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Biological Effects of Nonionizing Electromagnetic Radiation

VOLUME II

NUMBER 2

DECEMBER, 1977

A DIGEST OF CURRENT LITERATURE

A Quarterly Publication
Produced for
Office of Telecommunications Policy
and
United States Navy

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THE FRANKLIN INSTITUTE RESEARCH LABORATORIES
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BIOLOGICAL EFFECTS
OF NONIONIZING ELECTROMAGNETIC RADIATION

A Digest of Current Literature

A Quarterly Publication
Produced for
Office of Telecommunications Policy
and
United States Navy

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

Bruce H. Kleinstein, Ph.D., J.D., Project Manager
Elena P. Saboe, Production Manager, Editor

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BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION

December, 1977 Volume II, Number 2

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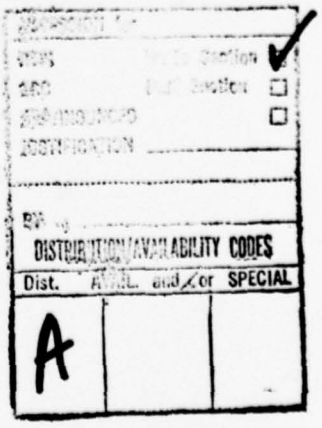
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PREFACE

Biological Effects of Nonionizing Electromagnetic Radiation is a publication researched and prepared by the Franklin Institute Research Laboratories, Science Information Services Department, under a contract with the U.S. Navy and administered by the Office of Telecommunications Policy.

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

Biological Effects of Nonionizing Electromagnetic Radiation is published quarterly. The issues of Volume II, 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.

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ABBREVIATIONS AND ACRONYMS

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

μ - micro--

NEWS ITEMS

TRANSIT SYSTEM GENERATES MAGNETIC FIELDS

Underground trains in San Francisco have been found to generate magnetic fields that are 1,000 times stronger than the natural background and may have long-term effects in people, points out the Stanford University researcher who discovered the phenomenon. Anthony Fraser-Smith of the Stanford Radioscience Laboratory explains that San Francisco's new Bart system, as well as other rapid transit systems, are really a set of varying current loops that can generate a vertical ultra-low-frequency magnetic field at frequencies below 0.3 Hz. Because a train may draw up to 7 mW at 1,000 V direct current, the current can be as large as 7,000 amp, resulting in a huge magnetic field. Fraser-Smith explains that "The human body is an electrically conducting fluid--just a big sack of salty water. A fluctuating magnetic field in a conducting fluid sets up electric currents." Furthermore, cells have their own electric field that would be affected by a varying electromagnetic field. There is a danger, Fraser-Smith argues, that the large electromagnetic signals now being added to our environment may generate currents in the body, which have long-term disruptive effects. "No one monitors our total exposure to electromagnetic fields (of all frequencies) and it is conceivable that the Bart signals, although probably harmless themselves, may increase the possibility of harm from other electromagnetic signals."

New Scientist 75(1064): 358-359; 1977.

MICROWAVES LESS EFFECTIVE THAN CONVENTIONAL HEATING FOR MICROBIOLOGIC DESTRUCTION

Both conventional high- and low-temperature oven cooking were found to be more effective than microwave cooking in the destruction of microorganisms usually present in meat in studies performed at the Department of Animal Science of Ohio State University. Researchers inoculated selected strains of microorganisms into "asceptic" beef muscle tissue and subjected patties of the inoculated and incubated beef to different temperature treatments in a conventional or in a microwave oven. Microwave heating to the same endpoint internal temperature was found to be less effective for microbiologic destruction than conventional heating. The low thermal destruction with microwave heating is explained by the quick rise in temperature in this process, implying that microorganisms are exposed to the lethal temperature for a shorter period of time than in conventional cookery. Also, temperature is more uniformly distributed throughout the food in microwave cooking than in oven cooking so surface temperature does not exceed internal temperature as much as in conventionally cooked food. It is advised that "in order to achieve the same microbiological safety as with traditionally cooked samples, it will be necessary to increase the final internal cooking temperature or maintain the product at the final temperature for a longer period of time in the microwave oven."

Ohio Report on Research and Development pp. 38-41; May/June 1977.

SENATE COMMITTEE INVESTIGATES REPORTED MICROWAVE BURNS

The United States Senate Commerce Committee is investigating burns reportedly sustained by two waitresses while heating food in a microwave oven. The women reported feeling tingling sensations when they took food from the oven and later experienced pain, swelling, and discoloration in the hands. A burn specialist who examined the women said he observed abnormalities in the injuries unlike any other burns, and he assumes the burns were caused by microwave energy. However, a spokesman for the oven manufacturer maintains that the oven is safe and suggests that the women may have burned themselves by touching food that had been heated in the ovens. The manufacturer's claim is supported by the Bureau of Radiological Health, which was unable to find any fault in the oven involved.

New York Times August 9, 1977.

MICROWAVE POWER SYMPOSIUM ANNOUNCED

The International Microwave Power Institute's 13th Annual Microwave Power Symposium will be held at the Chateau Laurier Hotel in Ottawa, Ontario, Canada on June 27-30, 1978. The symposium will include technical sessions as well as a short course on microwave power. Original and review papers related to the biologic effects of microwaves are being solicited. Dr. Stan Stuchly, recently appointed editor of the Journal of Microwave Power, will serve as the 1978 Symposium Chairman.

MEAN 10(3): 14-16; 1977

BRH APPROVES MICROWAVE OVEN CORRECTIVE ACTION PLAN

The Bureau of Radiological Health has approved corrective action plans submitted by Sears, Roebuck and Company for microwave oven, model 564.9927710, manufactured by Sanyo. The ovens were declared in noncompliance when inspection tests revealed that some were leaking microwave radiation in excess of the limit specified by the standard. Of the 7,000 ovens manufactured, 504 were shipped to Sears stores, and it is estimated that no more than 50 units were sold. The correction plan calls for Sears personnel to reinforce the seam of the waveguide and cavity

by mounting screws, nuts, and washers in the existing holes in the magnetron support plate and the seam of the waveguide and cavity, apply a chemical compound on the screws and nuts to secure them permanently, and apply an adhesive aluminum strip over the welds on the seam between the two holes. Following modification, leakage measurements will be made, and each modified oven will be stamped with the letter "0" on the name plate located on the back of the oven.

BRH Bulletin 11(17): 4; 1977

NEW YORK COMMISSION REPORTS BIOEFFECTS OF HIGH-VOLTAGE TRANSMISSION LINES

The New York State Public Service Commisssion (PSC), in the latest stage of a continuing health and safety controversy over upstate power lines, has reported that chronic exposure to 765,000-volt electric-transmission lines "probably would cause biological effects in humans." Citing laboratory tests that showed that electrical fields around ultra-high-voltage lines affect animals, the PSC called for additional research, to be directly controlled by the commission, to "determine whether the proposed transmission lines actually cause specific biological effects under various conditions of exposure that are expected during operation of these lines." The report did not specify the biologic effects. Until the research is completed, the PSC said the public would be adequately protected against undue exposure to electrical and magnetic fields by a protective zone 500-feet wide under the lines.

New York Times September 18, 1977

STUDY REFUTES ANALGESIC PROPERTIES OF MAGNETS

Despite clinical claims and popular interest, the alleged analgesic properties of magnets have not been rigorously tested. However, researchers at the Department of Psychiatry and Psychology of the University of Manitoba, Canada recently assessed the pain thresholds of people wearing a magnetic bracelet with claimed analgesic properties (Aimante, model CS-5). Pain thresholds were assessed on the back of the hand of 16 healthy volunteers using a radiant-heat apparatus. Each volunteer acted as his or her own control, being tested five time both with and without a bracelet; the hand being tested and the bracelet/no bracelet order of testing were counterbalances. One-half of the volunteers wore an indistinguisable placebo bracelet 5 min before and during bracelet testing, while the remaining volunteers wore the magnetic bracelet for the same duration. Neither volunteer nor observer knew at the time of testing whether the bracelet was magnetic. No significant differences in pain thresholds between the volunteers wearing magnetic and those wearing placebo bracelets were revealed.

The Lancet 2(8027): 47; 1977

UTAH UNIVERSITY INSTALLS MICROWAVE SPECTRAL MEASUREMENT SYSTEM

A solid state computer-controlled system for swept frequency measurements of the absorption spectra of biologic specimens over the frequency band 26.5-90 GHz has been installed at the University of Utah, Salt Lake City. The completely automated system with an on-line x-y plotter has been assembled for use on the National Cancer Institute-sponsored grant, "Effects of millimeter waves on living tissue."

Utah Bioengineering Newsletter 5(5): 1977

MICROWAVE ENZYME INACTIVATOR TO BE DEVELOPED

A pilot study is being initiated at the University of Utah, Salt Lake City, to develop a microwave applicator for uniform inactivation of enzymes in rat brains. The project, headed by Drs. Dickman, Gandhi, and Grosser is funded by the University Research Committee.

Utah Bioengineering Newsletter 5(5): 1977

ITEMS FROM THE COMMERCE BUSINESS DAILY

☐ **LOW POWER MICROWAVE EFFECTS RESEARCH.**

The Office of Naval Research, Arlington, Virginia has contracted with the University of Utah, Salt Lake City for the above study. (June 29, 1977)

☐ **BIOLOGICAL EFFECTS OF RADIATION.**

The U.S. Energy Research and Development Administration, Argonne, Illinois has contracted with Case Western Reserve University, Cleveland, Ohio for the above muti-discipline approach study. (September 19, 1977)

Biological Effects of Nonionizing Electromagnetic Radiation II(2), December 1977

NON-IONIZING RADIATION: EUROPEAN HIGHLIGHTS

Dr. Paul D. Gillespie, Managing Director
The Franklin Institute, GmbH, Munich, Federal Republic of Germany

In Europe, the research activities surrounding the biological effects of non-ionizing radiation (NIR) are somewhat unsettled. Since national standards do not exist, European-wide exposure limits can not be established. Further, the impetus for establishing such standards has not come from the studies of the Commission of the European Community (CEC, the European Economic Community's research arm) that are presently undergoing review in Luxembourg and whose publication date is uncertain. The individual European Economic Community (EEC) member nations including Belgium, Denmark, Federal Republic of Germany, France, Ireland, Italy, Luxembourg, the Netherlands, and the United Kingdom are taking a wait-and-see attitude to avoid altering national standards to meet eventual European-wide agreements.

According to Dr. F. Kossl, Director of the German Health Ministry's Medical Radiation Technology and Radiation Protection Institute, Germany is reluctant to establish exposure limits and product performance standards that may require re-evaluation in light of EEC guidelines. And, Dr. Hans Eriskat, Director of the CEC Health Protection Directorate's division for EEC standards, studies, and regulations indicates that the picture is not bright for rapidly establishing these guidelines. The problem, explains Dr. Eriskat, is one of coordinating the national requirements and finding a workable middle ground. Since many national agencies have no clear position, Dr. Eriskat finds himself with the difficult task of finding the mid-point for a situation without well-defined boundaries. He hopes, however, that the CEC studies on laser and microwave radiation can be published in late 1977 and that 1978 will find the European community in some agreement.

In spite of these difficulties, research studies in the field have begun to receive increased financial support. Dr. Michael Seuss, Regional Environmental Pollution Control Officer for the World Health Organization's (WHO) office in Copenhagen, which coordinates all WHO activities for NIR problems, reports that an International Radiation Protection Association (IRPA)-WHO meeting for developing a joint program in NIR research support was held in November. Eastern European representatives, including the USSR, also participated in the meeting. In 1978, a small WHO working group of specialists will meet to evaluate the need for health regulations and safety standards for workers in institutions using microwave ovens.

Dr. Seuss emphasizes that the WHO-NIR program depends heavily upon contributions from many national experts, and he encourages unsolicited communications from the medical and scientific community on subjects of common interest. For example, a pressing problem for NIR studies is the necessity of standardizing the nomenclature used to describe effects and organism response as well as terminology, techniques, and criteria used by different countries. WHO is in the process of producing a glossary of terms and is seeking international standardization of terminology and definitions through cooperation with reference centers and/or national organizations.

Certain events, indicates Dr. Seuss, have served to confound international progress in NIR problems. The WHO has concluded studies concerning the suggestion that there was a correlation between the incidence of cardiovascular problems and the exposure to radar radiation in northern Finland (Karelia). It was shown that the incidence of such disorders existed in this region for at least 30 years prior to radiation exposure. Over-reaction to suspected cases of NIR-induced disorders has the effect, Seuss explains, of creating doubt about the real dangers surrounding exposure to NIR.

Along the same lines, Dr. Kossl refers to a study conducted by the University of Ulm, just southeast of Stuttgart, which investigated reports of cardiac pacemaker irregularities in hospital patients near the city of Bremen, Germany. The upper floors of the hospital were exposed to radar from a nearby airport. Exhaustive investigations revealed that no pacemaker irregularity could be traced to radar exposure. In fact, certain hospital practices were considered the more likely causes of the problem.

Regarding WHO NIR priorities, Dr. Seuss concludes that emphasis must be placed upon studies that generate information on NIR biological effect monitoring to form a foundation for coordinating European research.

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MEETINGS AND CONFERENCES

IAEA INTERNATIONAL SYMPOSIUM ON NATIONAL AND INTERNATIONAL STANDARDIZATION OF RADIATION DOSIMETRY

Date: December 5-7, 1977
Place: Atlanta, GA
Sponsor: International Atomic Energy Agency
Requests for Information: John H. Kane, Special Ass't. for Conferences, Office Public Affairs, ERDA, Washington, DC 20545

INTERNATIONAL UNION OF RADIO SCIENCE-U.S. NATIONAL COMMITTEE (URSI-USNC)

Date: January 9-13, 1978
Place: Boulder, CO
Sponsor: URSI-USNC
Requests for Information: S. W. Maley & J. R. Wait, Dept. Electrical Engineering, Univ. Colorado, Boulder, CO 80309

VIII INTERNATIONAL CONFERENCE OF PREVENTIVE AND SOCIAL MEDICINE

Date: March 27-31, 1977
Place: Mexico City, Mexico: National Medical Center
Sponsor: International Federation for Hygiene, Preventive Medicine, & Social Medicine
Requests for Information: Dr. P. R. Lauriola, 11, via Cola de Rienzo, 00192 Rome, Italy

ELECTROMAGNETIC COMPATIBILITY CONFERENCE

Date: April 4-7, 1978
Place: Guildford, UK: Univ. Surrey
Sponsor: Inst. Electronic & Radio Engineers [UK], Inst. Electrical & Electronic Engineers [UK], Inst. Electrical & Electronics Engineers [Int], Inst. Quality Assurance [UK], Inst. Marine Engineers [UK], Royal Aeronautical Society [UK]
Requests for Information: P. M. Elliott, IERE, Conference Services, 345 East 47th St., New York, NY 10017

AMERICAN OCCUPATIONAL HEALTH CONFERENCE

Date: April 9-14, 1978
Place: New Orleans, LA: Fairmont
Sponsor: American Occupational Medical Assoc., American Assoc. Occupational Health Nurses
Requests for Information: H. N. Schulz, AOMA, 150 N. Wacker Drive, Chicago, IL 60606

FEDERATION OF AMERICAN SOCIETIES FOR EXPERIMENTAL BIOLOGY: Annual Meeting

Date: April 9-14, 1978
Place: Atlantic City, NJ
Sponsor: FASEB
Requests for Information: Mrs. H. B. Lemp, FASEB, Office Science Meetings, 9650 Rockville Pike, Bethesda, MD 20014

THIRD INTERNATIONAL SYMPOSIUM ON THE NATURAL RADIATION ENVIRONMENT (NRE III)

Date: April 23-28, 1978
Place: Houston, Texas
Sponsor: Univ. Texas & Energy Research and Development Admin.
Requests for Information: Thomas F. Gesell, Univ. Texas Health Science Center at Houston, School of Public Health, PO Box 20186, Houston, TX 77025 or Wayne M. Lowder and James E. McLaughlin, ERDA Health & Safety Lab., 376 Hudson St., New York, NY 10014

INTERNATIONAL MAGNETICS CONFERENCE (INTERMAG)

Date: May 9-12, 1978
Place: Florence, Italy
Sponsor: Inst. Electrical & Electronic Engineers (Mag Gp) [Int] Italian Physics Society, Italian Assoc. Electrical & Electronics Engineers (AEI)
Requests for Information: J. Suozzi, Bell Telephone Lab., Whippany, NJ 07981

INTERNATIONAL MICROWAVE SYMPOSIUM

Date: May 15-17, 1978
Place: Ottawa, Canada
Sponsor: Inst. Electrical & Electronic Engineers (Microwave Theory Technique Group)
Requests for Information: A. L. Van Koughnett Communications Research Center, Box 11490, Station "H", Ottawa, Ontario, Canada K2G 8S2

MICROWAVE POWER SYMPOSIUM

Date: May 17-19, 1978
Place: Ottawa, Canada: Univ. Ottawa
Sponsor: International Microwave Power Inst.

Requests for Information: Dr. W. R. Tinga, IMPI, Edmonton, Canada T5J 2N7

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS: ANNUAL CONVENTION (ELECTRO/78)

Date: May 23-25, 1978
Place: Boston, MA: Sheraton Boston & Hynes Auditorium
Sponsor: Inst. Electrical & Electronic Engineers, Electronic Reps. Assoc.
Requests for Information: W. C. Weber, Jr. C/O IEEE Boston Office, 31 Channing St., Newton, MA 02158

CONFERENCE ON PRECISION ELECTROMAGNETIC MEASUREMENTS

Date: June 26-29, 1978
Place: Ottawa, Canada
Sponsor: Inst. Electrical & Electronic Engineers (IM), National Bureau Standards, International Union Radio Science (US Nat'l Committee)
Requests for Information: A. F. Dunn, National Research Council, Montreal Road, Ottawa, Ontario, Canada

0179 BIOPSYCHOLOGICAL STUDIES OF MICROWAVE IRRADIATION. Justesen, D. R.; Sheridan, C. L.; Levinson, D. M. (U.S. Veterans Admin. Hosp., 4801 Linwood Blvd., Kansas City, MO 64128).

Studies of Pavlovian conditioning of microwave-induced hyperthermia in rats are being performed. Both irradiated rats and controls (unconditioned stimulus [US] equals electrical shock) demonstrated a generalized conditional hyperthermia (colonic temperature approximately 39 C) that was resistant to extinction. The conditioned response was not discriminative to the acoustic conditioned stimulus (CS); a persistent state of hyperarousal occurred after a few pairings of US and CS that was accompanied by a rise of body temperature. Studies of guinea pigs with indwelling electrodes and thermal sensors in the brain have revealed that animals with microwave-induced rises of temperature to 43°C exhibit changes of conduction velocity of primary afferent nerves. Velocity, as indexed by latency-to-peak of the N1 component of the visually-evoked response, first increases and then decreases as a function of increasing temperature. (6/77-5/78)

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

0180 EFFECTS OF CHRONIC EXPOSURE TO MICROWAVE ON SQUIRREL MONKEYS. Kaplan, J. (Stanford Res. Inst., 333 Ravenswood Ave., Menlo Park, CA 94025).

Pregnant squirrel monkeys and their offspring are being exposed to microwave radiation in a cavity-cage module for varying periods of time to determine possible deleterious effects on physiologic and behavioral function. The length of exposure ranges from 5.5 wk in the case of pregnant animals to approximately 16 mo in the case of monkeys exposed both in utero and postpartum. Groups of animals receive either 0.1, 1.0, or 10.0 mW/cm^2 radiation 3 hr/day, 5 days/wk. Physiologic parameters under investigation include cardiac function as determined by electroencephalogram, and stress as reflected by urinary catecholamine output. Behavioral studies include tests of learning ability, activity level, and patterns of reflex development. (1/77-12/77)

Supporting Agency:EPA, Office of Res. & Development

0181 PRE- AND POSTNATAL EFFECTS OF MICROWAVE IRRADIATION. Jensh, R. P.; Weinberg, I.; Brent, R. L.; Vogel, W. H. (Thomas Jefferson Univ., Sch. Medicine, 1025 Walnut St., Philadelphia, PA 19107).

The overall objectives of this project are to determine dosage and monitoring procedures through refinement of techniques and instrumentation of microwave irradiation and by measuring modulated and pulsed transmission of two-frequency (2,450 ± 50 MHz, 915 ± 25 MHz) and two-power ranges. To determine exposure levels that do and do not result in embryopathy, chronic exposure of pregnant rats at low dose levels of microwave irradiation during pregnancy, during the implantation period, during the organogenic period, and during the fetal period will be determined. The specific objectives are to determine: (a) possible increases in rates of embryotoxicity or abnormal offspring and how the threshold dose may vary with different types of microwave exposure and different embryopathies; (b) whether the reproductive performance following in utero or adult exposure is a sensitive measure of microwave exposure; (c) whether the central nervous system will manifest functional or architectural alternations following in utero microwave irradiation; and (d) a comparison between the threshold sensitivity of behavioral changes with observable anatomic or histologic changes in the embryo. (6/77-5/78)

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

0182 MICROWAVE IRRADIATION OF BRAIN THROUGH CRANIOPLASTY. Sutton, C. H. (Univ. Miami, Sch. Medicine, 1400 N.W. 10th Ave., Miami, FL 33124).

This project is part of a broader program that supports the Comprehensive Cancer Center for the State of Florida as a multi-disciplinary cancer center. The center's participants are involved in clinical and basic cancer research, cancer education at all levels, and intensive community outreach programs throughout Florida. Cooperative programs have been established with the state's other universities, the American Cancer Society, and HEW. The overall objectives of this program are the establishment of a core of excellence in cancer research for the State of Florida and the development of interrelationships with other cancer-directed interests in the State (and nation). (6/76-5/77)

Supporting Agency:HEW, PHS, NIH, NCI

0183 NAVY ENVIRONMENT: EFFECTS OF MICROWAVE RADIATION ON CELLS IN TISSUE CULTURE. Chen, K. C.; Taylor, J. D. (Wayne State Univ., Sch. Liberal Arts, 4841 Cass Ave., Detroit, MI 48202).

The complete understanding of the consequence of microwave exposure (as from navy radar) requires an understanding of the interactive mechanisms that occur at the cellular and subcellular level. This research will attempt to elucidate the mechanisms that occur in human (and other) cells in culture following nonthermal microwave irradiation. The biologic activity of microwave-exposed transforming DNA on recipient bacteria will be investigated. The degree of biologic damage attributable to the nonthermal factor will be measured on the basis of the relative frequencies of transformation. The change in the surface structure of cells induced

by microwaves will be examined in terms of their reactions to various concentrations of the carbohydrate-binding protein, concanavalin A. Chinese hamster cells will be used. Cell specific responses to microwave damage will be examined on human and animal cell lines. Cytotoxicity will be measured by evaluating the cloning capability of exposed and unexposed cells. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy

0184 BIOLOGIC RESPONSES TO A CHRONIC MICROWAVE ENVIRONMENT. Lebovitz, R. M.; Seaman, R. L.; Guterman, L. (Univ. Texas Sch. Medicine, 5323 Harry Hines Blvd., Dallas, TX 75230).

As microwave energy becomes increasingly present in our environment, an unmonitored population is placed at risk even though there is an insufficient body of data regarding the biologic effect of such exposure. The basic aim of this project will be to determine the effects of a long-term (4 mo exposure to microwave radiation (MWR) at low incident power densities. The behavioral effects of administratively safe MWR (i.e., less than 10 mW/cm^2 incident power density) will be examined. Data will be obtained from several behavioral variables, and a dose/response curve over the range of 0-20 mW/cm^2 will be defined. The chronic MWR environment will comprise individual radio frequency chambers into which control and experimental animals will be individually introduced for 3-4 hr of whole body MWR exposure/day. Pulse-modulated MWR at 1.3 GHz will be used. In the first part of the study, the effects of 0, 2, 5, 10, and 20 mW/cm^2 MWR on open field behavior and on instrumental behavior for food reward will be determined in rats. Besides the 0 mW/cm^2 group, additional control groups will be exposed to a mild thermal and acoustic stress. In the second part of the study, the changes in instrumental behavior relevant to learning will be determined and extrapolated to humans. Again, dose/response curve will be defined, via radiation at 5, 10, and 20 mW/cm^2 with dual control groups. These studies will provide needed data regarding the origin of chronic low level MWR effects on cognitive behavior and learning. (5/77-4/78)

Supporting Agency:HEW, PHS, FDA

0185 ELECTROMAGNETIC RADIATION INDUCED LENS CHANGES. Bonney, C. H.; Shacklett, D. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Cataracts from a variety of causes will be studied and compared with cataracts produced by microwave energy to determine if a microwave cataract develops in a manner clinically distinct from cataracts produced by other causes. Rabbits, dogs, cats, and rhesus monkeys will be irradiated with ionizing radiation, nonionizing radiation, and a nonradiation source. Fifteen animals of each species will be utilized for each etiology. In all treatments the left eye will be exposured, and the right eye will serve as a control. All exposures will be made with the animals anesthetized with sodium pentabarbital. Clinical examination of the anterior segment will be made with a photoslit lamp so that changes may be recorded photographically. Anterior segment angiograms will be made to assess any change in capillary detail or function. Posterior segment examinations will also be conducted with direct and indirect ophthalmoscopes and fundus camera. Photographs of the fundus as well as fluorescein angiograms of the fundus will be made. Histopathologic evaluations will be made when the lens changes have progressed to the stage of obscuring the fundus. At this point, the animals will be sacrificed and ocular tissues will be collected for histologic examination. Glutaraldehydeformalin mixture will be used for fixation and whole eye sections will be cut and stained utilizing standard light and electron microscopy. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Air Force

0186 ELECTROMAGNETIC BLOOD WARMING. Silva, J. (U.S. Navy, Human Factors Technology Div., San Diego, CA 92152).

The feasibility of using electromagnetic energy to thaw frozen blood products for clinical use in the Navy will be determined. Literature, materials, and products relevant to existing methods for thawing forzen blood products will be reviewed, and the problems associated with these processes identified. An alternative method using electromagnetic heating will be developed over a 3-yr period. The use of energy at different frequencies from approximately 30 MHz to approximately 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 a function of frequency and energy level, will be determined. Subsequently, tests using real 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 flood to its clinically useful form. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy

0187 DETECTION, SURVIVAL AND CONTROL OF PLANT PATHOGENIC BACTERIA ON SEEDS AND PLANT PROPAGATIVE MATERIAL. Ries, S. M. (Univ. Illinois, Agriculture Experiment Station, Urbana, IL 61801).

The effect of microwave irradiation on pathogen survival in infested seed and propagative plant parts will be investigated. Several phytobacterial diseases overseason in infected plant parts, frequently in seeds. Hot water dips, prolonged storage, or pesticide treatments of infected seeds

have been moderately successful in reducing pathogen numbers in seed sources, but these methods are expensive, time consuming, and involve pesticide usage. The application of microwave heat, a physical treatment, would be extremely quick and very inexpensive. *Pseudomonas glycinea*, infested soybean seed, will be the model for these studies. *P. glycinea* is seed-borne in all soybean cultivars. Although probably present in a hypobiotic state, there may be a moisture differential between the moisture content of the seed and the bacterium. This moisture differential will be exploited by irradiating with microwaves. selective death of the pathogen should occur before seed death, if the pathogen has a higher moisture content than the seed. Infected seed will be adjusted to a selected moisture content, irradiated for varying periods, and assayed for germinability and for *P. glycinea*. Preliminary evidence suggests that soybean seed at 6% moisture can be irradiated for 2 min with a complete destruction of *P. glycinea* and without reducing seed germinability. (10/76-9/77)

Supporting Agency:U.S. Dep. Agriculture

0188 TREATMENT OF ACROMEGALY WITH RADIOFREQUENCY TELETHERMO HYPOPHYSECTOMY (HUMAN). Bøden, G. (Temple Univ., Sch. Medicine, 3223 N. Broad St., Philadelphia, PA 19122).

This project is part of a broader program of the General Clinical Research Center at Temple University Hospital to provide a carefully controlled environment for coordinated research of some of the more human common disorders. The Center employs interdepartmental scientists of diverse interests and physicians of various medical disciplines. (12/76-11/77)

Supporting Agency:HEW, PHS, NIH, Res. Resources Div.

0189 FLUID SHEAR OR MAGNETIC ALIGNMENT OF BLOOD COMPONENTS. Gardner, R. A. (Washington Univ., Sch. Engineering & Applied Sciences, 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. (6/77-5/78)

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

0190 CUMULATIVE TERATOGENESIS FROM LOW LEVEL MICROWAVES. Rosenbaum, F. J. (Washington Univ., Sch. Engineering & Applied Sciences, 4559 Scott Ave., St. Louis, MO 63130).

It has recently been shown that prolonged exposure to low-level microwave radiation (0.5 mW for 8 hr at 9 GHz) will induce putatively cumulative teratogenic damage in pupae of the darkling beetle *Tenebrio molitor*. The proposed work will determine (a) whether intermittent exposure to microwave energy during pupation causes damage like that predicted by previous results; (b) the power level for putatively thermally-induced damage and the distribution of types of damage below the thermal level; and, (c) the influence of microwave frequency in the production of teratogenesis and thereby help identify possible mechanisms for the nonthermal effects already observed. (5/77-4/78)

Supporting Agency:HEW, PHS, FDA

0191 MICROWAVE CATARACTOGENESIS. Oosta, G. M.; Mathewson, N. S. (U.S. Dept. Defense, Armed Forces Radiobiological Res. Inst., Bethesda, MD 20014).

This research will determine the effect of microwave radiation on proteins in the rabbit lens and the relationship between expected microwave-induced alterations of lenticular proteins and duration of exposure at constant power density. Test animals will be exposed to subcataractogenic and cataractogenic levels of 2.45 GHz radiation. Possible conversion of soluble lens proteins to an insoluble form during microwave-induced cataractogenesis will be investigated. The quantity of soluble protein will be determined after extraction of all soluble lens proteins in a suitable solvent. Variables in extraction procedure will be studied to determine if soluble protein is converted to insoluble protein by the extraction procedure itself. After suitable extraction of lens proteins, quantity of alpha, beta, and gamma crystallins will be measured to determine possible alterations in protein concentration in rabbit lens as result of irradiation. Each crystallin will be further analyzed to deter-

mine shifts in subunit composition and changes in chemical/physical properties attributable to microwave damage. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Def. Nuclear Agency

0192 MICROWAVE DIATHERMY AND RADIOFREQUENCY OF MALIGNANT TUMORS. Miller, L. S.; Raymond, U. (U.S. Veterans Admin. Hosp., 508 Fulton St., Durham, NC 27705).

This study will evaluate the effectiveness of microwave diathermy alone and in combination with ionizing radiation in the management of human cancer. Patients with metastatic malignant disease considered unmanageable by conventional surgery, radiotherapy, or chemotherapy and with measurable lesions in the skin, subcutaneous tissues or other accessible locations and a life expectancy of at least 2 mo will participate. The microwave diathermy to be used in the study poses no significant risks. Risks posed by x-ray and gamma-ray therapy are conventional, and at the doses specified, no added risks are anticipated. There is a small risk of bleeding and/or infection from needle implantation of the temperature-monitoring devices (thermistors). Potential benefits to the patient include reduction in pain, cessation of bleeding, healing of ulceration, and regression of tumor masses. (4/77-3/78)

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

0193 HYPERTHERMIA--A DIFFERENTIAL RADIOSENSITIZER IN VIVO. Gibbs, F. A.; Dethlefsen, L. A.; Johnson, C. C.; Gordon, G. A. (Utah Higher Education System, Sch. Medicine, 1400 E. 2nd St., Salt Lake City, UT 84112).

The potential of hyperthermia as a radiosensitizer will be evaluated for a rapidly proliferating normal murine tissue (duodenal crypt lining epithelium), a slowly-turning-over normal murine tissue (spinal cord), as well as a slow-growing (slow line) and a fast-growing (S102F) C3H mouse mammary tumor. This combination of tissues will allow the assessment of hyperthermic radiosensitization for both the early and late effects on normal tissue and on tumors with widely varying growth kinetics. The hyperthermia will be induced locally via a 915 MHz microwave system and the effects on the tissues will be assayed, respectively, by microcolony crypt survival, hind-leg dysfunction, tumor growth delay and local tumor control (TCD50/120). Several temperatures and heating intervals will be studied as will heating before and after x-irradiation. The therapeutic indices for tumor versus normal tissue will be determined for the various protocols. The long-term goal is to assess the feasibility of introducing hyperthermia as an adjuvant for clinical radiation therapy. (5/77-4/78)

Supporting Agency:HEW, PHS, NIH, NCI

0194 EFFECTS OF MICROWAVE RADIATION ON THE NERVOUS SYSTEM. Gandhi, O. P. (Utah Higher Education System, Sch. Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

The effects of long-term, low intensity microwave exposure on the nervous system of rodents, will be investigated. Effects on the physiologic function of the nervous system, particularly the brain, will be measured and correlated with behavioral results. Biochemical analyses of the cholinesterase activity of the blood, the sulfhydryl groups in the blood, and ketosteroid in the urine will be performed and correlated with nervous system and behavioral measurements. (6/77-6/78)

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

0195 SEQUENTIAL CHEMOTHERAPY AND HYPERTHERMIA IN THE TREATMENT OF EXPERIMENTAL GLIOMAS. Sutton, C. H.; Carroll, F. B. (U.S. Veterans Admin. Hosp., 1200 Anastasia Ave., Miami, FL 33134).

Temperature gradients combining local heating of neoplasms with body-core temperature at 37 C or 28 C were investigated to determine their ability to enhance or inhibit the selective accumulation of parenterally administered antineoplastic agents in tumor implants. The Zimmerman murine ependymoblastoma was implanted subcutaneously in both flanks of C57BL/6 mice. In each animal, one flank tumor was heated to 40 C, 41 C, or 45 C with a 2.45 GHz microwave diathermy generator. The contralateral implant and the remainder of the animals were shielded with microwave-absorbing Eccosorb. Tracer doses of either ^{3}H-cytosine arabinoside or ^{3}H-methotrexate were injected either intraperitoneally or intravenously. These were measured in plasma, in heated tumor, in contralateral unheated tumor, and in liver and kidney 15-120 min post-injection. It was found that peak plasma concentrations of both agents were reached after 30 min. The greatest uptake of each agent during a 45-min period after intraperitoneal injection was obtained by heating tumors to 41 C. With both agents, the peak plasma concentrations achieved were two to three times greater in hypothermic than in normothermic mice. Higher concentrations were achieved in heated tumors using cytosine arabinoside than were achieved with methotrexate. Systemic hypothermia at 28 C served to minimize the amounts of antineoplastic agents entering liver and kidney during this 45-min period. These results confirmed that the distribution of antineoplastic agents can be affected by temperature gradients. The results also demonstrated an enhanced accumulation of antimetabolites selectively in microwave-heated tumors in the presence of body-core hypothermia. It is suggested that the microwave heating of tumors to 41°C for periods of 30 to 45 min after the parenteral administration of antineoplastic agents may prove beneficial in the chemotherapy of human neoplasms. (9/76-8/77)

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

0196 BIOELECTRIC STIMULATION OF DOG CORTICAL BONE GRAFTS. Burchardt, H.; Rudner, C. (State Univ. Florida System, Sch. Medicine, 1600 Archer Rd., Gainesville, FL 32610).

Cortical bone grafts are used in repairing congenital defects and in many other applications in orthopedic surgery. However, fatigue fractures of the grafts and/or nonunion of the graft-host junctions occasionally occur. The proposed study is an attempt to find a noninvasive method of enhancing the incorporation and/or repair of cortical bone grafts. It has been demonstrated that electromagnetic stimulation of experimental fractures can increase the speed of callus formation and the strength of healing fractures. This study will determine whether electromagnetic stimulation will enhance the incorporation and/or repair of segmental cortical fibular autografts in dogs. Adult mongrel dogs weighing 20 to 25 kg will be employed. Each dog with bilateral segmental fibular autografts will carry an electromagnetic coil fixed to each hind leg over the grafted segment for 12 wk postgrafting. The coil on one hind leg of each dog will emit an electromagnetic signal, and the other will serve only as a sham coil for control purposes. When the fibular segments are removed at 12 wk they will be tested for torsional strength. The segments will then be analyzed for porosity and cumulative new bone formation using continuous tetracycline labeling with fluorescent photography and microradiography of serial cross-sections of the transplant segments. The data will be compared statistically with established data on homotypic autograft variation to determine whether bioelectric stimulation by means of electromagnetic fields alters the strength or repair process of autogeneous bone grafts. (11/76-10/77)

Supporting Agency:Easter Seal Res. Foundation

0197 BIOLOGICAL TEMPERATURE SENSOR USING OPTICAL ETALONS. Christensen, D. A. (Univ. Utah Sch. Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

This project will develop a nonmetallic temperature probe using a small optical etalon as the sensing element. The etalon--an optical flat coated to form a reflecting cavity--will be connected to the light source and detector by a fiberoptic bundle. Biologic applications of such a system include monitoring of microwave biohazards, microwave thawing of frozen organs and blood, and microwave therapy for cancer. Conventional thermistors, thermocouples and their metallic leads cannot be used in all these radiation experiments because they significantly perturb the electromagnetic fields and therefore cause temperature errors. The optical technique will rely upon the change in the wavelength-dependent reflection from the face of the etalon as the temperature varies. Temperature changes will cause thermal expansion or contraction in the etalon material as well as changes in the index of refraction, thus varying the resonant wavelengths. A similar technique, based upon the temperature shifts of the band energy gap in semiconductors, which can be sensed optically by measuring the wavelength of the adsorption edge, will be pursued. Prototype probes are under development. (4/77-3/78)

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

0198 REMOTE STIMULATION BY RADIOFREQUENCY TRANSMISSION. Glenn, W. W. (Yale Univ., Sch. Medicine, 333 Cedar St., New Haven, CN 06510).

This project is part of a broader program conducted by the Clinical Research Center at the Yale-New Haven Hospital and Yale University School of Medicine. The Center conducts clinical investigation concerning the mechanisms of disease. Therapeutic measures are developed or tested in this Unit. (12/76-11/77)

Supporting Agency:HEW, PHS, NIH, Res. Resources Div.

0199 EFFECTS OF MICROWAVE RADIATION ON THE NERVOUS SYSTEM. Lovely, R. H. (Univ. Washington, Sch. Medicine, 500 17th Ave., Seattle, WA 98122).

The effects of long-term, low intensity microwave exposure on the nervous system, particularly the brain, will be investigated. The effects of microwaves on the brain will be measured and correlated with behavior and biologic functions. (1/77-6/77)

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

0200 MICROWAVE THAWING OF FROZEN TISSUE. Lehr, H. B.; Holst, H. I.; Ketterer, F. (Univ. Pennsylvania, Sch. Medicine, 36th & Hamilton Walk, Philadelphia, PA 19104).

The microwave thawing process in frozen organic materials will be investigated. Since 1968 this laboratory has investigated the effects of microwave radiation on rat skin, canine kidneys, and gelatin molds. Radiation tolerance levels of cold cryoprotectant (DMSO) perfused canine kidneys have been established. Methods of thawing a frozen, cryoprotectant-perfused canine kidney have been evaluated by reimplanting the kidney in a dog's neck. To date, no kidney, after being frozen to a minimum of -40 C and stabilized at that temperature, has retained sufficient function to sustain a dog's life although survival of the kidney components as glomeruli and tubules has been obtained. Renal pelvis, ureter, and blood vessels survive consistently. Specifically, this investigation will measure the electrical properties of tissue in the frozen state. Improved qualitative models of microwave heating of kidneys by analysis and computer simulation will be developed and evaluated. A uniform thawing schedule employing more than one microwave

frequency will be developed for artificial organic gel kidneys that are similar in electrical and thermal properties to canine kidneys. Finally, these techniques will be applied to live mammal using rat skin and canine kidneys. (4/77-3/78)

Supporting Agency:HEW, PHS, NIH, NIAMDD.

0201 EFFECTS OF LOW INTENSITY MICROWAVE RADIATION ON MAMMALIAN SERUM PROTEINS. Cleary, S. F.; Berry, E. R. (Virginia Commonwealth Univ., Sch. Medicine, 1200 E. Broad St., Richmond, VA 23298).

Cis and *trans* isomers of beta mercaptoethylamine and gamma mercaptoprophylamine will be synthesized to determine their radioprotective properties. This research is relevant to maintaining military forces in the field during nuclear warfare, and it is in direct support of the Priority I Department of the Army Approved Qualitative Material Development Objective for Prophylaxis and Therapy to Offset Effects of Ionizing Radiation (CDOG 1212b[21]) dated 27 June 1968. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy.

0202 NAVY ENVIRONMENT - EFFECT OF MICROWAVE IRRADIATION (AS FROM RADAR) ON EMBRYONIC BRAIN TISSUE. Rioch, D. (Inst. for Behavioral Res., 2429 Linden Ln., Silver Spring, MD 20910).

This research will determine to what extent microwaves, such as are derived from Navy radars, alter the behavior and growth rate of rats that are exposed in utero. The experiments will be divided into three groups: Group I experiments involve exposure during the 6th to 9th and 12th to 16th days of gestation to determine post-natal changes in behavior and growth rate. Group II experiments will involve exposures at different times of the diurnal cycle to determine rhythmic influences. Finally, the relationship between intensity and duration of the exposure when total absorbed energy is constant will be explored. (10/76-9/77)

Supporting Agency:U.S. Dep. Def., Navy

0203 BIOLOGICAL AND ECOLOGICAL IMPACT OF ENERGY TRANSMISSION BY MICROWAVE BEAM (JOINT ERDA/NASA PROGRAM). Sharp, J. C. (U.S. Natl. Aerospace & Space Admin., Ames Res. Center, Moffett Field, CA 94035).

The National Aeronautics and Space Administration (NASA) is currently assessing the feasibility of a Space Power Satellite to generate electrical power in space and transmit it to earth by microwave beam. The environmental impact from the transmission, received over many square miles continuously for 30 yr, appears to be far less than that from many other proposed solutions to the energy crisis, but many aspects have not been researched or tested. The biologic and ecologic consequences on all forms of fauna and flora to be illuminated need to be well defined. In addition, the potential hazard to operational personnel from acute exposure and low-dose chronic exposure must be evaluated to establish areas of restricted use around the receiving area. An initial short-term funded effort (definition phase) will be implemented to develop a 3-yr research program to define major effects and anticipated problems; suggested approaches will be researched in subsequent years. The initial 5-mo study plan will be reviewed, and the accepted plan pursued for an intensive 3-yr research program (Phase A). Results of that research will be assembled in a form suitable for use in decisions by NASA to extend commitments to the Space Power Satellite Concept and to conduct additional biologic and ecologic studies on mechanisms and interactions (Phase B). A further extension of this effort (Phase C) will develop operational procedures and site selections and prepare environmental impact documentation. (10/76-9/77)

Supporting Agency:HEW, PHS, NIH, NIAMDD.

0204 STUDY OF BIOLOGICAL AND ECOLOGICAL EFFECTS OF ENERGY TRANSMISSION BY MICROWAVES ON INSECT BEHAVIOR. Gary, N. E. (Univ. California, Sch. Agricultural and Environmental Science, Davies, CA 95616).

No descriptive information is available. (3/77-9/77)

Supporting Agency:NASA, Organization & Management Office, Univ. Affairs Office

0205 STUDY OF BIOLOGICAL AND ECOLOGICAL EFFECTS OF ENERGY TRANSMISSION BY MICROWAVES. Guy, A. W. (Univ. Washington, Sch. Medicine, 500 17th Ave., Seattle, WA 98122).

No descriptive information is available. (3/77-9/77)

Supporting Agency:NASA, Organization & Management Office, Univ. Affairs Office

0206 ELECTRIC FIELD AND ELECTROMAGNETIC SENSOR CAPABILITIES OF MARINE ORGANISMS. Kalmijn, A. J.; Sheltema, R. (Woods Hole Oceanographic Inst., Main St., Woods Hole, MA 02543).

An analysis of how marine organisms perceive, orient, and react to weak electric and electromagnetic fields in the ocean environment is important for naval operations involving deployment of galvanic hardware systems and for the protection of naval swimmer/diver personnel. Such an analysis would explain shark attack on both personnel and hardware and also the orientation of marine bacteria, which may be initial components in marine corrosion biochemistry

systems. The neural mechanisms and associated behavioral responses in marine organisms to natural electric and electromagnetic fields will be investigated. The principal areas of concern are the biologic relevance of an electric sense, the biophysics of electroreceptor systems, and the central processing of electrical information at lower brain levels. (10-76-9/77)

Supporting Agency:U.S. Dep. Def., Navy

0207 MICROWAVE METHODS OF LUNG WATER MEASUREMENT. Durney, C. H.; Bragg, D. G.; Johnson, C. C.; Morris, A. H. (Univ. Utah, Sch. Engineering, 1400 E. 2nd St., Salt Lake City, UT 84112).

The objective of this research is to measure total lung fluid content by calculating the reflection of microwave energy applied to the thorax or the transmission of microwaves through the thorax. A pulmonary edema animal model will be developed, and microwave measurements will be made on lung phantoms with known water content and on dogs with artificially induced and measured pulmonary edema. Calculations based on a planar layered model will be used to account for differences in the size and shape of the thorax. The results will show whether microwave methods are feasible for monitoring changes in lung water or for measuring absolute levels of lung water. (12/76-11/77)

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

0208 GENETIC AND DEVELOPMENTAL EFFECTS OF MICROWAVE IRRADIATION OF MICE. Czerski, P. (Natl. Res. Inst. Mother and Child, 17 Kasprzaka, Warsaw, Poland).

A lifetime study of progeny of microwave-irradiated mice is proposed. The study will utilize a single exposure rate and a multiple low-level exposure to microwave radiation of two groups of animals. Progeny of one group will be examined for gross structural and induced chromosomal congenital anomalies. Irradiated parents and subsequent progeny of the second group will be observed to determine lifetime morbidity and mortality. (10/77-9/78)

Supporting Agency:HEW, PHS, FDA, Bureau Radiological Health

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5106 RISKS AND DAMAGES RESULTING FROM OCCUPATIONAL EXPOSURE TO HIGH FREQUENCY ELECTROMAGNETIC FIELDS. *(Ita.)* Alberti, S. (No affiliation given). *Securitas* 61(1-2): 27-35; 1976. (30 refs)

The effects from exposure to electromagnetic radiation were investigated in two groups of workers involved in the operation of high frequency (5-50 MHz) heating machines used in wood glueing. The clinical investigations were prompted by subjective symptoms developed by the workers. In a group of five workers (25-40 yr old) with total employment duration (TED) of 1.5-10 yr and similar rhythm of exposure (RE), the spermiogram (Page-Houlding index) showed values of 44, 23, 19, 3 and 0, respectively, versus normal values of 50-80. These indices indicated sterility in 2/5 and decreased fertility in 3/5, while 4/5 subjects showed a marked decrease of testicular pain sensitivity. A group of 26 workers (22 men and 6 women, 16-62 yr old) had a TED of 4-12 mo (12/26), 1-3 yr (10/26), and 3-6 yr (4/26). The RE was continuous (the whole shift in every working day) in 14/26, half shift in 1/26, and intermittent (a few hr/wk for a few days/mo) in 11/26. Recurrent subjective symptoms were found in 22/26: insomnia (9/22), asthenia (6/22), decrease of libido (4/22), and incessant headache (3/22). The spermiogram, performed in only 12 subjects, showed an index of >50 in 8/12, 5-50 in 3/12, and <5 in 1/12. Among the 8 with normal index, 5/8 had intermittent and 3/8 had continuous RE. Among the 4 with decreased index, 2/4 (index 4 and 8) had continuous RE of 6 and 8 mo., respectively; 2/4 (index 9 and 40) had a TED of 4 and 3 yr and continuous, followed by intermittent, RE. Results of other clinical examinations were not be correlated with the effects of nonionizing radiation. A review of the literature preceeds the presentation of the clinical results.

5107 EFFECT OF UHF ELECTRICAL FIELD ON THE BLOOD CLOTTING SYSTEM IN ANIMALS. *(Rus.)* Rusiaev, V. F. (Dept. Physics, Chita Medical Inst., Chita, USSR); Mulyndina, G. I. *Vopr Kurortol Fizioter Lech Fiz Kult* (4): 76-79; 1976. (8 refs)

The effect of exposure to ultra high frequency (UHF) electrical field (80 V/m, 5 min per day for 10 days) on various parameters of blood coagulation was studied in rats. The hemoglobin level decreased from 12.9 ± 0.5% in the control to 11.4 ± 0.3% ($P<0.05$); the erythrocyte sedimentation reaction increased to 7.6 ± 1.8 Hg mm from 2.6 ± 0.2 Hg mm ($P<0.02$); the viscosity of the blood decreased to 3.6 ± 0.1 cP from 4.2 ± 0.3 cP ($P<0.1$); the erythrocyte count dropped to 5.4 ± 0.4 x $10^6/mm^3$ from 6.4 ± 0.7 x $10^6/mm^3$ ($P<0.02$); and the leukocyte count increased from 3,900 ± 460 mm^3 to 4,800 ± 510/mm^3 ($P<0.2$). The recalcification time was 14 sec in the 1:30 dilution of aortic extract vs 13 sec in the control ($P<0.3$); the prothrombin consumption was 818 sec vs 1,200 sec in the control ($P<0.01$); the thrombin time was 21 sec in the control ($P<0.05$); and the fibrinolytic activity was 188 min vs 158 min in the control ($P<0.05$). The findings indicate that UHF electrical field causes hypercoagulability and suppresses the thromboplastic and fibrinolytic activity of the tissue extracts.

5108 EFFECT OF ELECTROSTATIC FIELD ON ANTIBODY SYNTHESIS. *(Rus.)* Tovmasian, V. S. (Central Scientific Res. Lab., Erevan Medical Inst., Erevan, USSR); Gevorkian, M. I.; Artsruni, G. G. *Zh Eksp Klin Med* 16(5): 42-44; 1976. (9 refs)

The effect of exposure to electrostatic field (potential 2,500 V/cm, 24 hr) on antibody synthesis was studied in strainless male mice 4 and 7 days after immunization with sheep erythrocytes (1 ml, 2% suspension, ip). The number of the antibody-forming splenocytes was determined by hemolysis testing. Group I was immunized immediately after exposure; Group II was exposed to the electrostatic field immediately after immunization, while Group III was exposed immediately after immunization, and three days later. The number of the antibody-forming spleen cells was significantly reduced compared with the control (125.6 ± 28.8 x 10^6) on the 4th day (44.1 ± 14.8 x 10^6 in Group I; 4.05 ± 2.83 x 10^6 in Group II, and 5.29 ± 46 x 10^6 in Group III). On the 7th day, the reduction was significant in Group III only (12.06 ± 2.63 x 10^6 vs 53.9 ± 12 x 10^6 in the control). The findings indicate that electrostatic fields cause a considerable immunosuppressive effect, especially when immunization precedes exposure.

5109 ON THE MAGNETIC FIELD DEPENDENCE OF THE YIELD OF THE TRIPLET STATE IN REACTION CENTERS OF PHOTOSYNTHETIC BACTERIA. *(Eng.)* Hoff, A. J. (Biophysical Lab., State Univ. Leiden, Wassenaarseweg 78, Leiden, The Netherlands); Rademaker, H.; Van Grondelle, R.; Duysens, L. N. M. *Biochim Biophys Acta* 460(3): 547-554; 1977. (22 refs)

The effect of an applied magnetic field on the yield of the triplet state in reaction centers of the photosynthetic bacterium *Rhodopseudomonas sphaeroides* was investigated. In chromatophores, the triplet yield in a high magnetic field was 15% lower than that in a zero-field, and the magnetic field at which half the effect was observed ($B_{1/2}$) was about 500 G. In reaction centers with an intact iron-ubiquinone complex, the triplet yield was 25% lower in a magnetic field, and the total extent of the effect was obtained in fields as low as 100 G. In reaction centers in which only ubiquinone acts as the primary acceptor, the triplet yield was 35% lower, with the effect fully developed at about 50 G. The iron in the iron-ubiquinone complex of the R-26 mutant form of *Rhodopseudomonas sphaeroides* is not essential for the magnetic field effect, since the wild type of the bacterium, which lacks a functional iron complexed to ubiquinone, also showed an effect on triplet state yield. Chromatophores of the wild type of *Rhodopseudomonas sphaeroides* that were

reduced with 100 mmolar dithionite initially gave almost no field effect. When *o*-phenanthroline was added, the triplet yield in zero-field remained the same, but field effect became much stronger (up to 15%). It is concluded that the magnetic field effect is critically dependent on the value of the exchange parameter that measures the exchange interaction between members of the radical pair P^+I^- (P is the primary donor and I the first identifiable acceptor).

5110 LOSS OF VIABILITY OF PEAS CAUSED BY MICROWAVE HEATING. *(Eng.)* Schrader, D. H. (Electrical Engineering Dept., Washington State Univ., Pullman, WA); Patel, B. M. *Trans ASAE* 20(2): 354-359; 1977. (18 refs)

Loss of pea seed *(Pisum sativum)* viability due to short-term thermal heating or microwave exposure (916 MHz at power levels up to 20 kW) was investigated. Temperatures and exposure times for 50% survival after microwave heating were 73 C and 3,600 sec, 81 C and 1,000 sec, 89 C and 1,000 sec, 97 C and 27-50 sec, 107 C and 13-25 sec, 113 C and 5-10 sec, and 106 C and 4-8 sec. For thermal heating, the temperatures and exposure times for 50% survival were 54 C and 4.73 wk, 58.9 C and 6 days, 69.5 C and 36 hr, 70 C and 35.6 hr, 73.5 C and 9.5 hr, 79 C and 80.5 min, 79.5 C and 3,600 sec, and 90 C and 280 sec. A statistical analysis of these data indicates that any extra-thermal effect due to the microwave exposure was less than the variability of the temperature measurements that were performed calorimetrically and by infrared radiation monitoring.

5111 STUDIES ON THE HEMATOLOGIC EFFECTS OF LONG-TERM, LOW-DOSE MICROWAVE EXPOSURE. *(Eng.)* Djordjevic, Z. (Inst. Aviation Medicine-Zemun, Yugoslavia); Lazarevic, N.; Djokovic, V. *Aviat Space Environ Med* 48(6): 516-618; 1977. (17 refs)

Hematologic and morphologic studies on Wistar rats exposed to 2,400 MHz continuous microwave radiation at a mean power density of 5 mW/cm^2 were conducted. The rats were irradiated for 1 hr/day for 90 consecutive days. No significant differences in hematocrit, mean cell volume, hemoglobin, total leukocyte and erythrocyte counts, neutrophilic leucocytes, and lymphocytes were observed between test rats and control rats before, during, and after irradiation. Although moderate leukocytosis was observed during the experimental period in irradiated rats, similar alterations in the number of leukocytes in peripheral blood were observed in control animals. Thus, the leukocyte shifts observed during the experiment do not appear to be the result of microwave irradiation. Morphologic studies did not reveal any evident changes in the spleen, liver, heart, brain, or testicles.

5112 ELECTRICAL BONE-GROWTH STIMULATION IN AN EXPERIMENTAL MODEL OF DELAYED UNION. *(Eng.)* Paterson, D. C. (Adelaide Children's Hosp., Adelaide, Australia); Carter, R. F.; Maxwell, G. M.; Hillier, T. M.; Ludbrook, J.; Savage, J. P. *Lancet* 1(8025): 1278-1281; 1977. (25 refs)

The effects of direct current stimulation on bone healing in an experimental model involving delayed bone healing of the tibia in adult dogs were assessed in a double-blind trial. A commercial bone growth stimulator was used to supply a constant sum current of 20 μA through one stainless-steel cathodic electrode; there were two platinum anodes carrying approximately half of the sum current. The electrodes were passed retrogradely into the defect area where the anodes were inserted into the medullary cavity at a point 1.5 cm above and below the defect; the cathode was made into a helix and inserted into the defect area. Two groups of 24 dogs each with delayed bone healing for 4 wk were attached to electrodes, which were connected to either active or inactive stimulators. Osteogenesis in dogs with active electrodes was superior to that in dogs with inactive electrodes when evaluated by the criteria of gamma imaging ($P = 0.05$) and clinical union ($P = 0.05$). Using these two criteria plus the additional criterion of histologic appearance, healing in dogs with active electrodes was found to be superior to that in dogs with inactive electrodes at the 1% level of significance. Histologic assessment revealed normal bone healing by endomembranous and endochondral ossification. Inflammatory changes were insignificant and did not inhibit osteogenesis. There was no evidence of dysplastic or neoplastic changes in dogs receiving direct current stimulation. Therefore, electrical stimulation can significantly accelerate bone healing in an experimental situation analogous with delayed bone union in man.

5113 HEMOLYSIS OF HUMAN ERYTHROCYTES BY A TRANSIENT ELECTRIC FIELD. *(Eng.)* Kinosita, K. (Dept. Physiological Chemistry, Johns Hopkins Univ. Sch. Medicine, Baltimore, MD 21205); Tsong, T. Y. *Proc Natl Acad Sci USA* 74(5): 1923-1927; 1977. (20 refs)

The exposure of human erythrocytes to a high voltage pulse of a few kV/cm under isotonic conditions led to total hemolysis of the red blood cells. Hemolysis was due to a field-induced transmembrane potential; neither the effect of current nor the extent of the rapid Joule heating to the suspending medium showed a direct correlation with the observed hemolysis. High ionic strength in the pulsation medium markedly reduced the hemolysis rate. When erythrocytes were treated with a 20 μsec pulse at 3.7 kV/cm and then transferred into an isotonic sodium-chloride solution, 50% hemolysis was attained at 0.2 min, 0.6 min, 13 min, and 4 hr, respectively, for pulsation media containing 3, 10, 30, and 100% isotonic sodium chloride. Voltage pulsation of the erythrocyte suspension was capable of inducing a transmembrane potential across the cell membrane, which at a critical point either opened up or created pores in the erythrocytes. In isotonic saline the pores were small and allowed passage of potassium and sodium ions but not sucrose and hemoglobin (Hb) molecules. In contrast, larger pores, which admitted

sucrose but not Hb were obtained by pulsation in 30% sodium chloride-70% sucrose isotonic mixture. Kinetic measurements indicated that the hemolysis of the erythrocytes followed a stepwise mechanism: leakage of ions led to an osmotic imbalance, which in turn caused a colloidal hemolysis of the erythrocytes.

5114 SENSITIVITY OF THE HOMING PIGEON TO AN EARTH-STRENGTH MAGNETIC FIELD. *(Eng.)* Bookman, M. A. (Dept. Psychology, Massachusetts Inst. Technology, Cambridge, MA 02139). *Nature* 267(5609): 340-342; 1977. (25 refs)

A flight tunnel constructed within a controlled magnetic environment was used to train three pairs of homing pigeons (*Columbia livia*) to discriminate between an earth-strength induced magnetic field (0.5 G) and a 0.02 G background field. The pigeons were allowed to travel the length of the tunnel and were trained to enter the correct feeding box associated with each magnetic field condition. Two basic patterns of response were observed during adaptation and training of the pigeons. After landing, the birds would either walk the length of the tunnel or engage in a period of spontaneous flutter activity before entering a feeding box. Flutter consisted of sustained hovering, jumping, rapid turning, and short flights. The data showed a statistically significant discrimination between the two magnetic field conditions that was even more apparent when the trials were separated according to flutter activity. In all cases, 'with flutter' trials were statistically nonrandom, while the 'no flutter' trials were random. Homing pigeons, therefore, appear to have a magnetic field sensitivity which is somehow associated with flutter activity.

5115 FLUOROSCOPE-GENERATED ELECTROMAGNETIC INTERFERENCE IN AN EXTERNAL DEMAND PACEMAKER. REPORT OF A CASE. *(Eng.)* Leeds, C. J. (Cardiology Dept., USPHS Hosp., Staten Island, NY 10304); Akhtar, M.; Damato, A. N. *Circulation* 55(3): 548-550; 1977. (8 refs)

Electromagnetic interference from a faulty fluoroscopy unit caused inhibition and resetting of the demand circuitry of a ventricular-inhibited temporary external pacemaker in a 70-yr-old man undergoing surgical implantation of a permanent bipolar pacemaker generator and lead. The external pacemaker was set at an automatic pacing interval of 850 msec with the sensitivity control at maximum. The stimulus output was adjusted to 2 mA, 1.4 mA greater than the ventricular pacing threshold. The fluoroscopy unit, which was used to observe the cardiac silhouette, was in the vicinity of the external temporary transvenous pacing equipment. The arrhythmia was due to oversensing of waveforms (modulated to simulate myocardial potentials) that were emitted by the fluoroscopy unit. Examination of the fluoroscopic unit revealed a faulty relay that interfered with the normal flux density of the transformer, causing a build-up during viewing and a release of excess transient current across the circuit upon deactivation. Replacement of the relay and the addition of a resistor and capacitor to the circuit eliminated the offending electromagnetic transmission.

5116 NONMETALLIC ELECTRODE SYSTEM FOR RECORDING EEG AND ECG IN ELECTROMAGNETIC FIELDS. *(Eng.)* Flanigan, W. F. (Biomedical Group, Undersea Sciences Dept., Naval Undersea Center, San Diego, CA 92132); Bowman, R. R.; Lowell, W. R. *Phys Behav* 18(3): 531-533; 1977. (5 refs)

A nonmetallic electrode/lead system for recording biopotentials in the presence of electromagnetic fields is described which minimizes field enhancement artifacts associated with metal and other electrode systems. The electrode is a 10-cm strip of 4 siemens (S)/m carbon-loaded teflon (CLT), which is 1 mm wide and 0.25 mm thick. The lead is a strip of 72 S/m CLT of identical width and thickness. In comparison with thin copper electrodes, which can have field enhancements on the order of 10^7, the electrode material used in the above system produces only a marginal field enhancement of 1.3 at 960 MHz and even causes a field reduction of 0.6 at a frequency of 2,450 MHz. By keeping the separation between the two electrodes and the two leads to a mininum, noise is effectively eliminated in the system when it is placed perpendicular to the electric field component of incident electromagnetic fields at power levels up to 100 mW/cm^2. The electrode system has been used to record brain wave and heart rate activity in both acutely and chronically implanted chelonians (turtles and tortoises). Electrode tips were inserted up to 2-3 mm between dura and skull and between underlying soft tissue and the upper shell for monitoring electroencephalograms and electrocardiograms, respectively. Recordings compared favorably with those obtained from animals chronically implanted with metal electrodes and connecting wires.

5117 THE BIOLOGICAL EFFECT OF THE ELECTRIC FIELDS OF HIGH-TENSION LINES ON MAN. *(Ger.)* Stimmer, H. (Vorstand des Instituts fuer Elektrische, Anlagen und Hochspannungstechnik der Technischen Universitaet Wien, Gusshausstrasse 25, A-1040 Wien, Austria). *Osterr Z Elektriz* 30(3): 86-89; 1977.

A survey of the effects of the electrical fields in high-tension lines on the human body is presented. A 1972 Soviet report pointed out that headache, nausea, and vertigo were observed in people working in new 500 kV high-tension switchgear plants after exposure of several months. Subsequently, a group of 250 persons employed in high-tension plants with longer and more frequent exposure to electric fields of up to 30 kV/m was investigated. The workers revealed breakdown symptoms in the central nervous system, disorders of the cardiovascular system, morphologic changes in the blood, and reduced sexual

potency in young men. Similar studies in various European countries involving groups of people exposed to electric fields of 20 kV/m, 200-400 kV did not show any significant changes in vital signs. A Spanish study reports that three workers who were employed for more than 10 yr at a 400 kV-plant, displayed vertigo, loss of appetite, insomnia, retching spells, and visual disturbances. These symptoms disappeared after cessation of field effect. Evaluation and comparison of the variable results were difficult because potential changes were not limited to the pathologic range alone. The effects never exceeded standard borderline values and could have been due to any number of everyday environmental causes.

5118 ARTERIAL PRESSURE UNDER THE INFLUENCE OF LOW-INTENSITY MICROWAVES AND HIGH TEMPERATURE. *(Rus.)* Sadchikova, M. N. (Inst. Labor Hygiene and Occupational Diseases, Acad. Med., Moscow USSR); Nikonova, K. V.; Denisova, E. A.; Snegova, G. V.; Lvovskaya, E. N.; Soldatova, V. A. *Gig Tr Prof Zabol* 2: 17-21; 1977. (8 refs)

The vascular tone of 885 individuals occupationally exposed to low-intensity microwave radiation and high temperature was investigated. Of the 885 people, 275 men and 78 women were in contact with microwave radiation sources, and 532 (411 males, 121 females) served as controls. The group under investigation was subdivided according to working conditions. Group I consisted of 182 men (up to 40 yr old-73.1%) manufacturing radiolocation equipment and UHF units with length of service of up to 10 yr. They were periodically exposed to microwave radiation ranging from a few to hundreds of $\mu W/cm^2$ at 2-3 hr/day. They also worked at high temperatures (37-39 C). Group II consisted of 93 men (up to 40 yr old-69.9%) and 78 women (up to 40 yr old-52.6%) working with radio relay control equipment and control-adjustment of electronic instruments, who received about 10 $\mu W/cm^2$. Service records ranged from 3-20 yr. Clinical examination showed the majority of all groups to be healthy; however, hypertension was noted in men exposed for 5 yr or longer to microwave radiation of hundreds of $\mu W/cm^2$ and high temperature and in women with 10-20 yr of work exposure to microwave radiation of up to 10 $\mu W/cm^2$.

5119 BIOLOGICAL EFFECTS OF MICROWAVE AND RADIOFREQUENCY RADIATION. *(Eng.)* Cleary, S. F. (Dept. Biophysics, Virginia Commonwealth Univ., Richmond, VA). *CRC Crit Rev Environ Control* 7(2): 121-166; 1977. (100 refs)

Studies conducted over the past 6 yr on the biologic effects of microwave (30-300 MHz) and radiofrequency (RF: 30-300 kHz) radiation are reviewed with particular emphasis on the existence and/or significance of low-intensity (less than 10 mW/cm^2) effects. Hematopoietic effects such as changes in leukocyte, lymphocyte, and neutrophile count; altered mitotic activity in erythroblasts, bone marrow cells, and lymphatic cells; and changes in blood urea nitrogen and serum glucose have been observed in experimental animals exposed to frequencies ranging from 1.28-24 GHz at power intensities of 0.5-165 mW/cm^2. Reported alterations in thyroid function associated with occupational microwave exposure suggest that the neuroendocrine system is sensitive to microwave and RF fields at intensities that can induce low levels of tissue heating. Microwave or RF exposure may also alter the susceptibility to stress of insult by viral or bacterial pathogens. For example, the granulopoietic reaction to staphylococcal insult in rabbits exposed for 6 hr/day to 3-GHz microwaves (3 mW/cm^2 intensity) was significantly different from that of unirradiated rabbits. The susceptibility of mice to the effects of certain drugs such as, pentetrazol, has been altered by exposure to 3-GHz pulse-modulated microwaves at an average power of 5 mW/cm^2. Although the effects of long-term low intensity occupational microwave exposure on the human lens are unclear, increases in the rate of lens aging have been reported in connection with such exposures. Experimental thresholds for microwave pulse-evoked auditory sensation have been related to the incident pulse energy, with values of 20 J/cm^2 for cats and 40 J/cm^2 for humans at pulse durations of 30 μsec or less. Additional research is necessary before any definite conclusions may be drawn about the effects of low-intensity microwave or RF exposure on mammalian reproduction and development. Although significant differences in the results of studies on microwave- or RF-induced central nervous system effects exist, low intensity fields at times induce detectable changes in nerve structure, electrophysiology, or behavior. Significant alterations in the behavior of albino rats trained to respond on multiple reinforcement schedules were induced by both S- and X-band irradiations at intensities of 5 mW/cm^2 or greater.

5120 TUMOR CURE AND CELL SURVIVAL AFTER LOCALIZED RADIOFREQUENCY HEATING. *(Eng.)* Marmor, J. B. (Div. Radiology, Stanford Univ. Sch. Medicine, Stanford, CA 94305); Hahn, N.; Hahn, G. M. *Cancer Res* 37(3): 879-883; 1977. (15 refs)

A 13.56 MHz unmodulated electromagnetic field from a radiofrequency generator was used to locally heat EMT-6 mammary sarcomas and KHJJ carcinomas, which were intradermally implanted (10^5 viable tumor cells) in BALB/cKa mice. Temperature profiles indicated uniform temperature distribution throughout the tumor volume with no systemic hyperthermia. Typical initial incident power levels were 0.9 W/cm^2, and average maintenance powers were about 0.6 W/cm^2. Host body temperature rose slowly but did not exceed 37 C. Both tumors were highly sensitive to cure by radiofrequency heating, with the cure rate being a function of temperature and exposure duration. Exposures of 20 min or longer at 44 C were sufficient to cure all mice with EMT-6 sarcomas. Approximately 50% cure rates were achieved with 5 min of exposure at 44 C with 10-min exposure at 43.5 C and with 30-min exposure at 43 C. The KHJJ tumor was more resistant to cure than the EMT-6 tumor. At 43.5 and 44 C, 20-min exposures were required to produce

a 50% cure rate; 100% cure rates were not achieved. Tumor cell survival studies on EMT-6 tumors treated in situ revealed that cell inactivation by radio-frequency heating was similar to that for hot water bath heating. However, direct cell killing cannot account for the observed cures, and it is postulated that an additional delayed mechanism involving either intratumor or host response must play a major role in tumor eradication.

5121 A MULTIPLE-ANIMAL ARRAY FOR EQUAL POWER DENSITY MICROWAVE IRRADIATION. *(Eng.)* Oliva, S. A. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, Bethesda, MD 20014); Catravas, G. N. *IEEE Trans Microwave Theory Techniques* 25(5): 433-436; 1977. (7 refs)

A Styrofoam and Plexiglas exposure array, which permits the simultaneous irradiation of multiple animals at a uniform average microwave power density, is described. The array consists of microwave transparent cages positioned in accordance with the natural characteristics of the microwave field and separated sufficiently to insure minimum interaction between animals due to microwave reflection. Experiments in which the array was tested in an anechoic chamber at a frequency of 2,450 MHz using an isotropic field probe, which was placed in a given cage concurrently with the placement of rats in all other cages, revealed that the average power density in any cage varied by no more than ± 5% from the composite average of all cages. Differences in perturbations between cages closest to the microwave antenna and those farthest from the antenna may be compensated for by rotating the animals through all cages on a day-to-day basis.

5122 SINGLE AUDITORY UNIT RESPONSES TO WEAK, PULSED MICROWAVE RADIATION. *(Eng.)* Lebovitz, R. M. (Dept. Physiology, Univ. Texas Health Science Center at Dallas, Dallas, TX 75235); Seaman, R. L. *Brain Res* 126(2): 370-375; 1977. (19 refs)

Extracellular single auditory unit responses were recorded from the proximal portion of the eighth nerve of cats exposed to pulsed microwave radiation (915 MHz) with an average absorved power density of 1 mW/g or less, a pulse repetition rate of 10/sec or less, and pulse width ranging from 25-300 µsec. The microwave energy was applied via a pulse-modulated source connected to a waveguide applicator located 2-5 cm from the dorsolateral side of the cat's head. Among 100 auditory units studied in seven cats, 32 were found to be responsive to both acoustic clicks and to pulsed microwave stimuli. The response amplitude varied directly with the microwave pulse amplitude at any given microwave pulse width. The microwave poststimulus time histograms (PSTH) of a given unit generally showed the same qualitative interval distribution for pulse energy densities ranging from threshold (less than 4 µJ/g/pulse) to about 40 µJ/g. The microwave-induced responses appeared to be shaped by the peripheral auditory apparatus based on the following observations: there was a 2-5 msec latency for the observed unitary response to the pulsed microwave radiation; the microwave PSTH was generally of the same form as the acoustic PSTH; and the single unit response appeared to be a nonmonotonic function of pulse width. The most satisfactory current hypothesis for the observed auditory response is that the incident microwave pulse sets up a thermo-acoustic wave in the head that mechanically stimulates the inner ear via bone conduction.

5123 THE LEVELS OF GABA IN MOUSE BRAIN FOLLOWING TISSUE INACTIVATION BY MICROWAVE IRRADIATION. *(Eng.)* Knieriem, K. M. (State Lab. Hygiene, Univ. Wisconsin, Center Health Sciences, Madison, WI 53706); Medina, M. A.; Stavinoha, W. B. *J Neurochem* 28(4): 885-886; 1977. (20 refs)

Postmortem gamma-aminobutyric acid (GABA) levels were determined in mouse brain tissue after inactivation by microwave (2,450 MHz) radiation. Preliminary experiments indicated that 200 msec was adequate time to stabilize postmortem brain GABA levels. The concentration of GABA in the brain of mice treated with 6 kW of microwave radiation for 200 msec was comparable to that previously observed in mice and rats after rapid freezing. When the brain was removed and allowed to remain at room temperature for 30 min prior to homogenization, GABA levels increased from 2.27 ± 0.16 µmol/g tissue at 0 time (within 2 min of death) to 2.37 ± 0.07 µmol/g after 30 min in decapitated mouse brain as compared with 0 and 30-min values of 1.99 ± 0.02 and 1.89 ± 0.05 µmol/g, respectively, for microwave-treated mice. Therefore, exposure to 200 msec of microwave radiation effectively prevented postmortem elevation of brain GABA. The lowest GABA level in microwave-treated mice were found in the cerebellum (0.88 ± 0.08 µmol/g) and the highest in the hypothalamus (3.55 ± 0.08 µmol/g).

5124 THERMAL RESPONSES TO HIGH-FREQUENCY ELECTROMAGNETIC RADIATION FIELDS. *(Eng.)* Frazer, J. W.; Merritt, J. H., Allen, S. J.; Hartzell, R. H.; Ratliff, J. A.; Chamness, A. F.; Detwiler, R. E.; McLellan, T. (USAFSAM (RAP), Aerospace Medical Div. (ARSC), Brooks Air Force Base, TX 78235). 19 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A032179]. (17 refs)

Male rhesus monkeys were exposed in a coaxial transmission line to 26 MHz continuous wave radiation for 6 hr (interrupted every 30 min for rectal temperature measurement) at field densities of 500, 750, and 1,000 mW/cm^2. An immediate rise in skin and rectal temperature with subsequent cooling was observed. Rectal temperature reached an equilibrium after about 1.5 hr of exposure, and this equilibrium was maintained throughout the remainder of the exposure period. At the highest exposure (1,000 mW/cm^2), the rectal temperature initially rose from 38.1 to 39.4 C and reached an equilibrium at 38.8 C.

Skin temperature rose from 36.1 to 38.6 C during the first 30 min of exposure, and the final reading was about 0.1 C above baseline. Uninterrupted exposure to 500 and 750 mW/cm^2 resulted in rectal temperature increases of 1 C and 1.7 C, respectively. At 500 mW/cm^2, the skin temperature initially increased and then reached its initial value after 6 hr. At 750 mW/cm^2, the skin temperature tended upward throughout the run and was about 2.8 C higher after 6 hr than the initial reading. Rectal cooling rates at 500, 750 and 1,000 mW/cm^2 were 0.36, 2.64, and 3.54 C/hr, respectively, and the corresponding skin cooling rates were 1.74, 2.46, and 1.75 C/hr. Such cooling rates were sufficient to bring the core and skin temperature to normal values in an hour or less, indicating that the thermoregulatory mechanisms were not impaired even at 1,000 mW/cm^2 and that the monkeys were able to dissipate the heat load following cessation of radiation. The 1,000 mW/cm^2 field applied to the primates is approximately equivalent to 400 mW/cm^2 in man.

5125 SOURCES AND BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION. *(Eng.)* Sosnicky, A. P. (Master's Thesis, Naval Postgraduate Sch., Monterey, CA 93940). 73 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A032367]. (46 refs)

The uses, characteristics, and possible hazards of radiation emitted by communications and radar equipment are described, and a review of Soviet and Western studies on the biological effects of nonionizing electromagnetic radiation is presented. Soviet studies of nonthermal effects indicate that frequencies ranging from 30-300,000 MHz at both thermogenic (greater than 10 mW/cm^2) and nonthermogenic intensities are capable of producing subjective symptoms in man, which include weakness, dizziness, depression, mental function impairment, sex drive inhibition, and gastrointestinal complaints. General clinical syndromes associated with microwave radiation exposure according to the Soviets include the asthenic syndrome, autonomic dystonia, and the diencephalic syndrome. Soviet studies at extremely low frequencies (50 Hz) and at fields strengths ranging from 15-420 mWb/m^2 indicate that such exposures are capable of producing nervous system changes associated with autonomic functions. Generally, the syndromes and organ responses described in Soviet literature have not been confirmed by Western studies, which stress the thermal effects of microwave exposure (potential damage to the eye lens and the testes). The Soviet maximum permissible microwave dose for human exposure is 0.1 mW/cm^2 are compared with the United States standard of 10 mW/cm^2.

5126 GEOMAGNETIC DISTURBANCE AND THE ORIENTATION OF NOCTURNALLY MIGRATING BIRDS. *(Eng.)* Moore, F. R. (Dept. Zoology, Clemson Univ., SC 29631). *Science* 196(4290): 682-684; 1977. (27 refs)

Direct visual evidence that the orientation of free-flying nocturnal migrants is affected by natural fluctuations in the geomagnetic field is presented. Data obtained from ceilometer watches and moon watches during the spring and fall seasons revealed a significant relationship between the K index, a measure of superimposed geomagnetic disturbance, and the angular deviation in the flight direction of free-flying passerine migrants. Variables reflecting geomagnetic activity before and after a watch were unimportant in both seasons, suggesting that any response to geomagnetic disturbance is immediate (within 3 hr). It is not known whether the magnetic disturbances act directly or indirectly on the avian orientation system.

5127 MICROWAVE ALTERATION OF THE BLOOD-BRAIN BARRIER SYSTEM OF RATS. *(Eng.)* Oscar, K. J. (U.S. Army Mobility Equipment R & D Command, Fort Belvoir, VA 22060); Hawkins, T. D. *Brain Res* 126(2): 281-293; 1977. (34 refs)

The effect of microwave exposure on the uptake of saccharides in the brain of male Wistar rats were studied. A single 20-min exposure to either pulsed (square wave) or continuous wave (CW) 1.3 GHz microwave energy induced an increase in the uptake of radiocarbon-labeled D-mannitol at average power densities of less than 3.0 mW/cm^2. The permeability change was greatest in the medulla, followed in decreasing order by the cerebellum and hypothalamus, with small or negligible changes in the hippocampus and cortex. Although permeability increases were observed for mannitol as well as for inulin, they *were not observed for dextran.* In general, mannitol uptake increased with increasing power density for both pulsed and CW microwave signals up to 0.5-2.0 mW/cm^2 where the brain uptake index (BUI) started to level off and then decrease. Increased permeability was observed both immediately and 4 hr after microwave exposure but not 24 hr after exposure. Pulsed energy with a high peak power, large pulse widths, and few pulses/sec affected mannitol uptake at an average power density of only 0.03 mW/cm^2; whereas, it took a CW energy of approximately 0.3 mW/cm^2 to cause the same magnitude of change. BUI measurements for pulse rates ranging from 5-1,000 pulses/sec, pulse widths ranging from 0.5-20.0 μsec, and peak power densities of 60-1,600 mW/cm^2 suggested that the BUI is a direct function of all three of the above parameters. The effect of peak power on mannitol seemed to be greater than the effect of pulse width, and both appeared to have a greater effect on permeability than the pulse rate. Microwaves appear to induce temporary changes in the permeability of the blood-brain system of rats for small molecular weight saccharides.

5128 A MICROWAVE IRRADIATION CHAMBER FOR SCIENTIFIC STUDIES ON AGRICULTURAL PRODUCTS. *(Eng.)* Olsen, R. G. (Dept. Electrical Engineering, Washington State Univ., Pullman, WA 99163); Geithman, G. A.; Schrader, D. H. *IEEE Trans Microwave Theory Techniques* 25(5): 428-433; 1977. (22 refs)

A waveguide microwave irradiation chamber in which homogeneous agricultural materials with simple geometrics can be heated uniformly in a controlled manner is described. A 25-kW microwave source (915 MHz) was coupled to a WR-975 waveguide and terminated in a water load. The material to be irradiated was formed into a post and placed in the center of the waveguide. Thermocouple measurements in plaster of Paris posts indicated uniform heating of the sample. A system for conducting irradiation tests on soils was designed that overcomes nonuniform distribution of temperature during the cooling period of the experiment. The soil was placed inside a cylindrical container constructed of lossless dielectric. A hole was machined in the waveguide below the soil and was covered by a thin piece of aluminum foil during irradiation. A pipe was used to connect the hole in the waveguide to a jar of cold water and a vacuum chamber, which was sealed during irradiation. Upon cessation of irradiation, the vacuum chamber was opened and the soil quickly drawn into the cold water, dispersed, and cooled quickly. Thus differences in temperature in the sample existed for such a short time that they were negligible.

5129 TERATOGENIC EFFECTS ON RAT OFFSPRING OF NON-THERMAL CHRONIC PRENATAL MICROWAVE IRRADIATION (MEETING ABSTRACT). *(Eng.)* Jensh, R. P. (Dept. Anatomy, Thomas Jefferson University, Philadelphia, PA); Ludlow, J.; Weinberg, I.; Vogel, W. H.; Rudder, T.; Brent, R. L. *Teratology* 15(2): 14A; 1977.

Ten pregnant rats were exposed in an anechoic chamber to 10 mW/cm^2 of microwave radiation at 915 MHz for 8 hr daily throughout gestation to determine the effect on the offspring. Total exposure time was 110 hr. It had been previously determined that dosage levels up to 10 mW/cm^2 were non-thermal; i.e., no increase in total body temperature was observed as measured by rectal thermistor probe. Control animals were placed in the chamber for similar periods of time. All animals were killed on the 22nd day of gestation. The fetuses were removed, weighed, and fixed after recording position and resorptions. There were no significant differences noted among the control groups, nor between the control and irradiated animals for the following parameters: embryonic or fetal death, abnormality, term fetal weight, term placental weight, term litter size, fetal sex ratio, and maternal weight and weight gain. These results indicate that exposure to a nonthermal level of microwave irradiation at 915 MHz throughout rat gestation does not adversely affect the offspring.

5130 A MODIFIED RADIOMETER FOR TEMPERATURE AND MICROWAVE PROPERTIES MEASUREMENTS OF BIOLOGICAL SUBSTANCES (MEETING ABSTRACT). *(Eng.)* Mamouni, A.; Bliot, F.; Leroy, Y.; Moschetto, Y. *In: Book of Abstracts of Seventh European Microwave Conference: The International Conference and Exhibition Designed for the Microwave Community. 5th-8th September, 1977, Copenhagen, Denmark.* p. 71; 1977. (0 refs)

The use of radiometers for biomedical applications needs a coherent understanding of thermal signals emitted by the tissues. In the conventional method, the detected signal generally depends on both the temperature of the material and the reflection coefficient. These parameters cannot be separated. In this study an alternative method was employed that allowed either a direct measurement of the temperature or a simultaneous determination of the reflection coefficient and the temperature. Measurements on organic liquids were performed using an X-band radiometer with a FET microwave amplifier. Possibilities of applications for biomedical topics are presented.

5131 MEASUREMENT OF ATP, ADP AND AMP IN MOUSE LUNG AFTER INACTIVATION BY MICROWAVE RADIATION (ABSTRACT). *(Eng.)* Hawkins, S. F. (Univ. Texas Health Science Center at San Antonio, Dept. Pharmacology, San Antonio, TX 78284; Medina, M. A.; Stavinoha, W. B. *Fed Proc* 36(3): 480; 1977. (0 refs)

Levels of adenosine triphosphate (ATP), adenosine diphosphate (ADP), and adenosine monophosphate (AMP) in mouse lung were measured after the lungs were inactivated in vivo by 6 kW microwave irradiation (MWR) for 440 msec. In another group the lungs were removed and homogenized in 0.4 N $HCLO_4$ within 2 min after sacrifice by decapitation. In a third group the lungs were inactivated by freeze clamping. There were no significant differences in the concentration of any of the metabolites regardless of the method of tissue inactivation. The absence of a decrease in the levels of these metabolites in the decapitated group was not anticipated because of the rapid postmortem decrease in these metabolites in other tissues. This may have been due to the presence of adequate postmortem Po_2 levels in the lungs. No ATPase activity was observed in the MWR tissue. Although rapid inactivation may not be an important factor in preventing postmortem changes of ATP, ADP, and AMP in lung, rapid irreversible inactivation produced by MWR would eliminate the possibility of postmortem changes in the levels of other labile lung metabolites.

5132 MAGNETIC ENHANCEMENT OF ELECTRON DOSE DISTRIBUTION IN A PHANTOM. *(Eng.)* Whitmire, D. P. (Dept. Physics, Univ. Southwestern Louisiana, Lafayette, LA 70501); Bernard, D. L.; Peterson, M. D.; Purdy, J. A. *Med Phys* 4(2): 127-131; 1977. (5 refs)

The effect of a 10-kG magnetic field on the dose distribution of electrons in a polystyrene phantom was studied to determine if radiotherapeutic tumor-to-skin dose ratios can be improved. Isodensity plots and depth-dose curves were obtained for 22- and 28-mega electron volt (MeV) beams with and without the applied magnetic field. For the 28-MeV beam, the maximum dose (density) region was shifted to about 3 cm below the surface of the phantom as

compared with about 1 cm from the surface for magnet-off conditions. The absolute value of the measured maximum density was about 20% greater for the magnet-on data. In addition to reducing surface dose, the magnetic field also produced a rapid falloff in dose past the maximum-density region. A comparison of the 28-MeV magnet-on case with the optimum magnet-off energy for treating a given tumor was made, and at 12 MeV the magnet-off dose distribution was found to fall off about as fast as the 28-MeV magnet-on distribution for a 10-kG field. In addition to improving the tumor-to-skin dose ratio, the magnetic field is also capable of shaping the distribution either symmetrically or asymmetrically, allowing to some extent for the generation of an optimum distribution for a given tumor volume. Symmetrical distribution is produced by reversing the magnet's polarity halfway through the administered dose, and the shape of this flared distribution depends on the axis chosen for the reversed dose. By shielding the fringe fields and holding the beam axis constant for both polarity cycles, good symmetrical dose distributions have been obtained for energies as low as 10 MeV, with the magnetic Bragg peak occurring at a greater depth than the magnet-off 80% depth for energies less than or equal to 25 MeV. Magnetic surface doses obtained with an 18.2-kG field are approximately half the magnet-off surface dose of the same energy.

5133 BIOLOGICAL EFFECTS BY MICROWAVES (MEETING ABSTRACT). *(Eng.)* Berteaud, A. J. *In: Book of Abstracts of Seventh European Microwave Conference: The International Conference and Exhibition Designed for the Microwave Community. 5th-8th September, 1977, Copenhagen, Denmark.* p. 64; 1977. (0 refs)

The biologic effects of microwave radiation are reviewed. Topics covered include: protection conditions and safety standards; the effects of low and high power density microwave radiation on unicellular and pluricellular organisms; the induction of hyperthermia, with emphasis on its role in cancer therapy; and the nonthermal effects of microwaves.

5134 DESIGN AND APPLICATION OF SPECIAL MICROWAVE INTERFEROMETERS FOR NON-INVASIVE STUDIES OF BIOLOGICAL EFFECTS (MEETING ABSTRACT). *(Eng.)* Griffen, D. W. *In: Book of Abstracts of Seventh European Microwave Conference: The International Conference and Exhibition Designed for the Microwave Community. 5th-8th September, 1977, Copenhagen, Denmark.* p. 70; 1977. (0 refs)

Microwave interferometers were designed to make noncontact measurement of the movements associated with various physiologic functions such as respiration, pulse, muscle action, reflexes, and involuntary tremors. For each interferometer the factors affecting resolution across a large moving surface, sensitivity to small amplitude displacement, and maintenance of calibration were studied and accurate direct measurement of surface displacement was achieved with very low incident microwave power levels. Interferometers based on three port circulators were most sensitive but those based on magic tee hybrids were easier to operate. Movement of the chest, hands, legs, and eyeball has been studied and potential for accurate correlation with electroencephalogram, electrocardiogram, or electromyogram records was demonstrated.

5135 MILLIMETER WAVE THERMOGRAPH AS SUBCUTANEOUS INDICATOR OF JOINT INFLAMMATION (MEETING ABSTRACT). *(Eng.)* Edrich, J.; Smyth, C. J. *In: Book of Abstracts of Seventh European Microwave Conference: The International Conference and Exhibition Designed for the Microwave Community. 5th-8th September, 1977, Copenhagen, Denmark.* p. 71; 1977. (0 refs)

A technique for remote noninvasive mapping of temperature elevations of human joints that uses the mm wave radiation emitted by the human body was evaluated. A solid state switched scanner for 68 GHz, which overcomes the depth limitations of conventional infrared thermographs and can measure to subcutaneous depths of several mm with a temperature resolution of 0.25 C was employed. Measurements on rheumatoid arthritic knee joints showed little correlation with simultaneously measured skin temperatures. Significant long-term thermographic changes induced by steroid injection indicate a potential for objective patient monitoring and development of new treatment methods.

5136 INFLUENCE OF ALTERNATING ELECTRIC FIELDS OF TECHNICAL FREQUENCY ON CHICKEN EMBRYOS (MEETING ABSTRACT). *(Eng.)* Wittke, G. (Dept. Veterinary Physiology, Free Univ. Berlin, Koserstr. 20, D-1000 Berlin 33, Germany); Bootz, A.; Bayer, A.; Brinkman, J. *Pfluegers Arch* 368(Suppl.): R27; 1977. (0 refs)

The effects of alternating electric fields on chicken embryos were studied. Fifty or 100 eggs from SPF hens were put into the upper part of an incubator (controls). Simultaneously, another group of the same size was placed beneath in a layer vertically penetrated by alternating electric fields (50 Hz) with intensities of 1, 1.5, or 5 kV/m (related to the homogenic field). Throughout the brooding period the usual precautions as to temperature, humidity, and periodic turning of the eggs were observed. After hatching, the chickens were held below an infrared lamp for 3 wk in a thermoneutral environment. Body weights were determined daily. The hatching rates of the fertilized eggs on the three increasing steps of field intensity were 88, 80, and 81%, respectively. The corresponding data in the control groups amounted to 80, 82, and 57%, respectively. The growth of chickens from eggs within and outside electric fields was identical. The grasp reflex was normal. These findings controdict the results of a previous study in which chickens exposed to electric fields during incubation exhibited malformations of feet and a high

mortality rate. It is hypothesized that the alterations noted in the earlier study were caused by factors other than electric fields.

5137 PGE_1-STIMULATION OF ADENYL CYCLASE IN THE BRAIN OF RATS EXPOSED TO LOW POWER DENSITY MICROWAVE RADIATION (MEETING ABSTRACT). *(Eng.)* Catravas, G. N. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, Bethesda, MD 20014); Katz, J. B.; Takenaga, J. *Radiat Res* 70(3): 691; 1977. (0 refs)

Groups of male Sprague-Dawley rats were exposed to continuous wave microwave radiation (2,450 MHz, 15 mW/cm^2) in an anechoic chamber. The animals were irradiated 8 hr/day for 5 wk between 0800 and 1600 hr. During exposure the animals were confined in styrofoam cages, the inner walls of which were coated with quinine to prevent the rats from chewing through the walls of the cages. Control animals, effectively protected from the microwave beam, were kept in the same exposure chamber under the same environmental conditions as the experimental animals. An increased sensitivity of brain adenyl cyclase to PGE_1 was observed with a shift of the dose/response curve to the left. This shift seemed to be more pronounced in irradiated animals sacrificed 8 hr postexposure than among those sacrificed immediately after removal from the exposure chamber. However, the maximal adenyl cyclase activity did not appear to be affected.

5138 THE ROLE OF RADIO SCIENCE IN INVESTIGATING ELECTROMAGNETIC BIOLOGICAL HAZARDS. *(Eng.)* Johnson, C. C. (Dept. Bioengineering, Univ. Utah, Salt Lake City, Utah 84112). *Radio Sci* 12(3): 349-354; 1977. (42 refs)

The involvement of the URSI in research concerning the possible human hazards of electromagnetic radiation is discussed. Particular areas of interest to the URSI include metrology for providing better electromagnetic field and absorbed power measurements in biological specimens and the application of field theory techniques to the determination of absorbed power in three-dimensional biologic models. Techniques that have been devised for the measurement of temperature and electromagnetic fields in tissue include an implantable probe with a very small thermistor and carbon-loaded Teflon lead wires, a liquid crystal fiber optic system, a combination of fiber optics with a Faraday-rotation optical crystal, and thermographic camera measurements using phantom materials. Theoretic dosimetry calculations are being used to predict absorbed electromagnetic power in tissues. Multi-layer analyses have resulted in significant understanding of the microwave absorption properties of tissue structures and have provided specific information about the optimum frequency for microwave heating applications. Theories based on the consideration of a plane wave incident upon a planar multi-layer biologic sample indicate that a microwave diathermy frequency of 915 MHz is more desirable than 2.45 GHz because of increased penetration and less power deposition in superficial fat layers. Numeric solutions to a biologic model of Mie's theory for spherical scattering have resulted in some very interesting internal power deposition profiles. For example, a 14-cm diameter spherical body, the size of a human head, focuses substantial amounts of power at its center (much like a spherical lens) at 915 MHz. Other results have indicated that the maximum power absorption resonance region for man occurs near 70 MHz when man's height equals the free-space wavelength multiplied by a factor of 0.4. These theories and experiments have further indicated that the power absorption varies greatly with the orientation of a biologic body with respect to the electromagnetic field vectors.

5139 ECOLOGICAL INFLUENCE OF ELECTRIC FIELDS. *(Eng.)* Kornberg, H. A.; Bankoske, J. W.; McKee, G. W.; Graves, H. B. (Westinghouse Electric Corp., 700 Braddock Ave., East Pittsburgh, PA 15112). 47 pp., 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB 260 641]. (6 refs)

Studies on the effects of electric fields on plants, meadow voles, chicks, and chicken embryos are reported. Plant leaf tip damage was observed for certain pointed leaves at field intensities of 25 kV/m or greater, but no leaf tip damage was observed at field strengths of 20 kV/m or less. The damage observed was minor, however, and self-limiting. Electric fields no greater than 17.2 kV/m are anticipated 2 m above ground level underneath 1500-kV transmission lines. Meadow voles were exposed to 50 kV/m fields for periods up to 4 wk, and no statistically significant effects as a result of this exposure were observed. Chicks exposed to 40 and 80 kV/m fields exhibited a short term increase in early growth, which amounted to 5-10% in magnitude for body weight differences; however, there were no observed differences between exposed and unexposed chicks by 20 days after hatching. No effects from short-term exposure to fields up to 67 kV/m no egg hatchability or embryo behavior were observed.

5140 RADIO FREQUENCY ERADICATION OF TUMOURS. *(Eng.)* Whalley, W. B. (891 Loma Verde Ave., Palo Alto, CA 94303). *Electronics and Power* 23(5): 415-417; 1977. (2 refs)

An electric field approach to the radiofrequency (RF) eradication of tumors is described. Preliminary experiments involving the use of a 300-W amateur radio transmitter to heat a sodium chloride water solution, similar in salt concentration to human tissue and blood, indicated that passing an electric current through the solution resulted in uniform temperature increases throughout the solution. A thermometer, which was 15 cm away from the electrodes, rose uniformly with thermometers close to the electrodes. For experiments on dogs and humans, a frequency of 13.56 MHz and a current magnitude of 0.2 A

(root mean square)/cm of electrode diameter were chosen. It was necessary to tie together the outer sheaths of the coaxial cable lead wires at the ends close to the electrodes to provide optimum current flow between the electrodes. An inductor was inserted inside an insulating handle attached to the electrodes to neutralize the capacitive reactance between the electrode and the body tissue. A direct current inverse feedback loop between RF output and the master crystal oscillator was used to provide high stability at a given power setting and constant current at various electrode spacings. Experiments with dogs and humans indicate that the usual time for a successful treatment of a tumor is 30 min. In general, human malignant tumors change to a sack of liquid containing dead cells after RF treatment. If the tumor is less than about 50 mm in its largest dimension, the patient's body automatically removes the liquid and dead cells through the normal circulatory system. When the tumor is larger, the liquid from the treated tumor can often be removed with a hypodermic needle. The method allows for the selective destruction of tumors and damages only a very small volume of tissue directly in contact with the tumor.

5141 TEMPERATURE MEASUREMENT IN MICROWAVE DIATHERMY FIELDS: PRINCIPLES AND PROBES. *(Eng.)* Cetas, T. C. (Temperature Section, Heat Div., Natl. Bureau Standards, Washington, DC 20234). 12 pp; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB 259 744]. (17 refs)

Probes for measuring temperature in microwave diathermy fields are discussed. Although thermistor-based devices assembled with microwave integrated circuit techniques are suitable for measurements in media that absorb power (heat) as readily as bone, they are unsuitable for nonabsorptive materials. Developments in passive thermometer probes include an optical thermometer probe that uses only dielectric nonabsorptive components. A probe that uses the reflectance of red light from a mixture of liquid crystals as the sensitive parameter has been developed with a temperature range of approximately 25-50 C and an instrumentation resolution of better than 0.1 C. Hysteresis effects and drifting in the liquid crystal result in temperature uncertainties of 0.3-0.5 C. Another type of liquid crystal thermometer has been developed that uses the optical rotary power of the liquid crystal mixture. A sandwich composed of a dichroic polarizer, the liquid crystal mixture, a polarization analyzer, and a mirror are attached to a bundle of optical fibers; the reflected light intensity is related to the sensor temperature. An optical thermometer that uses the birefringence of a pure single crystal as the thermometric parameter has also been constructed. The sensor consists of a dichroic polarizer, the crystal, and a dielectric mirror mounted at the end of a pair of fiber optic bundles. Output signals from the latter type of probe range from 0.1-1 V, with sensitivities of up to 30 mV/°C. The noise level is less than 1 mV. Thermometers based on this principle have been designed with a temperature range of 11-68 C.

5142 RADIOFREQUENCY HEATING OF TUMOURS IN RODENTS. *(Eng.)* Dickson, J. A. (Cancer Res. Unit, Univ. Dept. Clinical Biochemistry, Royal Victoria Infirmary, Newcastle upon Tyne, Great Britain); Calderwood, S. K.; Jasiewicz, M. L. *Eur Cancer* 13(7): 753-763; 1977. (42 refs)

The use of low power (less than 6 W) radiofrequency (13.56 MHz) heating for the treatment of rodent tumors is reported. The tumors were included in the output circuit of the radiofrequency generator by capacitive coupling between paddle electrodes, which were applied directly to opposite sides of the tumor mass. A 100% regression rate was obtained for MC7 sarcomas and Yoshida sarcomas (tumor volume, 1-1.5 ml) growing subcutaneously in the foot or flank of rats when these tumors were heated at 45 C for 15 min. When large (6-12 ml) Yoshida tumors in leg muscles were heated at 45 C for 30 min or 50 C for 15 min, all rats died soon after treatment. Subcutaneous D23 carcinomas (0.7-1.5 ml) in rats were not cured by hyperthermia at temperatures up to 45 C for 15 min. Mice bearing Ehrlich ascites tumors, which were heated at 42 C for 1 hr, 43 C for 30 min, or 44 C for 15 min died during or immediately after heating as did normal mice receiving the same hypothermic treatment. When both rear legs of rats bearing 6 ml intramuscular Yoshida tumors were heated to 45 C for 15 min, the normal muscle of the rat maintained a temperature that was consistently 2-3 C higher than the tumor. The electrical resistance of the heated tissue was not altered by the presence of tumor, and it appears that blood flow in this tumor was greater than in adjacent normal tissue. Therefore, there seems to be an upper limit on the temperature/time regimen that can be used to destroy the tumor.

5143 ENDORPHINS IN BRAINS OF DECAPITATED AND MICROWAVE-KILLED MICE. *(Eng.)* Cheung, A. L. (Addiction Res. Foundation and Stanford Univ., Palo Alto, CA 94305); Stavinoha, W. B.; Goldstein, A. *Life Sci* 20(7): 1285-1290; 1977. (27 refs)

The size distribution of opioid peptides (endorphins) in the brains of Swiss male mice undergoing either decapitation or quick killing by microwave irradiation (2,450 MHz for 200 msec) was determined by gel filtration. Inhibition of stereospecific ^{3}H-labeled etorphine binding to guinea pig brain membranes was used as a measure of endorphin activity. Three peaks of endorphin activity were observed. The first peak, just beyond the void volume, eluted in the position that would correspond to β-endorphin. This also corresponded to the elution behavior of the 3,000-dalton endorphin found in beef brain. The second peak, of intermediate size, probably corresponded to the endorphin of about 1,400 daltons in beef brain. The third peak, which emerged beyond the salt volume, eluted in the same position as ^{3}H-leucine-enkephalin. In all three experiments, every peak had somewhat lower activity after decapitation than after microwave killing, suggesting that some degradation may have occurred in situ after decapitation. However, there was no indication of preferential loss of any peak in the decapitated animals as compared with

those killed by microwave irradiation. The possibility of differential degradation of the three peaks during the binding assay was investigated by performing assays with and without bacitracin, an inhibitor of peptidase action on opioid peptides. The relative contribution of any particular size class to the total brain endorphin activity was not found to be selectively underestimated in the original experiment. Opioid peptides of all three size classes appear to be present in the brain in vivo.

5144 THE HUMAN MAGNETOENCEPHALOGRAM: SOME EEG AND RELATED CORRELATIONS. *(Eng.)* Reite, M. (EEG Lab., Dept. Psychiatry, Univ. Colorado Medical Center, 4200 East Ninth Ave., Denver, CO 80220); Zimmerman, J. E.; Edrich, J.; Zimmerman, J. *Electroencephalogr Clin Neurophysiol* 40: 59-66; 1976. (13 refs)

Simultaneous magnetoencephalographic (MEG) and electroencephalographic (EEG) data were recorded from six normal adult subjects in a shielded enclosure. MEG signal strength and EEG voltage level appeared to be linearly correlated. Spectral analysis suggested that the MEG and EEG data were produced by similar but nonidentical generator systems. A well-defined vertex region-evoked response to a visual flash was recorded in only one of four subjects exposed to the stimulus; the response was similar to the simultaneous EEG evoked response, with the two responses being nearly 180 degrees out of phase. In this case, cortical negativity was associated with a magnetic field directed into the scalp. Eye movement artifact, which can seriously compromise EEG recordings, did not appear to be a major problem in MEG recordings.

5145 THE PHYSICAL CHARACTERISTICS OF EM FIELD INTERACTION WITH MOLECULAR SYSTEMS. *(Eng.)* Anonymous. (No affiliation given). *Neurosci Res Program Bull* 15(1): 62-64; 1977. (0 refs)

The interaction of electromagnetic fields with molecular systems is discussed. Electromagnetic (EM) waves penetrate a conducting material to a depth that is a function of the frequency of the wave and the conductivity of the material. Therefore, EM waves exhibit skin effects, i.e., they remain near the surface of most conducting materials. For the microwave spectrum, maximum energy absorption in tissue occurs near the surface and decreases sharply at increasing depths. The magnetic component of an EM wave could interact with the magnetic component of spinning atomic nuclei, but even for a magnetic field of 10,000 G, the energy of interaction would be of the order of 1 Kelvin (K), and the coupling of such a field with brain tissue would be negligible. The coupling energy in the earth's magnetic field is of the order of 10^{-8} K for typical ring molecules oriented with the magnetic field. Ringlike structures, such as, benzene or naphthalene, which act like diamagnetic material, are unlikely to be the basis of a significant interaction with EM fields. However, if tissue molecules are organized as in a liquid crystal, the van der Waals forces would be strong enough to couple one molecule to another, producing a swarmlike structure. It is suggested that a biologic system with molecular properties of swarming could act as an information-processing device. A chain of neurons with this property could detect the forces of an electric field applied along the chain. The cerebellum is suggested as being a highly organized structure that is suitable for testing this model.

5146 EVIDENCE FOR ELECTRICALLY INDUCED PARTIAL STRAND SEPARATION OF DNA. *(Eng.)* Pollak, M. (Dept. Physics, Univ. California, Riverside, CA 92502); Glick, H. A. *Biopolymers* 16(5): 1007-1013; 1977. (8 refs)

Electrically induced changes in optical properties of calf thymus DNA-salt solutions were measured. Electric fields were applied in the form of 50-300 μsec pulses at field strengths up to 20 kV/cm. The following qualitative predictions expected from the theory of electrically induced partial denaturation of DNA were observed: a decrease in the reduced dichroism at high fields, a concurrent increase in the absorption coefficient, a critical field (about 14 kV/cm) above which the first two effects began to occur, a decrease in the magnitude of the above effects with increasing salt (sodium phosphate) concentration, and a return to the status quo ante after short pulses (about 50 μsec). The above experimental findings support the prediction that fields of the order of 10 kV/cm can induce a partial strand separation in DNA.

5147 THE PROPERTIES OF BIRD FEATHERS AS CONVERSE PIEZOELECTRIC TRANSDUCERS AND AS RECEPTORS OF MICROWAVE RADIATION. I. BIRD FEATHERS AS CONVERSE PIEZOELECTRIC TRANSDUCERS. *(Eng.)* Bigu-Del-Blanco, J. (Anatomy Dept., Queen's Univ., Kingston, Ontario, Canada); Romero-Sierra, C. *Biotelemetry* 2: 341-353; 1975. (22 refs)

The properties of bird feathers as piezoelectric transducers in the audiofrequency range and as dielectric receptors of electromagnetic radiation in the microwave range were studied. Parts of the inner and outer surfaces of calami removed from bird feathers were painted with silver paint, and two fine wire electrodes were electrically secured to each painted surface. Excitation of the feathers was performed with an audio amplifier and matching transformer that were driven by a sine wave oscillator. The excitation voltage (100-300 V, peak-to-peak) was swept through a frequency range of 1-20 kHz. Mechanical vibrations induced in the specimen by the applied signal were detected with a piezoelectric ceramic phonograph cartridge or with a low impedance broad-band electromagnetic transducer. The phonograph cartridge gave little response above 15 kHz; whereas, the electromagnetic transducer had a frequency range extending to the MHz range. The results revealed piezoelectric resonances in the 1-20 kHz region for the calami of feathers. A

linear relationship between specimen electrical output and electric field strength between the electrodes indicated that the observed effect was strictly first order (piezoelectric) rather than electrostrictive (dependent on the square of the electric field). Signal amplitude at resonance decreased as a function of increasing feather area subjected to electrical stress. Increasing relative humidity decreased the amplitudes of the resonance peaks, and increasing temperature resulted in a decrease in resonance frequency. The electric field strength across the specimens excited was about 22 V/cm per V of applied voltage. Thus, for the voltages normally used, electric field strengths of several thousand V/cm were obtained.

5148 THE EFFECT OF WEAK MAGNETIC FIELDS ON SOME BACTERIAL SPECIES. *(Rus.)* Vyorkin, B. I. (Physio-Technical Low-Temperature Inst., Acad. Science, USSR); Bondaryenko, S. I.; Shermet, V. I.; Tsutsaeva, A. A.; Safonova, T. S.; Yurchenko, G. G. *Mikrobiologiia* 45(6): 1067-1070; 1976.

The effects of weak magnetic fields on bacterial species are described. The bacteria involved in this study were *Escherichia coli, Staphylococcus aureus 209, Serratia marcescens, Bacteriodes anthracoides.* The bacteria were cultivated in a weak magnetic field for 4 mo and transferred to fresh medium every 18 hr at 37 C. The control bacteria were grown in the same way under conditions of a constant geomagnetic field. Every 15 days, the microorganisms were checked for change. Changes in staining, morphology, culture and biochemistry occurred after 2 mo. Metachromatic deviations were seen in gram stains of *E. coli* and *S. marcescens.* In *Staph. aureus 209,* disconnected single cocci predominated; in *Bac. anthracoides,* rod dimensions were larger, and they stained more intensely. Under the protracted influence of weak magnetic fields, gas and acid formation of the bacteria either increased or decreased depending on the type of sugar in the culture medium.

5149 MECHANICAL MASSAGE WITH ELECTRICAL FIELD: A NEW COMBINATION THERAPY. *(Ger.)* Klemm, J. (Rontgenabteilung, II. Med. Univ.-Klinik, Ziemssenstrasse 1, 8 Munich 2, W. Germany). *Fortschr Med* 95(13): 851, 854; 1977.

The pain-relieving effect of vibratory massage combined with electrical field (0-30 V) was studied in 44 patients with gelosis of the splenius and trapezius muscles and traumas. The pain threshold was measured by the Seeligmuller-Trummer algimetric method 5 min after treatment. The treatments were given four times a day. Vibratory massage combined with electrical field increased the pain threshold by 30-40%, while massage alone caused an increase of only 15-20%. The pain threshold increased by 98% after 12 treatments in cases of recent trauma. The combined therapy also alleviated mild inflammatory processes and improved motion. It is recommended for the treatment of rheumatoid diseases, neuralgia, and dull trauma.

5150 ELECTRIC BIREFRINGENCE STUDIES OF CARTILAGE PROTEOGLYCAN AGGREGATION. *(Eng.)* Foweraker, A. R. (Physics Dept., Brunel Univ., Uxbridge, Middlesex, U.K.); Isles, M.; Jennings, B. R.; Hardingham, T. E.; Muir, H. *Biopolymers* 16(6): 1367-1369; 1977. (10 refs)

Electric birefringence measurements were made on a sample of pig laryngeal proteoglycan exposed to electric fields. Electric fields of up to 600 V/cm with pulse durations of up to 160 msec were applied to solutions of proteoglycans in distilled water containing 209 µg/ml of uronic acid. The sample exhibited a large birefringence and a rotary relaxation time of 3.6 ± 0.3 msec. A hyaluronic acid solution of 20 µg/ml uronic acid (approximately 60 µg/ml of hyaluronic acid) was added in steps of 0.1 ml to 10 ml of the proteoglycans solution and successive optical transients were recorded. Birefringence amplitude changed significantly, and its sign was also possibly changed. A change in birefringence sign is consistent with the reversal of the optical anisotropy from the proteoglycan to the aggregated molecules. The relaxation time of the complex was about 650 ± 30 msec of 180 times that of the constituent proteoglycan molecules. Treating the individual proteoglycan molecules as prolate ellipsoids of 40 nm semiminor axes, a rotary relaxation time of 3.6 ± 0.3 msec corresponds to a molecular length of 380 ± 20 nm, which is in reasonable agreement with a previous estimate of 300-400 nm and which suggests that the molecule was maximally extended under the conditions of low ionic strength used in this study.

5151 DIATHERMY VERSUS THE MICROWAVES AND OTHER RADIO-FREQUENCY RADIATIONS: A ROSE BY ANOTHER NAME IS A CABBAGE. *(Eng.)* Justesen, D. R. (Lab. Experimental Neuropsychology, US Veterans Admin. Hosp., Kansas City, MO 64128). *Radio Science* 12(3): 335-364; 1977. (31 refs)

Weak-field and strong-field hazards associated with microwave and radiofrequency radiation are discussed. Focal or general thermal insult from simple heating of tissues can, in principal, result from exposure to fields as low as or even lower than 1 mW/cm^2, although the practical likelihood of damage at this density is remote. There is a scientific consensus that exposure to radiofrequency fields of high flux density, 100 mW/cm^2 or more, are thermally dangerous, and there is an increasing prevalence of belief that lengthy exposures to fields between 1 and 100 mW/cm^2 may be thermally dangerous. Animal experiments with microwaves have produced paradoxic results in some cases. When male mice were irradiated with 3-cm microwaves for 4.5 min/day, 5 days/wk for a maximum of 59 wk at an incident power density of 100 mW/cm^2, radiation-induced testicular damage was observed; however, an analysis of the survival data indicates that irradiated mice lived longer than controls. In another experiment where fetal mice were irradiated with 2,450-MHz microwaves and were then injected on the 16th day postpartum with a homogenate of a lymphoreticular cell sarcoma, the irradiated mice had a low incidence of tumor takes (3/24) as compared

with controls (11/24), suggesting that intrauterine exposure to microwave radiation may enhance the development of immunologic competency. It is suggested that only when dosimetry is adopted as a rule of procedure in the laboratory will consensual resolution to the existence and nature of weak-field hazards, thermal and nonthermal, be achieved.

5152 ON MICROWAVE-INDUCED HEARING SENSATION. *(Eng.)* Lin, J. C. (Dept. Electrical and Computer Engineering, Wayne State Univ., Detroit, MI 48202). *IEEE Trans Microwave Theory Techniques* 25(7): 605-613; 1977. (28 refs)

A theoretic analysis of the acoustic wave generated in the heads of animals and man exposed to pulsed microwave radiation as a result of rapid thermal expansion is presented. Using a spherical model of the head, the problem was formulated in terms of thermoelasticity theory in which the absorbed micro-energy represented the volume heat source, which depended on both space and time. The inhomogeneous thermoelastic motion equation was solved for the acoustic wave parameters under stress-free surface conditions using boundary value technique and Duhamel's theorem. The numeric results indicated that pulsed microwave-induced sound pressure amplitude depended on both pulse width and peak power density. In addition, there is apparently an optimal pulse width for maximum sound pressure generation, which varies according to the sphere size and the frequency of the impinging radiation. For a peak absorbed power density of 1,000 mW/cm^3, which corresponds to 600 mW/cm^2 incident power at 2,450 MHz impinging on a 3-cm spherical head, and to 2,200 mW/cm^2 incident power at 918 MHz impinging on a 7-cm spherical head, the pressure amplitudes generated at the center of the sphere are 15-30 dB above the reported threshold of hearing by bone conduction (60 dB) 0.0002 dyne/cm^2, 5-10 kHz) for pulses between 1 and 50 μsec wide. Estimations of the fundamental sound frequency generated inside the head show that the frequency varies from about 8 kHz for a man-sized sphere to approximately 80 kHz for a small animal's head, such as mouse's head. Assuming an equivalent radius of 1.5 cm for the brain of a guinea pig, a fundamental sound frequency of 48 kHz is calculated; this is in reasonably good agreement with the 50-kHz cochlea microphonic oscillations recorded from the round window of guinea pigs.

5153 PHYSICAL ENVIRONMENTAL FACTORS. *(Eng.)* Ferris, B. G.; Cook, R.; Elder, J. A.; Horvath, S. M.; Lamola, A.; Mills, W. A.; Storer, J. B.; Von Gierke, H. E.; Walsh, P. *In: Human Health and the Environment--Some Research Needs.* (Washington, DC: Dept. Health, Education, and Welfare): Report of the Second Task Force for Research Planning in Environmental Health Science. vol. 2, pp. 127-181; 1977. (96 refs)

The biologic effects associated with various forms of nonionizing radiation are reviewed. Thermal hazards have been established for exposure to microwave radiation (300 MHz to 300 GHz), particularly for temperature-sensitive systems such as the avascular lens of the eye and the male gonads. Short-term acute exposures of animals to power levels in excess of 100 mW/cm^2 have been observed to cause cataracts and temporary sterility. Recent reports suggest biologic effects on the central nervous system (CNS), heart, and chromosomes, in addition to the effects of radiofrequency heating, as a result of exposure to low levels (less than 10 mW/cm^2) of nonionizing radiation. The effects are apparently separate from generalized heating injury. Regarding exposure to extra-high voltage transmission lines (345 kV or above), most studies fail to reveal any prompt or acute adverse effects in humans or animals. However, effects of extremely low frequency (ELF) fields on the CNS have been reported, which suggest that ELF field thresholds are frequency-dependent and affect the CNS in a manner that takes days to fully attenuate. Research is continuing on the effects of ELF, particularly in the 60 Hz range, which is the standard frequency of electrical power in the United States. Other sources of nonionizing radiation include near-visible ultraviolet light and visible light. Reactions elicited in humans by such radiation occur in the presence of photosensitizers or under abnormal conditions such as those involved in immune system hypersensitivity.

5154 BIOLOGICAL EFFECTS OF MICROWAVE RADIATION. *(Pol.)* Bogucka, A. (Affiliation not given). *Ochrona Pracy* 31(2): 4-5; 1977.

A total of 72 workers exposed to electromagnetic fields in television and radio work in the USSR had a variety of complaints from epigastric pain to hyperacidity; hypoacidity was seen in persons working longer than 10 yr. In 69%, functional disorders of the central nervous and cardiovascular systems were observed. Microwave irradiation also led to leukopenia and simultaneous eosinophobia of the blood. These disorders were initially reversible in the majority of cases, but long-term radiation could turn them irreversible requiring thorough treatment. Occupational change was seen as indispensible for afflicted workers. Contraindications for this line of work include active tuberculosis, diseases of the blood, central nervous system, endocrine glands, and eyes, and vegetative neurosis. Periodic medical checkups with particular attention to eyes, central nervous system, alimentary tract, and the hematopoietic system were considered a necessity.

5155 POLLUTION CAUSED BY HIGH FREQUENCY ELECTROMAGNETIC FIELDS. *(Ita.)* Bernardi, P. (No affiliation given). *Securitas* 61(1-2): 9-16; 1976. (0 refs)

Protection from electromagnetic pollution due to microwaves (300-100,000 MHz) or radiofrequencies (1-300 MHz) generated by communication systems, radar and science installations, medical apparatus, domestic appliances, and industrial machinery is

discussed. Thermal (general or localized) and nonthermal (weak or strong) effects are reviewed with reference to machinery using electromagnetic heating. Studies using electromagnetic models have established that the type of irradiation source (shape, dimensions, and interaction area), the location (housing of iron or reinforced concrete; other objects present in the area), and the type of irradiated structure (humans, animals, and in vitro tissues) are the factors which influence the interaction of electromagnetic waves and biologic tissue. Several methods for measuring increased body temperature resulting from exposure to radiofrequency machinery are listed. Screening irradiation sources, heating part of the machinery, modifying machinery housing, wearing protective clothing, and working shorter hours are suggested as protective measures against electromagnetic pollution.

5156 MICROWAVE RADIATION-MEDICAL SURVEILLANCE. *(Eng.)* Tyler, P. E. *Presented at the 1976 International Microwave Symposium in Cherry Hills, NJ).* 5 pp.; 1976. (0 refs)

A plan for medical surveillance of workers occupationally exposed to microwave radiation is discussed. The Medical Surveillance Subcommittee of the American National Standards Institute is developing a physical examination, which is designed to protect both the employer and employee; at the same time, this examination may provide a basis for observing trends in the physical condition of employees exposed to electromagnetic radiation. The Committee recommends that a normal industry pre-employment physical examination be developed encompassing the following tests: lipid profile (fasting sample) including total lipids, cholesterol, triglycerides, and phospholipids; serum cortisol (morning sample); immunoglobulin electrophoresis; complete blood count test including hematocrit (capillary tube methods), white blood cell count, red blood cell count, and differential; dilated ophthalmologic examination including a biomicroscopic examination for opacities, vacuoles, and posterior subcapsular irradiance; opthalmoscopic examination of fundus oculi; and a routine neurologic examination. It is also recommended that a note be made in the medical history of previous exposure to occupational ionizing or nonionizing radiation. If adequate facilities are available, T-3 and T-4 tests for thyroid evaluation should be included as well as an electroencephalogram.

5157 THE LEVELS OF GABA IN MOUSE BRAIN FOLLOWING TISSUE INACTIVATION BY MICROWAVE IRRADIATION. *(Eng.)* Knieriem, K. M. (State Lab. Hygiene, Univ. Wisconsin, Center for Health Sciences, Madison, WI 53706); Medina, M. A.; Stavinoha, W. B. *J Neurochem* 28(4): 885-886; 1977. (20 refs)

Levels of gamma-aminobutyric acid (GABA) in mouse brain following tissue inactivation by microwave irradiation were determined. Sprague-Dawley mice were positioned in a waveguide chamber perpendicular to the microwave E field for exposure to 2,450-MHz microwave radiation. The instrument delivered 5.5 kW directly to the mouse head. After 200, 300, or 400 msec of microwave exposure, the mean GABA level was 1.9 μmol/g of tissue. After exposure to 200 msec of microwave radiation, the activity of glutamate decarboxylase and GABA-transaminase was 5 and 25%, respectively, that of control values. From these results, 200 msec was chosen as an adequate time to stabilize postmortem brain GABA levels. The GABA concentration in the brain of microwave-irradiated mice was comparable to that found in mice and rats after rapid freezing. A comparison of decapitated versus irradiated mice indicated that the levels of brain GABA in the decapitated group were 14% higher than those found in irradiated animals. If the brain was removed and allowed to remain at room temperature for 30 min prior to homogenization, the brain GABA levels increased by 19% in decapitated mice, while no difference was observed in irradiated animals. Therefore, exposure to 200 msec of microwave irradiation effectively prevented postmortem elevation of brain GABA. When GABA levels were determined in eight discrete brain areas from six animals killed by exposure to 200 msec of microwave radiation, the lowest GABA values were found in the cerebellum (0.88 ± 0.08 μmol/g) and the highest in the hypothalamus (3.55 ± 0.08 μmol/g).

5158 LEVELS OF CYCLIC NUCLEOTIDES IN MOUSE REGIONAL BRAIN FOLLOWING 300 MS MICROWAVE INACTIVATION. *(Eng.)* Jones, D. J. (Dept. Anesthesiology and Pharmacology, Univ. Texas Health Science Center, San Antonio, TX); Stavinoha, W. B. *J Neurochem* 28(4): 759-763; 1977. (27 refs)

The uniformity and speed of inactivation of mouse brain adenylate cyclase, guanylate cyclase, and cyclic nucleotide phosphodiesterase were measured after white Swiss mice were exposed to 6-kW of microwave radiation. Inactivation of the enzymes was uniform throughout the brain during microwave heating. Activities of adenylate cyclase, phosphodiesterase, and guanylate cyclase were reduced by 100% after heating times of 200, 300, and 150 msec, respectively. When exposure to 6-kW microwave radiation for 300 msec was compared with exposure to 1.5-kW radiation for 4 sec, the level of cyclic adenosine 3', 5'-monophosphoric acid (AMP) in all brain areas except the corpus striatum was at least 50% lower in the 6-kW, 300-msec exposed animals than in the 1.4-kW, 4-sec exposed animals. In the corpus striatum, a 33% difference according to the above trend was observed. Cyclic guanosine 3', 5'-monophosphoric acid (GMP) levels did not significantly differ between the two exposure groups. When cyclic AMP and cyclic GMP levels were measured from the same regional brain tissue samples, the ratio of cyclic AMP:cyclic GMP varied from 1.5-11.5 after 300 msec deactivation treatment as compared with 3.4-19.1 after 4-sec deactivation treatment. The ratios after 300 msec heating were much lower than those previously reported after liquid nitrogen freezing was used for enzyme deactivation, suggesting that slow inactivation times provide for the measure-

ment of regional brain cyclic nucleotide values, which are not consistent with the in vivo state. A maximal field strength of 6 kW microwave radiation provides for the accurate measurement of cyclic nucleotides in various regional areas of the brain by minimizing the effects of processes that alter the levels during inactivation of this tissue.

5159 NON IONISING ELECTROMAGNETIC FIELDS: ENVIRONMENTAL FACTORS IN RELATION TO MILITARY PERSONNEL. *(Eng.)* Servantie, B.; Tyler, P. E. (Defense Medical Service, France). 31 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A035844]. (140 refs)

Thermal and nonthermal effects of microwave radiation are reviewed with emphasis on the exposure of radar personnel to microwave radiation. Information about human pathology due to the thermal effects of microwaves is very poor. Peritonitis and subsequent death was reported to have occurred in a technician working approximately 3 m from an antenna. Two cases of infarction of the spleen with hemorrhage following severe irradiation have also been reported. Oligospermia with infertility reportedly occurred in a man exposed several times to intense irradiation. Severe headache followed by a meningeal syndrome was observed in an engineer working on a parabolic aerial-emitting X-band radiation. Experimentally, it has been shown that general irradiation at high power densities leads to the death of an animal through hyperthermia. Hyperthermia caused in this way is accompanied by salivation, behavior indicating a desire to escape, and convulsions. Localized irradiation of the head may produce similar manifestations. Other organs that are particularly sensitive to the thermal effects of microwave radiation are the testicles and the lens of the eye. Soviet reviews have published a large number of cases of occupational diseases found in technicians working for some time in an electromagnetic environment. The clinical signs are numerous and cover the endocrine glands, cardiovascular, and nervous systems. Experimentally, a large number of biologic effects have been observed in animals exposed to low power densities, generally less than 10 or even 1 mW/cm^2. Such effects include: microwave-induced auditory sensations; disorders in behavior, neuromuscular functioning, and balance; increased egg production by hens; changes in electroencephalographic recordings; changes in certain biologic rhythms; mitotic changes; and hormonal, biochemical, and blood changes. A discussion of safety standards and health protection of personnel working in the vicinity of microwave radiation is also presented.

5160 APPARENT REGIONAL TURNOVER OF ACETYLCHOLINE IN MOUSE BRAIN: METHODOLOGICAL AND FUNCTIONAL ASPECTS. *(Eng.)* Nordberg, A. (Dept. Pharmacology, Faculty Pharmacy, Univ. Uppsala, Biomedical Center, Box 573, S-751 23 Uppsala, Sweden). *Acta Physiol Scand* 445(Suppl.): 7-50; 1977. (108 refs)

Studies on the levels of acetylcholine (ACh) in different brain regions of mice following alternative methods of sacrifice by microwave irradiation are reviewed. To achieve a shortened enzyme inactivation time two methods of microwave killing were used: whole body 2,450-MHz microwave irradiation for 7 sec (1.3 kW; brain temperature of 85-90 C at 11 sec postirradiation) and 2,450-MHz irradiation of the head for 0.25 sec (5 kW; brain temperature of 85-90 C at 10 sec postirradiation). A markedly higher content of tritium-labeled ACh was preserved, especially in the striatum, when the time of enzyme inactivation was reduced from 7 min (decapitation) to 7 sec (microwave). A comparable increase in the steady state concentration of ACh was obtained by reducing the time of enzyme inactivation further to 0.25 sec (microwave irradiation). These findings indicate the existence of several pools of ACh in the brain. Although ACh in the brain region does not appear to be homogeneous, plots of the specific radioactivities of ACh and choline (Ch) at different time points after the injection of tritium-labeled Ch indicate a precursor-product relationship in all brain regions (except the cerebellum) at the shorter enzyme inactivation time (0.25 sec, microwave).

5161 ELECTRIC FIELD EFFECTS IN BACTERIORHODOPSIN. *(Eng.)* Shinar, R. (Dept. Physical Chemistry, Hebrew Univ. Jerusalem, Jerusalem, Israel); Druckmann, S.; Ottolenghi, M.; Korenstein, R. *Biophys J* 19(1): 1-5; 1977. (16 refs)

The exposure of aqueous suspensions (1.5×10^{-5} molar) of fragments of the purple membrane of *Halobacterium halobium* to a strong transient electric field applied in a (Joule heating) temperature-jump instrument led to transient linear dichroism phenomena. Experiments in which the analyzing light beam was plane-polarized parallel or perpendicular to the applied electric field (about 10 kV/cm) were conducted to discriminate between T-jump and orientational electric field effects. Transient changes in absorbance were found to be almost exclusively due to a time-dependent linear dichroism. Two observed relaxation times were observed. One (about 100 msec) was attributed to rotation of the whole membrane fragments, while the other (about 260 μsec) was attributed to a much faster reorientation of the chromophore within the membrane.

5162 ELECTROKINETIC PROPERTIES OF BLOOD ELEMENTS UNDER THE EFFECT OF PHYSICAL FACTORS. *(Rus.)* Rusiaev, V. F. (Chita State Medical Inst., Chita, USSR); Kuksinskii, V. E.; Sheftel', I. E. *Biofizika* (47): 679-683; 1976. (16 refs)

The effect of the electromagnetic field on the electrophoretic properties of the blood was studied in in vitro experiments. Human and dog erythrocytes and thrombocytes were irradiated (10 min) with a constant magnetic field (300 Oe), with variable electric fields (3 V/cm, 50-20,000 Hz) and with acoustic fields (50-20,000 Hz). In all experiments, irradiated erythrocytes and thrombocytes showed a

decrease in the electrophoretic mobility. The highest effect was observed at 500-1,000 Hz for both acoustic and electromagnetic fields.

5163 MOTOR ACTIVITY OF MUSCLES IN A MAGNETIC FIELD OF VARYING INTENSITY. *(Rus.)* Andrianova, L. A. (No affiliation given); Smirnova, N. P. *Kosm Biol Aviakosm Med* 11(1): 54-58; 1977. (8 refs)

The effect of a constant magnetic field (250-4,000 Oe, exposure 10-30 min) and an alternating magnetic field (100 Oe, 100 Hz) on the motor activity of muscles was studied in CBA mice by counting generated impulses during 10-min periods. Exposure to constant magnetic field with 4,000 Oe caused a significant reduction in the number of impulses (7.2 ± 1.9 during the first 10 min, 2.7 ± 0.9 during the second 10-min period, and 0.6 ± 0.2 during the third 10-min period; 7.7 ± 2.6 during the first 10 min after exposure, 13.5 ± 2.8 during the second 10-min period, and 13.3 ± 5.5 during the third 10-min period, vs 50.6 ± 7.6 before the exposure. The number of impulses was 16.63 ± 5.21 during the first 10 min, 9.47 ± 2.7 during the second 10 min, and 8.1 ± 2.94 during the third 10 min of exposure to the alternating magnetic field, vs 38 ± 4.1 before exposure. There were 9.63 ± 2.73 impulses during the first 10 min after exposure, 4.63 ± 0.68 during the second 10 min, and 3.31 ± 1.1 during the third 10-min period. Exposure to constant magnetic field with 1,000 Oe also inhibited the motor activity significantly, while exposure to 500 Oe slightly activated activity during and immediately after exposure.

5164 ACTION OF A LOW-FREQUENCY ELECTROMAGNETIC FIELD ON THE BODY IN CASE OF SHORT-TERM DAILY IRRADIATION. *(Rus.)* Koziarin, I. P. (A. A. Bogomolets Kiev Medical Inst., Kiev, USSR); Gabovich, R. D.; Popovich, V. M. *Gig Sanit* (4): 18-21; 1977. (0 refs)

To evaluate the health hazards of low frequency electromagnetic fields, 200 male albino rats were irradiated 2 hr daily for 4 mo. Animals were divided into six groups: Group I served as control; Group 2 was exposed to the field of 1 kW/m; Group 3 to 2 kW/m, Group 4 to 4 kW/m, Group 5 to 7 kW/m, and Group 7 to 15 kW/m. By the end of the experiment, animals in Groups 5 and 6 had significantly lower weight (261.6 ± 10.1 g and 253.9 ± 10.7 g, respectively) than controls (296.2 ± 10.7 g). By the end of the 2nd mo of the experiment, animals in Group 6, and by the end of the 3rd mo, animals in Group 5 showed significant decrease in the ratio of muscle reaction time (0.4 ± 0.04 and 0.5 ± 0.08, as compared with 1.9 ± 0.2 in the controls). Exposure to the electromagnetic field resulted also in the inhibition of the function of the thyroid gland (accumulation of ^{131}I dropped from 59.4 ± 3.6% in Group I to 40.8 ± 1.9% in Group 5 and to 47.2 ± 3.7% in Group 6); by the end of the 1st mo, rats in Groups 5 and 6 exhibited an increased level of residual nitrogen (28.2 ± 0.9 mg% and 30.3 ± 1.2 mg%, as compared with 24.8 ± 0.9 mg% in the controls), an increased level of urea (39.8 ± 1.6 mg% and 40.5 ± 2.1 mg%, while 29.7 ± 1.8 mg% in the controls) and an increased level of glucose (85.5 ± 1.3 mg% and 86.7 ± 2.9 mg%, while 77.5 ± 1.8 mg% in the controls). After the termination of the experiment all indices returned to the normal values. Data indicates that 7 kW/m was the threshold intensity and 3-7 kW/m was the subthreshold intensity of the electromagnetic field.

5165 A MICROWAVE RADIOMETRIC METHOD FOR THE STUDY OF THE SEMICONDUCTOR PROPERTIES OF LIVING TISSUE (MEETING ABSTRACT). *(Eng.)* Bigu-del-Blanco, J. (Dept. Anatomy, Queen's Univ., Kingston, Ontario, Canada); Schneiter, A.; Beal, J. C. *In: Book of Abstracts of Seventh European Microwave Conference: The International Conference and Exhibition Designed for the Microwave Community. 5th-8th September, 1977, Copenhagen, Denmark.* p. 70; 1977. (0 refs)

A microwave (MW) radiometric method for the study of the semiconductor properties of tissue was tested. This method employed the nonlinear properties of tissue in conjunction with its radiative properties as described by blackbody theory. The region of the body under examination was illuminated by a monochromatic MW field that mixed with the MW field generated by this region. This mixing resulted in an intermodulation spectrum (IS) that was detectable with a radiometer tuned to a predetermined frequency, or alternatively, to a sum frequency of the IS.

5166 MICROWAVE RADIATION (MR) HEATING OF SURFACE TUMORS (MEETING ABSTRACT). *(Eng.)* Block, J. B. (UCLA-Harbor General Hosp., Torrance, CA 90509); Hirose, F.; Battista, S. *Proc Am Assoc Cancer Res* 18: 306; 1977. (0 refs)

Microwave radiation (MR) was applied to cancers metastatic to the skin to define clinical tolerance and to establish doses of heating associated with objective changes in such tumors. Using a magnetron microwave source at 80 W/cm^2 (2.45 GHz frequency) and tissue coupler, 12 patients with multiple surface metastatic tumors were treated. Two patients with adenocarcinoma (primary uterus and colon) and 10 with melanoma were treated for up to 30 min. Needle thermistors were placed immediately beneath the skin (or tumor) surface at the site of MR and at the central irradiated tumor core (1-2.5 cm below the tumor surface). A technique for surface cooling and adjustment of MR permitted skin surfaces to be maintained between 41 C and 45 C with tumor core temperatures induced and maintained to 50 C with 1-4 W/cm^2. Two patients did not tolerate MR due to local pain. There was no clinical discomfort, evident toxicity, or residual surface burns in the remaining 10 patients. Tumor biopsy of MR-heated tumors demonstrated induction of massive necrosis with an abrupt demarcation from nonaffected deeper-lying tumor; lymphocytic infiltration of normal tumor tissue was occasionally seen at this interface.

Tumor regression was also observed. These studies demonstrated patient tolerance to MR heating and the potential for objective evaluation of MR dose-response curves for tumor regression in man.

5167 SOME EFFECTS OF LOW-LEVEL DOSAGES OF MICROWAVES ON ISOLATED NERVE ACTIVITY (MEETING ABSTRACT). *(Eng.)* Lott, J. R. (North Texas State Univ., Denton, TX 76203); Smith, G. H. *Radiat Res* 70(3): 690; 1977. (0 refs)

The effects of microwaves at dose levels below 10 mW/cm^2 on the activity of isolated sciatic nerve fibers from frogs (*Rana pipiens*) were determined. Changes in chamber temperature, action potential amplitude, and conduction velocity were recorded before and during exposure to microwaves. The nerves were stimulated every 30 sec during each experiment (360 min/wk). Photographs of the resultant action potentials were taken via an electronic thermistor. The microwave power generator was set to deliver about 42 W at 2,450 ± 25 MHz to the antenna horn. The chamber was located in an electrically sealed cage, and the antenna horn was placed 42 cm about the test nerve. Each test nerve was irradiated continuously during each experiment. The effects observed were: (1) a gradual and prolonged increase in the amplitude of the action potential followed by a sharp decline after about 4 hr of exposure, (2) a gradual and sustained increase in nerve impulse conduction velocity followed by a decline at 4 hr postirradiation, and (3) a slight but sustained increase in chamber temperature after 1 hr of exposure (1.4 C).

5168 INCREASE IN X-RAY SENSITIVITY OF CANCER AFTER EXPOSURE TO 434 MHZ ELECTROMAGNETIC RADIATION. *(Eng.)* Holt, J. A. G. *In: Digest of 1977 IEEE MTT-S International Microwave Symposium held in San Diego, CA on June 21-23, 1977.* Inst. Electrical and Electronic Engineers, Inc. (New York, NY): pp. 259-262; 1977. (8 refs)

The use of 434-MHz electromagnetic radiation 15 min before the application of low doses (50-80 rads) of X-radiation was found to enhance the proportion of cancer cells killed by a factor ranging from 3 to over 100 in comparison to X-irradiation alone. When three groups of 52 patients each all with proven eye, nose, or throat cancer were treated with megavoltage X-rays that were combined with 434 MHz irradiation in air, 3 atmospheres pressure of hyperbaric oxygenation, or simply air at 37 C, the corresponding rates of resolution of the primary tumor and involved lymph nodes were 81, 61, and 32%, respectively. The corresponding death rates during the first 2 yr after treatment were 42, 63, and 71%, respectively. Both response and survival duration were improved with the use of 434-MHz irradiation. The increased radiation sensitivity produced by 434-MHz irradiation appeared to be chiefly nonthermal in origin. Temperature measurements revealed a maximum differential rise of over 3.0 C in large avascular cancers. X-ray sensitivity of some cancers after 434-MHz irradiation remained enhanced for approximately 30 min, even when the tumor was cooled to its temperature before 434-MHz irradiation. A second period of increased X-ray sensitivity appeared to exist between about 20 and 30 hr after 434-MHz irradiation.

5169 A BOLUSING TECHNIQUE FOR BATCH MICROWAVE IRRADIATION OF TUMORS IN THE FAR FIELD. *(Eng.)* Cheung, A. Y.; McCulloch, D.; Robinson, J. E.; Samaras, G. M. *In: Digest of 1977 IEEE MTT-S International Microwave Symposium held in San Diego, CA on June 21-23, 1977.* Inst. Electrical and Electronic Engineers, Inc. (New York, NY): pp. 357-359; 1977. (6 refs)

A bolusing technique for the simultaneous irradiation of multiple mouse tumors (C3H/HeJ) in the far field is described. Each animal is enclosed within a cylindrical metal shield, with its superficial flank tumor drawn through a slot aperature for exposure to 2,450 MHz microwave hyperthermia. By encapsulating the tumor in a larger bolus of tissue-equivalent material, tumor heating uniformity was markedly improved (±0.15 C at 45 C heating). A replicable bolus shape was formed using expanded polystyrene molds. Placement of the tumor mold assemblies on an equipower surface of an anechoic microwave range permitted the simultaneous irradiation of multiple mouse tumors.

5170 PRELIMINARY IN-VIVO PROBE MEASUREMENTS OF ELECTRICAL PROPERTIES OF TUMORS IN MICE. *(Eng.)* Burdette, E. C.; Seals, J.; Toler, J. C.; Cain, F. L.; Magin, R. L. *In Digest of 1977 IEEE MTT-S International Microwave Symposium held in San Diego, CA on June 21-23, 1977.* Inst. Electrical and Electronic Engineers, Inc. (New York, NY): pp. 344-347; 1977. (7 refs)

In vivo probe measurements of dielectric properties of tissue exposed to microwave-induced hyperthermia are reported. The in vivo measurement probe is based on an antenna modeling theorem, which relates the impendance of a short monopole antenna in air to its impedance in a lossy dielectric medium. The system used to measure the impedance of the probe consists of a reflectometer in conjunction with a network analyzer. Measurements on standard materials (water and ethylene glycol) indicate that the probe is potentially useful at frequencies up to at least 8 GHz. Measurements on muscle-equivalent phantom modeling materials and tissue were performed only up to 2.0 GHz because of procedural limitations. Preliminary dielectric constant and conductivity measurements were made in vivo on canine thigh muscle tissue and six different malignant tumors in mice (Lewis lung carcinoma, melanotic melanoma B16, Barrett mammary adenocarcinoma, Mendecki mammary adenocarcinoma, glioblastoma, and ependymoblastoma) over a frequency range of 0.01-2.0 GHz. The resulting dielectric constant and conductivity values appear reasonable in relation to in vivo values previously measured using normal tissue. The above

measurement system, once automated with a swept frequency capability and an increased sensitivity, could represent a potentially useful diagnostic tool for differentiating between normal and malignant tissues.

5171 NEAR ZONE MICROWAVE OF A BIOLOGICAL SPHERE. *(Eng.)* Al-Badwaihy, K.; Hafiz, S. A. *In: Digest of 1977 IEEE MTT-S International Microwave Symposium held in San Diego, CA on June 21-23, 1977.* Inst. Electrical and Electronic Engineers, Inc. (New York, NY): pp. 352-353; 1977. (1 ref)

Power deposited into a spherical model of biologic tissues is computed for an exciting axial electric or magnetic dipole at different locations and for different frequencies. It is found that near zone fields may deposit higher power into biologic structures than plane waves having the same incident strength. The relative power deposited into the sphere increases as the dipole gets closer to the sphere and is larger for the magnetic dipole than for the electric dipole. The relative power is almost frequency independent in the frequency range 1-10 GHz because of the increase in conductivity of biologic tissues with frequency. The power distribution inside the sphere is frequency dependent, with lower frequencies showing more even power distribution than higher frequencies.

5172 TERATOGENIC POWER OF SHF FIELDS. FURTHER EXPERIMENTS ON *TENEBRIO MOLITOR* COLEOPTERON (MEETING ABSTRACT). *(Eng.)* d'Ambrosio, G. (Universita di Napoli, Istituto Electrotecnico, Naples, Italy); La Manna, V. *In: Book of Abstracts of Seventh European Microwave Conference: The International Conference and Exhibition Designed for the Microwave Community. 5th-8th September, 1977, Copenhagen, Denmark.* p. 71; 1977. (0 refs)

The frequency dependence of microwave-induced teratogenic effects in *Tenebrio molitor* was investigated. Power absorption of the specimen and the influence of the age of the exposed pupa was investigated. The previously known energy dosage law was also tested at various levels.

5173 NON-PERTURBING MICROPROBES FOR MEASUREMENT IN ELECTROMAGNETIC FIELDS. *(Eng.)* Deficis, A.; Priou, A. *In: Digest of 1977 IEEE MTT-S International Microwave Symposium held in San Diego, CA on June 21-23, 1977.* Inst. Electrical and Electronic Engineers, Inc. (New York, NY): pp. 348-351; 1977. (7 refs)

The design and application of noninterfering microprobes for measuring the temperature of materials exposed to electromagnetic fields are described. A cholesteric crystal probe, which operates over a temperature range of 10-40 C has been developed, but this type of probe requires recalibration due to liquid crystal aging and instability. A dielectric microthermometer has been developed and operates over a temperature range of -40 C to +150 C in steps of 40 C. The principle of operation involves the reflection of a light beam on a thermodilatable liquid contained in a small capillary glass pipe. Measurements over frequency ranges of 900-915 MHz, 2,400-2,500 MHz, and 8.2-12.4 GHz reveal that perturbation caused by the thermometer is very low (less than or equal to 0.1 dB), regardless of the orientation of the probe in relation to the electric field. The standing wave ratio of the probe is less than 1.1:1. Experiments have been run in which the microwave thawing process of chopped beef was recorded over a temperature range of -30 C to +20 C. These experiments indicate that the microwave thawing process can be continuously recorded. The sensitivity of the probe is about 0.5 C, and the probe response time is less than 15 sec. The probe should be useful for local dosimetry applications, studying electromagnetic energy penetration and absorption by biological media, and many other medical and industrial applications.

5174 THE DESIGN AND PERFORMANCE OF A CIRCULARLY POLARIZED DIRECT CONTACT APPLICATOR FOR MICROWAVE DIATHERMY. *(Eng.)* Kantor, G.; Witters, D. M.; Greiser, J. W. *In: 1977 IEEE MTT-S International Microwave Symposium held in San Diego, CA on June 21-23, 1977.* Inst. Electrical and Electronic Engineers, Inc. (New York, NY): pp. 364-367; 1977. (2 refs)

A circularly polarized direct contact applicator for microwave diathermy is described. The applicator is a circularly polarized conical horn operating at a frequency of 2.45 GHz with a far field beamwidth of 55.5 degrees and a maximum input power capability of 300 W. The design consists of a circular waveguide fed with a coaxial probe, two sets of posts placed in the guide at 45 degrees to the input probe to generate a circularly polarized field, and a resistive card at the input end of the horn to minimize mismatch while applied to human tissue. The design includes a microwave choke around the output aperture to suppress leakage. The performance of the applicator was evaluated by mapping the near field at 5 mm from the aperture. The heating pattern in planar phantoms of simulated fat and muscle tissue was symmetrical, with a maximum value of 15.7 mW/cm^2 per W of forward power at the center and a minimum of about 0.2 mW/cm^2 per W of forward power at its periphery. Impedance matching data revealed a standing wave ratio of less than 2.1:1 at four locations on the back of a person and for free space radiation. Thermographic analysis of the microwave heating of a planar phantom revealed that the width of the heating pattern (defined as the width of the trace for which the temperature rise is half the maximum temperature rise) was 7.5 cm and the depth of penetration (defined as the distance between the fat-muscle interface and the depth at which the temperature decreased by 50% with respect to the maximum) was 2.2 cm for the symmetrical case where the center of the applicator was directly above the phantom midplane. For the case where the center of the aperture was moved 3.81 cm from the separation midplane along the z-axis, the corresponding width

and depth values were 7.0 cm and 2.0 cm, respectively. The relatively large values of heating pattern width suggest uniform heating in the center of the heating pattern. Maximum leakage for direct contact loading (applicator on top of a planar phantom) was 0.8 mW/cm^2 per 100 W of forward power.

5175 A SYSTEM FOR DEVELOPING MICROWAVE INDUCED HYPERTHERMIA IN SMALL ANIMALS. *(Eng.)*
Baker, R. J.; Smith, V.; Phillips, T. L.; Kobe, L.; Kane, L. *In: Digest of 1977 IEEE MTT-S International Microwave Symposium held in San Diego, CA on June 21-23, 1977.* Inst. Electrical and Electronic Engineers, Inc. (New York, NY): pp.360-363; 1977. (18 refs)

A system for developing microwave-induced hyperthermia in small animals is described. The waveguide components include a conventional WR-650 coax-to-waveguide adapter; an electrically compensated one dimension transition section, which tapers to a reduced height test section; and a reduced height coax-to-waveguide adapter, which is followed by a coaxial dummy load. The test animal is placed in a plastic test tube, which is inserted in a 1-inch diameter hole centered in the broad face of the waveguide. A frequency of 1,210 MHz produces maximum energy absorption in the test animal. Thermographic studies of sacrificed sectioned mice heated in the applicator revealed deep heating and preferential heating in the center of the animal. The preferential heating was also seen in mouse phantoms (agar and sodium chloride). In an initial trial where anesthetized mice were heated at either 40 C for 25 min or 43 C for 15 min, one LAF_1 mouse died 16 hr postheating to 43 C in the abdominal region, while the remaining mice (Balb/C strain) survived lesser times. In a second trial, the anesthetic dose was reduced (60 mg/kg Diabutal), and two thermistors in different anatomic positions were used to monitor temperature. One thermistor was inserted into the rectum (final position being mid-abdomen), and the second thermistor was implanted subcutaneously, with its position being mid-height in the waveguide (as was the rectal thermistor). Rotation of the test tube containing the mouse revealed that the subcutaneous thermistor reading was essentially independent of angular orientation (near microwave generator or near load) and that the reading was consistently 1-2 C warmer than the rectal thermistor. All of five Balb/C mice heated to 40 C, as indicated by the subcutaneous thermistor, over periods of 15-45 min are alive and appear healthy at 5 days postheating.

5176 EFFECT OF SURFACE COOLING AND BLOOD FLOW ON THE ELECTROMAGNETIC HEATING OF TISSUE. *(Eng.)* Kritikos, H. N.; Foster, K. R.; Schwan, H. P. *In: Digest of 1977 IEEE MTT-S International Microwave Symposium held in San Diego, CA on June 21-23, 1977.* Inst. Electrical and Electronic Engineers, Inc. (New York, NY): pp. 354-356; 1977. (8 refs)

Temperature profiles are calculated in tissue models exposed to microwave radiation by solving the heat transport equation and taking into account thermal conduction, thermal convection due to blood flow, and surface cooling of the tissue. Two idealized models representing limiting cases of the microwave heating behavior of actual tissue sections are considered. The first consists of a semi-infinite tissue slab exposed to plane electromagnetic radiation, and the second considers focused microwave heating in a finite volume of tissue. In both cases, the steady state temperature profile is largely determined by the blood flow; the effective heating depth can be much larger than the energy penetration depth in tissue, an effect particularly noticeable for 10 GHz radiation. In the steady state, the blood flow at physiologic levels creates an effective thermal diffusion length of 1-2 cm, which leads to an effective averaging of microwave heating patterns over distances of this magnitude. To some extent, this effect will reduce the non-uniform tissue heating due to hot spots and also the ability to focus the microwave heating to specific regions in the tissue by external means. The results also imply that microwave irradiation at the generally recognized safe level of 10 mW/cm^2 is not likely to increase tissue temperature by more than 0.5 C.

5177 MEASUREMENTS OF 1.8-2.7-GHZ MICROWAVE ATTENUATION IN THE HUMAN TORSO. *(Eng.)*
Yamaura, I. (Electrotechnical Lab., 5-4-1 Mukodai-cho, Tanashi-shi, Tokyo, Japan). *IEEE Trans Microwave Theory Techniques* 25(8): 707-710; 1977. (8 refs)

Measurements of 1.8-2.7 GHz microwave attenuation in the human torso are reported. Sweep-frequency measurements indicated that leakage effects were the most troublesome measurement problem. To minimize these leakage effects, close coupling between the antenna and the body was maintained using flanged aperture antennas as the transmitting and receiving antennas. Power at the receiving antenna was recorded over a frequency range of 1.8 to 2.7 GHz, with the maximum power density on the human subject about 0.5 mW/cm^2. Attenuation constants for the abdomen and the left thorax were about the same as those for muscle tissues. Changes in attenuation caused by heartbeats or respiration were observed for the left thorax. The attenuation constant of the right thorax was smaller than that for muscle but much larger than that of fat, implying that the attenuation in the right thorax is mainly caused by lung tissues. It was estimated that the close-coupling condition has over a 10-dB margin for leakage at a frequency of 2 GHz.

5178 EFFECT OF SUPER-HIGH FREQUENCY ELECTROMAGNETIC IRRADIATION ON THE ELECTROPHORETIC MOBILITY OF ERYTHROCYTES. *(Rus.)* Ismailov, E. Sh. (Dagestan Polytechnical Inst., Makhachkala, USSR). *Biofizika* 22(3): 493-498; 1977. (14 refs)

The effect of irradiation (1,009 MHz, intensity 2-45 mW/cm^3, duration 4, 8, or 15 min) on the electrophoretic mobility (EM) of human erythrocytes

was studied in vitro at 37 C immediately or 10-90 min after irradiation. Immediately after irradiation at an intensity of 45 mA/cm^3 for 4, 8, and 15 min, the EM (in 10^{-4} cm/V/sec) was 1.20, 1.30 and 1.38, respectively, compared with 1.28-1.33 in the control. The EM was highest 30 min after the irradiation and reduced comparatively with the initial values after 70 min (1.32, 1.28, and 1.25, respectively). The EM, measured immediately after irradiation for 30 min at the intensities of 2, 5, 10, and 20 mA/cm^3 was 1.20, 1.12, 1.26, and 1.34, respectively. The highest values were measured 30 min after irradiation. The EM was 1.32 after 80 min irradiation at 10 mA/cm^3 and after 90 min irradiation at 20 mA/cm^3. The changes in the EM are due to the deformation of the double electric layer and to the structural rearrangement of the erythrocyte membrane as a consequence of the phase transition of the structured water in the membrane into a more liquid state. The changes in the EM are reversible.

5179 HEAT-DISSIPATION RATE OF MICE AFTER MICROWAVE IRRADIATION. *(Eng.)* Ho, H. S. (U. S. Dept. Health, Education, and Welfare, Public Health Service, Food and Drug Admin., Bureau Radiological Health, 5600 Fishers Lane, Rockville, MD 20852); Mc Manaway, M. *J Microwave Power* 12(1): 93-100; 1977. (10 refs)

The heat dissipation rate from individual CF1 male mice before and after microwave irradiation was determined with a biocalorimeter. The mice were irradiated singly in an environmentally-controlled waveguide apparatus (24 C temperature and 50% relative humidity) with 2,450 MHz continuous wave microwave radiation. Incident power levels of 0 (sham), 0.4, 0.8, 1.7, and 3.3 W resulted in corresponding mean average absorbed dose rates of 0, 7, 12, 27, and 39 mW/g. An increased heat dissipation rate in comparison with sham-irradiated mice was observed for mice receiving average absorbed dose rates of 12 mW/g or more.

5180 EFFECT OF HIGH FREQUENCY RADIATION ON THE TANNING PROCESS IN THE COLEOPTERA *TENEBRIO MOLITOR*. *(Fre.)* Tchao, Y. H. (Laboratoire d'opto-acousto-electronique de Valenchiennes, Laboratoire associe au C.N.R.S., 59300 Valenciennes, France); Huet, C.; Lenoir-Rousseaux, J. J. *C R Acad Sci [D] (Paris)* 284(16): 1589-1592; 1977. (10 refs)

High frequency radiation allows blocking of enzymatic reactions controlling metabolic processes. The technique was used to study cuticular tanning of the insect Coleoptera *Tenebrio molitor* as it underwent transformation from the pupal to imago stage, a process under the control of the hormone, bursicon. A total of 170 nymphs, of both sexes and without apparent malformations, were irradiated individually from a high frequency (9,300 MHz) source. An adaptor impedance minimized reflected power to less than 40db of the incident power, and an attenuator and commutator measured power and duration of radiation. After radiation, insects were placed in individual boxes at elevated temperatures.

5181 ON THE INTERDEPENDENCE OF THERMAL AND ELECTROMAGNETIC EFFECTS IN THE RESPONSE OF *BACILLUS SUBTILIS* SPORES TO MICROWAVE EXPOSURE. *(Eng.)* Wayland, J. R. (Sandia Lab., Albuquerque, NM 87115); Brannen, J. P.; Morris, M. E. *Radiat Res* 71(1): 251-258; 1977. (4 refs)

Spores of *Bacillus subtilis* were inactivated in a microwave field at a frequency of 2,450 ± 50 MHz at power levels of up to 30 kW, and the inactivation rates were compared with those obtained by exposure to heat alone in an effort to distinguish the thermal interdependency of electromagnetic effects. The spore samples were exposed in the center of a WG-340 waveguide operating in the transverse electromagnetic$_{10}$ mode to produce as uniform an electric field as practicable. At electric fields of 9, 15, 20, and 30 kW, the inactivation rates (min^{-1}) were 0.00132 ± 0.00036, 0.0754 ± 0.0237, 0.7314 ± 0.0077, and 1.06 ± 0.083, respectively; the corresponding spore temperatures at these inactivation rates and power levels were: 103 ± 4, 120 ± 4, 136 ± 7, and 170 ± 9 C, respectively. When spores were exposed to heat alone at temperatures of 105, 120, and 135 C, the inactivation rates were 0.0251 ± 0.0026, 0.0973 ± 0.0058, and 0.254 ± 0.011, respectively. These results suggest a strong interdependence of thermal and electromagnetic effects based on the difference in the inactivation rates. The differences are a clear indication of a nonthermal microwave effect.

5182 LOCAL TUMOR HYPERTHERMIA IN COMBINATION WITH RADIATION THERAPY. I. MALIGNANT CUTANEOUS LESIONS. *(Eng.)* Kim, J. H. (Dept. Radiation Therapy, Memorial Sloan-Kettering Cancer Center, New York, NY 10016); Hahn, E. W.; Tokita, N.; Nisce, L. Z. *Cancer* 40(1): 161-169; 1977. (25 refs)

The use of local tumor hyperthermia (43.5 C) in combination with radiation therapy (electron or photon beam irradiation) for the treatment of 36 patients with multiple cutaneous malignant lesions (mycosis fungoides, Kaposi sarcoma, malignant melanoma, lymphoma cutis, synovial sarcoma, squamous cell carcinoma, sweat gland carcinoma, and rectal carcinoma metastatic to the skin) is reported. Hyperthermia was produced by either wet heat or radiofrequency (27.12 MHz) inductive heating using a modified diathermy unit. In general, initial tumor regression rates were faster in patients treated with radiation plus hyperthermia than in patients treated with radiation alone, particularly in patients with Kaposi sarcoma and lymphoma cutis. Among 26 patients receiving combination therapy, 10 had a recurrence, with seven of these showing an improved disease-free interval. Among five patients receiving fractionated (twice/wk) hyperthermia (radiofrequency heating) alone, complete regressions were observed in one patient receiving 45 min of

hyperthermia in eight fractions for malignant melanoma, in two patients receiving 30 min of hyperthermia in six fractions for mycosis fungoides, and in one patient receiving 30 min of hyperthermia in three fractions for lymphoma cutis. The skin surface temperature in these cases was 43.5 ± 0.5 C. A partial regression was observed in one patient receiving 30 min of hyperthermia (43.0 C) in five fractions for lymphoma cutis. At 27.12 MHz, the depth of heat penetration is limited, and the inductive heat distribution is modified to an extent by the thickness of the subcutaneous fat tissue. No unusual disproportionate normal skin teactions were observed in patients receiving fractionated radiation therapy followed by hyperthermia as compared with patients receiving radiation alone.

5183 LOW-TEMPERATURE EXPERIMENTS IN RADIATION BIOPHYSICS. *(Nor.)* Moan, J. (Biofysisk Avdeling, Norsk Hydros Institut for Kreftforskning, Det Norske Radiumhospital, Oslo, Norway). *Fra Fysikkens Verden* 39(2): 33-36; 1977. (0 refs)

The high-speed biochemical reactions induced by ionizing and non-ionizing radiation in biologic substances (tryptophan, adenosine, bacteriophage T_1, trypsin) in vitro can be slowed down for more convenient study by irradiating them at cryogenic temperatures. The damage to bacteriophage T_1, irradiated in dry state in a magnetic field of 506 G at 130 K appears to be due to the reaction of H atoms formed by the irradiation with DNA molecules.

5184 PHYSIOLOGICAL EFFECTS OF NAACH VOLTAGES. *(Eng.)* Jacobson, F. H. (Crew Systems Dept., Naval Air Development Center, Warminster, PA 18974). 29 pp., 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A033679]. (16 refs)

Acute and chronic experiments with cats to determine possible hazards associated with the Navy's non-acoustic audio coupling to the head (NAACH) earphone are reported. No evidence of direct current (dc) flow between or around NAACH electrodes was observed. In acute experiments with audio signal voltages as high as 750 V (root mean square) biased by dc voltages as high as 900 V, the measured integral of the total rectified electrical activity of the trapezius muscle increased with each increase in the voltage of the audio signal applied to the NAACH electrodes. This increase in the integral was accompanied by increased audiofrequency current passing through the head and being picked up by the muscle electrodes or their connectors to a Winchester plug mounted on the head. One cat that was exposed to 4-hr daily NAACH receptions of a 3-kHz signal at the above voltages 4 days/wk for 4 wk exhibited a small increase in spindle and slow-wave sleep on the 5th day of each week but not in rapid-eye-movement sleep. Three other cats received NAACH-transmitted speech daily except on days 7, 12, and 17. The speech signal voltage fluctuated continuously between nearly 0 and 1,000 V with a mode of about 400 V and was biased by 1,020 V dc. No consistent effects on sleep time or stages were detected as a result of NAACH exposure. A single-channel electrocardiogram was recorded in six cats during presurgical anesthesia and during surgical-level anesthesia after 6-14 days of exposure to NAACH voltages. Clinically significant effects were not observed, although one cat developed a sinus tachycardia. A causal effect between NAACH exposure and the tachycardia was not demonstrated. Overall, no impairment of alertness or disturbance of sleep that would preclude exposing human subjects to NAACH voltages was discerned.

5185 THE ELECTRICAL RESISTIVITY OF AQUEOUS CYTOPLASM. *(Eng.)* Foster, K. R. (Armed Forces Radiobiology Res. Inst., Defense Nuclear Agency, Bethesda, MD 20014); Bidinger, J. M.; Carpenter, D. O. 23 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A033257]. (19 refs)

Electrical resistivity measurements of aqueous cytoplasm were made for neurons and muscle fibers of the sea slug, *Aplysia californica*. Each cell was penetrated by a metal microelectrode whose complex impedance was measured as a function of frequency between 500 kHz and 5.7 MHz using an active radio-frequency vector impedance meter. By plotting the measured impedance data on the complex Z plane and extrapolating the data to infinite frequency, the substantial effects of electrode polarization were overcome. The extrapolated cytoplasmic specific resistivities for *Aplysia* giant neurons and barnacle muscle fibers were 40 ± 14 ohm-cm and 74.1 ± 29.0 ohm-cm, respectively. Excluding one experiment where the electrode tip was possibly pushed through the cell and into the seawater below, the average resistivity of barnacle fibers was 82 ± 21 ohm-cm. Electrical polarization impedance in the barnacle muscle fiber was not greatly different from that in a potassium chloride solution of similar resistivity. When the *Aplysia* neuron was penetrated with the electrode, the frequency-dependent part of its impedance increased tenfold in magnitude. The results indicate that there is a significant resistance of some intracellular membranes. However, by extrapolation to infinite frequency and therefore avoiding the effects of both membranes and polarization impedance, the data show that neither water nor ions are bound to an extent greater than that for most other tissues. These results, indicating relatively little bound water, suggest but do not prove that radiation does not act via effects on bound water in the central nervous system.

5186 FORMATION AND RESEALING OF PORES OF CONTROLLED SIZES IN HUMAN ERYTHROCYTE MEMBRANE. *(Eng.)* Kinosita, K. (Dept. Physiological Chemistry, Johns Hopkins Univ. Sch. Medicine, Baltimore, MD 21205); Tsong, T. Y. *Nature* 268(5619): 438-441; 1977. (11 refs)

Erythrocytes in an isotonic sodium chloride solution were treated with a 3.7 kV/cm, 20-μsec pulse, and

the subsequent change in cell volume was monitored by light scattering measurement. Under these conditions, intracellular potassium ion leaked out and was replaced with sodium ion within a few minutes. Further entry of sodium chloride caused swelling of the red cells. When the volume reached 1.1 times the volume of untreated cells, a small amount of isotonic solution of various substances was added to the suspension. The cells kept swelling because of the continuous influx of sodium chloride. However, when the same amount of sucrose solution was added, the swelling immediately stopped. When the added substance was xylitol (molecular weight of 152 as compared with 342 for sucrose), only partial blocking of the cell swelling was achieved. The permeability of the pulse-treated membrane to 11 different carbohydrates was measured under various conditions. Data for untreated control cells revealed that molecules larger than erythritol do not enter the cells to any appreciable amount except D-glucose, which is carried by a specific transport system. Treatment of the cells with a 3.7 kV/cm, 20-μsec pulse increased the critical size for permeation, with molecules smaller than sucrose penetrating the membrane and the rate decreasing with molecule size. The exception to this was D-glucose where the specific transport system seems to be intact even after the pulse treatment. The addition of a sufficient amount of impermeant substance to the suspension of pulse-treated erythrocytes retarded the hemolysis indefinitely. While the cells were prevented from lysis, the membrane spontaneously resealed, with the resealing process being strongly temperature-dependent. Electric pulsation followed by an appropriate resealing procedure makes it possible to prepare erythrocytes with altered intracellular compositions. Although alteration of cellular cations can also be achieved by lactose treatment or chemical modification of the cell membrane, the present method allows for the incorporation of larger molecules such as sucrose by introducing pores of adequate size.

5187 TUMOR ERADICATION IN THE RABBIT BY RADIOFREQUENCY HEATING. *(Eng.)* Dickson, J. A. (Cancer Res. Unit, Univ. Dept. Clinical Biochemistry, Royal Victoria Infirmary, Newcastle upon Tyne, England); Shah, S. A.; Waggott, D.; Whalley, W. B. *Cancer Res* 37(7): 2162-2169; 1977. (37 refs)

Radiofrequency (RF) equipment for heating tumors consisting of a generator circuit with a crystal-controlled oscillator operating at 13.56 MHz (22 m wavelength) and a resonator circuit tuned to the generator circuit is described. The circuits are linked by capacitive coupling with two flat paddle electrodes, and the tissue becomes part of the output circuit. Compensating inductance coils tuned to the circuit, contained in the paddle, maximize the heating component of the current in the tissue. Efficient contact between the paddles and skin (hairless) is crucial, as is the length of the tissue cylinder heated in relation to its diameter. Other important factors include the use of the lower end of the short-wave diathermy spectrum with its greater depth of penetration in tissue and minimal current spread beyond the electrodes, use of the electrostatic (condenser) field technique, and incorporation of compensating coils in paddle handles. Temperatures were measured by thermistor probes and a 12-channel direct-reading electric thermometer and thermocouple sensors. In vitro metabolic studies were used to determine the minimal operational temperature of 47 C for destruction of the solid intramuscular VX2 tumor in New Zealand White rabbits. At low power outputs (up to approx 6 W), the analog meters (thermistor and thermocouple systems) were unaffected by the RF field; at 10-12 W, only the potentiometer readings remained unaffected, while the thermistors read consistently 1.0-1.5 C high. Temperature was routinely monitored with thermistor sensors and the RF field off. Ten VX2 carcinomas (12-22 ml in volume; tumors relatively non-necrotic and metastases present in regional, iliac, and paraaortic lymph nodes and in lungs) were heated at 47-50 C for 30 min. At 47 C, temperature differential of 2-3 degrees was usually seen between multiple sensors in a large tumor; rectal temperature was within normal range. Seven animals were cured, with tumors regressing in 6-8 wk; in three rabbits, limb paralysis (not specifically associated with RF heating) required their sacrifice within 3-4 wk of therapy, but there was no increase in tumor volume during this time. The presence of tumor in the muscle did not significantly alter the electrical resistance of the leg(s), and results suggest that selective RF heating of this carcinoma may be conditioned by poor blood flow through the tumor compared with normal adjacent tissue.

5188 EFFECT OF THE ELECTRICAL FIELD OF POWER TRANSMISSION LINES ON LINEMEN. *(Rus.)* Kaliuzhnyi, V. F. (No affiliation given); Mikhailov, M. I. *Elektrosviaz* (3): 30-34; 1977. (6 refs)

The permissable distances between three-phase alternating current power transmission lines of 330-1,200 kV and telecommunication lines were calculated in view of the dangers of generated electric fields for linemen working on telecommunication lines. The maximum permissible electric field potential is 5 kV/m. The minimal distances between the vertical projections of the outer conductor of power lines and telecommunication lines should be 5-6 m for a line voltage of 330 kV, 10 m for 500 kV, 15 m for 750 kV, and 25 m for 1,200 kV.

5189 INFLUENCE OF MICROWAVES ON THE RESTING POTENTIAL OF GIANT NEURONS OF THE MOLLUSK *HELIX POMATIA*. *(Rus.)* Arber, S. L. (Moscow, USSR). *Elektronnaia Obrabotka Materialov* 6(72): 78-79; 1976. (8 refs)

The effect of microwaves (2.45 GHz, absorbed energy 15.5 mW/cm^3, exposure time 1 hr) on the resting potential of the giant neurons of the mollusk *Helix pomatia* was studied in vitro by means of implanted microelectrodes. The resting potential was 51.1 ± 2.5 mV without irradiation. Irradiation caused

hyperpolarization by 1.5 ± 0.3 mV after exposure for 25-30 min; by 3.2 ± 0.6 mV after exposure for 1 hr, and by 4.6 ± 0.8 mV 1 hr after the 1-hr exposure. No hyperpolarization was observed at pH 4, and it was reduced by ouabain. The findings indicate that microwaves cause an increase in the membrane permeability for potassium and sodium ions that leads to the intracellular accumulation of sodium and subsequently to an activation of the "electrogenic sodium pump". This activation accounts for about 60% of the radiation-induced hyperpolarization.

5190 DO ELECTRICAL FIELDS HAVE BIOLOGICAL EFFECT? *(Dut.)* Anonymous. (No affiliation given). *Elektrotechniek* 55(7): 461; 1977. (0 refs)

Rats were exposed to an electrical field of 100 kV/m for 1 yr to verify Soviet findings that exposure to 5-20 kV/m fields causes disturbances in the central nervous system and changes in the heart rate and blood pressure in workers. The animal experiments revealed no significant differences between the experimental and control animals in terms of weight gain, motor activity, escape reaction, circadian rhythm, heart rate, and differential blood picture.

5191 BIOMAGNETIC EFFECTS: A CONSIDERATION IN FUSION REACTOR DEVELOPMENT. *(Eng.)* Mahlum, D. D. (*Battelle Pacific Northwest Lab., Richland, WA 99352*). 35 pp; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. BNWL-1973]. (64 refs)

A summary of the current state of knowledge concerning the biological effects of magnetic fields alone and in combination with ionizing radiation is presented in connection with potential biologic hazards associated with fusion reactor systems. The most extensive calculations of magnetic field patterns have been performed for reactor designs that produce toroidal and poloidal fields. The toroidal field may vary from 10,000 G in the area surrounding the nuclear island to less than 1 G at the outer edge of the reactor building (about 50 m). Poloidal fields as high as 70-450 G may be encountered by people working in the transport and hot cell regions. People working in the region immediately surrounding the reactor building and associated facilities could be subjected to field strengths of 1-70 G for substantial periods. Changes in the electrical activity of the brain and heart have been found after exposure of humans, monkeys, rabbits, and pigeons to fields of 500-91,000 G. Some investigations suggest that preexisting lesions may be exacerbated in the presence of magnetic fields. The genetic effects of magnetic fields have been studied primarily in lower organisms, houseflies, and flour beetles. Changes in mortality and the induction of wing abnormalities have been reported. Evidence for an influence of magnetic fields on growth and development has come from studies on frogs, salamanders, fruit flies, sea urchins, and mice; however, most of the studies have been performed at field strengths above 2,500 G, and the results varied markedly from no effect to complete prevention of development. In general, studies which examine the response of biologic systems to magnetic fields have produced results that are highly variable and often nonreproducible.

5192 PROTECTION AFFORDED BY THE METAL CAPSULE OF PACEMAKERS AGAINST EXTERNAL ELECTROMAGNETIC EFFECTS: FACT OR FICTION? *(Fre.)* Grand, A. (Service de Medecine, Centre Hospitalier de Valence, B.P. 831, F26008 Valence Cedex, France); Drouin, B.; Ferry, M.; du Charlat, G.; Tabet, R.; Morel, C. *Nouv Presse Med* 6(10): 855; 1977. (1 refs)

The function of various models of pacemakers, implanted subclavicularly, in the presence of electric toilet articles (e.g., razors, tooth brushes) was tested. The effect of electromagnetic interference on the pacemaker is unpredictable: constant for a given apparatus, null for an identical one of the same make implanted in the same place. A titanium capsule (ELA Stanium SM, Telectronics P 150B) did not always prevent interference; boxes in acid (Biotronik IDP 54) appeared to be better protected. Other pacemakers without metal capsules (Intermedics C-MOS 1, Medtronic Xytron 5951) appeared to be perfectly isolated from electromagnetic interference. More important than the metal capsule appeared to be the quality of isolation of the electronic circuits and the stimulator probe.

5193 THE HYPNOGENIC EFFECT OF MODULATED ELECTROMAGNETIC FIELD. *(Rus.)* Sudakov, K. V. (P. K. Anokhin Inst. Normal Physiology, USSR Acad. Medical Sciences, Moscow, USSR); Antimonii, G. D. *Biull Eksp Biol Med* 34(8): 146-149; 1977. (8 refs)

Behavioral and electrocardiographic changes were studied in strainless male and female rats exposed to modulated electromagnetic field (40 MHz, modulation frequency 50 GHz, modulation factor 80-100%, field potential 100-120 V/m) for 2-150 minutes. The animals displayed four distinct phases of the behavioral changes during the course of the exposure. The first phase, observed in 54% of the animals after an exposure time of 5-20 min, showed local epileptiform activity in the dorsal hippocampus. The second phase, observed in 75% of the animals after exposure for 20-45 min, was characterized by epileptiform activity in the hippocampus, hypothalamus, septum, amygdala, as well as in the temporal and occipital regions of the brain cortex. During the third phase, observed in 86% of the animals after exposure for 45-60 min, the epileptiform activity spread over all brain structures investigated. Slow waves with 150-200 μV amplitude or depression on the electroencephalogram were observed during the first phase in 35% of the animals after exposure for 90-150 min. Catalepsy

was observed in 5% of the rats during this phase. The exposure also caused disturbances in the conditioned food and defense reflexes of the animals. The findings indicate that the behavioral changes induced by modulated electromagnetic field are due to changes in the normal cortico-subcortical relationships.

5194 GALLOPING OF PACEMAKER DURING HIGH-FREQUENCY THERAPY. *(Ger.)* Effert, S. (Lehrstuhl fur Innere Medizin I, Technische Hochschule, 5100 Aachen, Goethestr. 27-29, W. Germany). *Dtsch Med Wochenschr* 102(24): 909; 1977. (0 refs)

A 62-yr-old man with an implanted CPI model pacemaker received microwave therapy (wavelength 69 cm corresponding to 433.92 MHz) for arthritis in the left shoulder joint. The first three sessions were without any complication, but the patient died suddenly during the fourth session. The cause of death could not be established by autopsy; the pacemaker was operating at normal frequency. The pacemaker was then irradiated with the same therapeutic radiation source at 12 cm distance, which caused a rise in the pacemaker frequency up to 214/min. The death is assumed to have been due to the rise in the pacemaker frequency during the irradiation. The patient may have been at greater distance (about 18 cm) from the microwave generator during the first three sessions.

5195 STUDY OF THE INACTIVATION OF VIRUS-CONTAINING WATER BY MEANS OF ELECTRICAL CURRENT. *(Rus.)* Muzychuk, N. T. (Kiev, USSR); Kul'skii, L. A.; Vorob'eva, A. M.; Matskevich, V. S. *Elektronnaia Obrabotka Materialov* 6(72): 76-78; 1976. (9 refs)

The effect of direct current (30 V/m, current density 8-16 mA/cm^2) on the inactivation (elimination) of *Escherichia coli* B. bacteriophage T_2 in water was studied in the presence of aluminum sulfate or lanthanum chloride (usually 0.88 mg-equivalent/l). Aluminum sulfate alone caused 56% deactivation vs. 82.3% after 1-min treatment with a current density of 14 mA/cm^2, and 90.5% after 4-min treatment with 16.6 mA/cm^2. Lanthanum chloride alone had a deactivation rate of 10%, while electric treatment (1-7 min, current density 8-12 mA/cm^2) of the water containing lanthanum chloride inactivated the bacteriophages at rates of 97.3-99.2%. The reduction of the virus concentration was caused by deactivation by the electric field and the salts and not by the transfer of the viruses to the electrodes or to adsorption.

5196 INFLUENCE OF TECHNICAL ALTERNATING ELECTRIC FIELD OF HIGH TENSION ON THE ORGANISM. *(Ger.)* Schaefer, H. (Im Neuenheimer Feld 326, D-6900 Heidelberg 1, W. Germany); Silny, J. *Int Arch Environ Occup Health* 39(2): 83-96; 1977. (47 refs)

The effects of an electric field (50 Hz, 80 kV/m) on some physiologic parameters were studied in 82 immobilized rats and 46 non-immobilized cats. The animals, kept in Teflon cages, were exposed for two 4-hr phases with 4-hr intervals. In rats, the heart rate showed a 21% increase during the first 4 hr of exposure, which was followed by a slow decline during the 4-hr pause and the next 4-hr exposure. The respiration rate and the blood pressure showed only insignificant changes. Seven immobilized rats died during the exposure with symptoms suggesting hyperthermia: collapse after a sharp rise in the heart rate and increased skin temperature. The alpha- and beta-bands of the electroencephlogram of cats showed a 60% decline during exposure. This phenomenon, as well as the hyperthermia observed in the rats, can be interpreted as the result of hair vibration which causes a stress in the animals. The stress leads to increased myotonia, which results in increased heat production by the muscles. The findings indicate that the electric field has no harmful effect on non-immobilized animals.

5197 INTRODUCTION. *(Eng.)* Baranski, S.; Czerski, P. *In: Biological Effects of Microwaves.* (Stroudsburg: Dowden, Hutchinson & Ross, Inc.) pp. 11-23; 1976. (refs)

Equipment generating radiofrequency and microwave radiation is discussed with emphasis on the risk of exposure to non-ionizing radiation-emitting sources. From the point of view of biomedical considerations three basic parts of microwave equipment may be distinguished. These include the transmitter where the generation and amplification of microwaves occurs, the power transmitting and guiding system, and the receiver. The receiver may absorb all the transmitted energy, or it may be a radiating element (antenna) that emits radiant energy into the surroundings. For hygienic considerations in the use of microwave equipment, an arbitrary distinction of intended and nonintended radiation must be made. The radiation of the frequency, direction of propagation, and point of origin that conform to and are determined by the destination (intended use) of the equipment are designated intended radiation. However, because of physical laws and despite the perfection of design of the transmitter, nonintended radiation may be generated. Unlike intended radiation, nonintended radiation is predictable only to a limited extent, and it constitutes one of the principal sources of health risks. Nonintended radiation is insufficiently considered or even completely omitted in the evaluation of exposure or analysis of occupational health risks. Additionally, in certain instances nonintended radiation is not considered when experimental situations for research purposes are devised or when the bioeffects of microwaves are evaluated on the basis of animal experimentation. It is concluded that source characteristics, propagation of the radiation in the environment, penetration of radiation into the biologic object, and energy absorption inside it must be taken into account in considerations of the biologic effects of microwaves.

5198 PHYSICAL CHARACTERISTICS OF MICROWAVES. *(Eng.)* Baranski, S.; Czerski, P. *In: Biological Effects of Microwaves.* (Stroudsburg: Dowden, Hutchinson & Ross, Inc.) pp. 24-45; 1976. (refs)

The basic physical characteristics of electromagnetic waves, the components of microwave equipment, and the modes of microwave generation and emission are discussed. Time-varying currents are the source of electromagnetic waves, and these waves may be represented as a field consisting of an electric vector and a magnetic vector. The velocity of propagation of the electromagnetic wave through a given medium is determined by the dielectric constant, inductivity, and permeability of the medium. Partial transmission and partial reflection of the electromagnetic wave occur at the boundary of media with different electric properties. Microwave power is distributed by transmission lines and waveguides and is absorbed by receivers or radiating elements (antennas). There are various modes for the generation and emission of microwaves including harmonic waves where the electric and magnetic field vectors oscillate according to the law of sines or cosines (sinusoidal waves) and modulated waves where the amplitude, phase, or frequency may be changed in an arbitrary manner. It is stressed that in analyzing hygienic exposure conditions the source characteristics and the spatial relationship of the source and target should be taken into account.

5199 INTERACTION OF MICROWAVES WITH LIVING SYSTEMS. *(Eng.)* Baranski, S.; Czerski, P. *In: Biological Effects of Microwaves.* (Stroudsburg: Dowden, Hutchinson & Ross, Inc.) pp. 46-77; 1976. (refs)

The interaction of microwaves with living systems is discussed with respect to the penetration of microwaves into a biologic target and their propagation within it, the primary interaction of microwaves with living matter (mechanism of microwave absorption), and the secondary effects induced by the primary interaction. Results of studies on microwave penetration and propagation in biologic material warrant the following conclusions: theoretic models of microwave propagation inside biologic objects must be carefully analyzed as to their applicability; multilayered planar models are admissible to a limited extent; more sophisticated approaches for approximating the complex geometry of the body shape and of internal organs are needed, i.e., multilayered spherical or cylindrical models; thermography of irradiated phantom models or test animals seems to be the best practical solution for wider use at present; and advanced measuring techniques and the development of implantable probes are needed. From the results of basic theoretic and experimental investigations on the absorption of microwave and radiofrequency energy in biologic media, it is theorized that the primary effects of electromagnetic radiation at the molecular level include primary heating, effects on mono- and poly-H_2O, segmental rotation of biopolymers, conformation changes in biopolymers, and excitation of ionic currents in ion distribution. These effects may lead to temperature rises, metabolic rate effects on biochemical reactions through conformation changes, excitation, changes in ion distribution, and structural changes in subcellular elements. At the subcellular and cellular level the primary effects may include interference with biomembranes, semi-conductor effects, and changes in bound water. The secondary chain of events may involve chromosomal effects, lymphoblastoid transformation, interference with mitosis, genetic effects, carcinogenic and/or leukemogenic effects. In organs and systems focal thermal stimulation and/or lesions may occur leading to local and/or generalized cardiovascular effects, peripheral receptor stimulation and disorganization of nervous system function, disorganization of endocrine system function, and changes in metabolic rate and/or abnormal metabolites. In highly organized living systems microwave radiation may possibly interfere with electromagnetic wave transmission and/or reception of biologic information causing stress effects, adaptive responses, disadaptation, and interference with biorhythms and their synchronization.

5200 BIOLOGICAL EFFECTS OF MICROWAVES. EXPERIMENTAL DATA. *(Eng.)* Baranski, S.; Czerski, P. *In: Biological Effects of Microwaves.* (Stroudsburg: Dowden, Hutchinson & Ross, Inc.) pp. 78-152; 1976. (refs)

A comprehensive review of the biologic effects of microwave irradiation is presented. Inhomogeneity of the heating system of irradiated animals presents serious difficulties in quantifying the heat-balance characteristics. Power densities over 100 mW/cm^2 are a high level of exposure and cause death from overheating in a majority of laboratory animals in a short time. Power densities of 10-100 mW/cm^2 cause varied body rectal temperature increases in rabbits, guinea pigs, rats, and mice; in small laboratory animals thermal death may be obtained within this power density range. No lethal effects are obtained, except in mice, at 10 mW/cm^2. In principle, exposure at power density levels below 10 mW/cm^2 do not lead to body rectal temperature increases exceeding the compensatory possibilities of thermoregulatory mechanisms, even in small laboratory animals; 1 mW/cm^2 may be considered the "athermal" exposure level, even at higher ambient temperature and air humidity. Exposure to microwaves, especially in the decimeter range, at power densities of about 1 mW/cm^2 (according to certain authors within the 0.2- to 10-mW/cm^2 power density range) may disturb normal unconditioned and conditioned reflexes in dogs when the whole body or head is irradiated. Attempts to use microwave exposure as a conditioned stimulus did not succeed in most experiments; however, certain experiments obtained a negative defense reflex to 20-sec irradiation with 2,200-MHz waves at 20 mW/cm^2 after 30 to 50 exposures accompanied by an electroshock. Microwave exposures affect the behavior of various animals, mainly rats and mice. It has been demonstrated that electromagnetic fields modulated at extreme low frequencies (8-16 Hz) interfere with

calcium ion binding to the greater neuronal membrane. A quantum mechanical explanation of this phenomenon and its significance for the interpretation of electroencephalogram changes has been offered. It has also been found that exposure to power density levels sufficient to cause temperature increases induces a hemodynamic response related to the thermoregulatory compensatory reaction. Cholinergic, adrenergic, modern cardiovascular drugs, and various inhibitors could be applied for an exploration of the mechanisms involved in cardiovascular responses to microwave exposure. Although the endocrine and metabolic effects of microwaves need further investigation, particularly with respect to the course and dose dependence of the described phenomena and the mechanisms involved, several effects are well documented. These include alterations of the hypophysis, adrenals, and thyroid gland function. Additionally, morphologic observations have demonstrated changes in the pineal body. Other effects include disturbance in protein metabolism, carbohydrate metabolism, and oxido-reductive processes. In experimental animals, microwave irradiation of the male genital system at power density levels that cause temperature increases results in reversible testicular lesions, particularly damage to spermatogenesis. Similar damage to the female genital system, particularly the ovaries, may be expected. Temperature effects seem to play the most important role in fetal development: early stages of development are more sensitive, and microwave exposure at these stages may cause serious injury. Chromosomal aberrations and changes in the duration of particular phases of mitosis (mitotic abnormalities) are reported in human lymphocyte cultures and cultures of monkey kidney cells following exposures at 3-7 mW/cm^2 to 10-cm pulse width and continuous wave microwaves. No satisfactory evidence of microwave-induced genetic effects or fetal damage in mammals exists. In an investigation of the effects of a 10-cm microwave exposure on several generations of white outbred mice, a decrease in fertility and slower body weight-gain in young animals was found, but no definite abnormalities or inborn genetic defects were found. A survey of studies on the effects of microwaves on the chest, abdomen, and digestive tract revealed on necropsy various macroscopic and microscopic lesions seen in animals exposed to particular microwave bands at different power densities. Lesions were seen most frequently in the liver, in certain instances in the kidneys, or in the spleen. Results of experiments point to disturbances in secretion and absorption, which may be related to vascular responses and changes in blood flow. The effects of microwaves on blood and the blood-forming system are well-documented. Single exposures to high-power density microwaves cause various peripheral blood picture changes attributable to and explained by temperature increases and the resulting displacement of blood or of water in the body. Low-dose repeated exposure in short-term experiments at or below 1 mW/cm^2 do not affect the peripheral blood picture to any significant degree. After pulse width repeated or prolonged exposures, peripheral lymphocytosis accompanied by stimulation of lymphopoiesis may occur. Microwave irradiation (repeated low-dose exposures) may affect iron metabolism and red cell production; the mechanism of this effect merits special attention. Prolonged periods of repeated low-dose exposures induce changes in nuclear structure and mitotic abnormalities in lympoid cells and erythroblasts; chromosomal effects are a possibility. One of the best known effects of microwave exposure at high-power-density levels is the formation of lens opacities and cataracts. Although it has been established that exposure of eyes at high power densities causes either the appearance of immediate massive cataracts or delayed cataracts or opacities, sufficient data do not exist for the determination of threshold values for lenticular damage following prolonged periods of repeated exposures.

5201 HEALTH STATUS OF PERSONNEL OCCUPATIONALLY EXPOSED TO MICROWAVES, SYMPTOMS OF MICROWAVE EXPOSURE. *(Eng.)* Baranski, S.; Czerski, P. *In: Biological Effects of Microwaves.* (Stroudsburg: Dowden, Hutchinson & Ross, Inc.) pp. 153-169; 1976. (refs)

Literature regarding the health effects of occupational exposure to microwave radiation is surveyed, and the symptoms of overexposure to microwaves are characterized. Except for microwave-induced cataracts, no incidence of injury following acute microwave exposure is revealed. Soviet, Polish, Czechoslovakian, United States, United Kingdom, and French studies document the existence of central nervous system and vegetative disturbances and asthenic syndromes in personnel occupationally exposed to microwave irradiation, though the origin and development of these syndromes remains controversial. Abnormal findings occur only at conditions of overexposure (>5-10 yr of work) and are characterized by neuro-vegetative symptoms. Individual variations in adapting to the microwave environment involve initial subjective complaints of headaches, nausea, and fatigue; these complaints are followed by a period of adaptation, the length of which varies with individuals. Later, complaints recur and objective symptoms occur on neurologic and electroencephlographic examinations. Depending on the duration and exposure conditions, acute exposure over 10 mW/cm^2 produces various thermal injuries. Limited repeated thermal stimulation of the nervous system, endocrine glands, or liver may induce delayed or secondary effects. It is stressed that most available data concern adult male exposure, and investigations on the effects of intermittent or continuous exposure of children is needed.

5202 SAFE EXPOSURE LIMITS AND PREVENTION OF HEALTH HAZARDS. *(Eng.)* Baranski, S.; Czerski, P. *In: Biological Effects of Microwaves.* (Stroudsburg: Dowden, Hutchinson & Ross, Inc.) pp. 170-187; 1976. (refs)

The biomedical aspects of existing radiation exposure standards are reviewed, and the requirements for determining safe exposure limits are discussed. The safe exposure regulations of Western countries

including the United States and Canada are mostly based on human thermal balance characteristics, which consider that the principal bioeffect of microwaves is the temperature increase in the irradiated object; that the heat balance characteristics of man allow infinite exposure at 10 mW/cm^2 and short term exposure at higher values; that lens opacities are expected at power densities below 100 mW/cm^2; that functional disturbances may occur following repeated exposures at 50 mW/cm^2; and that no evidence of untoward effects of microwave irradiation in man at power densitites below 10 mW/cm^2 has been presented. Safe exposure limits in Eastern European countries are based on different biomedical considerations. Results of animal experimentation and the effects of occupational exposure in man are the basis of USSR regulations, while in Poland the new safe exposure limits are based on discussions of Soviet, Czechoslovakian, and American findings as well as radiation protection guides and statistic and epidemiologic analysis of the health of personnel professionally exposed to microwaves. To determine safe exposure limits the following basic principles may be used: the principle of zero interaction where no effects are demonstrated; the principle of maximal comfort where certain signs are observed but no differences in functional efficiency are demonstrated at optimal conditions and on exposure; and the principle of the limit of physiologic compensation where exposure causes various reversible disturbances and imposes a stress on compensatory mechanisms. It is recommended that safe exposure limits be initially set at lower values and considered temporary and that adequate periodic examinations and constant medical surveillance be the main safeguards in the prevention of health damage during occupational exposure.

5203 FINAL COMMENTS. *(Eng.)* Baranski, S.; Czerski, P. *In: Biological Effects of Microwaves.* (Stroudsburg: Dowden, Hutchinson & Ross, Inc.) pp. 188-192; 1976. (refs)

Comments and recommendations are finalized, and the accomplishments of several microwave bioeffects meetings, held post-writing, are discussed. The authors conclude that much of the experimental and human exposure data are incomplete and that multidiscipline research programs are needed. Further studies should clarify the primary interaction of microwaves with living matter, examine the chain of events leading to secondary and delayed effects, and standardize measuring methods and techniques. The lack of conclusive data is emphasized, and it is suggested that the bioeffects of lower frequency radiation may be a more serious health hazard than microwave radiation. The authors review the principal recommendations of the international symposium held at Laughborough University in England (1973), of the international symposium held in Warsaw (1973), and of the New York Academy of Science Conference (1974) and stress the need for continuing international exchange of information.

5204 HYGIENIC ASSESSMENT OF THE METHOD OF MAGNETIC TREATMENT OF WATER IN THE HOT WATER SUPPLY SYSTEM. *(Rus.)* Tsyplakova, G. V. (F. F. Erisman Moscow Scientific Res. Inst. of Hygiene, Moscow, USSR). *Gig Sanit* (5): 8-12; 1977. (6 refs)

The hygienic effect of magnetic treatment of hydrocarbonate type tap-water was studied in vitro and in vivo. The water was exposed to 1,300, 2,000 or 5,000 Oe. The treatment had no direct effect on the chemical and organoleptic properties of the water, but it accelerated the decomposition of calcium dicarbonate. The magnetic field also enhanced the in vitro amylolytic activity of the saliva, depending on the composition of the water and of the field intensity. After oral administration, water treated with magnetic fields of 1,300 and 2,000 Oe caused no functional disturbances in the blood cells, cardiovascular system, central nervous system, salt and histamine turnover, nor on the hematologic barriers in experimental animals (species not given). Water treated with 5,000 Oe caused qualitative and quantitative changes in the blood cells (increased leukocyte and erythrocyte counts, appearance of more stable erythrocyte populations), tendency to reduced blood cholesterol level, and increased lability of the cortical cells of the brain. Hydrophil swelling of the cells of the cornea was observed in rabbits. A survey of 4,000 persons, who were supplied with water treated with 1,300 or 2,000 Oe, revealed no complaints. The findings suggest that water should be treated with magnetic fields not stronger than 1,300-2,000 Oe to avoid possible hazards.

5205 EFFECT OF ELECTROMAGNETIC FIELD OF INDUSTRIAL FREQUENCY ON THE GENERATIVE FUNCTION IN RATS. *(Rus.)* Andrienko, L. G. (A. N. Marzeev Kiev Scientific Res. Inst. General and Communal Hygiene, Kiev, USSR). *Gig Sanit* (6): 22-25; 1977. (9 refs)

The effect of exposure to electromagnetic field of industrial frequency (field potential 5 kV/m) on the reproductive functions of 500 sexually mature albino rats (270 males and 230 females) was studied. The animals were exposed to the electromagnetic field for 1.5-4.5 mo and mated with intact animals at different stages of the exposure. Prolonged exposure caused an increase in the time necessary for fertilization, a reduction in the litter size (7.7-8 for males and females mated after exposure for 4.5 mo, vs. 8 in the control), a reduction in the live births (85-88 per group vs. 120 in the control), an increased number of stillborn rats (2.2-4.3% vs. 0% in the control), a reduction of the mean weight of the neonates at birth (5.65-5.8 g vs. 6.7 g in the control), and an increased mortality rate during the first 21 days of life (12.-14.7% vs. 7.6% in the control). Increased incidence of hematomas (especially of the head and spine) and of developmental anomalies (retarded growth of hair, defects of the front legs, reduction of the number of estrous

cycles and of normal cycles) was observed in the offspring. Plethora of the uterus and ovaries, dystrophy of the epithelial cells of the secondary follicles, and desquamation of the granulosa cells from the basal membrane were found in exposed females. The exposed males showed reduced number of spermatozoa (40,000,000/ml after 3.5 mo exposure vs. 56,000,000/ml in the control, $P<0.05$), increased percentage of dead spermatozoa (46.4 ± 4.7% vs. 23 ± 4.6% in the control, $P<0.05$) and of atypical forms (39.1 ± 5.55% vs. 16.2 ± 3.7% in the control, $P<0.01$). The findings indicate the deleterious effect of the electromagnetic field on the reproductive function and the need for a revision of the maximum permissible field potential in industrial environment.

5206 INFLUENCE OF AN ADDITIONAL MAGNETIC FIELD ON HORNET NEST ARCHITECTURE. *(Eng.)* Kisliuk, M. (Dept. Electronics, Sch. Engineering, Tel-Aviv Univ., Tel-Aviv, Israel); Ishay, J. *Experientia* 33(7): 885-887; 1977. (12 refs)

The influence of weak (1.3 Oe) and strong (23.3 Oe) additional magnetic fields on the behavior and nest building activity of hornets was studied using artificial breeding boxes, which were placed both inside a magnetic coil where the magnetic field is uniform and outside the coil where the magnetic field rapidly decreases with distance from the coil's winding. Under both field strength conditions, adult hornets died within 4-5 days without performing any building. Juvenile hornets built at least one comb in each breeding box, commencing in the regions of high field intensity and proceeding in the direction of field intensity decrease. During the first 4-5 days of exposure, the juvenile hornets were almost motionless, and their building activity began 5-7 days after that of control hornets. Larvae did not survive the fourth or fifth instar when exposed to the magnetic field. In an artificial breeding box provided with an inverted comb and subjected to a nonuniform weak magnetic field of 0.3-0.6 Oe, the hornets built upwards instead of downwards, constructing a stalk on the surface of the original comb with a knob-like comb on top of it. The openings of the cells were oriented in all directions of the horizontal plane. The queen oviposited in the inverted cells, and the workers attended the larvae. As the distance of the new cells from the coil's winding reached 7-8 cm, their openings gradually began to face downwards. Upon switching off the coil's current and placing inside the coil three incadescent lamps, which dissipated about 70 W of heat and restored temperature of the breeding box to that of the coil-on condition, the hornets continued to build cells whose openings were gradually oriented downwards.

5207 USAF EXPOSURE STANDARDS FOR RADIOFREQUENCY/MICROWAVE HAZARDS CONTROL. *(Eng.)* Mitchell, J. C. *In: AGARD Conference Proceedings No. 202 on Special Aspects of Aviation Occupational and Environmental Medicine.* 8 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A039173]. (11 refs)

United States Air Force exposure standards for radio frequency (RF)/microwave radiation (10 kHz to 300 GHz) are discussed. Based on the fact that radiation insult to man is frequency dependent, permissible exposure levels for Air Force personnel are set at 50 mW/cm^2 for emissions in the 10 MHz frequency range and at 10 mW/cm^2 for emissions in the 10 MHz to 300 GHz range. These exposures can be adjusted to allow higher power densities for exposure times of 6 min or less, but the exposures cannot exceed the time averaged exposure levels of 3,600 $mW/sec/cm^2$ for the 10 MHz to 300 GHz frequency range and 18,000 $mW/sec/cm^2$ for the 10 kHz to 10 MHz range. An additional exposure limitation is that single pulses of RF emission to which personnel may be exposed shall not exceed an electric field level of 100 kV/m. With regard to biologic effects, studies on the effects of RF radiation on the nervous system and human behavior are not sufficiently conclusive to justify changes in current RF exposure safety criteria. With regard to lenticular opacities of the eye, the bulk of experimental evidence supports the position that RF radiation exposures greater than 100 mW/cm^2 for periods longer than 1 hr are required to produce lens opacification. However, questions remain concerning possible changes in the injury threshold due to intensely pulsed fields and due to the cumulative effects of fractionated longer-term exposures. With regard to cardiac pacemaker interference, about 50% of the pacemakers in use now meet the 200 V/m criterion as recommended by the Air Force to the FDA, and essentially all pacemakers should be compatible with pulsed fields of at least 200 V/m by 1977-78.

5208 1976 ANNUAL REPORT: ADMINISTRATION OF THE RADIATION CONTROL FOR HEALTH AND SAFETY ACT OF 1968 PUBLIC LAW 90-602. *(Eng.)* U. S. Dept. Health, Education, and Welfare. 93 pp.; 1977. [available through National Technical Information Services, Springfield, VA 22161, Document No. PB 265 793]. (139 refs)

An annual report is presented that covers the detailed operation of the Bureau of Radiological Health's day-to-day administration of the Radiation Control for Health and Safety Act of 1968 for the calendar year 1976. There are six standards (television receivers, cold-cathode gas discharge tubes, microwave ovens, diagnostic x-ray systems, cabinet x-ray systems, and laser products) now in effect. A total of 118 compliance actions, affecting more than 588,560 radiation producing products, were in progress during 1976. During the year, 230 television receiver models, eight major components of x-ray systems, six complete x-ray systems, and 85 production or preproduction microwave ovens were laboratory tested. Research activities and technologic development, particularly in the areas of calibration and testing of equipment, have been pursued in the fields of ionizing radiation, radio-

frequency-microwave radiation, light, and ultrasound. In terms of reported accidental exposures to nonionizing radiation, there were eight incidents involving 73 persons exposed to ultraviolet radiation, one incident involving the accidental exposure of two persons to microwave radiation, and one incident involving the exposure of one person to infrared radiation.

5209 INFLUENCE OF EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS UPON GROWTH DEVELOPMENT AND BEHAVIOR IN DOMESTIC BIRDS. *(Eng.)* Durfee, W. K. (Dept. Animal Science, Univ. Rhode Island, Kingston, RI 02881); Polk, C.; Smith, L. T.; Keefe, T. J.; Muthukrishnan, S. 47 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A034526]. (5 refs)

The influence of continuous exposure to modulated extremely low frequency (ELF) fields of low intensity on the growth and development of the chick embryo, the early postnatal growth of the chick, the subsequent growth of the sexually immature bird, and on the social interaction of sexually mature female birds was investigated. The fields used were modulated between 72 and 80 Hz (76 ± 4 Hz). The magnetic fields were maintained at intensities of 1 or 8 G. The electric fields were maintained at either 10 V/m, 1 V/m, 10 V/m plus 60 Hz, 3.5 V/m, or 1 V/m plus 60 Hz, 3.5 V/m. Uniform fields at identical frequencies and amplitudes were provided for continuous exposure of embryos and chicks during the preincubation holding period, incubation and hatching periods, and during the first 28 days of brooding. Statistical analyses of the results revealed that neither the magnetic nor electric field had significant or consistent effects on the following: hatchability of fertile eggs, embryo survival during the most critical stages of development, early posthatching growth and development, growth and development of the sexually immature bird, carbon dioxide production of the developing embryo, subsequent aggressiveness (as adults) of females exposed early in life, and hematocrits of birds at 4-6 wk or at 8 mo of age. The fields may have prolonged the incubation period slightly but not enough to interfere with hatchability. More precise procedures are necessary to better evaluate the effects of exposure to these ELF fields on the length of incubation period and on the growth of chicks which have been removed from field exposure soon after hatching. The ELF fields examined do not appear to have been detrimental to the survival or well-being of the exposed chicks.

5210 HOW BIRDS FOLLOW INVISIBLE MAPS. *(Eng.)* Cherfas, J. (No affiliation given). *New Scientist* 75(1063): 292-294; 1977. (0 refs)

Evidence for magnetic sensitivity in birds is reviewed. In one study where restless robins were put into an octagonal cage, the birds reversed their preferred migratory direction of north-northeast to geographic west-southwest (magnetic north-northeast) when the horizontal component of earth's magnetic field around the cage was reversed with Helmoltz coils. When the vertical component alone was reversed, the same result was obtained. When both the horizontal and vertical components were reversed, the orientation of the birds was normal. When the vertical component was completely removed to produce a field with only horizontal lines of force, the robins were disorientated completely. Experiments with pigeons equipped with bar magnets or electromagnets have shown that under cloudy sky conditions the flight direction of such birds is influenced by the magnetic field. Artificial magnetic fields around gull chicks have also been reported to result in a disruption in flight orientation. The conditioning of pigeons to discriminate between the presence and absence of a magnetic field has also been reported. Night migrant birds flying over the Navy's project Seafarer radar antennae have reportedly changed altitude more often when the radar is on than when it is off.

5211 THE NATURAL HISTORY OF ELECTRICAL INJURY. *(Eng.)* Solem, L. (Univ. Minnesota Burn Center at Saint Paul-Ramsey Hosp., Saint Paul, MN 55101); Fischer, R. P.; Strate, R. G. *J Trauma* 17(7): 487-492; 1977. (12 refs)

The natural history of electrical injury, exclusive of electrical flash burns, was determined in 64 patients (60 males and 4 females; mean age, 28 yr) treated over a 10-yr period. Three-fourths of the patients were injured by electrical potentials in excess of 1,000 V. The mean burn area was 11%. There were 114 major complications in 46 patients. Cardiac arrhythmias or electrocardiographic abnormalities developed in 36% of the 64 patients. Neurologic sequelae were observed in 16 patients and involved the central nervous system in eight cases and the peripheral nervous system in eight cases. A total of 19 patients required 32 amputations, with 17 involving the digits, one the hand, two the foot, three the leg, and nine the arm. Electrical vascular injury with subsequent arterial occulsion was responsible for many of the major amputations. Cataracts developed in four patients; three of them were bilateral. There were two entrance wounds of the head and two of the arm. All four patients sustained high-voltage injuries. This correlation between entrance site, voltage, and subsequent cataract formation is a common observation. Early patient referral and vigorous fluid resuscitation minimized renal failure (1.5%) and mortality (3.1%). Early fasciotomy and vigorous debridement appeared to decrease wound sepsis (8%) but had little effect on major limb salvage.

5212 ELECTRICAL STIMULATION OF PREGANGLIONIC NERVE INCREASES TYROSINE HYDROXYLASE ACTIVITY IN SYMPATHETIC GANGLIA. *(Eng.)* Zigmond, R. E. (Dept. Pharmacology, Harvard Medical Sch., 25 Shattuck St., Boston, MA 02115); Ben-Ari. Y. *Proc Natl Acad Sci* 74(7): 3078-3080; 1977. (16 refs)

The effect of synaptic stimulation on tyrosine hydroxylase activity in the superior cervical ganglion of Long-Evans rats was studied. The preganglionic cervical sympathetic trunk of anesthetized rats was stimulated unilaterally with 100 μA of current at a frequency of 10 Hz and a pulse duration of 2 msec for a period of 30 min. Beginning 48 hr later, tyrosine hydroxylase activity was 33% higher on the stimulated than on the control side, and the enzyme activity remained elevated in the stimulated ganglia for up to 96 hr after stimulation. These stimulation experiments were performed in decentralized animals to avoid changes in sympathetic activity resulting from the anesthesia and surgery or from the possible central effects of stimulation. However, when rats that had not been decentralized were stimulated unilaterally with silver wire electrodes placed on the intact preganglionic trunk, tyrosine hydroxylase activity was 38% higher on the stimulated side than on the control side when measured 72 hr after stimulation. Preganglionic stimulation at a frequency of 50 Hz was pertormed in freely moving animals, and tyrosine hydroxylase activity was increased in the stimulated ganglia by an average of 64% when measured 72 hr after stimulation. These results show that electrical stimulation of the preganglionic trunk for a short period in animals, either under anesthesia or moving freely, results in a delayed increase in tyrosine hydroxylase activity in the superior cervical ganglion and that the enzyme activity remains elevated for at least 2 days.

5213 A COMPARISON OF INTRINSIC NERVE SUPPLIES OF TWO MUSCULAR LAYERS OF DUODENUM. *(Eng.)* Anuras, S. (Div. Gastroenterology, Veterans Admin. Hosp., Iowa City, IA 52242); Christensen, J.; Cooke, A. R. *Am J Physiol* 233(1): E28-E31; 1977. (17 refs)

Muscle strips of the duodena of opossums and cats were stimulated with 5-sec trains of 50-70-V electrical rectangular pulses at a frequency of 10 Hz and a pulse duration of 0.5 msec. Electrical field stimulation caused contraction in longitudinal strips (strips cut in the direction of the oral-caudal axis), and this contraction was abolished by atropine (10^{-7} molar). Electrical field stimulation caused relaxation of circular strips (strips cut at 90 degrees to the oral-caudal axis); this relaxation was abolished by tetrodotoxin (10^{-7} M), but it was not affected by antagonists to adrenergic and cholinergic transmission nor by some gastrointestinal hormones. Reserpinization (1 mg/kg for 3 days) of opossums did not affect or alter the relaxation of circular strips or the contraction of longitudinal strips. When circular muscle and longitudinal muscle strips were exposed to frequencies ranging from 0.1-50 Hz without changing the other parameters, relaxation in circular muscle strips appeared at 0.8 Hz and was maximum at 8 Hz; contraction appeared in longitudinal muscle strips at 0.5 Hz and was maximum at 8 Hz. Although propranolol (10^{-4} M) abolished the relaxation and contraction of circular and longitudinal muscle strips, respectively, direct electrical field stimulation of the muscle with a longer pulse duration (5 msec) caused contractions in both circular and longitudinal muscle strips, indicating that the muscle was still viable in propranolol. This was probably a nonspecific effect of propranolol due to the high dose used. Overall, the findings suggest that the longitudinal muscle is dominated by an excitatory cholinergic innervation and that the circular muscle is dominated by a nonadrenergic, noncholinergic inhibitory innervation.

5214 EFFECT OF MILLIMETER RADIOWAVES IN COMBINATION WITH FTORAFUR ON THE HEMATOPOIETIC SYSTEM. *(Rus.)* Sevast'ianova, L. A. (No affiliation given); Potapov, S. L.; Vasil'eva, N. N.; Krusanova, N. I.; Kubatkina, E. I.; Vilenskaia, R. L. *Biol Nauki* (12): 27-31; 1976. (7 refs)

The effect of radiofrequency irradiation (1 to 3 irradiations, duration 1 hr, wavelength 7.1 mm, intensity 2.5 mW/cm^2) on the regeneration of the hematopoietic system following administration of ftorafur (5-fluoro-1-(tetrahydro-2-furyl)-uracil: 100 mg/kg x 1-3 or 500 mg/kg x 1 was studied in the femoral bone marrow of male hybrid mice. In ftorafur-treated irradiated mice, the bone marrow cell count decreased to 90% of the initial level and normalized in 5 days. Without irradiation, ftorafur decreased the bone marrow cell count to 60%, and the count normalized on day 10 only. With and without irradiation, the cell count normalized in 10 days following the administration of three 100 mg/kg doses of ftorafur on 3 consecutive days, but the degree of depression was smaller in irradiated animals (20% vs. 35% in the control on the third day). The protective effect of radiation was mainly due to the accelerated regeneration of the erythroblasts, reticulocytes, mature granulocytes, and partly due to the myeloid cells. The irradiation enchanced the biosynthesis of uroporphyrine, coproporphyrine and protoporphyrine in the erythrocytes, liver, and muscles. The irradiation did not prevent the toxic action of ftorafur on the lungs, liver, and intestines.

5215 BIOLOGICAL EFFEC OF MILLIMETER RANGE RADIOWAVES. *(Rus.)* Zaliubovskaia, N. P. (Mechnikov Kharkov Scientific Res. Inst. of Microbiology, Vaccines, and Sera, Kharkov, USSR). *Vrach Delo* (3): 116-119; 1977. (7 refs)

The complex biologic effects of microwaves (wavelengths 5-8 mm, intensity 1 mW/cm^2, exposure 15 min/day for 60 days) were studied in Wistar rats and CBA mice. Deformation of the receptor apparatus, pronounced reactive changes, hypertrophy and partial demyelinization of nerve fibers were seen in the skin. Hemodynamic disorders, changes in the permeability of the vascular membranes, micronecroses, and dystrophy of tissues were found in the myocardium, liver, kidneys, and spleen. Eosinopenia, neutrophilia, lymphopenia, reduced hemoglobin level, and reduced erythrocyte count were found in the blood. The exposure caused disturbances in the conditioned reflex activity. The increased plasma 17-oxycorticosteroid level (22.62 μg/100 ml vs.

14.98 µg/100 ml in the control) and a 32% drop of the ascorbic acid level in irradiated rats indicates the effect of radiowaves on the hypothalamo-hypophyseal-adrenal system. Increased catecholamine level was found in the blood, while the epinephrine level was increased, and the norepinephrine level was decreased in the hypothalamus. The irradiation caused 64% inhibition of the phosphorylation processes in the liver and kidneys. Reduced nucleic acid levels and reduction of ^{14}C-thymidine incorporation in DNA and of ^{14}C-uridine incorporation in RNA were observed in the liver, spleen, kidneys, and lungs. Irradiation caused a reduction of the serum albumin level and an increase in the globulin level. Similar biochemical changes were found in 97 workers exposed to microwave radiation.

5216 INFLUENCE OF STATIC AND LOW-FREQUENCY MAGNETIC FIELD ON BEHAVIORAL AND VEGETATIVE REACTIONS OF HUMAN OPERATOR. *(Rus.)* Medvedev, M. A. (Chair of Normal Physiology, Medical Inst., Tomsk, USSR); Urazaev, A. M.; Kulakov, Iu. A. *Zh Vyssh Nerv Deiat* 26(6): 1131-1136; 1976. (28 refs)

The influence of direct current (dc) and alternating current (ac) (50 Hz) magnetic fields (tension 8,000 A/m on the head) on behavioral and vegetative reactions was studied in 68 practically healthy men aged 19-26 yr. The test persons were required to push a button upon randomly repeated signals, and various physiologic parameters were measured along with the reaction time. Without irradiation, significant increase was observed in the length of respiratory cycles in 18 men, significant reduction in 22 men ($P<0.05$ in each case). The period of cardiac contractions increased in 20 and decreased in 25 individuals. The skin resistance increased in 13 and decreased in 32 individuals. In dc field, the length of the respiratory cycle increased in 40 individuals, decreased in 14. The length of the cardiac contractions increased significantly in 45, decreased in 15. The skin resistance increased in 39, decreased in 13 men. In the ac field, the length of the respiratory cycle increased in 10; the length of the cardiac contractions increased in 12; the skin resistance increased in 9 cases; while the length of the respiratory cycle decreased in 40; the length of the cardiac contractions decreased in 46; and the skin resistance decreased in 50 individuals. DC magnetic field intensified the sympathetic reaction in compensating the effect of the magnetic field and the vegetative back-up of the conditioned reflex activity, while the ac field had a contrary effect.

5217 MECHANISMS OF THE EFFECT OF STATIONARY MAGNETIC FIELD ON INDUCED CARCINOGENESIS. *(Rus.)* Kogan, A. Kh. (Dept. Pathophysiology, I. M. Sechenov First Moscow Medical Inst., Moscow, USSR); Kulitskaia, V. I. *Patol Fiziol Eksp Ter* (2): 63-68; 1977. (38 refs)

The effect of a stationary magnetic field (350 ± 30 Oe), induced by subcutaneously implanted magnetic plates, on chemical carcinogenesis was studied in 330 male rats. The carcinogens, which were introduced with the magnetic plate, were 2 mg of 3,4-benzo(α)pyrene in Group 1 and polyvinyl chloride film in Group 2. Magnetic plates without carcinogens were implanted into control animals. The tumor development progressed through the same stages with and without the magnetic field. However, the magnetic field increased the average latency of the tumors (sarcomas) from 3 mo 2 wk to 4 mo 2 wk in Group 1 ($P<0.01$) and from 12 mo to 13.5 mo in Group 2 ($P<0.05$). Regardless of exposure, the minimal latency time was 2 mo 3 wk in Group 1 and 7 mo in Group 2. The magnetic field caused an increase in the growth rate of the sarcoma: the tumor-somatic coefficient rose from 2% to 5.2% ($P<0.05$) in Group 1 and from 8.28% to 11.5% in Group 2 ($P<0.05$). The incidence of less differentiated (polymorphocellular) sarcomas was 50% in Group 1 vs. 29.4% in the control and 19.5% in Group 2 vs. 9.5% in the control. The overall tumor incidence was 84% in Group 1 compared with 93.3% in the control and 27% in Group 2 vs. 28.4-34% in the control. The peroxide-free radical type lipid oxidation was potentiated by the magnetic field at all stages of the precancerous period. This action facilitates the accumulation of lipid peroxide compounds and free radicals, which are known to have mutagenic and carcinogenic effects.

5218 STREPTOMYCIN RESORPTION FROM THE PLEURA UNDER THE EFFECT OF INDUCTOTHERMY CURRENTS. *(Ukr.)* Popova, A. M. (Dept. Pathophysiology and Biophysics, Odessa Agronomic Inst., Odessa, USSR); Faitel'berg-Blank, V. R. *Fiziol Zh* 22(4): 546-548; 1976. (16 refs)

The influence of inductothermy (electromagnetic field with anode currents of 120-280 mA, frequency 13.56 MHz, length of exposure 10-20 min) on the resorption of streptomycin (2.25 µcuries/100 g) from the pleural cavity into the blood, liver, kidneys, spleen, and lungs was studied in Wistar rats. The percentages of radioactivity found in the blood (after 30 min), liver, kidneys, spleen, and lungs (10 min after injection) were 13.74%, 13.43%, 12.18%, 10.45%, and 11.70%, respectively. Under the influence of inductothermy (120 mA, 20 min), the corresponding percentages measured after 10 min were 16.45%, 20.01%, 20.05%, 10.92%, and 24.61%. The corresponding percentage were 19.6%, 22.27%, 28.55%, 15.12%, and 33.01% after exposure to a field of 200 mA for 10 min. After exposure to a field of 280 mA for 10 min, 19.77% of the radioactivity was found in the liver, 33.24% in the kidneys, 13.59% in the spleen, and 35.58% in the lungs. The findings indicate that inductothermy increases the rate of resorption of streptomycin from the pleural cavity.

5219 BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS. *(Eng.)* Royal Swedish Academy of Engineering Sciences. (Stockholm: Royal Swedish Academy of Engineering Sciences): 160 pp.; 1976. (196 refs)

Studies on electromagnetic radiation sources and fields, their biological effects, and techniques for measuring such sources and effects are reported. The investigations cover the frequency range of 0-300 GHz and include microwaves, radiowaves, power-frequency electric and magnetic fields, and static electric and magnetic fields. The investigations cover sources of natural and artificial electromagnetic fields; biologic effects in man and animals, including particular effects on biologic organs; techniques for measuring nondisturbed and disturbed electromagnetic fields; and safety aspects. Examples of biologic effects over the above frequency range include: changes in cell division frequency in the bone marrow and liver, light sensation caused by electric or variable magnetic fields, the stimulation of nerve-muscle preparations in magnetic fields, the influence of pulse-modulated microwave fields on heart frequency, the occurrence of sound sensations in intense radar fields, behavioral disturbances in experimental animals exposed to high frequency electromagnetic fields, and eye lens turbidity resulting from long-term exposure to microwaves. It is suggested that additional research is needed in the development of measurement techniques, with particular reference to the calculation and measurement of the distribution of electric and magnetic fields around a human body. An inventory of radiation sources is recommended as background for epidemiologic field studies.

5220 THE CARDIOVASCULAR SYSTEM OF MAN UNDER THE EFFECT OF SUPER-HIGH FREQUENCY ELECTROMAGNETIC FIELDS. *(Rus.)* Medvedev, V. P. (S. M. Kirov Inst. Postgraduate Medical Studies, Leningrad, USSR). *Gig Tr Prof Zabol* (1): 18-22; 1977. (35 refs)

Studies and observations on the effects of super-high frequency electromagnetic fields on the cardiovascular system of occupationally exposed personnel are reviewed. Hypotension has been observed in 6-61% of the subjects examined by various authors, but hypertension has also occurred in 5.8-29%. Changes in the electrocardiogram were found in 16-95%. Bradycardia, tachycardia, sinus arrhythmia, prolonged intraatrial and intraventricular conduction, a few cases of atrioventricular block, atherosclerosis of the coronary arteries, hypodynamia cordis, increase of the systolic and minute volume, increase or decrease of the vascular tonus and of the peripheral resistance, neurocirculatory dystonia, dystrophy of the myocardium, and coronary insufficiency were observed under super-high frequency electromagnetic fields. Most of these changes became aggravated with increasing length of service and are characterized by slight reversibility.

5221 SANGUINE/SEAFARER EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS: EFFECT OF LONG-TERM EXPOSURE ON SOIL ARTHROPODS IN NATURE. *(Eng.)* Greenberg, B. (Dept. Biological Sciences, Univ. Illinois at Chicago Circle, Chicago, IL 60680). 45 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A027513]. (16 refs)

The results of a study on the long-term biologic impact of the Navy's SANGUINE and SEAFARER projects for developing an extremely low frequency (ELF) low energy communications system at the Wisconsin Test Facility are presented. The studies involve population analyses of soil arthropods and a floral survey of nine exposed and six control plots. Since March 1971, the test facility has been operated at an antenna current of 300 A, using either a north-south or east-west antenna or both antennas simultaneously. The operating schedule has been roughly 5 days/wk, 6 hr/day, at 42 or 45 and 75 or 76 Hz. Some experiments have been performed for continuous wave operation, and others have been performed with low chip modulation (roughly 16 Hz). Comparisons with floral surveys taken 3 or 4 yr earlier suggest normal vegetational changes and succession in exposed plots. After 6 yr of exposure to nonionizing ELF radiation, the ratio of *Cryptostigmata* to *Collembola* in the original Hazleton test plot is almost exactly the same as in 1969 before the test facility was energized. Since 1972, the average annual production of *Collembola* in the Main test and control subplots has been practically the same: 1,488 in the former and 1,432 in the latter. The above and other data do not support the hypothesis that low-level nonionizing ELF fields have had a demonstrable impact on populations of soil arthropods and surrounding flora after 6 yr of exposure.

5222 ON THE EFFECT OF FREQUENCY IN ELECTROMAGNETIC INTERACTIONS WITH BIOLOGICAL SYSTEMS. *(Eng.)* Wayland, J. R. (Sandia Lab., Albuquerque, NM 87115). 12 pp.; 1976. (5 refs)

An equation is derived for predicting the effect of frequency on reaction rate in biologic systems using the theory of absolute reaction rates. However, a lack of measurements of the dielectric constant over large frequency ranges presents a problem of finding suitable biologic systems to which to apply the derived equation. As an illustrative example, yellow birch is considered in the presence of only an electric field. The example clearly shows that changes in reaction rate of the order of 400 times can occur for biologic materials with similar dielectric constants.

5223 RADIOFREQUENCY RADIATION DOSIMETRY HANDBOOK. *(Eng.)* Johnson, C. C. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112); Durney, C. H.; Barber, P. W.; Massoudi, H.; Allen, S. J.; Mitchell, J. C. 128 pp.; 1976. [available through National Technical Information Services, Springfield, VA 22161, Document No. AD A030874]. (17 refs)

A radiofrequency radiation dosimetry handbook is presented, which gives the best estimates of the

calculated dosimetry for human and animal models over a relatively wide frequency range (10^{-2} to 10^{4} MHz). The primary purpose of the document is to enable the user to estimate the specific absorbed power in man at a given frequency as a function of the incident power density and to make corresponding calculations for experimental animals so that animal experimental data can be extrapolated to hazard implications for humans. Specific absorbed power calculations are made at low frequencies by a perturbation method, at frequencies up to the first resonance for human models by extended boundary condition method, and at the upper frequency limits by geometric optics approximation. All of the specific absorbed power data are for planewave irradiation in free space with an incident power density of 1 mW/cm^2. Calculated dosimetric data for the average specific absorbed power of humans and various animals irradiated by planewaves in free space are presented graphically and are calculated from both prolate spheroidal and ellipsoidal models for the standard polarizations.

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

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