAL EFFECTS. *(Eng.)* Veum, T. L. (Dept. Animal Husbandry, Animal Science Res. Center, Univ. Missouri, Columbia, MO

65211); Ellersieck, M. R.; Durham, T. L.; McVickers, W. R.; McWilliams, S. N.; Lasley, J. F. *J Anim Sci* 48(3): 446-452; 1979. (30 refs)

Stress susceptible (SS) and stress resistant (SR) purebred Hampshire swine, weighing approximately 100 kg, were utilized to study the effects of electrical stress on plasma creatine phosphokinase (CPK), blood pH, plasma lactic dehydrogenase (LDH), plasma glucocorticoids, rectal temperature, heart rate, and respiration rate. Blood samples were obtained from jugular cannulas 15 min and 5 min pre-stress, and subsequently at 0, 5, 10, 15, 30, 60, and 120 min post-stress. The electrical stress (.05 A and 30 V) was administered intermittently (2 sec on and 1 sec off) directly on the skin at the point of the poll between the ears and on the medial side of the fore leg above the point of the elbow for a total stress time of 4 min over a 6-min period. Each pig was stressed three times with 3 days rest between stimulations. Post-stress responses ($p<.01$) were obtained over time for all the variables measured except respiration rate. Plasma CPK levels were greater ($p<.01$) for SS pigs at all the pre-stress and post-stress bleeding times. Thus, CPK may have value in differentiating between SS and SR pigs under standardized environmental (stress) conditions. The SS pigs had marked post-stress decrease ($p<.01$) in blood pH compared to SR pigs, although pre-stress blood pH was similar for both groups of pigs. Pre-stress plasma LDH levels were similar for the SS and SR pigs while several post-stress levels were greater for the SS pigs. Plasma glucocorticoid levels were similar for the SS and SR pigs at all the pre- and post-stress bleeding times. The SS pigs had a higher ($p<.05$) overall mean rectal temperature compared to the SR pigs. Both the SS and the SR pigs had elevated post-stress rectal temperatures. The heart rate of the SS pigs was higher at 0 min post-stress compared to the SR pigs while both groups were similar at the other times. Respiration rates were similar for both groups.

6198 RESPONSE OF STRESS-SUSCEPTIBLE AND STRESS-RESISTANT HAMPSHIRE PIGS TO ELECTRICAL STRESS. II. EFFECTS ON BLOOD CELLS AND BLOOD MINERALS. *(Eng.)* Ellersieck, M. R. (Dept. Animal Husbandry, Animal Science Res. Center, Univ. Missouri, Columbia, MO 65211); Veum, T. L.; Durham, T. L.; McVickers, W. R.; McWilliams, S. N.; Lasley, J. F. *J Anim Sci* 48(3): 453-458; 1979. (20 refs)

Stress-susceptible (SS) and stress-resistant (SR) purebred Hampshire pigs were used to study the effects of electrical stress (.05 A and 30 V) on the total number of red blood cells (RBC), white blood cells (WBC), neutrophils (NEU), lymphocytes (LYM), eosinophils (EOS), monocytes (MON), basophils (BAS), hematocrit (HEM), and the serum levels of sodium (Na), potassium (K), and magnesium (Mg). Blood samples were obtained from jugular cannulas 15 min and 5 min pre-stress and 0, 5, 10, 15, 30, 60, and 120 min post-stress from each pig on 3 separate days. The SS pigs had higher ($p<.01$) pre-stress levels of WBC, LYM, and K compared to the SR pigs even though the blood cannulas allowed blood collection with a minimum of stress. The post-stress WBC, NEU, EOS numbers, and K level were similar for the SS and SR pigs until 60 and/or 120 min post-stress when the levels of WBC, NEU, and K values were higher for SS pigs and the EOS number was lower for SS pigs when compared to SR pigs ($p<.05$). The LYM numbers of the SS pigs were consistently lower throughout the post-stress bleedings when compared to the SR pigs. The post-stress LYM numbers of the SS pigs at 15 min and 120 min ($p<.05$) and 60 min ($p<.01$) were lower than those of the SR pigs. The SS and SR pigs had similar MON and BAS numbers at each pre- and post-stress bleeding time comparison. The pre-stress HEM levels were similar for SR and SS pigs, although an immediate post-stress increase ($p<.01$) in HEM levels was obtained for the SS pigs, which remained to the end of the bleedings. Na and Mg levels showed no difference between SS and SR pigs over both pre- and post-stress times of bleeding ($p<.05$). However, at every bleeding time the SS pigs' Na levels were lower and the Mg serum levels were higher when compared to the SR pigs' Na and Mg serum levels.

6199 LOW POWER RADIO-FREQUENCY AND MICROWAVE EFFECTS ON HUMAN ELECTROENCEPHALOGRAM AND BEHAVIOR. *(Eng.)* Bise, W. (Pacific Northwest Center for the Study Non-Ionizing Radiation, Box 22053, Portland, OR 97222). *Physiol Chem Phys* 10(5): 387-398, 1978. (30 refs)

Temporary changes in electroencephalograms (EEG) and behavior were observed in a pilot study involving the exposure of five men and five women (ages, 18-48 yr) to radio frequency (RF) and microwave radiation at levels substantially below typical urban levels. Continuous wave (CW) RF radiation at frequencies ranging from 0.1-960 MHz and at power levels ranging from 10^{-16} to 10^{-13} W/cm^2 was delivered via a 1-m wire rod monopole antenna placed parallel to and 1 m from the upper torso and head. Pulse-modulated (2 μsec on and 6 μsec off) X-band radiation (8.5-9.6 GHz) was delivered at a power level of 10^{-12} W/cm^2 via an open waveguide 1 m from the subject and directed at the sternum. Frequencies that produced an increased amplitude of EEG alpha component, increased slow wave index, and desynchronizations included 200, 350, 360, and 365 MHz CW radiation and 9,100 and 9,150 MHz pulsed radiation. Frequencies that produced decreased amplitude of EEG alpha component, increased slow wave index, and desynchronizations ranged from 130-960 MHz for CW radiation and 9,150 MHz for pulsed radiation. Mental and behavioral changes were also noted and included short term memory impairment followed by concentration inhibition and irritability, apprehension, and mental and physical sluggishness. Brain wave alterations almost immediately reverted to their normal patterns when the generator frequency was changed or turned off. Since the relaxation frequency of protein-bound water is considered to fall between 100 MHz and 1 GHz, absorptions and quantum effects may be the mechanistic basis for the EEG changes

observed in most of the subjects. The EEG changes seen in most of the participants were produced by CW RF radiation between 100 and 960 MHz. Therefore, it is likely that resonance absorptions occurred.

6200 FUNCTIONAL ELECTRICAL STIMULATION: APPLICATIONS IN NEURAL PROSTHESES. *(Eng.)* Hambrecht, F. T.; Reswick, J. B., eds. (New York: Marcel Dekker, Inc.): Volume 3, 561 pp.; 1977. (560 refs)

A book based on selected papers and discussions from a workshop on functional electrical stimulation, held at Kellogg-West Conference Center in Pomona, California, May 17-19, 1976, is presented. The contents are divided into eight general sections covering the following: striated muscle stimulation, micturition reflex simulation, cerebellar stimulation, visual prostheses, auditory prostheses, neurophysiologic considerations, mechanisms of neural damage, and instrumentation and electrodes used for functional electrical stimulation. The book is provided with a subject index.

6201 SELECTIVE ACTION OF DECIMETER WAVES ON CENTRAL BRAIN STRUCTURES. *(Eng.)* Faitel'berg-Blank, V. R. (Dept. Pathological Physiology and Biophysics, Agricultural Inst., Odessa, USSR); Perevalov, G. M. *Neurosci Behav Physiol* 8(2): 172-176; 1977. (28 refs)

The sensitivity of some central brain structures to the action of an electromagnetic field (EMF) of decimeter waves (DW) was studied. Spike activity of 193 neurons in various brain formations (dorsal hippocampus, specific and nonspecific nuclei of the thalamus, hypothalamus, and mesencephalic reticular formation) was investigated in experiments on 29 chinchilla rabbits. The animals were irradiated with a Volna-2 physiotherapy apparatus that generates EMF within the DW range at a frequency of 460 MHz. The action of EMF with an energy flux of 2 or 5 mW/cm^2 was investigated. After irradiation of the animal's head with an intensity of 2 mW/cm^2, an increase in the discharge frequency was observed in 45.6% of the brain neurons tested, and the spike frequency decreased in 39.7% of the brain neurons tested. The activity was unchanged in 14.7% of the neurons tested. Neurons of the hippocampus and hypothalamus with an excitatory type of response had the greatest reactivity to EMF of DW; the percentage of nerve cells with an excitatory type of response to EMF was 64.3% in the dorsal hippocampus and 58.3% in the hypothalamus. The number of neurons with an inhibitory type of response to EMF was greatest in the nuclei of the thalamus and mesencephalic reticular formation. After an exposure of the animal's head to an EMF of 5 mW/cm^2, an increase in discharge frequency was observed in 43.8% of the neurons, a decrease in 41.1% of the neurons, and no response to irradiation in 15.1%. The number of excitatory neurons in the hippocampus fell by 7.2% and in the hypothalamus by 8.3%. Meanwhile an increase in the number of neurons responding by inhibition to the action of an EMF of 5 mW/cm^2 was observed. In the hippocampus the number of neurons with an inhibitory type of response was 35.7% compared with 42.9% in the hypothalamus. The smallest number of neurons not responding to the EMF was observed in these same brain structures. The dynamics of spike activity of the neurons of the dorsal hippocampus was characterized by a shorter period of after-activity than in the case of animals irradiated by an EMF of 2 mW/cm^2. The time taken for spike activity of the hypothalamic neurons to return to its original level, on the other hand, was increased by 1.5 times. These results show that exposure of the rabbit's brain to EMF of DW at different intensities gives rise to opposite changes in the unit activity of central brain structures.

6202 EFFECTS OF MODULATED RF ENERGY ON THE EEG OF MAMMALIAN BRAINS: EFFECTS OF ACUTE AND CHRONIC IRRADIATIONS. *(Eng.)* Takashima, S. (Dept. Bioengineering, D2, Univ. Pennsylvania, Philadelphia, PA 19104); Onaral, B.; Schwan, H. P. *Radiat Environ Biophys* 16(1): 15-27; 1979. (30 refs)

The effects of nonthermal levels of modulated radio frequency (RF) fields on electroencephalogram (EEG) power spectra were investigated in male rabbits receiving acute or chronic irradiations. Acute irradiation (2-3 hr) using frequencies of 1-30 MHz at power levels of 0.5-2 kV/m that were amplitude modulated at a frequency of 60 Hz produced no EEG abnormalities as long as intracranial recording electrodes, which generate strong local fields, were not used. Chronic exposure to amplitude modulated (14-16 Hz) RF fields (1-10 MHz) at a field strength of 500 V/m for 6 wk (2 hr/day) resulted in enhanced low frequency components at 4 Hz and reduced high frequency activities. This pattern began to appear after about 2 or 3 wk of exposure. Since most irradiations were performed in the absence of metal electrodes, the abnormal EEG observed was not due to local fields created by internal electrodes. An analysis of EEG power spectra histograms revealed that abnormal EEGs contained two major peaks at 2 and 10 Hz, whereas normal EEGs contained three major peaks at 4.5, 8, and 11.5 Hz. The approximate current density in the rabbit head during chronic experiments (0.082 mA/cm^2) was below that needed to cause noticeable thermal effects, and it is concluded that the mechanism responsible for the EEG abnormalities is nonthermal in nature.

6203 ELECTROCUTANEOUS NERVE STIMULATION--II: STIMULUS WAVEFORM SELECTION. *(Eng.)* Butikofer, R. (Eidgenossische Materialprufungsanstalt, Dubendorf, Switzerland); Lawrence, P. D. *IEEE Trans Biomed Eng* BME-26(2): 69-75; 1979. (28 refs)

The influence of electrocutaneous nerve stimulation parameters on tissue heating and nerve stimulation was theoretically investigated. Rectangular, sym-

metric, positive onset pulses and pulse trains were investigated using computer models for tissue heating and myelinated nerve stimulation. Based on these models the following conclusions were drawn. Minimum heating will be obtained over the full range of pulse width if the pulse separation is equal to 0 (at constant charge). For zero pulse separation the threshold charge required will be minimized at a particular value of pulse width. A unique threshold transmembrane depolarization voltage does not exist for biphasic pulse stimulation. Multiple biphasic pulses (Saunders' "Quantal Stimulation") decrease the threshold charge per pulse and thus act to increase the dynamic range of the stimulator. The methods used in this study can also be applied to other pulse shapes such as asymmetric pulses (e.g., produced by capacitive coupling of a single positive pulse), sine wave like pulses, and pulses starting with the opposite polarity.

6204 COMPARISON OF MICROWAVE IRRADIATION AT 986 VERSUS 2450 MHZ FOR IN VIVO INACTIVATION OF BRAIN ENZYMES IN RATS. *(Eng.)* Meyerhoff, J. L. (Dept. Medical Neuroscience, Div. Neuropsychiatry, Walter Reed Army Inst. Res., Washington, DC 20012); Gandhi, O. P.; Jacobi, J. H.; Lenox, R. H. *IEEE Trans Microwave Theory Tech* MTT-27(3): 267-270; 1979. (16 refs)

The pattern of succinic dehydrogenase (SD) inactivation in the brains of male Walter Reed strain rats sacrificed by exposure to high-intensity microwave irradiation at two different frequencies and four different angles of rotation was studied to demonstrate the effects of angular orientation on the spatial distribution of energy in the rat brain at different frequencies. Four animals were exposed to frequencies of 2,450 MHz or 986 MHz in one of the following four angular positions: 0, 90, 180, or 270 degrees. Unlike the 2,450-MHz applicator in which only the head of the animal was exposed to irradiation, the 986-MHz applicator exposed nearly half of the animal's body. Inactivation of SD enzymatic activity was markedly altered by rotation of the rat when exposed to 2,450 MHz radiation; absorption of energy was much greater at the 0 and 180 degree positions. In contrast, when rats were exposed to 986-MHz radiation, the degree of rotation produced almost no effect on the pattern of enzyme inactivation. These findings suggest that the use of lower frequencies may reduce regional variability of enzyme inactivation and lessen the requirement for immobilization during sacrifice.

6205 FUNCTIONAL STIMULATION OF THE SPINAL CORD IN MULTIPLE SCLEROSIS. *(Eng.)* Cook, A. W. (Dept. Neuroscience, Long Island Coll. Hosp., Brooklyn, NY); Taylor, J. K.; Nidzgorski, F. *J Med Eng Technol* 3(1): 18-23; 1979. (8 refs)

The use of functional electrical stimulation of the spinal cord in patients with multiple sclerosis is described along with some therapeutic results. A pair of electrodes for bipolar stimulation is placed in the epidural space of the spinal canal in the thoracic area through a needle inserted percutaneously. The electrodes, which are stainless steel wires coated with teflon with platinum tips, are left in place for trial stimulation for 3-8 days. If a significant change in motor function occurs, the electrodes are left in place and connected to a passive radio frequency receiver system implanted subcutaneously along the chest wall. Stimulating pulses are provided to the electrodes from the receiver by virtue of inductive coupling through a surface antenna that is connected to the transmitter. The stimulating wave form is a series of unidirectional square wave pulses. The rate and pulse duration are varied from 7-200 pulses/sec and from 50-400 μsec, respectively. Under usual circumstances, a 33-Hz repetition rate and a pulse duration of 200 μsec with graded increments of voltage are employed. The radio frequency carrier of the signals is 2.05 MHz. Recently, the same electrode and transmitting system has been employed in some patients but with the introduction of only a single electrode into the epidural space for cathodal stimulation. The anode is placed in the subcutaneous tissue of the back. This has resulted in greater clinical improvement than that obtained with bipolar stimulation. A review of 166 patients with multiple sclerosis who were treated with functional stimulation of the spinal cord via permanent percutaneous placement of the electrodes revealed that 99 patients showed functional improvement, which was maintained at the end of 1 yr of treatment. The most prominent results were favorable changes in urinary dysfunction, voluntary motor function of limbs, pain, and equilibratory and non-equilibratory coordinant dysfunction.

6206 EFFECT ON DIFFERENT DOSES OF CENTIMETER ELECTROMAGNETIC OSCILLATIONS ON BIOCHEMILUMINESCENCE OF THE CENTRAL NERVOUS SYSTEM AND LIVER TISSUES. *(Ukr.)* Faitel'berg-Blank, V. R. (Odessa Inst. Public Health, Odessa, USSR); Orlova, A. V. *Dopov Akad Nauk Ukr RSR* (11): 1035-1038; 1978. (12 refs)

The effects of whole-body exposure to electromagnetic waves in the centimeter range (intensity 12, 23, and 30.5 mW/cm^2, length of exposure 10 min) on the chemiluminescence, and on the accumulation of lipid peroxide oxidation products in the liver, brain, and spinal cord were studied in 78 male albino rats. The chemiluminescence was studied over a 120-hr period after irradiation. The irradiation caused a significant increase in the maximum chemiluminescence at doses of 12-23 mW/cm^2 in all tissues, but irradiation with 30.5 mW/cm^2 caused only an insignificant increase in the maximum chemiluminescence compared with nonirradiated animals. The lipid peroxide oxidation product levels in the brain and spinal cord were highest after irradiation at 30.5 mW/cm^2, and in the liver after irradiation at 23 mW/cm^2.

6207 THE EFFECTS OF ELECTRICAL POWER TRANSMISSION RIGHTS-OF-WAY ON SMALL MAMMAL DISTRIBUTION, DIVERSITY, AND COMMUNITY STRUCTURE. *(Eng.)* Quarles, H. D. (Ph.D. Dissertation, Univ. Virginia, 1978); 77 pp. [available through Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 7903512]. (60 refs)

The response of small mammal populations to altered habitats formed where powerline rights-of-way penetrate otherwise homogeneous deciduous forests was investigated over a 15-mo period at five study areas containing rights-of-way representative of different widths (30-68 m), line voltages (110 and 500 kV), and stages in the vegetation management sequence. The changing character of the habitat associated with the sequential right-of-way management parall led the natural process of vegetation succession. Each of the most frequently captured species (*Blarina brevicauda, Peromyscus leucopus, Tamias striatus, Microtus pennsylvanicus, Reithrodontomya humilis*, and *Pitymys pinetorum*) responded to the altered habitat in a manner consistent with its ecologic requirements. Electrical field strength and corridor width did not produce apparent effects on the small mammal communities.

6208 SPACE OSTEOPOROSIS: AN ELECTROMAGNETIC HYPOTHESIS. *(Eng.)* Marino, A. A. (Veterans Admin. Medical Center, 800 Irving Ave., Syracuse, NY 13210); Becker, R. O.; Hart, F. X.; Anders, F. *Aviat Space Environ Med* 50(4): 409-410; 1979. (14 refs)

Metabolic studies of astronauts indicate that spaceflight causes a net loss of body calcium, which does not appear to be caused by a deficiency in diet or exercise. During earth-orbital flight, the motion of the spacecraft through the geomagnetic field results in exposure to an extremely low frequency (ELF) magnetic field, and it is hypothesized that the change in the electromagnetic environment of the astronaut has a causative role in space osteoporosis (SO). Calculations of the maximum electric field induced in an astronaut's body during space flight produce a value of 0.4 V/m. In earth-bound experiments this internal electric field has been shown to be produced by ELF magnetic and electric fields of 1 G and 10,000 V/m, respectively. These latter values have been shown to be associated with various biologic effects, including altered behavior and serum triglycerides in humans and altered circadian rhythms and reaction time in humans. While earth-bound experiments support the hypothesis that motion of the periodic type that an astronaut goes through in the geomagnetic field induces internal fields that are biologically active, such experiments do not indicate that SO will occur. Testing the possibility of a link between motion through the geomagnetic field and SO could begin with thorough physiologic monitoring of the effects on earth-bound test animals of an ELF magnetic field, which best simulates the induced electric field caused by spaceflight, especially when the animal is undergoing weightlessness.

6209 THE MEASUREMENT OF cAMP AND cGMP IN MICROWAVE IRRADIATED CHEST AND HEART MUSCLES. *(Jpn.)* Nagada, J. (Dept. Pharmacology, Sekinishi Medical Univ., Japan); Matsuda, S.; Morita, M. *Folia Pharmacol Jpn* 74(7): 119P-120P; 1978. (0 refs)

The temperature changes and the concentrations of cAMP and cGMP in the chest and heart muscles of microwave-irradiated mice and rats were investigated. The temperature of the chest muscles irradiated with 2-kW microwaves rose to 80-90 C after a 1-1.5 sec exposure for mice and after 2-3 sec exposure for rats. The temperature of heart muscles irradiated with 2-kW microwaves for 1.5-2 sec (mice) and approximately 6 sec (rats) increased to 80 C. The concentrations of cAMP and cGMP in the auricle and ventricle of rats irradiated with 2-kW microwaves for 10 sec were: (cAMP) 72.5 ± 18.8 picomoles/g tissue in auricle and 159 ± 6.7 in ventricle; (cGMP) 15.1 ± 1.3 picomoles/g tissue in auricle and 13.6 ± 1.3 in ventricle. The concentration of cAMP in excised rat papillary muscles electrically stimulated with 2 Hz at 30 C was greater than in muscles irradiated with microwaves. The concentrations of cAMP and cGMP in these tissues when frozen (-80 C) were 5.8 ± 0.6 and 1.4 ± 0.2 picomoles/mg protein, respectively. When irradiated with 2 kW for 2 sec the levels were 4.1 ± 1.3 and 2.1 ± 1.3 picomoles/mg protein, respectively. When homogenized after excision the levels were 2.9 ± 0.2 and 0.8 ± 0.1 picomoles/mg protein, respectively. Rat heart auricles were excised, induced to autokinesis with isoproterenol, and irradiated with 1.5-kW microwaves for 4 sec. The concentrations of cAMP in the sinoatrial nodal structure and the atrium before irradiation were 2.1 and 8.8 picomoles/mg protein, respectively; 10 sec after irradiation the concentrations were 9.2 and 22.3, respectively; 20 sec after irradiation they were 26.3 and 26.6, respectively; and 30 sec after irradiation they were 16.3 and 23.5, respectively. Faster beats and stronger contractions were induced in the autokinetic auricle following irradiation than after isoproterenol administration alone.

6210 EFFECT OF HIGH-POWER DENSITY MICROWAVE IRRADIATION ON THE SOLUBLE PROTEINS OF THE RABBIT LENS. *(Eng.)* Oosta, G. M. (Sidney Farber Cancer Inst., Rm. J409, 35 Binney St., Boston, MA 92115); Mathewson, N. S. *Invest Ophthalmol Visual Sci* 18(4): 391-400; 1979. (25 refs)

Ten New Zealand rabbits were irradiated on the left side of the head with 2.45-GHz microwaves at a power level of 300 mW/cm^2 for 20 min on each of 2 consecutive days to investigate lens changes as observed by biomicroscopy and changes in soluble protein distribution (SPD) as determined by pore-gradient electrophoresis (PGE). Only five of the animals survived the irradiation, and changes ranging from vacuoles along the posterior suture to very small posterior subcapsular opacities were observed in the left lenses only of four of the five survivors. No significant defects were found by biomicroscopy in the lenses of six control ani-

mals or in the right lenses of the exposed animals. A study of the SPD of the lens cortex and nucleus by PGE revealed a marked difference in distribution between the two lens components and a progressive shift in molecular weight from approximately 6 x 10^4 (beta-crystallin) to approximately 8 x 10^5 (alpha-crystallin) in lenses damaged by microwave exposure. It also appeared that the right lenses of irradiated animals had been comprised despite the fact that they remained free of defects visible by biomicroscopy. The results indicate that PGE can be applied to detect lens protein alterations even if changes are in localized regions of the lens. It may be possible with this technique to develop a more detailed understanding of the early stages of protein involvement in opacity formation.

6211 MICROWAVE-INDUCED HAZARDOUS NONLINEAR THERMOELASTIC VIBRATIONS OF THE OCULAR LENS IN THE HUMAN EYE. *(Eng.)* Neelakantaswamy, P. S. (Sch. Applied Sciences, Univ. Science Malaysia, Minden, Penang, Malaysia); Ramakrishnan, K. P. *J Biomech* 12(3): 205-210; 1979. (14 refs)

A theoretic analysis of microwave-induced hazardous nonlinear thermoelastic vibrations of the ocular lens of the human eye is presented. Assuming a dielectric spherical shell model to depict the ocular globes, the temperature distribution within the eye was evaluated when a plane microwave (2,450 MHz, 100 mW/cm^2) irradiated the eye. The temperatures at the posterior and anterior surfaces of the lens were computed to be 40.5 and 38 C, respectively. The rise in temperature at the lens surface was used to calculate the thermal stresses developed in the lens medium. A thermoelastic equation of motion was also formulated to assess the nonlinear transverse vibrations of the lens. For this purpose, the lens suspended anatomically by the zonal ligaments was considered as an isotropic circular plate with variable rigidity clamped along its peripheral boundary. The relevant nonlinear differential equation thus formulated was solved in terms of Jacobian elliptic functions. The hazardous effects due to the thermoelastic stresses, such as the evoked physiochemical processes in the ocular tissues resulting from stress-induced micromassaging, were quantified in terms of damage parameters and a thermal shock resistance coefficient. It is concluded that exposure of the human eye to pulsed microwave environments would correspond to the situation wherein the ocular lens is subjected to cyclic thermal shocks and is therefore vulnerable to fatigue failures in vivo.

6212 MICROWAVE RADIATION-INDUCED CHROMOSOMAL ABERRATIONS IN CORNEAL EPITHELIUM OF CHINESE HAMSTERS. *(Eng.)* Yao, K. T. (Bureau Radiological Health, Food and Drug Admin., Rockville, MD 20857). *J Hered* 69(6): 409-412; 1978. (15 refs)

The production of lens opacities in Chinese hamsters and the concomitant induction of chromosomal aberrations in the corneal epithelium following exposure to microwave radiation are reported. A 2.45-GHz microwave diathermy machine with a modified type-C applicator was used to irradiate the eyes of 5-mo-old female Chinese hamsters. For lens opacity studies, the right eye of each of seven animals was irradiated for 10 min in the immediate vicinity (2 mm) of the aperture at an equivalent power density of 75 mW/cm^2. Three of the animals were irradiated twice, with a 1-wk separation. Slit lamp examination 1 mo after irradiation revealed lens opacities in the exposed eyes of two animals that had been irradiated only once. Lens opacities were not observed in the other animals, including those irradiated twice. No lens opacities were observed in the unexposed eyes of the seven animals. For chromosomal studies, the right eye of each of 32 animals was irradiated in the immediate proximity of the aperture (2 mm) or at 5 cm from the aperture for 5, 10, 20, or 30 min. The equivalent power densities were 100 mW/cm^2 and 25 mW/cm^2, respectively. In the cells from eyes irradiated proximal to the aperture (100 mW/cm^2) for 5, 10, 20, and 30 min, there were 0.0488, 0.0819, 0.0794, and 0.1562 chromosomal breaks per cell, respectively. Tetraploid cells and cells with chromosomal endoreduplications were also observed and constituted 0-4.7% of the cells. The frequencies of abnormal cells among microwave-irradiated cells ranged from 0.8-9.4% of the total number of cells observed. The group of animals with the highest and longest exposure (100 mW/cm^2, 30 min) scored significantly greater than a control group for both percentage of abnormal cells and number of chromosomal breaks per cell.

6213 TESTS OF BIOLOGICAL INTEGRITY IN DOGS EXPOSED TO AN ELECTROMAGNETIC PULSE ENVIRONMENT. *(Eng.)* Baum, S. J. (Experimental Hematology Dept., Armed Forces Radiobiology Res. Inst., Bethesda, MD 20014). *Health Phys* 36(2): 159-165; 1979. (9 refs)

The acute effects of electromagnetic pulse (EMP) exposure on the hematopoietic system and on some aspects of the reproductive system was investigated in healthy, purebred beagle dogs (1-2 yr old). A total of 26 dogs were employed; 9 (4 males, 5 females) were exposed to the simulated EMP environment and 9 (4 males, 5 females) served as sham-irradiated controls. Four pregnant female dogs were exposed to the EMP environment between day 10 and day 55 of gestation to measure possible radiation effects on the fetuses, and 4 nonexposed pregnant female dogs served as controls. The animals were exposed to the EMP environment 8 hr/day for 45 days. At the end of that time they received 5.8 x 10^6 EM pulses at 5 pulses/sec, with a peak electric field intensity of 447 kV/m. Blood samples were obtained 1 wk prior to exposure and thereafter every week during the 45-day exposure period and for 3 wk thereafter. Final blood samples were obtained 1 yr after the last EMP exposure. The concentrations of erythrocytes, leukocytes, neutrophils, lymphocytes, reticulocytes, and platelets were routinely determined in 1 mm^3 of blood. Bone marrow samples were obtained 7 days before and 7 days after the last EMP exposure. A

comparison of concentrations of the circulating erythrocytes and reticulocytes indicated that exposure to EM pulses had no injurious effects. The number of peripheral leukocytes, neutrophils, and lymphocytes of irradiated dogs was similar to that of nonirradiated control animals. No changes were observed in the concentration of platelets. No differences were observed in blood values obtained from the same dogs 1 yr after the last EMP exposure. The percentage of mitotic erythrocytic and myelocytic bone marrow cells in all dogs 7 days prior to irradiation did not differ significantly from that obtained in similar determinations 7 days after the last exposure. At no times during periodic examinations were any damaging effects observed in the exposed animals. The litters of the 4 irradiated pregnant female dogs were similar in size (4-6 pups/litter) to those of the 4 unirradiated controls. All pups were clinically normal. When the 4 EMP-exposed male dogs and their 4 nonexposed controls were mated with normal female beagles, sizes of litters were normal (5-6 pups) in all cases and no differences in mating capabilities between the irradiated and nonirradiated male dogs were observed. Veterinary examinations of the pups disclosed no abnormalities in the newborn dogs sired by previously irradiated male beagles. It is concluded that the absence of any deleterious effects observed in dogs exposed to the EMP environment, which closely simulated human occupational exposure conditions, strongly suggests that humans face no hazards under these conditions.

6214 PROGRAMMED SIX-CHANNEL ELECTRICAL STIMULATOR FOR COMPLEX STIMULATION OF LEG MUSCLES DURING WALKING. *(Eng.)* Strojnik, P. (Faculty Electrical Engineering, Univ. Ljubljana, Ljubljana, Yugoslavia); Kralj, A.; Ursic, I. *IEEE Trans Biomed Eng* BME-26(2): 112-116; 1979. (21 refs)

Recent trends in the use of functional electrical stimulation (FES) for the treatment of stroke patients are reviewed along with the development of a six-channel FES unit for complex stimulation of leg muscles during walking. The state of art in the field of FES clearly shows that complex multichannel systems for support and correction of principal gait functions are still at an initial stage. However, it may be expected that present systems for therapeutic and training stimulation will develop in the course of commonly used orthotic devices. A six-channel FES unit is described that uses a shoe-insole heel switch to synchronize stimulation with the gait. To exclude any accidental occurrence of cross stimulation pulses, only one generator with a frequency six times higher than the required stimulation frequency is used. A ring counter distributes the pulses among the channels so that overlapping and cross-talk between the electrodes cannot arise. The stimulation frequency can be set within the range of 20-60 Hz and the pulse width between 0.1 and 1 msec. The six-channel FES unit has been used on 20 patients so far, and most of them have accepted the walking pattern given by the stimulator. After having used the stimulator for 3 wk, several patients were able to walk without a cane. Moreover, the walking pattern remained for a while after stimulation was stopped. This preliminary experience indicates that multichannel FES represents a successful approach to complex correction of the hemiplegic patient's gait.

6215 EFFECTS OF 9.4 GHz MICROWAVE EXPOSURE ON MEIOSIS IN MICE. *(Eng.)* Manikowska, E. (Dept. Genetics, Natl. Res. Inst. Mother and Child, Kasprzaka 17A, 01-211 Warsaw, Poland); Luciani, J. M.; Servantie, B.; Czerski, P.; Obrenovitch, J.; Stahl, A. *Experientia* 35(3): 388-390; 1979. (13 refs)

The effects of microwave exposure on meiosis in mice was investigated. Adult male Balb/c mice were exposed 1 hr/day for 2 consecutive wk (5 days/wk) to 9.4 GHz pulsed microwaves (pulse width 0.5 μsec, repetition rate 1,000 Hz) in far-field conditions in an anechoic chamber at incident mean power densities of 0.1, 0.5, 1.0, and 10.0 mW/cm^2. Four animals were exposed at each power density (16 animals in total), and seven mice served as controls. Following exposure the animals were sacrificed, testicles extracted and examined. The results of qualitative analysis of meiotic metaphase I indicated the presence of aneuploid metaphases. Hypoploid metaphases were seen both in control and experimental animals. However, no significant differences were noted in the frequency. In control animals, the presence of quadrivalents was noted in three metaphases out of 175. In two metaphases besides bivalents, two and four univalents were seen. Following exposure to 0.1, 1.0, and 10.0 mW/cm^2, the incidence of metaphases with quadrivalents (and in some instances of hexavalents) increased significantly. The chromosome associations (translocations) occurred at random and no particular chromosome pairs demonstrated a tendency for translocations. Metaphases with one or more (up to 6) chromosome pairs remaining at metaphase I as univalents were significantly (chi^2 test) more frequent in all groups of exposed animals. The largest proportion of such metaphases was seen following exposure to 0.1 and 10.0 mW/cm^2, 15.2% and 30.4%, respectively. The results indicate that repeated microwave exposure at incident power levels equal to or lower than values accepted as maximum exposure levels may interfere with meiosis. The high incidence of metaphases with the presence of univalents, instead of bivalents, may indicate that microwave exposure interferes with chiasma formation and/or behavior. Possible consequences of the observed phenomena in terms of reduced fertility or hazards to offspring remain to be verified in studies employing a larger number of animals, other mice strains, and other animal species.

6216 STIMULATORY ACTION OF AN ELECTROSTATIC FIELD ON DEVELOPMENT OF A *Candida tropicalis* CULTURE. *(Eng.)* Kradenov, V. P. (No affiliation given). 4 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. HC A03/MF A01]. (7 refs)

The effects of electrostatic fields of varying intensity on the development of 2- to 3-day old *Candida tropicalis* (SK-4) cultures were studied. Yeast suspensions were exposed to 1-7 kV/cm from a direct electrostatic current source for 3, 10, or 1,200 sec. At all field intensities, suspensions treated for 3 sec showed an inhibitory effect on survival. A 10-sec treatment produced a stimulatory effect on survival at all intensities except for 6 kV/cm. The greatest stimulatory action was observed at 3 kV/cm for 1,200 sec producing a 14-fold increase in the number of treated suspensions compared to the untreated controls. Exposure of the yeast suspension to 6 kV/cm for 300 sec induced intensive cell growth during the first 6 hr after treatment; by 8-12 hr, however, there were more cells in the unexposed cultures than in the treated suspensions and by 24 hr, there was a threefold increase in cell numbers in the treated groups. A similar pattern was observed for feed yeast biomass accumulation and at 6 hr, the treated suspensions had developed two times more biomass than the untreated controls. These experiments indicate that electrostatic treatment of yeast suspensions produces either inhibition or stimulation of cell development depending on the duration and intensity of exposure.

6217 EFFECT OF PERMANENT MAGNETIC FIELD ON THE SPERM OF BREEDING BULLS. *(Rus.)* Kovalev, M. G. (Belorussian Scientific Res. Inst. Animal Husbandry, USSR). *Veterinariia* (11): 83-84; 1978. *(0 refs)*

The effect of a permanent magnetic field (parameters not given) on 61 ejaculates of breeding bulls was studied. Some ejaculates were placed into the south pole of the magnetic equilibrator for 5-6 hr immediately after dilution with lactose medium (Group 1), after which the samples were frozen. Other samples (Group 2) were diluted with lactose medium previously exposed to the magnetic field for 6 hr. After thawing, the activity (motility) of the sperm was 5.2 units in Group 1, 4.9 in Group 2, and 3.6 in the untreated controls. The percentages of the samples that had to be rejected after thawing were 10% in Group 1, 12% in Group 2, and 32% in the controls. The survival of the sperm at 38 C after thawing was 9.6 in Group 1, 8.2 in Group 2, and 6.3 in the controls (no unit given). The fertility of cows inseminated with the treated sperm was 16% higher than in the cows inseminated with untreated sperm.

6218 RODENT REPELLERS ATTRACT EPA STRICTURES. *(Eng.)* Smith, R. J. (No affiliation given). *Science* 204(4392): 484-486; 1979. (0 refs)

Tests conducted by the EPA on electromagnetic insect and rodent repellers indicate that the devices do not work. Three of the repellers have been taken off the market by EPA order, and 10 other models may soon follow. Because none of the devices had any effect on insects and rodents, the EPA has concluded that the entire concept of electromagnetic repellency at low levels may safely be dismissed. Although some creatures are sensitive to magnetic fields, tests conducted by the NBS indicate that the repellers generate a field far too weak to have this effect, a field roughly comparable to that generated by a hair dryer, for example. At a distance of 10 feet from the repeller, the field strength is less than that normally present in nature. No measurable electromagnetic field was detected emanating from three of the repellers. One of these three, the Nature Shield, is claimed to operate on a principle called contro-clusive magnetism. This term is defined by the manufacturer as a multiple vortex energy flow resolving in an elastic expansion and capacitance in relation to space and position.

6219 CYTOFLUOROMETRY OF ELECTROMAGNETICALLY CONTROLLED CELL DEDIFFERENTIATION. *(Eng.)* Chiabrera, A. (Electrical Engineering Dept., Univ. Genoa, Viale F. Causa 13, 16145 Genoa, Italy); Hinsenkamp, M.; Pilla, A. A.; Ryaby, J.; Ponta, D.; Belmont, A.; *et al.* *J Histochem Cytochem* 27(1): 375-381; 1979. (23 refs)

Controlled alterations in the electrochemical environment of the frog nucleated red blood cell in vitro resulted in changes in cellular morphology that appeared to be related to dedifferentiation (despecialization). These changes were achieved by a selective modification of the ionic concentrations of an isotonic amphibian Ringer solution and by the induction of low-frequency pulsating electromagnetic currents having specific waveform parameters. Laser flow microfluorometry showed that the modified Ringer solution was able, per se, to partially trigger the process during the same time interval that certain induced current waveforms significantly affected the number of cells in the dedifferentiated state. For a given waveform, the repetition rate had a significant effect on the rate of cell change. A frequency window of 40-70 Hz was found such that if the fundamental frequency of the signal was external to the window, the dedifferentiation process was inhibited. On the other hand, if the fundamental frequency of the signal was inside the window and close to 55 Hz, the process was enhanced. Laser flow microfluorometric measurements revealed a bimodal distribution in the green fluorescence of red blood cells that depended on the time of exposure and the waveform characteristics of the external signal. The two subpopulations had a different level of dye uptake. Sorting of the two populations showed that the second peak of higher fluorescence intensity corresponded to dedifferentiated cells and that the lower fluorescence intensity corresponded to control differentiated cells. Preliminary results obtained by the automated image analysis of cell smears stained with a Feulgen method suggested that dedifferentiated and normal cells have the same integrated optical density but different nuclear areas, resulting in an increased chromatin dispersion (larger area per unit of deoxyribonucleic acid) for dedifferentiated cells, which corresponds perfectly to the increase in their green fluorescence (increase in chromatin-

deoxyribonucleic acid binding sites). It appears that one of the first stages of the dedifferentiation process is the unfolding of chromatin supercoiling without any deoxyribonucleic acid synthesis.

6220 THE PERCEPTION OF WEAK ELECTRIC A.C. CURRENTS BY THE EUROPEAN EEL, *Anguilla anguilla*. *(Eng.)* Berge, J. A. (Inst. Marine Biology and Limnology, Univ. Oslo, Oslo, Norway). *Comp Biochem Biophys* [A] 64(4): 915-919; 1979. (24 refs)

The perception of weak electric fields of alternating polarity and the regional sensitivities of the European eel, *Anguilla anguilla*, were investigated at different water resistivities (6×10^2 to 3.6×10^4 ohm cm). Nine eels, in cylindrical plastic cages, were placed either parallel or perpendicular to the alternating current. Shocking electrodes were attached to the tail-end of the cage or to the middle of the fish (for regional sensitivity testing). The threshold current was established as that current intensity giving a 50% probability for conditioned brachycardia to occur. Sensitivity to 0.5, 2, 5, and 50 Hz were tested in fresh water (resistivity 3×10^4 ohm cm). Voltage gradient thresholds with the eel parallel to the current direction average 0.97 mV/cm (range, 0.47-1.9 mV/cm) at 0.5 Hz, increasing to 19 mV/cm at 50 Hz. There was a linear relationship between stimulation frequency and thresholds. With the eels perpendicular to the current, the thresholds average 3.6 and 50 mV/cm at 0.5 and 50 Hz, respectively. Current density thresholds decreased with increasing resistivity with the eel oriented parallel to the current, from 0.88 $\mu A/cm^2$ in brackish water (resistivity 6.3×10^2 ohm cm) to 0.031 $\mu A/cm^2$ in fresh water (resistivity 2.9×10^4 ohm cm). The corresponding voltage gradients were approximately 1 mV/cm irrespective of resistivity. When part of the eel's body was shielded from the current, the front half was four to five times more sensitive than the tail half, mean thresholds being 2.0 and 9.0 mV/cm in fresh water at 0.5 Hz. The results demonstrate maximum sensitivity to electric currents in the European eel at low frequencies (0.5 Hz). There was no evidence that the eel was more sensitive to alternating than to direct current and the results do not support the hypothesis that the eel can orient in the Earth's geomagnetic field.

6221 MAGNETITE IN FRESHWATER MAGNETOTACTIC BACTERIA. *(Eng.)* Frankel, R. B. (Francis Bitter Natl. Lab., Massachusetts Inst. Technology, Cambridge, MA 02139); Blakemore, R. P.; Wolfe, R. S. *Science* 203(4387): 1355-1356; 1979. (18 refs)

A fresh-water magnetotactic bacterium spirillum (MS-1), isolated from swamp sediments, was cultured in chemically-defined media and magnetic and nonmagnetic whole cells were analyzed by Mossbauer spectroscopy. The cells analyzed included magnetic cells grown in medium containing bog water, magnetic cells grown in chemically-defined medium containing 3.6 μmolar iron, and nonmagnetic cells grown in chemically-defined medium containing 3.6 μmolar iron. The Mossbauer spectrum of the magnetic cells grown in medium with bog water was identical to that of magnetic cells cultured in the chemically-defined medium. Based on the comparison of the spectra of the iron in magnetite of the magnetic cells and that of stoichiometric magnetite, the iron-containing material can be described as ferrimagnetic Fe_3O_4, with either approximately 4% vacancies in the octahedral sublattice or with a small admixture of a γ-Fe_2O_3 phase. The calculated magnetic moment of each cell is 1.3×10^{-12} electromagnetic unit, sufficient to produce alignment in the geomagnetic field (H=0.5 G) at ambient temperatures. Thus, the magnetite in these cells constitutes a biomagnetic compass and it is speculated that its presence may also be involved in the orientational responses of some eukaryotic organisms to geomagnetism.

6222 MEASUREMENTS OF ELECTROMAGNETIC FIELDS IN THE CLOSE PROXIMITY OF CB ANTENNAS. *(Eng.)* Ruggera, P. S. (Div. Electronic Products, Bureau Radiological Health, Food and Drug Admin., Rockville, MD 20857). *HEW Publication* (FDA) 79-8080: 23 pp.; 1979. (6 refs)

Measurements of near fields generated by citizen band antennas operating at a frequency of 27.12 MHz are reported. Types of antennas for which data are presented with full legal power of 4 W input include 1/4-wavelength whip; base-, middle-, and top-loaded; two sets of twin antennas; and a hand-held walkie talkie. Measured emission levels at 5 cm from all of the antennas tested exceeded either 200 V/m or 0.5 A/m or both at some point along the vertical height of the antenna. These field strengths (equivalent to a far-field power density of 10 mW/cm^2), which were exceeded, are the radiation protection guides for continuous unmodulated field strengths recommended by the American National Standards Institute with respect to personnel exposure of 0.1 hr or more. For some of the antennas, emission levels exceeding these guidelines persisted at a 12-cm separation distance. The health implicat'ons of these observations are not clear at this time.

6223 MORE PROTECTION FROM MICROWAVE RADIATION HAZARDS NEEDED. *(Eng.)* Comptroller General of the United States. (General Accounting Office, Washington, DC). *General Accounting Office Publication* HRD-79-7: 84 pp.; 1978. (112 refs)

A General Accounting Office (GAO) report by the Comptroller General of the United States on the need for protection from microwave radiation hazards is presented. Although the FDA has identified two microwave products that need performance standards —microwave ovens and medical diathermy equipment— only a performance standard for microwave ovens has been issued. No standard for medical diathermy machines has been issued to protect the patient, operator, and the public from microwave radiation. The GAO believes such a standard should be estab-

lished because of potentially adverse biologic effects reported in human and animal studies at exposure levels well below those to which machine operators and patients may be exposed. The FDA has also failed to always review manufacturers' reports promptly so that problems could receive early attention. The GAO also recommends that the FDA develop material for training diathermy equipment operators to help minimize patient and operator exposure to unnecessary radiation. Although voluntary guidelines setting 10 mW/cm^2 as a maximum safe level of occupational exposure have been published, no Federal standards exist to protect the general public and workers from potential microwave hazards. A review of 112 reports that were either cited as reference material supporting the FDA's microwave oven emission standard or that were identified by Administration officials as particularly important to the evaluation of the standard's adequacy indicates that over half of these reports state that animals and humans exposed to microwave radiation levels of 10 mW/cm^2 or less experienced biologic effects, some undesirable. Overall it is concluded that the FDA should improve its regulation of microwave radiation-emitting products and that mandatory standards to protect the public and workers from microwave exposure should be established.

6224 A COMPARISON OF MEASUREMENT TECHNIQUES TO DETERMINE ELECTRIC FIELDS AND MAGNETIC FLUX UNDER EHV OVERHEAD POWER TRANSMISSION LINES. *(Eng.)* Lambdin, D. L. (Electromagnetic Radiation Analysis Branch, EPA, P. O. Box 15027, Las Vegas, NV 89114). *EPA Publication* ORP/EAD-78-1: 14 pp; 1978. (3 refs)

The magnetic flux and electric field strength under extra high voltage (510 kV) overhead transmission lines were measured, and comparisons were made between U.S. and Russian techniques. A Polytech Model FBM 100 field meter was used to measure the primary electric field strength and magnetic flux; supplemental measurements were made with a Monroe Electronics Model 238A-1$_1$ field meter. Field strength measurements were made in three geometries with each of the instruments: 1) a U.S. technique--the meter was held 1 m above ground level and 1 or 2 m from the observer, with a Monroe or Polytech meter, respectively; 2) a Russian technique--the meter was held 1.8 m above ground as if attached to an 11-inch handle; 3) 1.8 m above ground and 1 or 2 m from the observer; and 4) 1 m above ground with an 11-inch handle. Magnetic flux measurements were made in two geometries: 1) with the sensing coil 1 m above ground level and 2) with the coil 1.8 m above ground. Both meters gave similar results when used with equal-length handles. The major difference in measured values using different geometries occurred at 1.8 m above ground level. Electric field strength was greatest when the observer was closest to the meter. Measurements made at 1 m above ground were not as critically affected by the observer's position with respect to the instrument. The variations in the measured value were minimized when the instrument was held at least 2 m from the observer. Measurements at 1 m and at 1.8 m above the ground were similar if a 2-m handle was used. Magnetic flux measurements were not significantly affected by the observer's position with respect to the sensing coil. The magnetic flux increased by 1.09-fold in the area directly under the three phases of the transmission line when the coil was elevated from 1 m to 1.8 m above ground. Magnetic flux measurements were significantly affected by the angular orientation of the coil and by changes in the current flow through the transmission lines. Further studies are necessary to determine the relation between magnetic flux and current flow.

6225 MEASUREMENTS OF RADIOFREQUENCY FIELD INTENSITY IN BUILDINGS WITH CLOSE PROXIMITY TO BROADCAST STATIONS. *(Eng.)* Tell, R. A. (Electromagnetic Radiation Analysis Branch, EPA, P. O. Box 15027, Las Vegas, NV 89114); Hankin, N. N. *EPA Publication* ORP/EAD-78-3: 35 pp; 1978. (3 refs)

The radio frequency (RF) field intensity was measured in eight tall buildings located in five cities (New York, Chicago, Miami, Houston, and San Diego) that were situated in close proximity to frequency modulation (FM) radio and/or television transmitting antennas. All of the buildings had the upper parts of their structure illuminated by the main beam of radiation from the transmitting antenna. The RF intensities were measured to facilitate the development of an analytical technique for the estimation of field intensities and to determine the exposure level for persons living and working in sites similarly exposed to RF. RF measurements were made in conjunction with a ground level survey of the given metropolitan area by a tuned half-wave dipole receiving antenna connected through coaxial attenuators to a scanning spectrum analyzer. Measurements of polarization components in two orthogonal planes demonstrated electric field intensities as high as 19 V/m in one high-rise building about one block from an FM transmitter and about 10 V/m in a building several blocks away from a television transmitting antenna. Higher levels were observed at unobstructed locations on the roofs of some buildings. The maximum exposure did not exceed 100 $\mu W/cm^2$ in any of the buildings. Field intensities at distances very close to an FM antenna array were significantly lower, as much as 14 dB less at a distance of 26 m for a 12-bay FM antenna, than that predicted by using the far-field effective radiated power of array, demonstrating a near-field gain compression effect. Analysis of near-field gain characteristics of the array were in agreement with this measurement. This observation is significant for estimating close-in fields from extended arrays with a large number of elements. The possible effect of the alteration of antenna calibrations of the half-wave may have affected the field intensity. In particular, use of a half-wave dipole in the near-field of RF transmitting antennas should be examined for spatial resolution of the incident field. It is possible that certain "hot spots" may not be accurately identified and measured by using tuned dipoles, at least at 100 MHz, since at this frequency, the wavelength is 3 M. Another factor found to affect the field was the location

of metallic objects within the field. Such conducting structures (e.g., the metallic leg of an office desk) were observed to create intensified local fields, sometimes as much as 10 times that of the local ambient value. Further investigations of these effects and other phenomena that influence the RF field intensity nearby tall buildings situated near radio and television transmitting antennas are indicated.

6226 NEAR-FIELD RADIATION PROPERTIES OF SIMPLE LINEAR ANTENNAS WITH APPLICATIONS TO RADIO-FREQUENCY HAZARDS AND BROADCASTING. *(Eng.)* Tell, R. A. (Electromagnetic Radiation Analysis Branch, Office Radiation Programs, EPA, P.O. Box 15027, Las Vegas, NV 89114). *EPA Report* ORP/EAD 78-4: 49 pp.; 1978. (41 refs)

Electric and magnetic field strengths in the near-vicinity of dipole and monopole linear transmitting antennas were computed, and the results were analyzed to evaluate potential radio frequency hazards that may exist very near dipole-like broadcast antennas. Calculations for a half-wave dipole indicated that, for distances less than 1.5 m from the antenna, areas radiating 1 kW at 100 MHz will exist in which the American National Standards Institute safety standard for indefinitely long exposure is exceeded. Thus, extreme caution should be exercised by personnel performing tower work in close proximity to very-high frequency broadcast antennas using dipole or dipole-like radiating structures. The phenomenon of gain compression within the near field of an antenna array was also examined by modeling a frequency-modulated (FM) antenna as a series of horizontally polarized dipoles with uniform power division and equal phasing. Significant reductions in field strength near the array were expected and were observed via actual field measurements. The reductions in near field gain were due to the vector summing of fields from the array as opposed to the inherent near field properties of the basic dipole radiator itself. The presence of grating lobes in some FM broadcast antennas suggests that the fields near the base of the FM antenna towers can be relatively intense, particularly for antennas mounted close to the ground or on roof tops.

6227 POPULATION EXPOSURE TO VHF AND UHF BROADCAST RADIATION IN THE UNITED STATES. *(Eng.)* Tell, R. A. (Electromagnetic Radiation Analysis Branch, Office Radiation Programs, EPA, P.O. Box 15027, Las Vegas, NV 89114); Mantiply, E. D. *EPA Report* ORP/EAD 78-5: 39 pp.; 1978. (12 refs)

EPA data on broadcast signal field intensities obtained at 373 locations distributed throughout 12 large cites in the United States and collectively representing about 11,000 measurements of very-high and ultra-high frequency signal field intensities are reported. A computer algorithm was developed that uses these measurements to estimate the broadcast exposure at 39,000 census enumeration districts within these 12 cities. The results indicate that the median exposure level for the population of these cities, which represents 18% of the total United States population, is 0.005 $\mu W/cm^2$ (time averaged power density). The data also suggest that about 1% of the population studied, or about 380,000 persons, are potentially exposed to levels greater than 1 $\mu W/cm^2$, the suggested safety guide in the USSR.

6228 MICROWAVE BIOPHYSICS. *(Eng.)* Lin, J. C. *In: Microwave Bioeffects and Radiation Safety: Transactions of the International Microwave Power Inst.* International Microwave Power Inst. (Edmonton, Alberta, Canada): Vol. 8: 15-54; 1978. (76 refs)

Biophysical aspects of microwave interaction with living systems are discussed. The propagation and absorption of microwaves in biologic materials are governed by dielectric constant, conductivity, and geometric composition. Theoretical studies and experiments on planar and curved tissue models show that microwaves with frequencies between 400 and 1,000 MHz can penetrate more deeply into tissues and that the peak specific absorption rate (SAR) may be five times greater than the average in spheres simulating human and animal brains. Absorption maxima or hot spots are seen in both spherical and prolate spheroidal models of biologic structures. The average SAR for humans is projected to be highest at 70 MHz, while that for rats occurs at 700 MHz. Because the average SAR for humans and for rats at a given frequency may differ by as much as 25 times, body size and operating frequency must be accounted for in relating animal results to humans. Other than the thermal mechanism and the microthermal interaction characterized by thermoelastic expansion of brain tissue in the auditory effect, the mechanisms underlying most observed effects remain speculative.

6229 MICROWAVE AND RADIOFREQUENCY PROTECTION STANDARDS. *(Eng.)* Stuchly, M. A.; Repacholi, M. H. *In: Microwave Bioeffects and Radiation Safety: Transactions of the International Microwave Power Inst.* International Microwave Power Inst. (Edmonton, Alberta, Canada): Vol. 8: 95-101; 1978. (16 refs)

Microwave and radio frequency (RF) protection standards in various countries are reviewed. All Western standards appear to base their recommendations on the thermal effects produced by exposure to RF and microwaves. However, the recognition that focal heating (hot spots), resonance absorption, and adverse environments can produce thermal damage in biologic materials in a field of 10 mW/cm^2 at certain frequencies and exposure conditions has resulted in the proposal of a Canadian Government standard and a revision of the United States exposure standard. Several unexplained inconsistencies in certain Russian standards are apparent. The USSR occupational standard specifies 5 V/m as the maximum permissible electric field intensity for frequencies between 50 and 300 MHz (equivalent power density is 6.7 $\mu W/cm^2$); however, at frequencies above 300 MHz, 10 $\mu W/$

cm^2 is permitted. In the 30-50 MHz frequency range, the electric field intensity of 10 V/m is permitted. The magnetic field intensity giving the same power density is 0.027 A/m, but a magnetic field intensity of 10 times greater is permitted (0.3 A/m). It is also unclear from the standard if the limits for rotating antennas correspond to the values measured with the antennas stationary as is required in the standard's section on measurements. Also confusing are requirements pertinent to stationary and rotating antennas in the Polish standard.

6230 CONTROL OF MICROWAVE EXPOSURE IN CANADA. *(Eng.)* Repacholi, M. H. *In: Microwave Bioeffects and Radiation Safety: Transactions of the International Microwave Power Inst.* International Microwave Power Inst. (Edmonton, Alberta, Canada): Vol. 8: 102-112; 1978. (6 refs)

Activities of the Canadian Radiation Protection Bureau concerning regulations produced on devices emitting microwave (MW) and radio frequency (RF) radiation are reviewed. Regulatory action has been completed or is at the proposal stage for MW ovens, MW diathermy devices, and MW blood warmers. Regulations also exist for industrial activities using radiation emitting devices. An advanced draft of a safety code on MW and RF devices has been developed that also specifies the acceptable maximum exposure limits for both the general public and for occupationally exposed persons. For general public exposure in the frequency range of 0.01-300 GHz, the maximum level is 1 mW/cm^2 over a 24-hr period. For occupational exposures in the 0.01-1 GHz range, maximum exposure levels of 60 V/m, 0.16 A/m, and 1 mW/cm^2 are permitted over an 8-hr period; for this same frequency range, maximum levels of 1-25 mW/cm^2 are permitted for durations in minutes equaling 60/power density (P). For occupational exposures in the 1-300 GHz frequency range, the maximum exposure level is 5 mW/cm^2 over an 8-hr period, 1-10 mW/cm^2 for durations in minutes equaling 300/P, and 10-25 mW/cm^2 for durations equaling 60/P. A criteria document for MW and RF radiation has just been completed by the Radiation Protection Bureau in two parts. Part I has been published and includes details on the characteristics of MW and RF radiations, sources of these radiations that could present potential health hazards, measurement techniques, and interaction mechanisms. Part II is in the final draft stage and includes an extensive review of the bioeffects literature and presents recommendations on protection standards.

6231 QUANTIFYING HAZARDOUS MICROWAVE FIELDS. *(Eng.)* Bowman, R. R. *In: Microwave Bioeffects and Radiation Safety: Transactions of the International Microwave Power Inst.* International Microwave Power Inst. (Edmonton, Alberta, Canada): Vol. 8: 113-128; 1978. (15 refs)

Considerations involved in quantifying hazardous microwave electromagnetic (EM) fields are reviewed. Topics discussed include: complexities of EM fields involving polarization, multipath interference, reactive near-field components, interactions between the source and nearby objects, and complicated modulation of the field; field strength and intensity parameters for EM fields; and instruments for measuring complicated fields. An EM survey device using three orthogonal dipoles is described in detail.

6232 RADIO WAVES AND MICROWAVES - BASIC DEFINITIONS AND CONCEPTS. *(Eng.)* Stuchly, M. A. *In: Microwave Bioeffects and Radiation Safety: Transactions of the International Microwave Power Inst.* International Microwave Power Inst. (Edmonton, Alberta, Canada): Vol. 8: 1-14; 1978. (3 refs)

Basic definitions and concepts dealing with radio waves and microwaves are presented. Definitions and descriptions are given for electromagnetic waves, waves in free space, polarization, reflection and transmission, transmission lines, radiation and antennas, electrical characteristics of materials (complex permittivity and complex permeability), wave modulation, and quantum energy. The activation energies of various molecular interactions and corresponding frequencies and quantum energies associated with various radiations are given in tabular form.

6233 BIOLOGIC AND PATHOPHYSIOLOGIC EFFECTS OF EXPOSURE TO MICROWAVES. *(Eng.)* Michaelson, S. M. *In: Microwave Bioeffects and Radiation Safety: Transactions of the International Microwave Power Inst.* International Microwave Power Inst. (Edmonton, Alberta, Canada): Vol. 8: 55-94; 1978. (209 refs)

Physiologic and pathologic effects of microwave exposure are reviewed. These effects are discussed in relation to cellular and genetic events, growth and development, the reproductive organs, neuroendocrine responses, the nervous system, the cardiovascular system, hematopoiesis, immune responses, auditory responses, cataract development, and cardiac pacemaker interference. For frequencies between 200 and 24,500 MHz, exposure to a power density of 100 mW/cm^2 for several minutes or hours can result in pathophysiologic manifestations of a thermal nature in laboratory animals. Such effects may or may not be characterized by a measurable temperature rise, which is a function of the thermal regulatory processes and active adaptation of the animal. At lower power densities, evidence of pathologic changes or physiologic alteration is nonexistent or equivocal. Several studies support nonthermal interactions between tissues and electric and magnetic fields, however.

6234 MICROWAVE THERMOGRAPHY: APPLICATION TO THE DETECTION OF BREAST CANCER. *(Eng.)* Barrett, A. H.; Myers, P. C.; Sadowsky, N. L. *In: Prevention and Detection of Cancer. Part II. Detection. Volume 1. High Risk Markers - Detection*

Methods and Management. Nieburgs, H. E., ed. (New York: Marcel Dekker, Inc.): 375-385; 1978. (6 refs)

The use of microwave thermography for the detection of breast cancer is discussed along with some preliminary results. The microwave radiometer used operates at a frequency of 3.3 GHz (free-space wavelength 9.1 cm). The antenna is a straight section of rectangular waveguide with aperture dimensions of 1.0 by 2.3 cm and is filled with a low-loss solid having a dielectric constant of 11. During data taking, the antenna aperture is placed flush against the skin to eliminate reflective loss at the tissue-air interface and to permit minimum spatial resolution for the given antenna size. The microwave thermography examination lasts about 20 min. Over 600 patients have been examined by xeromammography, infrared thermography, and microwave thermography at the Faulkner Hospital in Boston. A microwave detection criterion based on measured right-left temperature asymmetry gave true positive and true negative rates greater than 70%, which compares favorably with mammography and infrared thermography.

6235 RESULTS OF THE EPA ENVIRONMENTAL RADIO-FREQUENCY RADIATION MEASUREMENTS PROGRAM. *(Eng.)* Galpin, F. L. (Environmental Protection Agency, Washington, DC); Athey, T. W.; Hankin, N. N.; Janes, D. E. *In: 9th Annual Natl. Conference on Radiation Control*. HEW Publication (FDA) 78-8054: pp. 317-324; 1978. (9 refs)

The EPA environmental radio frequency radiation measurements program is described along with some of its results. The objectives of the program are to describe urban area environmental radiation levels as completely as possible with emphasis on areas containing the majority of the population and on locations near the highest power transmitters and to determine exposure levels that may result in relatively high level exposure (compared to median exposure levels) to few persons because of the unique locations of the transmitters. In the first, eastern phase of the program (September 1975 to October 1976) seven cities were selected for environmental radiation level measurements; these were Boston, Atlanta, Miami, Philadelphia, New York, Chicago, and Washington, DC. Based on data from the first four cities surveyed, the frequency modulated (FM) radio band appeared to contribute the most to environmental exposure between frequencies of 50 and 900 MHz, followed by the very high frequency (VHF) television bands. Land mobile frequency bands made an almost negligible contribution to the total power density, and other frequency bands made even smaller contributions. Only about 6% of the sites had power densities that exceeded 1 $\mu W/cm^2$. The median exposure level for the populations of these four cities was about 0.02 $\mu W/cm^2$, and only 1-2% of the population were exposed to levels above 1 $\mu W/cm^2$. Preliminary results from three more cities suggested that the median population exposures for all seven eastern cities will be about 0.01-0.02 $\mu W/cm^2$. In summary, it appears that the nonionizing radiation exposures of about 98% of the population can be adequately characterized and that the levels for this group could meet any exposure standard in the world. In some locations, such as tall buildings near broadcast transmitters, the levels may be hundreds of times higher than at ground level but still probably always below the OSHA/ANSI occupational standard. Further studies are necessary to adequately describe the above-ground exposures to broadcast radiation in urban areas or in the near vicinity of other specialized sources.

6236 BEHAVIORAL, ETHOLOGICAL, AND TERATOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION ON AN AVIAN SPECIES. *(Eng.)* Clarke, R. L. (Ph.D. Dissertation, Univ. Kansas, 1978); 175 pp. [available through Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 7904212]. (109 refs)

The behavioral, ethologic, and teratologic effects of electromagnetic radiation on the domestic chicken (*Gallus gallus*) were examined in a series of experiments. In one experiment, eggs were irradiated with 2,450-MHz microwave radiation at a period during the incubation cycle when the neural structures associated with agonistic behaviors and aggression are known to proliferate. Forced draft cooling in a multi-modal cavity produced more even temperature distribution and higher rates of energy absorption over longer periods (100 mW/g average power for 24 hr) than had been achieved in previous studies. No gross abnormalities were found in eggs irradiated in this manner. Microwave irradiation had little effect on the number of eggs hatched, but it did appear to increase the number of hatchlings that survived to 9 wk. Also, embryonic irradiation with 2,450-MHz microwaves during hr 36-60 of incubation was correlated with being low on the pecking order. In a second experiment, the effect of a low frequency 60-Hz magnetic field on locomotor activity was investigated. However, initial results were inconsistent, and the experiment was abandoned. In a third experiment, it was demonstrated that chickens are apparently able to detect the presence of a direct current (4.01 mtesla) and a 60-Hz alternating current (1.70 mtesla) magnetic field. Unlike other avians, the chicken appears to be able to demonstrate the ability to detect magnetic fields under laboratory conditions that involve classical and instrumental conditioning.

6237 ELECTRICAL AND BIOLOGICAL EFFECTS OF TRANSMISSION LINES: A REVIEW. *(Eng.)* Lee, J. M.; Bracken, T. D.; Capon, A. S.; Sarkinen, S. H.; Ihle, G. M.; Perry, D. E.; Eyler, T. R. (U.S. Dept. Energy, Bonneville Power Admin., Portland, OR). 64 pp.; 1977. [available through National Technical Information Service, Springfield, VA 22161, Document No. HC A04/MF A01]. (117 refs)

Studies on the electrical and biologic effects of high-voltage transmission lines are reviewed. In the small volume of air surrounding a conductor where corona is present, chemical reactions take place including the production of ozone and nitrous oxides. Experience and studies to date indicate

that the amounts of oxidants produced by transmission lines have no adverse effects on humans, animals, or plants. With regard to electric field effects of transmission lines, the EPA issued a request for data with which to determine if there is a need to provide guidance for radiation standards for transmission lines above 700 kV. A preliminary analysis of the data by the EPA did not identify any acute detrimental health or environmental effects. The experience of the electric utilities indicates that long-term exposure to electric fields at the levels that exist near transmission lines in the United States poses no hazard. Soviet studies on extra-high voltage substation workers exposed to 50-Hz fields with intensities ranging from 2-26 kV/m reported such effects as greater variability of pulse and arterial blood pressure, reduced sexual potency, and a number of other changes. Other than reports involving some substations in Spain, the complaints by Soviet workers have not been reported for substation workers in other countries. No harmful biologic effects are expected from exposure to magnetic fields under transmission lines because the magnetic field levels at which effects occur are generally much higher than levels under powerlines. Current information on cardiac pacemakers indicates that with possible rare exceptions high-voltage lines will not interfere with the performance of pacemakers for heart patients. Very little research has been specifically conducted to determine if organisms are affected by the electric fields and ion currents of a direct current (DC) transmission line. Preliminary findings from a study conducted along the Oregon portion of the Celilo-Sylmar DC power line involving natural vegetation, crops, wildlife, and domestic animals do not indicate that there are any significant adverse biologic effects attributable to electrical properties of the DC line.

6238 RESEARCH PLAN FOR STUDY OF BIOLOGICAL AND ECOLOGICAL EFFECTS OF THE SOLAR POWER SATELLITE TRANSMISSION SYSTEM. *(Eng.)* Newsom, B. D. (Bernard D. Newsom and Associates, Los Altos Hills, CA). 360 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. N78-32316/9GA]. (74 refs)

A research plan for the study of biologic and ecologic effects of the solar power satellite transmission system is presented. The satellite power concept proposes that solar panel arrays with lifetimes of 30 yr be placed in geosynchronous orbit to collect solar power for subsequent relay to ground collecting stations by continuous wave 2.45-GHz microwaves. The research plan involves studying information on the following categories: absorption of microwave energy in man and animals, chronic low level effects of microwaves, biobehavioral effects of microwave illumination on birds, the effect of microwave illumination on heterotherms, the effects of microwaves on insects and other terrestrial invertebrates, the effects of microwaves on fungi, the effects of chronic low-level microwave illumination on plant growth and development, and dosimetry and facility requirements. An abbreviated version of the plan at an annual funding level of $700,000 for a 3-yr period is presented in an appendix.

6239 FOREIGN SERVICE STATUS STUDY: EVALUATION OF HEALTH STATUS OF FOREIGN SERVICE AND OTHER EMPLOYEES FROM SELECTED EASTERN EUROPEAN POSTS. *(Eng.)* Lilienfeld, A. M.; Tonascia, J.; Tonascia, S.; Libauer, C. H.; Cauthen, G. M.; Markowitz, J. A.; Weida, S. (Dept. Epidemiology, Sch. Hygiene and Public Health, Johns Hopkins Univ., 615 N. Wolfe St., Baltimore, MD 21205). 436 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. PB-288 163/9GA]. (0 refs)

A biostatistical study of 1,827 Department of State employees and their dependents at the Moscow Embassy and 2,561 employees and their dependents from other Eastern European embassies who served between 1953 and 1976 was conducted to determine the possible effects on mortality and morbidity due to exposure to microwaves among employees at the American Embassy in Moscow. The basic information sources included health records, health questionnaires, and death certificates. The maximum exposure levels at the Moscow Embassy over this period of time were 5 $\mu W/cm^2$ for 9 hr/day between 1953 and May 1975, 15 $\mu W/cm^2$ for 18 hr/day between June 1975 and February 7, 1976, and fractions of a $\mu W/cm^2$ for 18 hr/day since February 7, 1976. Sources of radiation beams at the Moscow Embassy were identified using directional antennas and conventional receivers and power meters at various locations within the Embassy. It was concluded that personnel working at the American Embassy in Moscow from 1953 to 1976 suffered no ill effects from the microwaves beamed at the chancery.

6240 EFFECT OF MICROWAVES IN THE THERMAL INTENSITY RANGE ON MICE: BODY WEIGHT, RECTAL TEMPERATURE, RESPIRATION, ACTIVITY IN RUNNING WHEEL, PERCEPTION REACTIONS, AND TRAINING. *(Swe.)* Criborn, C. O. (Forsvarets Forskningsanstalt, Huvudavdelning 5, 104 50 Stockholm 80, Sweden). 47 pp.; 1977. [available through National Technical Information Service, Springfield, VA 22161, Document No. N78-29730/6GA]. (24 refs)

The effect of exposure to microwaves of the thermal intensity range (2,450 MHz, 100 mW/cm^2, length of exposure 3 or 6 min) on various physiologic parameters of 70-day-old male CBA mice was studied. All mice exposed for 6 min died, but those exposed for 3 min survived over 6 mo. The rectal temperature was 39.7-43.1 C 1 min after the 6-min exposure, versus 37.6 C in the controls, but it decreased to 34.5 C 20 min after the exposure. The rectal temperature was 39 C 1 min, and 36.8 C 20 min after the 3-min exposure. The respiratory minute volume was 6.8-11.6 (unit not specified) 1 min after the 6-min irradiation, versus 9.7 in the controls. In the group irradiated for 3 min, the respiratory minute volume was 13.4 during the exposure, and 8.2 20 min later. During the first 3 days after the 3-min exposure, there was no change

in the activity of the animals in the running wheel, or in their ability to learn to change direction after the wheel was braked down in one direction. Later, there was a stress symptom, manifested in impaired ability to learn. The changes in the activity in the running wheel appeared after about 1 wk; they were probably due to damage of the hematopoietic organs. The Hb level was 14.3 g/100 ml 9 days after the 3-min irradiation versus 15.2 g/100 ml in the controls.

6241 BIOMEDICAL EFFECTS OF MILLIMETER RADIO WAVES. *(Eng.)* Cherkasov, I. S.; Nedzvetskiy, V. A.; Gilenko, A. V. (Dept. Eye Diseases, Odessa Medical Inst., Odessa, USSR). 7 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. HC A03/MF A01]. *(27 refs)*

The effect of millimeter radio waves (MMW) on both normal and injured corneas and on corneal healing was studied in adult rabbits. The animals received MMW either to the right eye for 10-100 min; to the right eye with the rest of the body shielded from irradiation; to the occipital region after a 5-mm cut was made in the cornea of both eyes; and to both eyes with the intensity and exposure time increased by four and three times, respectively, daily for 10 days. For all experiments, the condition of the eye before and after injury and immediately after MMW exposure was monitored with a fluorescence test, ophthalmoscopy, and biomicroscopy. No abnormal deviations in the corneal morphology were detected in controls, MMW-exposed, or in treated rabbits observed for 1 yr. However, statistical analysis demonstrated an increase in the mitotic index (MI) of the irradiated cornea after 1 10-min exposure (16 ± 1) compared to the nonirradiated cornea of the same animal (11 ± 1), which increased with 30-min (25 ± 2 and 15 ± 1, respectively) and 60-min (53 ± 3 and 25 ± 2, respectively) of exposure and was most pronounced after 100-min of MMW (107 ± 7 versus 40 ± 3). In all cases, the mitotic activity was greatest 1 hr after exposure and the MI declined to its initial level 24 hr after MMW. Significant acceleration of wound healing was demonstrated following irradiation of the damaged cornea; highly stable healing occurred in 3 ± 0.5 hr in exposed animals and in 8 ± 0.5 hr in controls. When the rabbits were shielded, MMW-induced elimination of the defect was accelerated, but at a slower rate (5 ± 0.5 hr) than those receiving MMW without shielding. When one eye received MMW, healing of the nonirradiated eye was also accelerated, but was 1 hr slower than in the injured eye subject to MMW. Injuries to both eyes healed simultaneously following MMW to the occipital region, reducing defect elimination time to 1 ± 0.5 hr (from 8 ± 0.5 hr). These results indicate that MMW interacts with the body to produce a pronounced therapeutic effect; in particular, reparative regeneration becomes significantly more stable and accelerated. The effects of MMW on healing depend on the wavelength, irradiation time, the body systems that are irradiated, and the irradiation conditions.

6242 HEALTH AND SAFETY OF HIGH VOLTAGE TRANSMISSION LINES. *(Eng.)* Michaelson, S. M. (Univ. Rochester Sch. Medicine and Dentistry, Rochester, NY 14642). 33 pp.; 1977. [available through National Technical Information Service, Springfield, VA 22161, Document No. UR-3490-1255]. (32 refs)

A review of data on the biologic effects of high voltage transmission lines indicates that there is no demonstrable effect produced by such electric and magnetic fields that may be hazardous to human health and safety or to the general biologic environment. Experiments that have reported possible genetic effects have been poorly designed and have not yielded the same results on repetition. Reported effects of electromagnetic fields on litter size in mice and on the growth of rats and chicks are comparable in magnitude with natural biologic variabilities, related temporal factors, or normal biorhythms that are not otherwise accounted for. Studies of triglyceride increases associated with low frequency fields had serious control deficiencies, and well controlled studies have not shown any such association. Experiments in which very slight changes in circadian rhythms were found in human subjects shielded from natural background fields are not considered applicable to the possible effects of high voltage transmission lines. Also, experiments performed with silk tree leaflets, fluor beetles, and mice have not shown alterations in circadian rhythms under conditions considered applicable. It is not possible to define a cause-effect relationship from Soviet studies describing symptoms of listlessness, excitability, headache, drowsiness, and fatigue in persons occupationally exposed to high electric fields because these symptoms are also caused by many other occupational factors.

6243 CONDITIONED TASTE AVERSION IN RATS EXPOSED TO 2450 MHz CW MICROWAVES. *(Eng.)* Williams, W.; Michaelson, S. M. (Dept. Radiation Biology and Biophysics, Univ. Rochester, Rochester, NY 14627). 6 pp; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. UR-3490-1331]. (6 refs)

The ability of 2,450 MHz continuous wave microwaves to induce a behavioral aversion to saccharin was investigated in rats. Female rats adapted to a restricted water regimen (4 rats/group) were presented with a 0.01% saccharin solution and either sham-irradiated or exposed for 10 min to microwaves at incident power densities of 10, 20, 25, 35, 50, or 55 mW/cm^2. Some groups were re-exposed several weeks later to either 20 mW/cm^2 for 2 hr or 65 mW/cm^2 for 1 hr. A water-saccharin preference test was given to each group 24 hr later. Core body temperatures were measured with a rectal probe before and after microwave exposure. Only those rats irradiated with 65 mW/cm^2 for 1 hr demonstrated significantly reduced saccharin consumption. The aversion correlated with a rise of core body temperature to >39.8 C. Rats retested for saccharin aversion following an intraperitoneal injection of apomorphine-hydrochloride showed a significant reduction in saccharin intake, lowered core body temperature,

illness and malaise, indicating that rats previously unresponsive to microwave exposure develop saccharin aversion with an apomorphine stimulus. Repetitive irradiation with 65 mW/cm^2 for 1 hr following a 30-min drinking period had no effect on water consumption, indicating that decreased saccharin intake is a behavioral aversion to the novel stimulus and not due to the test chamber environment. It is concluded that the aversive response to saccharin solution after microwave irradiation is not the result of gastroenterologic disturbances and that it may be elicited when the core body temperature becomes hyperthermic or is raised to 40 C for $\geq$1 hr.

6244 THE COMBINED EFFECT OF AN SHF FIELD AND AN UNFAVORABLE MICROCLIMATE ON THE BODY. *(Eng.)* Zhuravlev, V. A. (No affiliation given). 6 pp.; 1978. [available through National Technical Information Services, Springfield, VA 22161, Document No. HC A03/MF A01]. (0 refs)

The combined effect of a super-high frequency electromagnetic field and an unfavorable microclimate on various biologic functions of female rats was investigated. One group of rats was irradiated for 1 hr/day by 10-cm microwaves at a power flux density of 5 mW/cm^2; after this, they were placed in a thermostat at an air temperature of 40 C and a relative humidity of 22-25% (air movement did not exceed 0.05 m/sec). A second group of rats was exposed to the unfavorable microclimate only under similar conditions. A control group was exposed neither to microwaves nor heat. The exposure period was 60 days for the first two groups. An increase in the number of erythrocytes and in hemoglobin concentration was noted in rats exposed to microwaves and heat, while rats exposed to heat alone only showed a tendency toward increased numbers of erythrocytes. Rats irradiated with microwaves also showed a lower blood viscosity than nonirradiated rats. Blood catalase activity decreased in both experimental groups, though more distinctly in microwave-irradiated rats. The percentage of reproducing females and the number of rats in a litter were lower in rats irradiated with microwaves than in rats treated with heat alone or control rats. Microwave-irradiated rats also showed more pronounced changes in internal organs than did rats from the other two groups. Weight coefficients of the liver and spleen were significantly lower in microwave-irradiated rats than in controls or rats exposed to heat alone. In the cardiac muscle, homogenation and fragmentation of muscle fibers coupled with minor subepicardial hemorrhaging were noted more frequently in response to microwaves plus heat, while circulatory disturbances dominated in rats subjected to heat alone. Signs of chronic venous plethora in the liver and spleen were more highly pronounced in response to microwaves in combination with heat.

6245 QUANTITATION OF MICROWAVE RADIATION EFFECTS ON THE HEAD AND EYES OF RABBITS, PRIMATES AND MAN. *(Eng.)* Kramar, P. O. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine, Univ. Washington Sch. Medicine, Seattle, WA 98195). 3 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD A058343]. (0 refs)

The effect of microwave irradiation on cataract formation and retrolental temperature was investigated in adult albino rabbits. The right eyes of five anesthetized rabbits were exposed to a 2,450-MHz "C" director in the near field at a power density of 300 mW/cm^2 for 5 min either every other day or every third day for a total of five exposures. The left eyes served as controls. Three cataracts developed in three rabbits exposed every other day to microwave radiation, whereas no cataracts developed in two rabbits exposed to the radiation every third day. Thus, it appears that 2 days are required between exposures to allow the lens to recover. Direct retrolental temperatures were measured in another group of adult albino rabbits exposed to 300 mW/cm^2 for 5 min. There was no progressive increase in the postirradiation temperatures, nor was there a consistent pattern of the preirradiation temperatures. However, the postirradiation temperatures were recorded between 42 and 46 C in all cases. Attempts to quantitatively determine ocular blood flow accurately in rabbits not exposed to microwaves were also performed, but only qualitative analysis was possible.

6246 DEPOSITION OF ELECTROMAGNETIC ENERGY IN ANIMALS AND IN MODELS OF MAN WITH AND WITHOUT GROUNDING AND REFLECTOR EFFECTS. *(Eng.)* Gandhi, O. P.; Hunt, E. L.; D'Andrea, J. A. (Dept. Electrical Engineering and Bioengineering, Univ. Utah, Salt Lake City, UT 84112). 11 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. AD A058289]. (10 refs)

Generalized curves for whole-body absorption of electromagnetic energy by models of human beings are given as a function of frequency for free space, for electrical contact with the ground, and for the presence of reflecting surfaces. Based on these curves, generalized graphs for specific absorption rates (SAR) for rats and mice were drawn, and the results were shown to be in good agreement with experimental data. Peaks of absorption with and without grounding, respectively, were projected to be (31-34 MHz) and (62-68 MHz) times (1.75/height of the model in meters). It was also shown that tremendous enhancements in rates of energy deposition resulted for targets that were placed in proximity to reflecting surfaces. Energy deposition rates are given for models of man and for animals subjected to fields at a power density of 10 mW/cm^2 under various conditions of exposure, and SAR values as high as 35-70 times the basal metabolic rate are predicted for adult human beings at resonant frequencies. Measurements of the mean time to convulsion for 100-g rats exposed to incident waves at power densities of 3-20 mW/cm^2 confirmed some of the predictions of enhanced absorption in the presence of reflecting surfaces.

6247 EFFECT OF CONSTANT MAGNETIC FIELDS OF VARIOUS DIRECTIONALITY ON THE GROWTH RATE OF WHEAT SPROUTS. *(Eng.)* Bogatina, N. I.; Verkin, B. I.; Kordyum, V. A.; Kordyum, Ye. L.; Litvin, V. M. (No affiliation given). 5 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. HC A03/MF A01]. (6 refs)

The effect of constant magnetic fields of varying polarity on the growth rate of wheat sprouts was investigated. Wheat grains placed on thin cotton balls in Petri dishes (at 23 ± 0.5 C) sprouted in the dark in man-made magnetic fields maintained up to 5 days. The earth's magnetic field was shielded with ferromagnetic screens by a net magnetic field with horizontal and vertical components of 0.2 and 0.5 mOe, respectively. The artificial fields, created by placing solenoids within the screen, had an instability of less than 0.1 mOe; the regular variation of the field was 0.1-1.0% of its value with time. The horizontal magnetic field substantially altered the growth pattern of the grains while the vertical field had no effect. The effects were less obvious on roots than coleoptiles. Orientation of the buds to the south with respect to the horizontal magnetic field accelerated the growth by 44%. Roots oriented to the north were longer than those oriented to the other directions. High intensity magnetic fields (2,570 Oe) produced inhibition of root growth directed along the field displayed by the central root. Further experiments are necessary to determine whether the effects of constant magnetic fields of varying polarity on the growth rate of wheat sprouts can be quantified.

6248 NEW SCIENTIFIC BRANCH ESTABLISHED FOR ELECTROMAGNETIC HYGIENE STUDY. *(Eng.)* Appenyanskiy, A. (Electromagnetic Hygiene Lab. Sanitary-Epidemiological Station, USSR). 4 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. HC A03/MF A01]. (0 refs)

Regulations for exposure to electromagnetic fields associated with industrial, medical, scientific, and other applications in the USSR are reviewed. The regulations cover electrical fields at industrial frequencies (50 Hz), radiowaves, infrared radiation, and visible and ultraviolet light. Regulations for work safety at substations and around electric transmission lines state that exposure to an electric field of 5 kV/m is acceptable for a working day period and exposure to a 10-kV/m field for not more than 3 hr at a time.

6249 A QUANTITATIVE REVIEW OF HUMAN SUSCEPTIBILITY TO MAGNETIC FIELDS. *(Eng.)* Schiff, A. (Lawrence Livermore Lab., Univ. California, Livermore, CA). 31 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. N79-11691]. (35 refs)

A review of the literature on human susceptibility to magnetic fields is presented. The results of this review suggest that exposure to the following types of magnetic fields should be avoided: alternating current fields in the body function frequency range at any magnetic intensity (0.3-10 Hz and 18-30 Hz); all frequencies for extended periods at intensities above 200 G; and all frequencies greater than 10 Hz at levels above 1 G for persons with cardiac pacemakers. The bibliography to this review includes 22 abstracted references.

6250 CELLULAR AND MOLECULAR EFFECTS AND THE MECHANISM OF ACTION OF MICROWAVE ELECTROMAGNETIC FIELDS ON BIOLOGICAL SYSTEMS. *(Eng.)* Arber, S. L. (No affiliation given). 17 pp.; 1978. [available through National Technical Information Service, Springfield, VA 22161, Document No. HC A03/MF A01]. (88 refs)

Cellular and molecular effects of microwaves on biologic systems are discussed. On the cellular level, two types of effects are observed: orientation or directed movement of unicellular animals and changes in physiologic functions. The first type of effect does not apparently have biologic significance. Mechanisms for the second type of effect are associated with the action of an electromagnetic field on subcellular structures and macromolecules. It has been demonstrated that cells absorb microwaves in the millimeter frequency range corresponding to the absorption bands of cellular components. Absorbed energy alters metabolic and biosynthetic processes and retards cell growth. An increase in membrane ion permeability in response to microwaves has been observed, which is a manifestation of the cell's nonspecific reaction to microwaves. It has also been observed that super-high frequency electromagnetic fields can alter enzyme activity; for example, a change in reaction rate was observed when a solution of lysozyme and its substrate was irradiated by a 10,000-MHz field. A review of various possible mechanisms for the high sensitivity of biologic systems to electromagnetic fields indicates that the biologic effects of microwaves are associated with the molecular level of organization of living systems.

MEETING ABSTRACTS

6251 BONE GROWTH IN ELECTRIC FIELDS (MEETING ABSTRACT). *(Eng.)* McClanahan, B. J. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352); Kaune, W. T.; Phillips, R. D. *Health Phys* 35(6): 891; 1978. (0 refs)

The influence of a uniform alternating current electric field on the normal skeletal growth pat-

tern of rats was examined. Juvenile rats received whole body exposure to uniform, vertical 60-Hz electric fields at 100 kV/m for 30 days. There were no marked alterations in the general growth pattern of the exposed animals compared to controls maintained under similar conditions. Bone growth rate, measured by tetracycline labeling, morphology of lumbar vertebrae and tibias and cortical bone area and marrow space area of tibias were not disturbed by exposure to the electric fields.

6252 FERTILITY AND TERATOLOGY IN RATS EXPOSED TO 100 kV/m ELECTRIC FIELD (MEETING ABSTRACT). *(Eng.)* Cantone, A. (Dept. Physiology and Nutrition, Medical Faculty, Univ. Milan, Milan, Italy); Viola, D.; Margonato, V. *Teratology* 19 (2): 22A; 1979. (0 refs)

To investigate the effects of electric fields on fertility and fetal development male rats were exposed to a 100 kV/m electric field during 48 days, 8 hr/day. Some were mated with unexposed females after 14, 35, or 48 days of exposure and some were sacrificed after 16, 32, and 48 days. In sacrificed rats, volume and weight of testes were normal. Oligospermia was detected in 20% after 16 days and in 12.5% after 48 days of exposure in comparison to 14.3% in controls; no azospermia or oligozoospermia were detected. Morphology and motility of spermatozoa were normal. In females mated with exposed males the fertility was not affected. At the cesarean inspection on day 20 of pregnancy, the total reabsorptions, early and late, were normal after 14 and 48 days of exposure; on day 35 of exposure reabsorptions were 10.8% in exposed and 7.9% in controls. The number of fetuses was normal, while the weight was generally lower in fetuses from exposed than from control animals; a significant difference was seen only after 35 days (3.86 ± 0.14 g in controls versus 3.44 ± 0.11 g). In fetuses from exposed animals, external, visceral, and skeletal examinations showed no major malformations; only in fetuses that showed weight reduction were some ossification centers delayed.

6253 MICROWAVES ALTER THERMORSGULATORY BEHAVIOR (MEETING ABSTRACT). *(Eng.)* Adair, E. R. (John B. Pierce Foundation, New Haven, CT 06519). *Fed Proc* 38(3, Part 2): 1295; 1979. (0 refs)

The minimal incident microwave energy that alters thermoregulatory behavior was determined, and the role of skin heating in this effect was assessed. Squirrel monkeys, trained to regulate environmental temperature (T_a) behaviorally, were exposed in the far field of a horn antenna to 10-min periods of 2,450 MHz continuous wave microwaves. Incident power densities ranged from 1 to 22 mW/cm^2. Controls included exposure to infrared radiation of equivalent incident energy and no radiation exposure. Normally, squirrel monkeys select a T_a of 34-36 C; microwave exposures at 6-8 mW/cm^2 stimulated selection of a lower T_a. Skin and rectal temperatures remained stable even at 22 mW/cm^2 where preferred T_a was as much as 4 C below control levels. No comparable reduction in selected T_a occurred during infrared radiation of equal incident energy. These results suggest that changes in thermoregulatory behavior triggered by absorbed microwaves result from stimulation of internal thermoreceptors whereas responses to infrared radiation result primarily from stimulation of receptors in the skin.

6254 BIOLOGICAL EFFECTS OF MICROWAVES ON ANIMALS. REPORT 2: ENVIRONMENTAL TEMPERATURE--SURVIVAL TIME RELATIONSHIP (MEETING ABSTRACT). *(Jpn.)* Anzai, I. (Public Hygiene Div., Dept. Medicine, Kanazawa Univ., Kanazawa City, Ishikawa-ken, Japan); Irie, S.; Higuchi, R.; Komoriya, U.; Okada, A.; Moroji, T. *Jpn J Hyg* 33(1): 243; 1978. (0 refs)

The relationship between body weight and environmental temperature on animal survival time during microwave irradiation was studied in Wistar rats. At 50 mW/cm^2 all rats died, but the length of time the rat tolerated the radiation increased with its average body weight: five 252-g rats survived 12.6 ± 1.9 min; five 312-g rats survived 15.8 ± 1.2 min; five 505-g rats survived 23.2 ± 1.1 min; and five 595-g rats survived 25.2 ± 0.7 min. Rats exposed to 10 mW/cm^2 radiation survived longer: five 215-g rats survived 40.6 ± 2.1 min, and four 297-g rats survived 73.5 ± 11.6 min. One 297-g rat and all five of the 462-g rats survived past the 180-min limit of administered 10 mW/cm^2 radiation. The lower the environmental temperature during the 50 mW/cm^2 irradiation, the longer was the survival time of the rats; survival time at 7 C was 29-33 min, at 12 C it was 28-32 min, at 17 C it was 20-22 min, and at 22 C it was 11-13 min. Rectal temperature at the time of death increased as the survival times decreased.

6255 BIOLOGICAL EFFECTS OF MICROWAVES ON ANIMALS. REPORT 3: EFFECTS ON BLOOD COMPONENTS (MEETING ABSTRACT). *(Jpn.)* Irie, S. (Public Hygiene Div., Dept. Medicine, Kanezawa Univ., Kanezawa City, Ishikawa-ken, Japan); Higuchi, R.; Komoriya, U.; Anzai, I.; Okada, A.; Moroji, T. *Jpn J Hyg* 33(1): 244; 1978. (0 refs)

The effects of 10 mW/cm^2 microwave radiation on the blood components of Wistar rats (average weight of 462 g) was studied. Six blood samples were taken: one before the irradiation, and one, 30 min, 60 min, 90 min, 120 min, and 180 min after. The rectal temperature increased until 30 min and then remained constant at 35.5 C in the control rats; the temperature of the test subjects rose to 39.6 C 90 min after the irradiation and remained constant thereafter. The hematocrit level of both control and test subjects decreased slightly after 180 min. The red blood cell count (RBC) in the controls decreased but there was no difference between the

pre-irradiation levels and the post-180 min irradiation levels; there was no RBC change in the test subjects. Acidophilic cells in controls decreased up to 120 min after and then leveled. The levels of the test subjects decreased to 9 ml^3 after 180 min. Both groups had significant decreases in white blood cell counts (WBC) after 180 min: there was a 44.9% decrease in WBC in the controls and a 52.5% decrease in the test subjects but the percentage difference between the two groups throughout the study was not significant. After 180 min there was a slight decrease in the lymphocyte count for the controls but the test subjects had a significant decrease to 46%. Neutrophils in both groups increased over time, with 3-lobed nuclei increasing more than 2-lobed nuclei. It is concluded that low-level, long-term microwave radiation affects the production of blood cells, particularly of leucocytes.

6256 STUDIES OF THE BLOOD-BRAIN BARRIER IN MICE AFTER EXPOSURE TO RF RADIATION, USING FLUORESCEIN AND UNUSUAL AMINO ACIDS (MEETING ABSTRACT). *(Eng.)* Spackman, D. H. (Pacific Northwest Res. Foundation, Fred Hutchinson Cancer Res. Center, Univ. Washington, Seattle, WA 98104); Riley, V.; Guy, A. W.; Chou, C-K. *Fed Proc* 38(3, Part 1): 357; 1979. (0 refs)

The increased permeability of the blood-brain barrier (BBB) that has been reported in rats after RF radiation (RFR) at low power densities was studied in mice using fluorescein (FCN) and amino acids not normally found in mice, as test compounds (T-cpds). Five min after intraperitoneal injection of the T-cpds, the mice were bled, killed, perfused, and the brain removed. Clear, deproteinized extracts of plasma and of brain homogenates were analyzed for FCN with a spectrofluorometer, and for amino acids with an amino acid analyzer. The concentration of T-cpds in brain and plasma were compared in control mice and in those given RFR. For RFR, mice were placed in a styrofoam holder mounted in a circularly polarized waveguide. Separate groups were exposed to either sham, continuous wave, or pulsed (100 pulses/sec, 10 μsec/pulse) radiation at 918 MHz for 30 min. Average power densities of 2.5, 33, and 132 mW/cm^2 were tested (average specific absorption rates of 0.52, 6.93, and 27.7 W/kg, respectively). Following sham or radiation exposure, plasma and brain samples were analyzed. No significant increase in permeability of the BBB in radiated mice as compared to non-irradiated controls was detected. No significant increase in permeability of the BBB in radiated mice as compared to non-irradiated controls was detected. The effects of heat and of several chemical compounds on the BBB were also studied in non-irradiated mice.

6257 MICROWAVE IRRADIATION FOR BRAIN ENZYME INACTIVATION: IMPORT OF POWER DISTRIBUTION (MEETING ABSTRACT). *(Eng.)* Stavinoha, W. B. (Dept. Pharmacology, Univ. Texas Health Science Center at San Antonio, San Antonio, TX 78284); Deam, A. P.; Modak, A. T.; Meyerson, L.; Dones, M.; Blank, L. *Fed Proc* 38(3, Part 1): 374; 1979. (0 refs)

Valid analysis of substances in the rodent brain that are rapidly metabolized by enzymes requires the swift termination of enzymatic action. This can be accomplished by properly heating with microwave irradiation. The assessment of the time of enzymatic inactivation in a region of the brain depends upon (1) a knowledge of the area of primary microwave power deposition; (2) diffusion of temperature in the brain; and (3) the combination of temperature and time required to inactivate the pertinent enzyme. Theoretic calculations of power distribution were followed by measurement of temperature distribution in mouse brain. The diffusion properties were computed in two dimensions for a cylindric rod in a material having the thermal properties of brain. Time and temperature requirements of the four enzymes of the dopamine system were studied and only catechol-*O*-methyl transferase was found to be difficult to inactivate and required 275 msec irradiation to a temperature of 86 C to reduce activity to 18% of control. Regional values for dopamine were the same for animals sacrificed by decapitation or heating except in the striatum where rapid heating yielded 8,440 ng/g as compared to a decapitation value of 4,700 ng/g.

6258 STUDIES CONCERNING THE EFFECTS OF LOW DOSAGE PRENATAL 6000 MHz MICROWAVE RADIATION ON GROWTH AND DEVELOPMENT IN THE RAT (MEETING ABSTRACT). *(Eng.)* Jensh, R. P. (Dept. Anatomy, Thomas Jefferson Univ., Philadelphia, PA); Vogel, W. H.; Ludlow, J.; McHugh, T. *Teratology* 19(2): 32A; 1979. (0 refs)

To investigate the effects of low dose prenatal microwave radiation on growth and development in the rat 12 pregnant Wistar rats were exposed to 35 mW/cm^2 of microwave radiation at a frequency of 6,000 MHz throughout gestation. Total mean exposure time was 102.3 hr. Four pregnant rats served as concurrent controls and were placed in the anechoic chamber for similar time periods, while 30 pregnant rats were baseline controls. Power levels in excess of 35 mW/cm^2 had been determined previously to cause an increase in body temperature as measured by a thermocouple probe. All animals were killed on day 22 of gestation. The uteri were exteriorized, and fetal and placental positions and weights and resorption sites were recorded. Following fixation in Bouin's fixative all fetuses were dissected using Wilson's cross-sectional technique to determine the abnormality rate. Data were compared among 117 exposed fetuses, 24 concurrent control fetuses, and 314 baseline control fetuses for the following parameters: maternal weight gain, maternal blood elements (hematocrit, hemoglobin, white blood cell count), litter size, fetal weight, placental weight, resorption rate, and abnormality rate. No significant effects due to exposure to 6,000 MHz microwave radiation at

35 mW/cm^2 were observed using these indices of prenatal growth and development.

6259 EXPERIMENTS IN ELECTRICAL STIMULATION OF BONE GROWTH (MEETING ABSTRACT). *(Eng.)* Paterson, D. (Dept. Orthopedic Surgery, Adelaide Children's Hosp., North Adelaide, South Australia, Australia); Tilbury, R. F. *Aust NZ J Med* 9(1): 97; 1979. (4 refs)

The construction of a surgical model of delayed union and the use of this model for bone growth stimulation experiments are described. Twenty-two pairs of dogs were subjected to stimulation, one of each pair had an active stimulator and one had an inactivated stimulator inserted. Three different methods of assessment of bone healing were used, i.e., clinical, histologic, and nuclear scanning. The results of each method of assessment were calculated separately and then together. The overall result when all three criteria were taken together was that there was a distinct positive association between active stimulation and the superiority of healing ($n=21$, $T=48$, $p<0.02$).

6260 THE GROWTH MODULATING EFFECTS OF NON-THERMAL, NON-IONIZING RADIATION (RADIO-WAVES, PULSED MAGNETIC RADIATION) ON NEUROBLASTOMA DIFFERENTIATION, TUMOR GROWTH AND EMBRYONIC MOUSE PALATAL DEVELOPMENT (MEETING ABSTRACT). *(Eng.)* Regelson, W. (Medical Coll. Virginia, Richmond, VA 23298); West, B.; DePaola, D.; Lieb, R.; Pilla, A. *Proc Am Assoc Cancer Res* 20: 118; 1979. (0 refs)

Neuroblastoma cells were placed in homogeneous time varying magnetic fields (2 G average) using 4-inch air gap coils. The induced current wave form (of μA/cm^2 level) was designed to either excite only surface or surface-coupled transport processes. Significant differences in the degree of dendritic outgrowth versus multiplication as a function of induced current wave forms were detected that were similar to those reported for calcium ionophores and for polar solvents in inducing tumor cell retransformation. Additional studies were conducted using 27 MHz (diapulse) whole body radiation in mice to investigate the effects on the growth rates of transplanted Lewis lung tumor. Inhibition or acceleration of tumor growth was dependent on pulsed frequency timing and type of pulsed frequencies used. Fourteen-day-old mouse embryo palatal explants were found to show in vitro epithelial destruction or chondrometaplasia depending on whether high or low frequency magnetic pulses were administered. These effects were non-thermal and establish a biologic role for nonionizing radiation that deserves further exploration utilizing different wave forms and frequency windows.

6261 EFFECTS OF PULSED ELECTROMAGNETIC FIELD ENERGY (DIAPULSE) ON THE NORMAL COMMON PERONEAL NERVE IN RATS (MEETING ABSTRACT). *(Eng.)* Raji, A. R. M. (Dept. Anatomy, Royal Free Hosp. Sch. Medicine, London, England). *J Anat* 127(3): 667; 1978. (1 ref)

The effects of pulsed electromagnetic field (Diapulse) on the normal common peroneal nerve were studied in 12 rats. Each animal received 400 pulses/sec for 15 min daily for a period varying between 1 and 8 wk. A control group of 12 rats was subjected to mock treatment of similar duration, i.e. they were in the machine but not subjected to a pulsed electromagnetic field. Paired, treated and untreated animals were sacrificed at intervals varying from 1 to 8 wk. The common peroneal nerves were subjected to quantitative and qualitative analysis using both light and electron microscopy. All specimens were fixed in buffered 4% glutaraldehyde, post-fixed in buffered 1% osmium tetroxide and embedded in Araldite. Thick 1-μm sections were stained in 1% toluidine blue in 1% borax; the ultrathin sections were stained with a saturated solution of uranyl acetate and Reynolds' lead citrate. The results indicated that the pulsed electromagnetic field had no morphologic effect on the normal nerves.

6262 ELECTRICAL PERTURBATION STIMULATES PROLIFERATION IN G_1 AND G_2 ARRESTED CELLS (MEETING ABSTRACT). *(Eng.)* Bourret, L. A. (Univ. Connecticut Sch. Dental Medicine, Dept. Oral Biology, Farmington, CT 06032); Rodan, G. A. *J Dent Res* 58 (Special Issue A): 416; 1979. (1 ref)

Electrical perturbations (EP) produced by oscillating external electric fields stimulate the incorporation of tritiated thymidine into cartilage cell DNA. In the present study the relationship of the EP effect to cell adherence, serum, and the cell cycle was examined. It was found that cells grown in siliconized tubes were susceptible to electrical stimulation. Electrical stimuli did not replace the serum requirements for growth and had no effect when cells were grown in the total absence of serum. Serum was, however, not required during exposure to EP. Growth enhancement by electrical stimuli and serum were additive at all serum concentrations, suggesting independent effects. In partially synchronized cells electrical stimuli increased by 35% the number of cells going into S phase without affecting the length of the G_1 phase (20 hr). In randomly growing cells electrical stimuli produced a burst of DNA synthesis at 20 hr. The number of G_1 arrested cells susceptible to electrical stimulation remained approximately constant throughout growth in culture. Electrical stimuli also acted on G_2 arrested cells promoting cell division during the lag phase and producing an increase in cell number 4-6 hr after exposure of randomly growing cells to EP. The findings demonstrate the ability of the electrical perturbation to shift a subpopulation of cells arrested in G_1 and G_2 to the proliferative mode.

6263 MECHANISM OF THE COMPRESSION OF BLACK LIPID MEMBRANES BY AN ELECTRIC FIELD

(MEETING ABSTRACT). *(Eng.)* White, S. H. (Dept. Physiology, Univ. California, Irvine, CA 92717). *Biophys J* 25(2, part 2): 9a; 1979. (2 refs)

Transmembrane electric fields decrease the thickness of planar bilayer membranes (black films) by displacing alkane solvent from the bilayer into the annulus (torus) and microlenses. The mechanism underlying this effect was investigated. It was found that the electric field produces an electrostrictive increase in the pressure acting on the alkane molecules in the bilayer but not in the annulus. This raises the chemical potential of the alkane in the bilayer relative to the annulus. Since the bilayer alkane must remain in equilibrium with the annulus alkane, the bilayer alkane concentration decreases to reduce the chemical potential to the annulus value. The consequent decrease in bilayer thickness would be small if the alkane formed an ideal solution with the bilayer. However, the bilayer solution is highly non-ideal as was found by controlling the activity of n-decane in the torus of glyceryl monooleate bilayers using squalene, which is insoluble in the bilayer. The relation between torus decane mole fraction (X_{DEC}) and bilayer thickness is such that large changes in thickness occur for relatively small changes in X_{DEC}. Thus, small changes in alkane chemical potential have large effects on thickness.

6264 EFFECT OF PULSED MAGNETIC RADIATION (DIAPULSE) ON EMBRYONIC MOUSE PALATE (MEETING ABSTRACT). *(Eng.)* Lieb, R. J. (Medical Coll. Virginia, Richmond, VA 23298); Regelson, W. L.; West, B.; DePaola, D. P.; Jordan, R. L. *J Dent Res* 58(Special Issue A): 213; 1979. (0 refs)

The effect of pulsed nonionizing radiation (radiowaves) on palate development in the mouse was investigated. A variety of radio frequency generators was used to study the nonthermal effects of nonionizing radiation. Palates from 14 day postconception Swiss Webster mice were explanted in Tyrode's horse serum (1:1) and irradiated for 20 min utilizing a pulsed nonionizing source (Diapulse) with a carrier frequency of 27 MHz at either 975 peak W with a pulse frequency of 600 pulses/sec on a 3.9% duty cycle (E_1) or at 493 peak W with a pulse frequency of 160 pulses/sec on a 1% duty cycle (E_2). Control tissues were treated in a similar manner except for the radiation procedure. All palates were cultured on solidified nutrient agar for 24 hr at 37 C with 5% CO_2 in air. The culture medium was composed of 1% agar, 1% glutamine, 10% dialyzed fetal calf serum, 6% chick embryo extract and 50 u/ml penicillin-streptomycin in Eagle's basal medium. Palates were then harvested and prepared for microscopy. Tissue from E_1 exhibited marked depletion of oral and medial edge epithelium, while tissue from E_2 showed development of cartilage within the mesenchymal compartment. The results indicate that pulsed nonionizing radiation results in epithelial destruction at higher frequencies and in chondrometaplasia of palate mesenchyme at lower frequencies. This effect is independent of temperature and differs from microwave effects.

6265 THE EFFECTS OF ELECTRIC FIELD ON THE IMMUNE SYSTEM OF EXPOSED MICE (MEETING ABSTRACT). *(Eng.)* Morris, J. E. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352). *Health Phys* 35(6): 890-891; 1978. (0 refs)

Swiss-Webster male mice were exposed for 30 and 60 days in a 60-Hz, 100 kV/m electric field to determine the effect of exposure on humoral and cellular components of the immune system. Quantitation of serum IgG and IgM with a double-antibody radioimmunoassay revealed no significant difference in the levels of these immunoglobulins between exposed and sham-exposed mice for the two time periods. In conjunction with the serum studies, the relative concentrations of T and B lymphocytes in the peripheral blood were measured using the spontaneous rosette assay and the binding of fluorescent-labeled goat anti-mouse immunoglobulins. No significant difference was observed in the distribution of these lymphocyte populations in exposed and sham-exposed mice.

6266 PHYSIOLOGIC RESPONSE OF RATS TO COLD STRESS AFTER EXPOSURE TO 60-HZ ELECTRIC FIELDS (MEETING ABSTRACT). *(Eng.)* Hilton, D. I. (Biology Dept., Battelle Pacific Northwest Lab., Richland, WA 99352); Phillips, R. D.; Free, M. J.; Lang, L. L.; Chandon, J. H.; Kaune, W. T. *Health Phys* 35 (6): 891; 1978. (0 refs)

In two experiments, the responses of the hypothalamo-pituitary-adrenal, thermoregulatory, and cardiovascular systems were assessed in rats subjected to cold stress after exposure to uniform 60-Hz electric fields of 100 kV/m for 1 mo. In the first experiment, plasma corticosterone levels were measured following exposure or sham exposure with the animals maintained at room temperature (~23 C). Corticosterone levels were also measured in rats subjected to cold stress (-13 C for 1 hr) immediately after the exposure period. Plasma corticosterone levels in the cold-stressed animals were significantly higher than in those kept at room temperature; however, there were no significant differences between exposed and sham-exposed animals for either the ambient or cold-stress situations. The second experiment followed the same field exposure and cold-stress protocol, only measurements of heart rate, deep colonic temperature, and skin temperature were made before, during, and after cold-stressing. The results for exposed and sham-exposed animals were essentially identical, failing to demonstrate any effect of electric field exposure on thermoregulatory and cardiovascular response to cold stress.

6267 TERATOGENICITY OF 27.12 MHz RADIOFREQUENCY RADIATION IN RATS (MEETING ABSTRACT). *(Eng.)* Lary, J. M. (Physical Agents Effects Branch, NIOSH, Cincinnati, OH); Conover, D. L.; Foley, E. D. *Teratology* 19(2): 36A; 1979. (0 refs)

To investigate the teratogenicity of 27.12 MHz radio frequency radiation, eight groups of 16 to 28 pregnant Sprague-Dawley rats were irradiated

at 27.12 MHz in a radio frequency (RF) near-field synthesizer facility operating in the dominant magnetic field mode at a magnetic field strength of 55 A/m. The groups were irradiated on gestation days 1, 3, 5, 7, 9, 11, 13, or 15, respectively. Dams were exposed one at a time until their rectal temperature reached 43.0 ± 0.1 C (about 20 to 40 min exposure duration). Eight matching control groups of 10 to 13 pregnant rats were sham-irradiated for 30 min at 0 A/m. An additional group of 29 pregnant rats was left untreated in the animal quarters. Sham control groups were combined to form early (days 1, 3, 5), middle (days 7, 9, 11), and late gestation (days 13, 15) control groups for statistical comparisons with the experimental groups and untreated control group. All dams were sacrificed on gestation day 20 (sperm day = day 0) and examined by standard teratology procedures. No significant differences were found between sham-irradiated controls and untreated controls. No significant effects were found in litters irradiated during preimplantation development (days 1, 3, or 5) compared to sham controls except for an increased incidence (3%) of grossly malformed fetuses on day 3. Rats irradiated during organogenesis (days 7 through 15) had a significant increase in the incidence of gross malformations and a significant decrease in fetal weight and fetal crown-rump length. Fetuses exposed on gestation day 9 appeared to be most sensitive to RF radiation (67% incidence of gross malformations). Postimplantation loss was also increased in rats irradiated on days 7 or 9.

6268 ENHANCEMENT OF NATURAL KILLER CELL ACTIVITY IN MICE AFTER EXPOSURE TO MICROWAVE RADIATION (MEETING ABSTRACT). *(Eng.)* Schlagel, C. (Naval Medical Res. Inst., Bethesda, MD 20014); Folks, T.; Woody, J.; Leach, W.; Sulek, K. *Fed Proc* 38(3, Part 2): 915; 1979. (0 refs)

The natural killer (NK) activity of spleen cells from Balb/c and CBA/J was assessed after exposure of these mice in an environmentally-controlled waveguide facility to a 30-min continuous exposure to microwaves at a frequency of 2,450 MHz and a forward power of 0.4 W and 0.6 W. Spleen cells were incubated with the ^{51}Cr labeled YAC-1 tumor target cells for 6 hr and the percent net ^{51}Cr release and the cytotoxic index (CI) were calculated as a function of NK activity. Spleen cells from sham-exposed adult CBA/J mice showed a CI of 37% whereas microwave-exposed littermate CBA/J mice showed a CI of 50.2% ($P<0.01$). Ontogeny studies carried out in Balb/c mice revealed that spleen cells from 8- and 13-day-old control Balb/c mice had NK activity of 5.6 ± 0.9 and 0.6 ± 1.3 CI, respectively. After exposure to microwaves, littermate 8- and 13-day-old Balb/c spleen cells gave CI of 10.1 ± 1.4 and 14.7 ± 7.4. Kinetic studies revealed that this increase in NK activity could be seen as early as 20 min after exposure to the microwaves to as late as 6 days after exposure. Experiments were performed to determine whether the increase in NK activity was due to an increase in the frequency of NK cells or to an inherent increase in the functional activity of these cells.

6269 THE EFFECT OF LOCAL HIGH FREQUENCY HYPERTHERMIA ON URINARY BLADDER CARCINOMA--EXPERIMENTAL AND CLINICAL STUDIES (MEETING ABSTRACT). *(Eng.)* Harzmann, R. (Dept. Urology, Univ. Tubingen, Calwer Str. 7, D-7400 Tubingen, W. Germany); Bichler, K. H.; Altenaehr, E.; Gericke, D. *Urol Res* 7(1): 40-41; 1979. (3 refs)

Experimental and clinical studies on the effect of local high frequency hyperthermia in the treatment of urinary bladder carcinoma are reviewed. The clinical use of hyperthermia for the treatment of urinary bladder carcinoma has yielded contradictory data. The effect of local hyperthermia on urinary bladder carcinoma was investigated experimentally in 80 rabbits with implanted Brown-Pearce carcinoma. Hyperthermic infusion of the bladder does not produce homogeneous warming of the bladder wall and therefore high frequency local irradiation was performed using two external electrodes and later by means of a transurethral probe. A high frequency long-wave current was used and a transurethrally inserted Teflon-insulated thermocouple was employed for temperature monitoring. The most efficient temperature was found to be 43 C for a period of 30-60 min. The heat-treated animals showed significantly smaller tumor volumes, less frequent metastases, and prolonged survival periods compared with controls. Transplantation of previously treated tumors resulted in a regrowth rate of 20% compared with 96% for untreated tumors. In a clinical study, 15 patients with urinary bladder carcinoma were treated by transurethral high-frequency heat application using an optically controlled probe. Edema and blanching of the tumor were observed as well as subsequent reduction in size. In 3 cases the tumor disappeared completely and in an additional 8 cases there was substantial improvement. Histology showed cell-cluster necrosis and hyalinization of the stroma in three cases. The best results were obtained in undifferentiated solid urothelial tumors. Some transient swelling of healthy epithelium occurred but without permanent damage.

6270 TREATMENT OF URINARY BLADDER CARCINOMAS WITH LOCAL HIGH-FREQUENCY (HF) HYPERTHERMIA (MEETING ABSTRACT). *(Eng.)* Harzmann, R. (Dept. Urology, Univ. Tubingen, Tubingen, W. Germany); Bichler, K. H.; Gericke, D.; Altenaehr, E.; Flachenecker, G. *Proc Am Assoc Cancer Res* 20: 113; 1979. (1 ref)

The ability of local high-frequency (HF) hyperthermia to guarantee homogeneous heating of the bladder wall was investigated. A special apparatus was constructed, using a teflon-insulated, optically-controllable active internal electrode and a belt-shaped inactive outer electrode. Male rabbits (76) with transplanted urinary Brown-Pearce carcinomas and 10 normal rabbits received treatment with HF-hyperthermia (43 C, 30 min). Tumor-bearing animals (20)

served as untreated controls. Six female beagles with invasive carcinomas of the urinary bladder induced by transurethrally-applied pellets and injections of chemical carcinogens received the same therapy. Rabbits with carcinomas that had been treated by local hyperthermia had significantly smaller tumors, fewer metastases, and a longer survival time than untreated animals. Urinary bladder cancer in dogs treated with hyperthermia yielded identical macroscopic findings. Histologically, the tumors necrotized gradually without lasting side effects on the healthy tissue. Because of these findings, 28 patients with undifferentiated advanced carcinomas of the urinary bladder were treated by the same technique. Cluster-cell necroses, seen 7 days after treatment, were followed by subtotal or total necrosis and pronounced stroma hyalinosis.

6271 SELECTIVE TUMOR HEATING BY SHORTWAVE RADIOFREQUENCY (RF) (MEETING ABSTRACT). *(Eng.)* Auda, S. P. (Univ. Maryland, Dept. Surgery, Baltimore, MD); Steinert, H. R.; Elias, E. G. *Int J Radiat Oncol Biol Phys* 5(Suppl. 1): 31; 1979. (0 refs)

Experimental tumors were treated with external high frequency dielectric heating to investigate any selectivity among tumor mass, subcutaneous tissue, and systemic temperatures. Methylcholanthrene-induced sarcoma cells were inoculated into the muscles of the posterior thigh of isologous Fisher rats. At day 14 when the size of the tumor mass averaged 1.10 cm^3, radio frequency (RF) dielectric heating was locally applied to the tumor-bearing area. A fixed frequency of 13.56 MHz was used. The power needed to bring the tumor temperature to 43 C or above ranged from 0.5 to 0.8 W/cm^2. The temperature was gradually increased to 43 C and maintained at or above that level for 1 hr. Thermocouple probes were inserted directly into the subcutaneous tissue immediately above the tumor and into two distinct areas of the tumor. Systemic temperature was monitored via a mercury thermometer inserted into the rectum. Temperature recordings were taken at 5-min intervals during which time the power was turned off to avoid RF interference and to allow thermal equilibrium between the probe and the tissue. The results indicated that there was a high selective temperature gradient with tumor mass. A highly statistical significance, $p<0.002$, was found comparing the tumor mass, subcutaneous tissue, and systemic temperatures using Scheffe's test. The systemic temperature was minimally elevated throughout the treatment. In a group of animals without tumors, treated in the same fashion, there was no significant difference between the temperatures measured in the subcutaneous tissue and in two different sites in the thigh muscle mass. Histologic investigation performed to evaluate both tumor and normal tissue damage indicated no tumor regression at the frequency employed.

6272 RESONANT INTERACTIONS BETWEEN BIOLOGICAL MOLECULES (MEETING ABSTRACT). *(Eng.)* Van Zandt, L. L. (Purdue Univ., West Lafayette, IN 47907). *Biophys J* 25(2, part 2): 186a; 1979. (0 refs)

Forces between localized, oscillating vibrations on molecules show strongly resonant dependence on the relative frequencies of the two oscillators; i.e. there is a force between the vibrating parts of two molecules if the frequencies are the same but none if the frequencies are different. A vibrating site on a large molecule can attract another specific type of molecule out of a medium, one that has a vibrational mode at the same frequency, without influencing other types of molecules in the medium. These resonant forces are thus highly selective. Other pairs of molecules could similarly interact using vibrations at a different frequency. In a complex medium such as a cell, many different types of interactions could be assisted by these resonant forces without interfering with each other. These forces could be useful in assisting some metabolic reactions since they are vulnerable to selective suppression or enhancement by externally applied electromagnetic radiation of correspondingly specific frequencies.

6273 BIOMAGNETIC RESEARCH AT THE LAWRENCE BERKELEY LABORATORY (MEETING ABSTRACT). *(Eng.)* Tenforde, T. (Biology and Medicine Div., Lawrence Berkeley Lab., Univ. California, Berkeley, CA 94720); Gaffey, C.; Yang, T.; Raybourn, M.; Roots, R.; Farinato, R.; *et al.* *Biophys J* 25(2, part 2): 166a; 1979. (0 refs)

Facilities have been developed at the Lawrence Berkeley Laboratory for large-scale experimentation on magnetic field effects in whole-animal, cellular, and molecular systems. Physiologic studies on small mammals and organ systems exposed to fields of ≤20 kG strength included measurements of deep-body temperature via telemetry, cardiac activity, nerve impulse conduction, behavioral tests, and visual function. Results indicated a strong effect of direct current magnetic fields on the electrocardiogram, with a sixfold increase in the T-wave amplitude occurring in a 20 kG field. No magnetic effects have yet been observed for other physiologic parameters under investigation. Studies are also being carried out to assess magnetic field effects on the growth and development of cultured mammalian cells, *Tribolium confusum* beetles, and *Zea mays* corn seeds. The possibility that conformational changes occur in supercoiled double-helical DNA as a result of alignment in strong magnetic fields is being studied by gel electrophoresis and electro-optical birefringence techniques. Preliminary results in each of these research areas are reported.

6274 SINGLE DOMAIN PARTICLES AND MAGNETOTATIC BACTERIA (MEETING ABSTRACT). *(Eng.)* Bean, C. P. (General Electric Corporate Res. & Development, P.O. Box 8, Schenectady, NY 12301). *Biophys J* 25(2, part 2): 216a; 1979. (2 refs)

Past research discovered a class of anaerobic bac-

teria that exhibit a magnetotactic response in the earth's magnetic field. Electron microscope studies coupled with x-ray emission measurements revealed chains of iron-rich particles in the body of the bacteria. It was suggested that the chains might serve as magnetic dipoles to provide an orienting torque in a magnetic field. It has been pointed out that the particles might be single magnetic domains. On this hypothesis it was possible to write an equation of motion for the passive orientation of the bacteria as $\theta = M_s B_o V \sin\theta / 8\pi\eta R^3$ where θ is the angle between the field B_o and the moment associated with a magnetization M_s in a saturated ferromagnet of volume V. The bacterium is approximated as a sphere of radius R in a fluid of viscosity η. For reasonable parameters the volume of Fe_3O_4 required to accomplish rotations in 1 min in the earth's field would amount to only two spheres ~400Å in diameter or four spheres ~300Å in diameter, etc. The observed electron dense regions are significantly larger. The theory of the magnetization of "chains of spheres" of magnetic single domains gives specific values for the coercive force (~350 Oe for a chain of two spheres of magnetite) and predicts a nonmonotonic dependence of coercive force on the angle of the applied field relative to the chain.

6275 DEVELOPMENTAL TOXICOLOGY STUDIES WITH 60-HZ ELECTRIC FIELDS (MEETING ABSTRACT).
(Eng.) Sikov, M. R. (Battelle, Pacific Northwest Lab., Richland, WA 99352); Montgomery, L. D. *Health Phys* 35(6): 890; 1978. (0 refs)

A series of replicate studies were undertaken to determine the effects of exposure to uniform 60-Hz electric fields (100 kV/m) on reproduction and on fetal and postnatal growth and development in the rat. In the first experiment it was found that a 6-day exposure prior to and during mating did not affect the reproductive performance of either males or females. Continued exposure of the mated females through 20 days of gestation, to a total of about 30 days, did not affect the size or morphology of the fetuses. A similar 30-day exposure of the males and of the unmated females did not affect their mating performance or fertility on subsequent testing. In the second experiment, exposure of the pregnant rat was begun on day 0 of gestation and continued until the resulting offspring reached 8 days of postnatal life. This 30-day exposure did not produce significant effects on the growth, survival, or neuromuscular development of the offspring. Tests of the reproductive integrity of the offspring disclosed no deficits. A third experiment involved a 30-day exposure, beginning at 17 days of gestation. Although this study is still in progress, evaluations of the first two replicates have not indicated any significant alterations.

6276 DESIGN OF EXPOSURE SYSTEMS FOR ELF ELECTRIC FIELD BIOEFFECTS RESEARCH (MEETING ABSTRACT).
(Eng.) Kaune, W. T. (Battelle, Pacific Northwest Lab., Richland, WA 99352); Decker, J. R.; Phillips, R. D.; Gillis, M. F. *Health Phys* 35(6): 890; 1978. (0 refs)

Two systems for exposure and sham-exposure of large numbers of rats and mice to uniform, vertical, 60-Hz electric fields have been constructed. The rat system contains four racks of four rectangular 1.0 m x 2.2 m exposure-electrodes that are stacked vertically with a separation between adjacent electrodes of 0.41 m. Any two of the four exposure racks may be energized to a maximum field strength of 150 kV/m. Each exposure electrode is equipped with 24 Lexan cages, each of which holds a single rat. The cage floor is a stainless steel screen that serves as one electrode. The system for watering animals is contained entirely within the electrode and does not protrude above the cage's floor, thereby preventing distortion of the exposure field and electrical shock or discharge as the animal drinks. The total capacity of the system is 288 rats. A similar system of two racks of five electrodes each is used to expose as many as 450 mice to fields at a maximum strength of 150 kV/m while sham exposing an equal number. Measurements of the electric field revealed an overall uniformity within 4% over the area to be occupied by experimental animals. The field inside a Lexan cage was reduced by about 3%. No corona-discharge was detected. Measurements of ozone concentration in the rat and mouse exposure systems showed no difference from background levels. Harmonic distortion was eliminated by damping and filtering the high-voltage supply. Animals housed in close proximity were partially shielded from the electric field; the total body current in a rat model was reduced by 35 ± 5% when rats were placed in adjacent cages.

6277 SOME THEORETICAL ASPECTS OF THE INTERACTION BETWEEN ELECTRICALLY EXCITABLE CELLS AND MAGNETIC FIELDS (MEETING ABSTRACT).
(Eng.) Jakobsson, E. (Dept. Physiology and Biophysics, Univ. Illinois, Urbana, IL 61801). *Biophys J* 25(2, part 2): 158a; 1979. (0 refs)

The problems associated with calculating magnetic fields produced by electrical activity were investigated and the effects on electrical activity of externally applied magnetic fields were calculated. Large magnetic forces were induced in nominally voltage-clamped membranes when the electric field was changing very rapidly, such as during the (almost) instantaneous step from one voltage to another during voltage clamp experiments. Possible effects of these forces on the results of voltage-clamp experiments are discussed.

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