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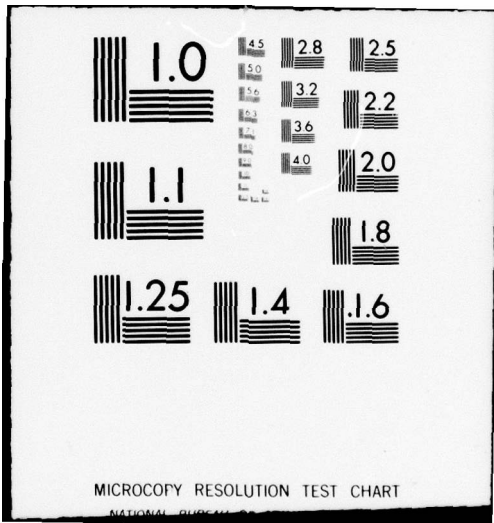
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# Biological Effects of Nonionizing Electromagnetic Radiation

VOLUME IV  
NUMBER 2  
DECEMBER, 1979


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## A DIGEST OF CURRENT LITERATURE

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A Quarterly Publication Produced for  
National Telecommunications and Information Administration  
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**BIOLOGICAL EFFECTS  
OF NONIONIZING ELECTROMAGNETIC RADIATION**

**A Digest of Current Literature**

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

*Literature Selected and Abstracted  
by*

*Biomedical Group, Science Information Services Organization*

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**BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION**

December, 1979    Volume IV, Number 2

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## PREFACE

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

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

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

## ABBREVIATIONS AND ACRONYMS

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

μ - micro--

## NEWS ITEMS

### HIGH-FREQUENCY ELECTROMAGNETIC TREATMENT FOR RHEUMOCARDITIS IS PATENTED BY RUSSIANS

An electromagnetic treatment for sluggish flow rheumocarditis using a high frequency electromagnetic field applied locally to the adrenal glands and epigastric region has been designed. The electromagnetic field, range 430-460 MHz and power 40-50 W, is applied first to the adrenal glands and then to the epigastric region. Each region is exposed for 7-8 min. This treatment is expected to reduce the rehabilitation time and prevent relapse. The patent number is F24458/24.

*Sov Invent Illust* B24: PQ-3; 1979.

### 36TH MEETING OF THE ELECTROMAGNETIC RADIATION MANAGEMENT ADVISORY COUNCIL HELD

The 36th meeting of the Electromagnetic Radiation Management Advisory Council (ERMAC) was held on August 30-31, 1978. This was the first meeting under the auspices of the NTIA; the Office of Telecommunications was the host for previous ERMAC sessions. Dr. John M. Richardson, Chairman, announced that the first session would be concerned with the up-date and review of the current environmental situations that are representative of the public concern over microwave and radio frequency (RF) potential health hazards. The environmental situations that were discussed included the Precision Acquisition of Vehicle Entry Phased-Array Warning System; radiation emission from a data communication system in Eugene, Or; the Coast Guard Vessel Traffic System; and the Solar Power Satellite. The activities of various organizations involved in the development of safety standards for RF and microwave emission were presented in the next session. The organizations included NIOSH, OSHA, EPA, BRH, American Natl. Standards Inst., Natl. Council for Radiation Protection and Measurement, Intl. Radiation Protection Assoc., and WHO. The Bioelectromagnetics Society was described. The Canadian, Russian, and New York City safety standards were also discussed. In addition, the involvement of the Federal Communications Commission in the application of microwave and RF emission safety standards was presented. The activities of the second day of the Council meeting included discussions of the study of the electromagnetic exposure environments produced by various types of emitters, the socio-economic impact of the potential standards, and the ERMAC report on program guidelines.

Minutes--36th ERMAC Meeting  
(available from NTIA).

### ERMAC HOLDS 37TH MEETING

The 37th meeting of the Electromagnetic Radiation Management Advisory Council (ERMAC) was held on December 7, 1978. Dr. John M. Richardson served as chairman. The emphasis of the morning session was on the presentation, discussion, and review of the biologic effects of radio frequency radiation in order to develop the scope, structure, and scheduling of the 1979 ERMAC report on the recommended federal program. Ms. Janet H. Healer provided some background information on the Council's past activities and on the progress made since the Council's 1971 recommendations. A discussion of the federal program goals, guidelines, research needs, priorities, agency roles, required resources, and implementation procedures followed. In the afternoon session, several reports on the Federal Communications Commission proposed Notice of Inquiry, the Foreign Service Health Status Study, and the proposed New York City Standards were presented. In addition, Amitai Etzioni presented the paper "Some Principles Governing the Management of Risk."

Minutes--37th ERMAC Meeting  
(available from NTIA).

### SENATE COMMITTEE REPORT ON EMBASSY EXPOSURE TO MICROWAVES IS AVAILABLE

The availability of the Senate Committee Print, *Microwave Radiation of the U.S. Embassy in Moscow*, was announced by Senator Howard W. Cannon, Chairman of the Senate Committee on Commerce, Science, and Transportation. The report reviews the history of microwave irradiation of the U.S. Embassy in Moscow from 1953-1977, including actions taken and studies conducted by the State Department to determine whether the health of U.S. personnel was jeopardized. To obtain a copy of the report send a self-addressed mailing label to the Subcommittee on Science, Technology, and Space; Committee on Commerce, Science, and Transportation; Washington, DC 20510. Questions should be directed to Ed Smick, Professional Staff Member, (202) 224-9351.

*Bioelectromagnetics Society Newsletter*  
(8): 1; July 1979.

### 20TH GENERAL ASSEMBLY OF THE URSI PLANNED FOR AUGUST 1981

The Twentieth General Assembly of the International Union of Radio Science (URSI) will be held August

## NEWS ITEMS

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10-19, 1981 at the Hyatt Regency Hotel in Washington, DC. The Union's nine international commissions, which will be responsible for generating the technical program, will be coordinated by William E. Gordon, Vice-President of the URSI. The U.S. National Committee (USNC) for the URSI, chaired by Dr. C. Gordon Little of Boulder, CO, will host the Assembly. For further information contact the Executive Secretary, R. Y. Dow, National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, DC 20418 or at (202) 389-6478.

*Bioelectromagnetics Society Newsletter*  
(8): 1-2; July 1979.

### IEEE MTT-S CALL FOR PAPERS FOR THE 1980 INTERNATIONAL MICROWAVE SYMPOSIUM

The IEEE MTT-S has announced the first call for papers for the 1980 International Microwave Symposium to be held May 28-30, 1980 in Washington, DC. The theme for next year's symposium, highlighting the expected growth of microwave use in the next decade, is "Technology Growth for the 80s." Previously unpublished papers of original work in the field of microwaves will be considered. The following areas are regarded as particularly appropriate: microwave and millimeter wave devices, circuits, and networks; low noise techniques; microwave acoustics; microwave communication systems; microwave field and network theory; microwave bioeffects; radiometry and remote sensing systems; computer aided design and measurement techniques; integrated optics, fiber optics, and optical techniques; and technology breakthroughs. Authors are requested to submit both a 35 word abstract and a 500-1,000 word summary explaining their contribution, its originality, and its relative importance to R. C. Van Wagoner, Chairman, Technical Program Committee, Code 5205, Naval Research Laboratory, Washington, DC 20375. IEEE MTT-S Announcement.

### BRH AND OSHA SPONSOR WORKSHOP ON POTENTIAL HEALTH HAZARDS OF RADIO FREQUENCY DEVICES

An open workshop dealing with the potential health hazards of personnel exposed to radio frequency (RF) energy emitted by sealers, heaters, and gluers was held on September 12 and 13, 1979. The workshop, sponsored by the BRH and OSHA, was held to bring together the users, manufacturers, and staff members of federal agencies and trade associations to ensure that the present knowledge of possible hazards is brought to the attention of the affected personnel. Because RF energy can penetrate deeply into the body without activating the skin's heat sensors, operators of RF equipment may be unaware of the RF exposure. The specific topics presented

at the workshop included the measurement of stray electric and magnetic field intensities generated by RF sealers, the biologic effects of exposure to RF frequencies between 3 and 100 MHz, the near-field conditions existing during exposure, RF radiation measurement (equipment and techniques), control of stray RF emissions, and possible federal agency initiatives for the control of RF-emitting devices.

*BRH Bulletin* 13(16): 1-2; 1979.

### SYMPOSIUM HELD ON THE PRACTICAL APPLICATIONS OF MICROWAVE ENERGY

A 1-day symposium on the practical applications of microwave energy was held on September 28, 1979 at the Kansas State University. The eleven presentations included some original research and reviews of the uses and hazards of various practical aspects of microwave use, particularly in the home and in industry. Questions concerning the symposium should be directed to Dr. D. Y. C. Fung, Chairman, or Dr. F. E. Cunningham, Co-chairman, Call Hall, Kansas State University, Manhattan, KS 66506 or telephone at (913) 532-5654.

*Environ Res* 19(2): 519; 1979.

### A NEW MICROWAVE LEAKAGE DETECTOR WILL BE MARKETED

A new low-cost microwave leakage detection device developed by the Commonwealth Scientific and Industrial Research Organization, an agency of the Australian government, will be marketed in North America by Vexilar, Inc. The hand-held device contains a light-emitting diode that glows red on contact with microwave radiation greater than 5 mW (the FDA standard maximum level). The instrument may be used to detect leakage from microwave ovens that have been misused or damaged, during diathermy treatment, and near industrial microwave heaters that operate in the industrial, scientific, and medical band.

*Am J Phys Med* 58(4): 200-201; 1979.

### FDA PROPOSES TO AMEND REQUIREMENTS FOR RF SEALER AND EM HEATER MANUFACTURE

The FDA is proposing that the manufacturers of radio frequency (RF) sealers and electromagnetic (EM) induction heaters be required to submit initial, annual, and model change reports and that they also maintain certain other records on these products. The agency is basing their request on available data that contends that the currently marketed RF sealers and EM induction heating equipment, which emit EM radiation in the frequency

range from 10 to 300 MHz, may present health hazards to persons exposed to the products. The industrial, scientific, and medical frequency bands centered at 13.56 MHz, 27.12 MHz, and 40.68 MHz, respectively, are of particular interest. The proposed requirements would appear as an amendment in Part 1002 (Section 1002.61, "List of Specific Product Groups") of the Radiation Control for Health and Safety Act (1968) of the Public Health Service Act. For further information contact R. S. Sternchak, BRH (HFX-460), FDA, Department of HEW, 5600 Fishers Lane, Rockville, MD 20857.

*Fed Regist* 41(166): 49699-49700; 1979.

interest stems from the growing public concern over the possible hazardous effects of exposure to non-ionizing radiation. The inquiry is designed to: 1) determine whether the existing standards for nonionizing electromagnetic radiation should be revised and 2) provide documentation to allow the FCC to participate in any rule-making proceedings to insure that any proposed standard adequately takes into account the impact on licensing and equipment. To obtain a copy of the Notice of Inquiry or for further technical information, contact Will McGibbon, Office of Science and Technology, FCC, Washington, DC 20554. Comments must be received by December 15, 1979.

*Bioelectromagnetics Society Newsletter*  
(9): 6; September 1979.

**EPA-SPONSORED SYMPOSIUM ON THE HEALTH  
ASPECTS OF NONIONIZING RADIATION  
TO BE HELD**

A symposium will be held to present up-to-date information on the physical aspects of microwave radiation in relation to man, the biomedical aspects of microwave radiation, the public issues, and the epidemiology and clinical applications. The symposium is being supported by the EPA, Office of Health and Ecological Effects. Dr. George Simon is serving as the Project Monitor.

*Smithsonian Science Information Exchange*  
No. GMA-5860

**COMMENTS ON THE ANSI  
PERSONNEL SAFETY LEVEL STANDARD  
ARE SOLICITED**

The American National Standards Institute (ANSI) is currently revising the standard "Safety Level with Respect to Personnel of Radio Frequency Electromagnetic Fields (300 KHz-300 GHz)." Subcommittee IV of the C-95 Standards Committee is responsible for this task, and is soliciting comments from committee members and research, medical, and engineering personnel. Comments may be sent to Dr. A. W. Guy, Bioelectromagnetics Research Laboratory, BB805, University Hospital RJ-30, University of Washington, Seattle, WA 98195.

*Bioelectromagnetics Society Newsletter*  
(9): 3-5; September 1979.

**NOTICE OF INQUIRY IS INITIATED BY THE FCC**

The Federal Communications Commission (FCC) has initiated a Notice of Inquiry to gather information in order to establish guidelines for regulating and/or promoting communications by radio. The Commission's

**1979 NONIONIZING RADIATION  
TRAINING RESOURCES AVAILABLE**

The 1979 Radiologic Health Training Resources are now available to borrowers on a free loan basis from the Training Resources Center. This program sponsored by the Division of Training and Medical Applications of the BRH, provides training assistance to state and local radiologic health agencies, physicians, university personnel, allied health professionals, scientists, students, and consumers. Specific topics include nonionizing radiation, biologic effects of microwaves, and natural and man-made radiation sources. The resource collection consists of training publications, course listings, videocassettes, movies, and printed material. For a list of the resources and to order material, contact the Training Resources Center (HFX-70), DTMA, BRH, FDA, 5600 Fishers Lane, Rockville, MD 20857 or telephone (301) 443-2554.

*HEW Publication (FDA) 79-8023, August 1979.*

**ITEMS FROM THE COMMERCE BUSINESS DAILY**

**RESEARCH CONCERNING THE EFFECTS OF  
MICROWAVES ON LEARNING AND ON DRUG UPTAKE.**

The Office of Naval Research, 800 N. Quincy St., Arlington, VA 22217 is negotiating with Battelle Memorial Ins., Pacific Northwest Laboratory, P.O. Box 999, Richland, WA 99352 for the above study. (August 10, 1979)

**NEWS ITEMS**

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**MICROWAVE INTERACTION WITH NERVE CELL MEMBRANES.**

The Environmental Protection Agency, Office of Administration, Research Triangle Park, NC 27711 has contracted with the Duke University, Office of Sponsored Programs, Durham, NC 27706 for the above study. (September 11, 1979)

**FURTHER RESEARCH ON MICROWAVE EFFECTS ON CELLS.**

The Office of Naval Research, 800 N. Quincy St., Arlington, VA 22217 has contracted with the Polytechnic Institute of New York, 333 Jay St., Brooklyn, NY 11201 for the above study. (September 19, 1979)

**RESEARCH IN ANALYSIS TECHNIQUES FOR MICROWAVE DOSIMETRIC DATA.**

The U.S. Army Medical Research and Development Command, Acquisition Group, Contracting Office, Fort Detrick, MD 21701 is negotiating with Technology-U.S.A., Inc., Oxon Hill, MD for the above study. (September 17, 1979)

**IDENTIFICATION OF SITES IN BRAIN TISSUE.**

The Environmental Protection Agency, Office of Administration, Research Triangle Park, NC 27711 has contracted with the Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709 for the above study. (October 3, 1979)

MEETINGS AND CONFERENCES

INTERNATIONAL RADIATION PROTECTION  
ASSOCIATION FIFTH INTERNATIONAL  
CONGRESS

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

1980 IEEE/MTT-S INTERNATIONAL MICROWAVE  
SYMPOSIUM

*Date:* May 28-30, 1980  
*Place:* Washington, DC: Shoreham-Americana Hotel  
*Sponsor:* Inst. of Electrical and Electronics Engineers (IEEE)--Microwave Theory and Techniques Society  
*Requests for Information:* B. Shelag, Arrangements Chairman, Naval Research Lab., Code 5251, Washington, DC 20375  
*Content:* Topics will cover the expected growth in microwave technology in the 1980s and will include microwave and millimeter wave devices, microwave acoustics, communication systems, field and network theory, and bioeffects

INTERNATIONAL MAGNETICS CONFERENCE

*Date:* April 21-24, 1980  
*Place:* Boston, MA: Sheraton Boston Hotel  
*Sponsor:* IEEE Magnetics Society  
*Requests for Information:* D. I. Gordon, U.S. Naval Surface Weapons Center, White Oak, Silver Springs, MD 20910  
*Content:* Topics will cover applied magnetism, including microwave devices and materials.

3rd INTERNATIONAL SYMPOSIUM ON CANCER  
THERAPY BY HYPERTHERMIA, DRUGS  
AND RADIATION

*Date:* June 22-26, 1980  
*Place:* Fort Collins, CO: Colorado State Univ.  
*Sponsor:* Natl. Cancer Inst., Colorado American Cancer Society, Journal Natl. Cancer Inst., Univ. Utah, Colorado State Univ.  
*Requests for Information:* Office of Conferences & Inst., Rockwell Hall, Colorado State Univ., Fort Collins, CO 80523

Abstracts of papers and posters to be presented should be submitted to the Office of Conferences & Institutes by March 1, 1980.

*Selected Bibliography of Papers to be Presented:*

15th ANNUAL MICROWAVE POWER SYMPOSIUM

*Date:* May 6-9, 1980  
*Place:* Ames, IA: University Iowa  
*Sponsor:* International Microwave Power Institute (IMPI)  
*Requests for Information:* Dr. Glen Fanslow, Dept. Electrical Engineering, Iowa State Univ., Ames, IA 50010  
*Content:* Technical sessions and short courses will be presented. Topics will include new technical contributions in noncommunication areas of radio frequency and microwave power such as biomedical applications; biologic effects on humans, animals, and microbiologic systems; chemical and plasma process; combination thermal and microwave food cooking systems; radio frequency and microwaves in the food industry; consumer microwave oven usage patterns; and industrial radio frequency and microwave systems and applications

HYPERTHERMIA AND ELECTRON AFFINIC COMPOUNDS. G. E. Adams

HEAT TRANSFER MECHANISMS AND THERMAL DOSIMETRY. H. F. Bowman

APPLICATIONS OF MICROWAVE, ULTRASOUND AND RADIO-FREQUENCY HEATING IN VIVO. J. Hunt

PHYSIOLOGICAL CONSIDERATIONS. C. W. Song

CLINICAL LOCAL HEATING--RF. J. H. Kim

CLINICAL LOCAL HEATING--RF. K. Storm

CLINICAL LOCAL HEATING--MICROWAVES. R. M. Scott

CLINICAL LOCAL HEATING--RF--INTERSTITIAL. M. L. M. Boone, M. Manning

CLINICAL TECHNIQUES AND RESULTS FOR WHOLE BODY HYPERTHERMIA. T. Herman, L. Parks, W. Levin, H. Reinhold

MEETINGS AND CONFERENCES

*Biological Effects of Nonionizing Electromagnetic Radiation IV(2), December 1979*

INTERNATIONAL SYMPOSIUM ON THE  
BIOLOGIC EFFECTS  
OF ELECTROMAGNETIC WAVES

*Date:* June 30-July 4, 1980

*Place:* Near Paris, France: Centre Supérieur d'Enseignement des Affaires (CESA), Near Paris, France

*Sponsor:* Intl. Union Radio Science (URSI), Comité National Français de Radioélectricité Scientifique (CNFRS), Intl. Protection Agency, Bioelectromagnetics Society

*Requests for Information:* M. A. J. Berteaud, CNRS, 2, rue Henry Dunant, 94320 THAIS, France

*Content:* Topics will include the interactions of electromagnetic fields with biologic systems; the industrial and domestic uses of electromagnetic radiations; dielectric properties of living matter; dosimetry; molecular and cellular effects; physiologic, physiopathologic, and genetic effects; behavioral effects; and medical applications, such as hyperthermia and microwave thermography

*Requests for Information:* K. J. Button, MIT Natl. Magnet Lab., Cambridge, MA 02139  
*Content:* Sessions will cover the biologic effects of electromagnetic radiation

TENTH L. H. GRAY CONFERENCE

*Date:* July 13-16, 1981

*Place:* Oxford, England

*Sponsor:* Inst. of Cancer Res.

*Requests for Information:* Dr. R. C. Hill, Inst. of Cancer Res., Royal Marsden Hosp., Sutton, Surrey, England

*Content:* The biology and biophysics of radio frequency, microwave, and ultrasonic radiation will be reviewed, particularly with respect to their potential therapeutic value

FIFTH INTERNATIONAL CONFERENCE ON  
INFRARED AND MILLIMETER WAVES

*Date:* December 8-12, 1980

*Place:* Wurzburg, West Germany

*Sponsor:* Inst. of Electrical & Electronics Engineers (IEEE)--Microwave Theory & Techniques Society

20th GENERAL ASSEMBLY OF THE URSI

*Date:* August 10-19, 1981

*Place:* Washington, DC: Hyatt Regency Hotel

*Sponsor:* International Union of Radio Science (URSI)

*Requests for Information:* Executive Secretary, R. Y. Dow, Natl. Acad. Sciences, 2101 Constitution Ave., N.W., Washington, DC 20418 or (202) 389-6478

## CURRENT RESEARCH

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

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

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

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

The University of Virginia, the Georgia Institute of Technology, and the BRH are cooperating in a program to produce in vivo electric field measurements from continuous wave and low frequency modulated electromagnetic radiation at frequencies of 100 MHz to 3 GHz. An analysis of insulated subminiature dipole probes is being conducted at Georgia Institute of Technology, using dipole probes designed by the University of Virginia Semiconductor Devices Laboratory and the BRH and calibrated and evaluated at the BRH. The probes will then be

used for in vivo measurements by research groups working on the electromagnetic field biologic effects with the BRH. Research into the problems associated with the use of a smaller field probe than that which is currently available is being performed to measure the in vivo electric field produced by microwave radiation. This involves the optimization of the probe, the diode parameters, and the microtechnology needed to produce a single axis probe. (funding period 2/79-7/81).

Supporting Agency:NSF, Div. Engineering

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

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

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

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

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

CURRENT RESEARCH

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Supporting Agency:American Cancer Society, Inc.

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

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

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

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

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

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

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

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

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

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

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

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

sponse time of the cell to the pulse of irradiation. (funding period 11/73-4/81)

Supporting Agency: NSF, Div. Engineering

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

A variety of radiation therapy oncology group protocols will be used to develop improved radiation therapy techniques for different types of cancer. A new endometrial carcinoma protocol is proposed. Instrumentation to improve heating by microwaves is being developed, and thermometry of hyperthermia and radiation will be combined to improve the results of radiation therapy in advanced lesions. Specifically, the equipment and measurements with a 434-MHz applicator will be developed. Newly developed solid state probes to measure heat in depth within microwave fields will also be tested. (funding period 4/73-3/80)

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

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

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

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

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

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

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

Supporting Agency:Koningin Wilhelmina Fonds

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

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

Supporting Agency:HEW, PHS, FDA, BRH

0549 ENGINEERING STUDY OF ELECTROMAGNETIC FIELD DISTRIBUTIONS IN LARGE ORGANS.

Toler, J. C. (Engineering Experiment Station, Georgia Inst. Technology, 225 North Ave., N.W., Atlanta, GA 30332).

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

Supporting Agency:NSF, Div. Engineering

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

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

Supporting Agency:Whitaker Foundation

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The use of external electromagnetic heating methods in cancer therapy is discussed with particular reference to clinical experience with microwave hyperthermia in combination with ionizing radiation therapy. With external heating methods, tumors with sluggish blood flow can be heated to a greater degree than normal tissues. While this should be particularly true for hypoxic foci that are at some distance from cooling capillaries, it seems unlikely that practical detectors can be designed

to measure the temperatures in these crucial micro-environments. A review of clinical experience with 52 patients with head and neck cancer who were treated with 434-MHz microwave radiation (probable tumor temperature,  $39.5 \pm 1$  C) for 20-30 min prior to treatment with megavoltage x-rays reveals that patients with early stage disease had a 2-yr survival rate of 100% and that patients with advanced disease had a 2-yr survival rate of 49%. These results are particularly encouraging since they were obtained with lower than conventional doses of ionizing radiation and normal tissue tolerance was excellent.

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

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

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

The effect of a static magnetic field on the emission yield of bacteriochlorophyll of whole cells and chromatophores of the photosynthetic bacteria *Rhodospirillum rubrum* (strain 2.4.1) and its carotenoidless mutant R-26) and *Rhodospirillum rubrum* (strain S1) was investigated. In state PIX, the emission yield was an increasing function of the strength of the magnetic field and was correlated with a decreasing yield of triplet formation. The results support the hypothesis that charge recombination predominantly generates the excited singlet state P<sup>\*</sup>1. In *Chlorella vulgaris* and spinach chloroplasts at a temperature of 120 Kelvin, the curve of the yield of the fluorescence versus the field strength, measured at 685 or 695 nm, was similar to that found for bacteria. It is suggested that in Photosystem II, an intermediary electron acceptor is present between P-680 and Q.

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

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

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

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

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

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

ent for directed movements in an inhomogeneous field.

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

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

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

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

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

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

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

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

See Current Literature 6250 for description of this article.

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

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

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

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

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

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

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

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

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

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

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

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

Polarized light fluorescence properties were studied in suspensions of magnetically-oriented (15 kG) *Chlorella vulgaris* and pea chloroplasts. The *Chlorella* suspension consisted of cells in the autospore stage. The chloroplast suspension contained about 1.0 mg/ml chlorophyll. The fluores-

cence spectrum was polarized parallel or perpendicular to the plane of the photosynthetic membrane in the field of the electromagnet, after which the suspension was cooled to -196 C. The fluorescence spectral analysis of *C. vulgaris* demonstrated at least six components with respective wavelengths of 680, 685, 695, 715, 719, and beyond 735 nm. Similar results were obtained for pea chloroplasts.

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

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

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

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

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

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

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

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

Several commercially available radiation survey instruments were evaluated in both the far and near field of a radiating slot of known characteristics at 915 MHz. One instrument, a Holaday probe, read high by a factor of two or more under certain conditions, while another probe, Narda Model 8100, read high by a factor of five or more under certain conditions. Overall, it appears that present instrumentation techniques are inadequate to accurately measure near field parameters of an arbitrary radiating source. One reason for this is

the use of sensors that have a large effective aperture and distort the radiating field. Also, auxiliary equipment such as handles and lead wires interact with the fields, further distorting the radiation pattern. Another inadequacy of present instrumentation techniques is that the coupling of an arbitrary radiating slot (such as a leak in a microwave enclosure), which is most likely a high impedance source, to a sensor probe loads this source and tends to lower the measured value. Since the near field of a slot radiator of simple geometric shape with well defined field boundary conditions has many components (both in-phase and quadrature), the location of a sensor element or combination of elements becomes a dominant factor in the variation of measured values. Thus, an isotropic sensor may not be the best choice for a particular measurement.

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

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

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

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

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

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

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

The effects of hyperthermia induced by microwave radiation of frequency 2,450 Hz (wavelength in air 12.25 cm) and/or local x-ray irradiation (1,130 rads, dose rate 100 rads/min) on the survival of 4-mo-old male B6D1 rats were studied in rats implanted subcutaneously with solid Walker carcinoma 256. All animals were irradiated with either x-rays or microwaves 7-8 d after the transplantation of  $5 \times 10^6$  tumor cells into the right hind leg. Group 1 animals served as controls. Group 2 rats were subjected to microwave hyperthermia for 30 min to raise the tumor temperature to 41 C. Group 3 animals were irradiated with x-rays only and group 4 rats received the same dose of x-rays 10 min after 30 min of hyperthermia. The tumor weight was 2-6 g at the beginning of the treatment. The 30-day survival rates were 17% in group 1, 27% in group 2, 57% in group 3, and 75% in group 4, indicating that hyperthermia, irradiation, and the combination of the two treatments significantly increased the survival rate. The average survival of the animals was 8.28 days in group 1, 9.82 days in group 2, 10.83 days in group 3, and 11 days in group 4.

6308 EFFECT OF A SELECTIVE  $\beta_2$ -ADRENOCEPTOR AGONIST, PROCATEROL, ON TISSUE CYCLIC AMP LEVEL. ITS DETERMINATION AFTER TISSUE FIXATION BY MICROWAVE IRRADIATION. (Eng.) Saitoh, Y. (Lab. Biological Res., Otsuka Pharmaceutical Co., Ltd., Tokushima, Japan); Hosokawa, T.; Igawa, T.; Irie, Y. *Biochem Pharmacol* 28(8): 1319-1322; 1979. (20 refs)

Determination of tissue cyclic adenosine monophosphate (cAMP) using rapid tissue fixation by microwave irradiation was used to investigate the effect of procaterol (PCL), a selective  $\beta_2$ -adrenoceptor agonist, on cAMP levels in male albino Wistar rat tissue. Tissue fixation was accomplished by exposing conscious rats to microwaves from a commercial oven (frequency, 2,450 MHz and power output, 1.3 kW). The intravenous injection of 1  $\mu$ mole/kg of observed 2 min after injection, at which time there were 2- to 3-fold increases in the heart and liver PCL into conscious rats caused an increase in cAMP levels in the trachea, heart, liver, and skeletal muscle. The peak level was observed 2 min after injection, at which time there were two- to three-fold increases in the heart and liver and six- to eightfold increases in trachea and skeletal muscle. PCL-induced alterations in cAMP levels in trachea and skeletal muscle were characterized by their long duration (over 2 hr). The duration of the PCL action reflected sustained stimulation of  $\beta$ -adrenoceptor-linked adenylate cyclase activity. The phosphodiesterase inhibitor 3-isobutyl-1-methylxanthine (50  $\mu$ moles/kg, subcutaneous-ly) was very effective in enhancing PCL-induced increases in cAMP in trachea, lung, and skeletal muscle. Tissue cAMP levels were found to respond to PCL in a dose-dependent manner; the minimum effective doses of PCL needed to increase tissue cAMP were 1, 10, 10, and 100 nmoles/kg for skeletal muscle, trachea, lung, and heart, respectively.

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The stimulatory action of PCL on heart cAMP levels was less than that of isoproterenol, a nonselective  $\beta$ -adrenoceptor agonist. Consequently, it appears that PCL-induced increases in cAMP were mediated by  $\beta_2$ -adrenoceptors rather than by  $\beta_1$ -adrenoceptors. Thus, tissue fixation by micro-waves enabled the in vivo measurement of the tissue content of cAMP and the determination of the  $\beta$ -adrenoceptor responses to procaterol.

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

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

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

The effects of electric fields of 50 Hz were studied in male albino rats that were exposed to electric fields with intensities of 7, 12, and 15 kV/m for 30 min/day for 4 mo. Significant increases were seen in the summation threshold index (15 ver-

sus 12 for the controls) and in the latent period of the unconditioned reflex (74.8 versus 47.6 msec) in the group exposed to 7 kV/m. At 7 kV/m, the hepatic glycogen level was significantly reduced (3,653.2 versus 5,269.2 mg%,  $p < 0.01$ ). The effects of the electric field were most pronounced in the group exposed to 15 kV/m: the swimming time was reduced (from 3.6 to 2.5 min,  $p < 0.01$ ) as was the brain cholinesterase activity (from 1,029.8 to 791.7  $\mu$ moles/g/hr,  $p < 0.05$ ), the liver glycogen level (to 3,668.7 mg%,  $p < 0.05$ ), and the iron saturation of blood transferrin (from 0.26 to 0.16 absolute units,  $p < 0.01$ ). In the same group, various parameters were increased: the summation threshold index (to 19.2,  $p < 0.01$ ), the latent period of unconditioned reflexes (to 78.8 msec,  $p < 0.01$ ), the blood cholinesterase activity (from 118.3 to 138.2  $\mu$ g/ml/min,  $p < 0.01$ ), the blood residual nitrogen level (from 24.1 to 31.6 mg%,  $p < 0.01$ ), the blood urea level (from 28.8 to 43.1 mg%,  $p < 0.01$ ), the blood glucose level (from 72 to 90.8 mg%,  $p < 0.05$ ), and the blood ceruloplasmin level (from 37.6 to 46 absolute units,  $p < 0.05$ ).

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

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

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

The tumor-inhibiting effects of local ultra-high

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

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

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

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

The effect of 3,100-MHz pulsed microwave radiation on the rabbit retina in vivo was investigated using fundus photography, blood-retinal barrier tracers, and light and electron microscopy after either a single 1- to 1.5-hr exposure or after up to 53 repeated 1-hr exposures during a 3-mo period. The mean intensity of microwave irradiation was 550 W/m<sup>2</sup> with a pulse peak intensity of  $1.3 \times 10^6$  W/m<sup>2</sup>. The pulse duration was fixed at 1.4  $\mu$ sec, and the pulse repetition rate was 300 Hz. Electron micro-

scopy of repeatedly exposed retinas revealed degenerative changes in the retinal neurons. The neurons appeared depleted of their cytoplasmic constituents and often contained phagolysosomal structures with myelin bodies. There were many degenerating synaptic boutons. The glial cells displayed reactive changes. A single exposure appeared to be sufficient to induce similar although much less extensive changes. These ultrastructural changes were not demonstrated by the other methods used. A single microwave exposure followed by the induction of a 70-100% increase in blood pressure did not enhance blood-retinal barrier permeability to tracers. There was no evidence of blood-brain barrier leakage. These findings indicate that lesions observable by electron microscopy can be produced in the rabbit eye at power levels lower than the cataractogenic threshold.

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

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

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

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

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Impulse photolysis produced by a UV light source generating impulses with a 2-nsec period and a 340-nsec wavelength was used for this study. In a 1 molar (M) aqueous solution of serum albumin transformed to a 0.1 M NaCl solution, a magnetic field (10-50 kOe) increased the effectiveness of hydrated electron recombination with ion radicals by  $1.5 \pm 0.2\%$ . The influence of the magnetic field on the recombination rate of photosensitive hydrated electrons and albumin ion radicals was due to Zeeman frequencies of the reacting radicals. In a  $10^{-4}$  M aqueous solution of methylene blue transformed by photolysis to a 10% ethanol solution, a magnetic field of 10 kOe increased the hydrated electron recombination with ion radicals by  $7.1 \pm 0.5\%$ . These experiments demonstrated the use of magnetic fields to study the transformation of short-lived ion radicals or radical pairs that are important in photosensitive biologic processes during the condensation phase.

6317 RESPONSE OF THE AMPULLAE OF LORENZINI TO A HOMOGENEOUS ELECTRIC FIELD. (Rus.)

Brown, H. R. (I. P. Pavlov Inst. Physiology, USSR Acad. Sciences, Leningrad, USSR); Il'inskiĭ, O. B.; Krylov, B. V. *Neirofiziologia* 11(2): 158-166; 1979. (9 refs)

The reactions of the ampullae of Lorenzini of *Raja clavata* in a homogeneous electric field were studied; the duration of the current pulses was 10 or 100 msec and the field intensity was 0.01-50  $\mu\text{V}/\text{cm}$ . The intensity of the impulse reaction was found to be a linear function of the projection of the ampullary duct on the field vector, which indicated that the potential difference between the pore and the capsule was the effective stimulus of the ampulla. The intensity of the impulse reaction decreased with the decrease in the length of the ampullary duct. The absolute sensitivity threshold of the ampullae was 1-3  $\mu\text{V}$ . The latent period, which was dependent on the length of the ampullary duct and on the intensity of the stimulus, was 9-150 msec.

6318 FOA ANIMAL EXPERIMENTS SHOW THE PHYSICAL AND PSYCHIC EFFECTS OF MICROWAVES. (Swe.)

Olsson, P. U. (No affiliation given); Ericsson, R. *FOA Tidningen* 16(3): 7-9; 1978. (0 refs)

Experiments carried out on the effects of microwave radiation at frequency of 2,450 MHz on male mice at the FOA Section for Biological Environmental Technique are reviewed. In one experiment, four mice were simultaneously exposed to microwaves at 100  $\text{mW}/\text{cm}^2$  intensity and acoustic pulses (twelve 2-sec/min, frequency 8 kHz) for 6 min. The acoustic reaction and the respiratory activity decreased. Two of the four mice died by the end of the 6-min exposure; their body temperatures were 42.2 C and 43 C, respectively. The two other mice survived; they maintained their respiratory activity, but demonstrated a suppressed acoustic reaction. Their body temperatures were 41.8 C and 39.7 C,

respectively, at the end of the exposure. The acoustic reaction normalized after 1 hr, and the respiratory activity and the body temperature normalized after 6 hr. In another series, mice were exposed to 100  $\text{mW}/\text{cm}^2$  for 3 min; the acoustic reaction disappeared after 1 min, and the respiratory activity increased rapidly from 1.5 min until the end of the exposure. The acoustic reaction returned after 20 min, and the respiratory activity and the body temperature normalized after 2 hr. Runwheel tests showed reduced running time and number of running periods beginning on the 7th day after exposure. The running time and the number of running periods normalized after 17 and 21 days, respectively. The hemoglobin level, which was normal during the first few days after exposure, decreased and then returned to normal 21 days after exposure. Mice that were exposed to 10  $\text{mW}/\text{cm}^2$  for 30 min showed no loss of the thermoregulatory capacity due to the reduction of the respiratory activity after the first 15 min. The respiratory activity normalized 15 min after the exposure. The acoustic reaction was suppressed after 15 min of exposure. The findings are of great importance in view of the fact that the maximum allowable microwave radiation intensity is 10  $\text{mW}/\text{cm}^2$  in the United States.

6319 A MECHANISM FOR HIGH-FREQUENCY ELECTROMAGNETICAL FIELD-INDUCED BIOLOGICAL DAMAGE? (Eng.) Nilsson, B. O. (Res. Lab. Electronics, Chalmers Univ. Technology, Goteborg, Sweden); Pettersson, L. E. *IEEE Trans Microwave Theory Tech* MTT-27(6): 616-618; 1979. (6 refs)

A mechanism for high-frequency electromagnetic field-induced biologic damage is presented. It is shown that microscopic wedge-shaped boundaries between regions with different dielectric constants are likely to be present in the mammalian body and may give rise to local fields, with extension on the order of  $10^{-9}$  m, about 100 times larger than the macroscopic fields. Field-induced local damage could therefore occur at  $10^4$  times lower incident radiation intensities. This phenomenon might explain biologic effects at low radiation power levels, especially in the case of low duty-cycle pulsed radiation. Although, quantitatively, only two-dimensional wedges were considered, three-dimensional structures with sharp tips are likely to be equally dangerous. Electron micrography of different body tissues revealed numerous structures with sharp edges or tips. Generally, there is no information readily available about the dielectric properties of the different microstructures. It is known, however, that the relative dielectric constants of fat and bone are small, of the order of 3-10, depending on the frequency. Therefore, wedges or tips formed by boundaries between these materials and water-rich tissues deserve special attention.

6320 CORAZOLE-INDUCED ENHANCEMENT OF CHANGES IN THE BRAIN BIOELECTRIC ACTIVITY IN A

CONSTANT MAGNETIC FIELD. (Rus.) Smirnova, N. P. (No affiliation given). *Bull Eksp Biol Med* 87(1): 21-24; 1979. (7 refs)

The effect of corazole (20-40 mg/kg injected intraperitoneally) on the background potentials and evoked potentials of the cerebral cortex, hypothalamus, and the cerebellar cortex was studied in 23 albino rats exposed to a constant magnetic field (500, 1,000, 3,000, and 4,000 Oe). Pretreatment with corazole caused a significant increase in the amplitude of the evoked potentials, and additional phases appeared. The amplitude measured after pretreatment and at 500 Oe was equal to that measured in nonpremedicated animals exposed to 1,000 Oe. The number of phases in the evoked potential increased from 1.9 before exposure to 2.5 at 500 Oe, 3.9 at 1,000 Oe, and 5.5 at 4,000 Oe. After premedication and exposure, the number of phases increased to 3.0 at 500 Oe, 4.8 at 1,000 Oe, and 6.7 at 4,000 Oe. The findings indicate that subconvulsive doses of corazole produced a considerable enhancement of the changes in the brain biopotentials induced by a constant magnetic field.

6321 RECOVERY CYCLES OF EVOKED BRAIN POTENTIALS IN THE RAT FOLLOWING EXPOSURE TO CONSTANT MAGNETIC FIELD. (Rus.) Smirnova, N. P. (No affiliation given). *Zh Vyssh Nerv Deiat* 29(2): 330-335; 1979. (17 refs)

The effect of a constant magnetic field (first 500-1,000 Oe, then up to 4,000 Oe) on the recovery of the evoked potential produced by the electric stimulation of the sciatic nerve (2-6 V, the intervals between the stimuli were increased from 20 to 120 msec) was investigated. The high-intensity homogeneous magnetic field caused elevations in the excitability level of the cerebral and cerebellar cortices and of the hypothalamus, indicated by the reduction of the length of the refractory (non-reactive) and subnormal periods in the recovery cycle of the evoked potentials. During exposure to "subthreshold" magnetic field (500-1,000 Oe), the double stimulation of the sciatic nerve caused an intensification or provocation of the "magnetic effect" (the appearance of additional oscillations in the structure of the evoked potentials) at certain intervals between the stimuli (above 60 msec).

6322 INFLUENCE OF A CONSTANT MAGNETIC FIELD ON NERVOUS TISSUES: II. VOLTAGE-CLAMP STUDIES. (Eng.) Schwartz, J. L. (Laboratoire de Physiologie Animale, Université de Poitiers, Poitiers, France). *IEEE Trans Biomed Eng* BME-26(4): 238-243; 1979. (15 refs)

The giant axon of the circumesophageal connective of the lobster was used to investigate the influence of a constant magnetic field on membrane potentials and transmembrane currents under voltage-clamp conditions using the double sucrose gap technique. When the axon was exposed for less than 5 min to a constant 1.2-Tesla magnetic field parallel

or perpendicular to the axon, neither the membrane potentials nor the transmembrane currents were affected in any detectable manner. Similar experiments were performed for longer exposures (up to 25 min). Although interpretation of these data was difficult because of large leakage currents that often developed as early as 15 min after the beginning of the experiment, again no marked change in membrane potentials was detected. It is concluded that magnetic exposure does not seem useful for the investigation of nerve membrane biophysics.

6323 STATE OF IMMUNOLOGIC REACTIVITY OF THE ORGANISM UNDER THE EFFECT OF SOME NOXIOUS INDUSTRIAL FACTORS. (Rus.) Kleiner, A. I. (Clinical Dept., Kharkov Scientific Res. Inst. Industrial Hygiene and Occupational Diseases, Kharkov, USSR); Getmanets, I. Ia.; Smolianinova, N. S.; Krylova, E. V.; Galas', G. S.; Rezenkina, L. D. *Vrach DeLo* (3): 98-102; 1979. (6 refs)

The immune status of 45 women (41 were less than 40 yr old) exposed occupationally to high-frequency electromagnetic fields (45-160 V/m) for less than 5 yr was studied. The phagocytic activity of the neutrophils and the serum complement titer for 100% hemolysis were significantly reduced. Autoantibodies to liver, stomach, pancreas, heart, and erythrocytes were found in 20-24% of the women, but the autoimmune reaction was usually weak. The harmful clinical effects of the electromagnetic field that were observed included functional disturbances of the nervous, cardiovascular, and digestive systems. The symptoms were mild and reversible. The findings demonstrate an impairment of the immune status in workers exposed to high-frequency electromagnetic fields.

6324 CHANGES IN TRANSAMINATION IN RAT LIVER AND SMALL INTESTINE AFTER EXPOSURE TO HIGH FREQUENCY ELECTROMAGNETIC FIELDS. (Rus.) Faitel'berg-Blank, V. R. (Odessa Agricultural Inst., Odessa, USSR); Lekhan, I. G. *Ukr Biokhim Zh* 51(1): 14-17; 1979. (16 refs)

The activities of transaminases located in the liver and small intestine mucus membrane were investigated in 69 male rats after exposure to high-frequency electromagnetic radiation. The animals were exposed to electromagnetic waves of frequency 13.6 MHz and intensity of 160  $\mu$ A for 10 min and to microwaves (MW) of frequency  $2,375 \pm 50$  MHz and intensity of 12 and 30  $\mu$ W/cm<sup>2</sup> for 10 and 20 min. The rats were decapitated following radiation and the levels of alanine and aspartate aminotransferase activities, expressed in moles of pyruvic acid formed per mg of protein during incubation, were measured. Induction heating with short-wave diathermy at 160  $\mu$ A for 20 min reduced the alanine aminotransferase activity by 69% in the liver and by 45% in the small intestine mucus membrane and reduced the aspartate aminotransferase activity by 52% and 66%, respectively. No significant changes were found in the blood. Irradiation with MW

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of intensity  $12 \mu\text{W}/\text{cm}^2$  for 10 min produced no significant changes in the enzyme activities in the liver and the small intestine mucus membrane; however, 20 min of exposure raised the specific alanine aminotransferase activity in the small intestine mucus membrane and raised the activity of aspartate aminotransferase in both tissues. Exposure to MW for 10 and 20 min at  $12 \mu\text{W}/\text{cm}^2$  increased the enzyme activities in the blood. The changes in transamination due to induction heating and MW irradiation at  $12 \mu\text{W}/\text{cm}^2$  disappeared after 24 hr exposure. Irradiation with  $30 \mu\text{W}/\text{cm}^2$  for 10 or 20 min lowered the specific alanine and aspartate aminotransferase activities in both tissues, but did not change the enzyme activities in the blood. The increased transamination activity resulting from irradiation with  $12 \mu\text{W}/\text{cm}^2$  may be due to accelerated gluconeogenesis associated with the mobilization of tissue proteins, which together with increased production of glucocorticoids, may reflect the organism's defense reaction.

6325 NONIONIZING RADIATION: BIOLOGIC EFFECTS--HEALTH ASPECTS OF SAFETY. (Ita.) Migliaccio, G. (No affiliation given); Pea, I. *Minis Poste Telecomun* 27(1): 95-108; 1978. (5 refs)

Because there is growing concern over the electromagnetic pollution of the environment, an overview of the biologic effects of nonionizing radiation, including microwaves (MW) and radio frequency (RF) radiation, is presented. In addition, the interaction of biologic tissues with UV radiation is reviewed. The absorption of electromagnetic radiation varies according to the structure, dielectric constant (DC), and water content of the biologic tissue. At a high water content, the DC decreases with increasing frequency, permitting calculation of an empirical relationship. This calculation is not possible for tissues with a low water content. Moreover, absorbed radiation that is reflected in tissues produces a transmission interference that can reinforce or cancel the radiation. When MW radiation is absorbed, most of the interfering reflections are quenched. The effects of absorbed MW and RF radiation depend also on the condition of the individual (e.g., age and physiologic state). A variety of effects have been cataloged: hematologic (variation in cell numbers and osmotic fragility), serologic (chemical and endocrine disturbances), gonadal (histologic damage and decrease in libido), ocular (cataract formation and retinal damage), and central nervous system effects (decrease in reflex and bioelectric activities and hypothalamus dysfunction). UV radiation has its greatest effects on the skin and eyes. Photoallergic reactions, arising from the interaction of UV with other agents in common use today (e.g., antibiotics, cosmetics, diuretics, tranquilizers, and detergents) are a particular problem. The risk of such effects increases with the numerous applications of lasers in research, industry, and medicine. Thus, it is important to analyze the risks associated with lasers and to establish threshold criterion for laser use.

6326 EFFECTS OF MICROWAVE IRRADIATION (2,400 MHz) ON RAT TISSUE DESTRUCTION AND REGENERATION. (Rus.) Tikhonchuk, V. S. (Biophysics. Inst., USSR Acad. Sciences, Moscow, USSR). *Biull Eksp Biol Med* 88(7): 29-30; 1979. (9 refs)

The destruction and regeneration of rat tissue following microwave irradiation were studied in 2,072 female rats exposed to microwaves of 2,400 MHz with power density of  $60-800 \mu\text{W}/\text{cm}^2$  and at 20-22 C. To produce the same destructive and regenerative effects, exposure time must be increased as power densities are decreased; thus, the relationship of the rate of destruction to the rate of regeneration is a function of the power density of radiation. This ratio has a greater absolute value for larger power densities associated with smaller degrees of destructive effect. By comparing the experimental data with data obtained from previously published experiments on mice, it was established that mice demonstrate destructive and regenerative effects in a shorter period of time than rats.

6327 CLINICAL AND BIOLOGICAL STUDIES OF LOCALIZED HYPERTHERMIA. (Eng.) Kim, J. H. (Dept. Radiation Therapy, Memorial Sloan-Kettering Cancer Center, New York, NY 10021); Hahn, E. W. *Cancer Res* 39(6, Part 2): 2258-2261; 1979. (14 refs)

Clinical and biological studies of localized radio frequency (27.12 MHz) hyperthermia in the treatment of malignant tumors are reported. Temperature measurements on a total of 20 normal and 24 tumor tissues in 12 patients indicated that inductive heating over a 30-min treatment period resulted in tumor temperatures of greater than 42 C in 17 of 24 instances; such temperatures appear to be desirable for achieving a good tumor response when applied after ionizing radiation therapy. Over 50 patients with a variety of cutaneous cancers were treated with heat alone, radiation alone, or a combination of heat plus ionizing radiation; the follow-up period ranged from 4-36 mo. Treatment with 27.12-MHz heating alone (41-43.5 C, 30-40 min/session) produced four complete and six partial responses among 19 patients treated. Radio frequency hyperthermia in combination with ionizing radiotherapy produced complete responses in 42 of 54 patients treated for cutaneous tumors compared with 12 complete responses among 49 patients treated by radiotherapy alone. Investigations with animal tumors indicated that the importance of the site of tumor growth is related to local tumor control by heat alone. Other studies with Dunn osteogenic sarcoma in mice indicated that mild (40.5 C) or moderate (42.5 C) heat alone or in combination with radiation does not increase metastatic spread and that hyperthermia in combination with radiation is effective in preventing dissemination of this tumor.

6328 TEST OF MAGNETIC SENSITIVITY IN THREE DIFFERENT BIOLOGICAL SYSTEMS. (Eng.) Iwasaki, T. (Nat'l. Inst. Radiological Sciences,

4-9-1, Anagawa, Chiba-shi 260, Japan); Ohara, H.; Matsumoto, S.; Matsudaira, H. *J Radiat Res* 19(4): 287-294; 1978. (25 refs)

The effects of a nearly uniform 5,000-G magnetic field on three different biologic systems were investigated. In one experiment, asynchronously growing, monolayered Chinese hamster cells in a plastic flask filled with growth medium were exposed to the magnetic field for 8 hr at room temperature. After the exposure, the cells were dispersed and replated for examination of cell growth and multiplicity and colony forming ability. In another experiment, naturally synchronous plasmidia of *Physarum polycephalum* were exposed to the magnetic field during the S-G<sub>2</sub> or M-S-G<sub>2</sub> stage of the cell cycle for 8 hr at 25 C under dark conditions. They were subsequently examined for any delay in mitosis. In a third experiment, fertilized or early cleavage (2- or 4-cell stage) eggs of *Xenopus laevis* were exposed to the magnetic field for up to 3 days at room temperature and were then examined for hatchability and delay in embryonic development. No significant biologic disturbances were observed in any of the above systems after exposure to the magnetic field.

6329 ABSENCE OF OCULAR PATHOLOGY AFTER REPEATED EXPOSURE OF UNANESTHETIZED MONKEYS TO 9.3 GHz MICROWAVES. (Eng.) McAfee, R. D. (Res. Service, VA Hosp., 1601 Perdido St., New Orleans, LA 60146); Longacre, A.; Bishop, R. R.; Elder, S. T.; May, J. G.; Holland, M. G.; Gordon, R. *J Microwave Power* 14(1): 41-44; 1979. (5 refs)

Unfettered and unanesthetized monkeys (*Macaca mulatta*) were individually irradiated with pulsed microwave radiation during 30-40 daily sessions and were observed over a 1-yr period for signs of ocular pathology. The monkeys had been trained to expose their face and eyes to 9.31-GHz microwave radiation with a pulse duration of 0.5  $\mu$ sec and a pulse repetition rate of 1,050 Hz. The average power density at the locus of the monkey's head was 150 mW/cm<sup>2</sup>. During half of the experiment, six adult monkeys were irradiated for 30-40 sessions, while another six acted as controls; during a second set of sessions, the groups were reversed. No cataracts or corneal lesions were observed at any time.

6330 AN RF SOLUTION TO A BEEF CANCER. (Eng.) BRINTON, J. B. (No affiliation given). *Electronics* 52(11): 44, 46; 1979. (0 refs)

A portable radio frequency hyperthermia applicator for treating cancer eye in cattle is described. The applicator consists of a 2-MHz oscillator with temperature-control circuitry and produces up to 10 W of power. Within seconds, the applicator brings the cancerous tissue up to a temperature of 50 C, which is maintained for about 30 sec. At this temperature cancerous bovine tissue is damaged, while normal tissue is sufficiently cooled by its blood supply to survive without injury. Remission of the cancer typically occurs within 2-4 wk, and

cure rates as high as 90% have been reported in pilot studies. This cancer remission rate is previously unheard of in either animals or humans.

6331 LARGE ANIMAL STUDIES OF HYPERTHERMIA AND IRRADIATION. (Eng.) Gillette, E. L. (Comparative Oncology Unit, Colorado State Univ., Fort Collins, CO 80523). *Cancer Res* 39(6, Part 2): 2242-2244; 1979. (18 refs)

Large animal studies of the effect on tumor growth of radio frequency (RF) hyperthermia alone or in combination with ionizing radiation is reviewed. In one study where 24 animals with a variety of tumors (some very advanced) were subjected to four treatments of RF hyperthermia (44 C for 30 min) alone, 50% of the tumors showed marked regression; complete remission for at least 6 mo was observed in nine instances. Included in this group were seven squamous cell carcinomas, and two of these regressed. Complete regression for greater than 10 mo was observed for 6 of 16 tumors subjected to one or two treatments with RF hyperthermia at a temperature of 45 C for 30-40 min. The six tumors controlled included one squamous cell carcinoma, three mast cell tumors, one perianal adenoma, and one basal cell carcinoma. Regression of a canine fibrosarcoma and a feline squamous cell carcinoma was reported following local current field hyperthermic treatment (43 C for 30 min) in combination with 700 rads of ionizing radiation that was given 10 min after hyperthermia. The dog was treated a total of seven times, and there was no evidence of the fibrosarcoma 8 mo after treatment. The cat was treated twice and had continuing regression 12 wk after therapy.

6332 MAN IN A GAS OF TACHYON MAGNETOELECTRIC DIPOLES--A NEW HYPOTHESIS. PART I. A SUMMARY OF SOME REAL BUT UNEXPLAINED BIOCOSMIC PHENOMENA. (Eng.) Cope, F. W. (Biochemistry Lab., Naval Air Development Center, Warminster, Pa 18974). *Physiol Chem Phys* 10(6): 535-540; 1978. (15 refs)

Various biocosmic phenomena that have been reported to affect man and other biologic systems but which are not measurable by present electromagnetic instruments are reviewed. These phenomena include the following: diurnal cycles in antigen-antibody reactions at magnetic electrodes, apparently due to magnetic radiation of an unknown type from the sun; rays from the sun of unknown type that can be detected by sick (and by some sensitive) humans, absorbed by metal plates, and conducted by metal wires; rays from the sun of unknown types that affect human health and can be trapped in bilayer metal boxes; colored clouds (auras) around magnets and man that can be seen by sick people (and by a few sensitive normals) and can be made visible to normals by chemical sensitizers; and grid lines parallel to lines of latitude and longitude that are observable by certain persons (dowers) but not by conventional magnetic or electric detectors. The above phenomena are explained neither by present classical or modern physics nor by any pre-

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sent chemical, biological, or psychological knowledge. The construction and the evaluation of a theory to explain these biocosmic phenomena are presented in two accompanying papers in this series.

- 6333 MAN IN A GAS OF TACHYON MAGNETOELECTRIC DIPOLES--A NEW HYPOTHESIS. PART II. INTRODUCTION TO THE THEORY. (Eng.) Cope, F. W. (Biochemistry Lab., Naval Air Development Center, Warminster, PA 18974). *Physiol Chem Phys* 10(6): 541-545; 1978. (25 refs)

Concepts from advanced theoretical physics, e.g., magnetic dipoles and tachyons, that were used to develop a theory for probably real but unexplained biocosmic observations are briefly described. The existence of magnetic dipoles has been predicted theoretically, but they have never been experimentally observed. Tachyons, which are particles traveling faster than light, have also never been detected experimentally. Despite the lack of physical evidence, some theoretical physicists, however, have theorized that tachyons may have magnetic and/or electric charge. The tachyon theory is closely linked to the magnetic monopole theory. The reliability of this data, particularly as it relates to the use of man as the detector of most biocosmic experiments, is discussed and defended. It is proposed that these phenomena may be understood in a unified manner by the hypothesis that we are surrounded by a gas of electromagnetic (EH) dipoles, each of which may (under special conditions) dissociate into a pair of EH monopoles, some of which are tachyons and which may be emitted by the sun.

- 6334 MAN IN A GAS OF TACHYON MAGNETOELECTRIC DIPOLES--A NEW HYPOTHESIS. PART III. DEVELOPMENT OF THE PHYSICS OF THE THEORY, AND EXPERIMENTAL CORRELATIONS: COSMIC RADIATION DETECTABLE BY MAN, AURAS OR MAGNETS AND MAN, DOWNSERS' GRID LINES OF EARTH, MEDIATION OF INTERACTION OF ELECTROMAGNETIC WAVES WITH MAN, INTERACTIONS WITH SOLIDS, AND CALCULATION OF MAGNETIC MOMENT. (Eng.) Cope, F. W. (Biochemistry Lab., Naval Air Development Center, Warminster, PA 18974). *Physiol Chem Phys* 10(6): 547-555; 1978. (27 refs)

A theory is developed to explain probably real biocosmic phenomena that cannot be explained by present scientific theory or measured by electromagnetic instruments. It is postulated that we are surrounded by a gas of electromagnetic (EH) dipoles that accumulate near and in man and other solids in accord with classical electromagnetic laws. However, it is also postulated that some of these EH dipoles are tachyons and thus have special additional properties. Detailed correlations are drawn between the predictions of this theory and the unexplained biocosmic phenomena, and a calculation from nuclear magnetic resonance measurements is given for the magnetic moment of a possible EH dipole ( $1.4 \times 10^{-9}$  Bohr magnetons). From this calculation it appears that the magnetic moment of an EH dipole is very much smaller than that of a

proton or an electron. Based on information indicating that EH dipoles may be trapped in superconductive microregions in man, it is proposed that electromagnetic radiation incident on man from the outside might perturb those trapped EH dipoles, in turn perturbing the molecular structure in which they are trapped and thus resulting in physiologic effects. This opens up a completely new possible mechanism for the interaction of electromagnetic radiation with man, and the effect of placing man within a metal shield takes on new significance. It had previously been taken for granted that the effect of placing man inside a shielded room was the prevention of interferences from outside electromagnetic radiation. However, if this new mechanism is operative, then placing man inside a metal shield may decrease (or increase) the concentration of EH dipoles trapped within man and thereby change the intensity of electromagnetic interactions. Experimental observations have shown that placing man within a shielded room significantly changes his reaction to electromagnetic radiation and that metal shields in the absence of any artificially applied electromagnetic radiation have effects on physiologic and psychologic behaviors.

- 6335 TECHNICAL NOTE: UPDATE OF RADIOLOGICAL QUALITY OF THE ENVIRONMENT. (Eng.) Anonymous. (No affiliation given). *Nucl Saf* 20(3): 342-344; 1979. (3 refs)

A tabulation of dose data for all sources of ionizing and nonionizing radiation in the United States is presented as part of the EPA's dose-assessment program. These data include both individual and population doses from each category of radiation source. Population doses from the different source categories can generally be added together to gain a perspective on the overall impact. However, doses to individuals vary greatly, and it can be misleading to total the individual doses. Thus, these data show totals only for population doses in the various source categories. For nonionizing electromagnetic radiation, the estimated individual exposure for broadcast towers and airport radars is  $10 \mu\text{W}/\text{cm}^2$ , and the exposure for all sources ranges from 0.1 to  $1 \mu\text{W}/\text{cm}^2$ .

- 6336 THE ANALGESIC EFFECT OF TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION (TNS) IN PATIENTS WITH RHEUMATOID ARTHRITIS. A COMPARATIVE STUDY OF DIFFERENT PULSE PATTERNS. (Eng.) Mannheim, C. (Clinic I, Vasa Hosp., Goteborg, Sweden); Carlsson, C. A. *Pain* 6(3): 329-334; 1979. (9 refs)

The effect of different pulse patterns of transcutaneous electric nerve stimulation (TNS) on severe pain in 20 patients (7 men, 13 women; 20-69 yr old) with verified rheumatoid arthritis was investigated. All patients had symptoms of spontaneous bilateral pain and/or pain on loading from the wrists, the metacarpophalangeal joints, and the proximal interphalangeal joints. Three forms of

stimulation were used: high frequency 70-Hz stimulation, low frequency 3-Hz stimulation, and stimulation with an internal frequency of 70 Hz and 80-msec pulse duration with a repetition rate of 3 Hz (3-70 TNS). Each electrode had an area of 9 cm<sup>2</sup>. The electrodes were placed immediately proximal to the patient's wrist with one electrode on the volar side and the other on the dorsal side. The stimulation period was 10 min. For all types of stimulation, the pulse amplitude was increased until the patient experienced paresthesia in all fingers; a final stimulation level immediately below that causing pain was used. The analgesic effect of TNS was evaluated by the patient's own estimate of pain relief and by a loading test in which the length of time the patient could hold a weight before and after TNS was measured. The number of patients who experienced marked subjective improvement was 18/20 after 70-Hz TNS compared with 14/20 after 3-70 TNS and 5/20 after 3-Hz TNS. Loading time was increased by 100% or more in 18/20 patients on 70-Hz TNS, 16/20 patients on 3-70 TNS, and 6/20 patients on 3-Hz TNS. The average duration of subjective effects was 18.2 hr (range, 4-36 hr) for 70-Hz TNS compared with 15.2 hr (range, 4-72 hr) for 3-70 TNS and only 4 hr (range, 3-6 hr) for 3-Hz TNS. No side-effects of TNS were observed. The results show that the analgesic effects of 70-Hz TNS and 3-70 TNS are almost identical, while 3-Hz TNS gives distinctly poorer results.

6337 BRAIN EVOKED POTENTIALS ARE FUNCTIONAL CORRELATES OF INDUCED PAIN IN MAN. (Eng.)  
Chen, A. C. (Dept. Anesthesiology, BB1411, HSB RN-10, Univ. Washington, Seattle, WA 98195); Chapman, C. R.; Harkins, S. W. *Pain* 6(3): 365-374; 1979. (29 refs)

Electric potentials evoked by five intensities of painful dental stimulation (9.6, 17.5, 26.0, 34.0, and 42.0  $\mu$ A) were recorded at the scalp in 10 male volunteers (24-28 yr old) to determine the relationships between stimulus intensity, subjective judgment of pain, and measures of the evoked potential (EP). For each volunteer, a healthy, unfilled central incisor was stimulated electrically to produce pain. The tooth was stimulated with a 3.5-mm diameter conductive rubber disk electrode (cathode); an anodal electrode was taped on the left zygomatic arch. The electric stimulus was produced by a Grass S-44 stimulator with modified constant current and isolation units. The dental electric stimuli consisted of single square wave pulses of 5-msec duration, delivered manually by the experimenter. Stimulus delivery was intentionally irregular so that expectancy could not contaminate measurement. The interstimulus interval ranged from 2 to 6 sec, with a mean of about 4 sec. At each intensity of painful dental stimulation, EPs were observed between 50 and 400 msec and were characterized by the following four waveform components: N<sub>65</sub>-P<sub>120</sub>, P<sub>120</sub>-N<sub>175</sub>, N<sub>175</sub>-P<sub>260</sub>, and P<sub>260</sub>-P<sub>340</sub>. The peak-to-peak amplitudes, but not the peak latencies, of all four EP components systematically increased with increased stimulation. The amplitudes of the two earlier components cor-

related with stimulus intensity when the effect of subjective painfulness was controlled, whereas the amplitudes of the two later components were associated with subjective painfulness but not with stimulus intensity. A strong linear relationship was observed between subjective painfulness and peak-to-peak amplitude for the EP component observed between 175 and 260 msec. These findings suggest that the earlier EP components may reflect sensory transmission processes while the latter components indicate brain activity when pain is perceived.

6338 CARDIOVASCULAR DISTURBANCES ATTRIBUTABLE TO OCCUPATIONAL FACTORS: APPROACHES TO THEIR STUDY. (Rus.) Monaenkova, A. M. (Inst. Industrial Hygiene and Occupational Diseases, USSR Acad. Medical Sciences, Moscow, USSR); Gladkova, E. V.; Radionova, G. K. *Gig Tr Prof Zabol* (4): 23-27; 1979. (0 refs)

Cardiovascular disturbances attributable to long-term exposure to chemical substances and physical factors (noise, electromagnetic waves, and ionizing radiation) are reviewed. Long-term exposure to microwaves can lead to the development of cardiovascular syndromes and changes in the nervous system, especially in the autonomic nervous system. Chronic asthenic symptoms accompanied by sinus bradycardia, arterial hypotension, and hypertonic vegetative-vascular dysfunction, and occasionally accompanied by diencephalic crisis with angiospasm, have been observed. In some cases, angiospasm can lead to coronary and cerebral circulation disorders. Prospective epidemiologic studies are necessary to evaluate the effects of occupational factors.

6339 OCCUPATIONAL HEALTH AND RADIATION HAZARDS. (Eng.) Michaelson, S. M. (Dept. Radiation Biology and Biophysics, Univ. Rochester Sch. Medicine and Dentistry, Rochester, NY). *Occup Health Saf* 48(4): 28-30, 32-34, 36-37; 1979. (17 refs)

Hazards associated with nonionizing electromagnetic radiation are reviewed, with particular emphasis on lasers and microwaves. The primary hazard from laser radiation is exposure of the eye; long-term exposure of the retina to wavelengths in the visible spectrum at levels not far below the burn threshold may cause irreversible effects. The type of damage inflicted on the eye by laser beams ranges from a small and inconsequential retinal burn in the periphery of the fundus, to severe damage of the macular area with consequent loss of visual acuity, and to massive hemorrhage and extrusion of tissue into the vitreous with possible loss of the entire eye. The biologic significance of exposure of the skin to lasers operating in the visible and infrared regions is considerably less than eye exposure. Effects may vary from a mild erythema to blisters and charring. Such conditions as depigmentation of the skin, ulceration, and scarring and damage to under-

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lying organs may occur from extremely high-powered laser sources. The basic biologic effects of microwaves occur in the presence of a significant temperature rise in biologic tissue; this rise requires exposure to relatively high levels of radiation and a substantial exposure duration. At high microwave frequencies, well above the usual heating frequencies, radiation is absorbed almost completely by the skin; these frequencies are felt in several seconds at exposure levels of a few mW/cm<sup>2</sup>. At the heating frequencies (918 and 2,450 MHz), the penetration is a few centimeters; at 2,450 MHz, microwave exposure is sensed at levels of 20-50 mW/cm<sup>2</sup> in a few seconds. At lower frequencies, like those of television broadcast, penetration and deep heating both increase. At still lower frequencies, the body shunts out or reflects the field so that less heating results even though the internal field is fairly uniform throughout the body. Thermal damage from microwaves occurs at exposure levels of more than 100 mW/cm<sup>2</sup> over extended durations of many minutes. Protection guides for nonionizing electromagnetic radiation sources in the United States are discussed and compared with the standards in the Soviet Union. In general, the Soviet standards are more numerous and more stringent than the American equivalents. This reflects differences in the concept of an environmental standard, the research applied, and the vigor with which the standards are enforced. Much of the Soviet research on environmental standards is not appropriate for the United States, since their standards are based on the lowest concentration producing measurable biologic damage, regardless of its importance.

6340 ROSES AND CABBAGES: MICROWAVE BIOEFFECTS LITERATURE IN 1978. (Eng.) Voss, W. A. (CE247, Univ. Alberta, Edmonton, Canada T6G 2N7). *J Microwave Power* 14(1): 77-78; 1979. (13 refs)

Microwave bioeffects literature published in 1978 is reviewed. One report brings together six introductory papers with basic information on definitions and concepts and includes dielectric and specific absorption data in tissue, an introduction to pathophysiological effects, and two sections concerning protection standards. A final section on measurement of microwave fields lacks tangible information. Detailed current data on electromagnetic radiation effects in relation to assessing potential health hazards can be found in another study. A clear assessment of current knowledge and future areas of study concerning the environmental impact of 2.45-GHz microwave beams for transmitting power from solar energy satellites has also been compiled. Essential, up-to-date information on dosimetry is available in another publication. The first edition is concerned with the frequency range of 10 kHz to 1.5 GHz and uses spherical and ellipsoidal theoretical models of animals and man. The second edition extends the frequency range to 100 GHz; additional mathematic models are used, and considerations of inhomogeneity are included.

6341 ASSESSMENT OF CURRENT HYPERTHERMIA TECHNOLOGY. (Eng.) Atkinson, E. R. (American Hosp. Supply Corp., Evanston, IL 60201). *Cancer Res* 39(6, Part 2): 2313-2324; 1979. (614 refs)

Current hyperthermia technology is reviewed. Radio frequency (RF) coupling at frequencies of 100 kHz to 100 MHz appears to be applicable both to superficial sites and to certain deep tissue sites. However, RF energy couples more readily to fatty tissue than to muscle, parenchyma, or connective tissue. The geometric location of in-dwelling electrodes may help to limit the tissue volume to be heated. At present, RF coupling techniques using implanted electrodes for the production of local hyperthermia appear to be ideally suited to the treatment of small, well-defined tissue volumes that are readily accessible. Microwave coupling complements RF coupling to a certain extent in that muscle, parenchyma, and connective tissue are more closely coupled than is fatty tissue. Microwave coupling may be implemented by means of surface contacting applicators or by means of tuned indwelling coaxial lines. Tissues are moderately transparent to microwave radiation; e.g., at a frequency of about 1 GHz, tissue penetration to a depth of 3-5 cm is possible. Depths of this order in many patients should permit tissue heating in virtually any part of the body. At the present time, microwave coupling appears to be ideally suited to the heating of larger regional tissue volumes. It may also be appropriate in whole body hyperthermia as a means of elevating whole body temperature more rapidly than may be accomplished by direct skin or blood thermal conduction heating or endogenous metabolic heat confinement.

6342 MICROWAVE BACKSCATTER DEPENDENCE ON SURFACE ROUGHNESS, SOIL MOISTURE, AND SOIL TEXTURE: PART II--VEGETATION-COVERED SOIL. (Eng.) Ulaby, F. T. (Center for Res., Inc., Univ. Kansas, Lawrence, KS 66045); Bradley, G. A.; Dobson, M. C. *IEEE Trans Geosci Electron* GE-17(2): 33-40; 1979. (6 refs)

The feasibility of using radar for measuring soil moisture in vegetation-covered fields is examined by experimentally determining the relationship between radar backscatter coefficient (RBC) and soil moisture for vegetation-covered soil. It is shown that radars with frequencies below 6 GHz and incidence angles less than 20 degrees exhibit minimal vegetation-attenuation effects on the RBC-soil moisture relationship. An examination of the effects of radar look direction relative to crop row direction on the RBC indicates that there are no row direction effects on the RBC if frequencies above 4 GHz are used for HH or VV polarization configurations; for HV polarization, no row direction dependence exists at any frequency between 1 and 8 GHz. The highest correlation between RBC and soil moisture (0.92) is obtained for the combined response of four crop types (corn, milo, soybeans, and wheat) measured at 4.25 GHz, a 10-degree incidence angle, and HH polarization. It is also shown that dependence on soil type can be minimized

by expressing soil moisture in units of percent of field capacity. The possibility of using a single radar for measuring soil moisture for both bare and vegetated fields is demonstrated with a linear estimation algorithm having an experimental correlation coefficient of 0.8.

- 6343 NORMAL TISSUE AND SOLID TUMOR EFFECTS OF HYPERTHERMIA IN ANIMAL MODELS AND CLINICAL TRIALS. (Eng.) Storm, F. K. (54-140 Center for Health Sciences, Univ. California, Los Angeles, CA 90024); Harrison, W. H.; Elliott, R. S.; Morton, D. L. *Cancer Res* 39(6, Part 2): 2245-2251; 1979. (20 refs)

The effects of radio frequency (13.56 MHz) hyperthermia (42-50 C) on both surface and deep visceral normal tissues as well as on spontaneously arising cancers in animals and humans were investigated. Toxicity tests in dogs, sheep, and pigs showed that progressive necrosis of normal and cancer tissue occurred at temperatures above 45 C. However, as normal tissues approached this temperature, intrinsic heat dissipation occurred so that temperatures below 45 C could be maintained; in contrast, most solid tumors did not have this adaptive capacity and could be heated to 50 C with virtually no injury to normal organs, subcutaneous tissue, or skin. In clinical trials, 69 treatments were administered to 36 refractory tumors in 30 patients with 10 types of cancer. Selective heating (45 C or greater) was observed in both primary and metastatic tumors. A total of 19 tumors arising in the skin or subcutaneous tissue were evaluated, and selective heating was observed in 14 (74%). Surface tumors treated to 50 C or more for 15 min on one or more occasions generally showed histologic evidence of coagulative necrosis and sloughed within 10-14 days. Of 17 intrathoracic or intra-abdominal tumors evaluated, selective heating (45 C or greater) was possible in 6 tumors (35%). While intratumor temperatures frequently were not uniform, tumors heated to 50 C or more for 15 min on one or more occasions generally showed coagulative necrosis and intravascular thrombosis. Overall selective heating was possible in 43% of the tumors less than 5 cm diameter and in 73% of tumors 5 cm or more in diameter, indicating that hyperthermia may be uniquely effective against larger tumors. Radio frequency hyperthermia with an absorbed power density of 1,000 W generally was well tolerated with virtually no normal tissue injury.

- 6344 CHANGE IN THE ACTIVITY OF CALCIUM IONS DUE TO THE MAGNETIZATION OF THE SOLUTION AS A POSSIBLE MECHANISM OF THE BIOLOGICAL EFFECT OF MAGNETIC FIELDS. (Rus.) Kartashev, A. G. (No affiliation given); Kaliuzhin, V. A.; Pliushch, R. A.; Vokhmintsev, A. V. *Elektron Obrab Mater* (6): 65-68; 1978. (10 refs)

The effect of permanent and alternating magnetic fields on the biologic activity of calcium ions in aqueous solutions was studied. The effect of

alternating and permanent magnetic fields of 320-64,000 A/m and 1-50 Hz on glycolysis by *Saccharomyces cerevisiae* was studied in solutions containing 0.16% Ca or Mg (control) ions. A reduced fermentation rate was observed in the irradiated solutions compared with the nonirradiated controls. In a second experiment, the minimum frequency inducing pectinase of a neuromuscular preparation of the frog was determined. The specimen was incubated in a 0.8% CaCl<sub>2</sub> solution and exposed to permanent magnetic field of 64,000 A/m. The magnetization of the solution caused a significant reduction of the minimum frequency by an average of  $14 \pm 7.5$  Hz ( $p < 0.01$ ). In a third experiment, the effect of magnetization at 8,000 A/m (gradient 50%) on fibrinolysis was studied in rabbit fibrin clots incubated in a CaCl<sub>2</sub> solution. Magnetic treatment decreased the fibrinolytic time from 90-300 min for control solutions to 60-270 min for ( $p < 0.01$ ) the irradiated solutions. The experiments demonstrated that the magnetic treatment of CaCl<sub>2</sub> solutions produces an effect analogous to the biologic inactivation of calcium ions; there was no significant effect on MgCl<sub>2</sub> and NaCl solutions. The findings support the hypothesis of the dominant role of Ca ions in the indirect action of magnetic fields on body fluids.

- 6345 THERMAL ANALYSIS AND DESIGN CONSIDERATIONS FOR A DUAL-BEAM MICROWAVE APPLICATOR FOR HYPERTHERMIA RESEARCH. (Eng.) Hannemann, R. J. (Coll. Engineering, Univ. Maryland, College Park, MD 20742); Robinson, J. E. *J. Biomech Eng* 101(2): 151-156; 1979. (17 refs)

Thermal analysis and design considerations are presented for a dual-beam waveguide microwave applicator that is being used for experimental hyperthermia treatment of implanted mouse tumors. The two waveguide applicators operate in a simulated TEM mode at 2,450 MHz and are in direct contact with either a slab of dielectric material encapsulating the tumor or a stirred, temperature-controlled dielectric bath in which the tumor specimen is immersed. By surrounding the tumor in this fashion with a tissue-equivalent material, the irregular spheroidal tumor boundary is transformed into a rectangular slab, thus promoting effective coupling of microwave energy to the tumor and a uniform field pattern within the illuminated region. One-dimensional models describing the heat transfer in the dual-beam applicator system with a stirred liquid bolus are presented. An examination of the temperature profiles reveals that for steady-state operations, maintaining the stirred liquid bolus near to the required elevated tumor temperature is desirable; setting the microwave power at a specific level then results in perfect temperature uniformity. The thermal models are verified by comparing predicted with measured temperatures at the tumor center using a leg-implanted tumor near the femur. The dual-beam microwave applicator system is of additional interest in that the use of four, eight, or even more narrow, coplanar microwave beams to produce highly localized hyperthermic

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fields at depth is a potential technique for clinical therapy on humans in the future.

6346 ELECTROMAGNETIC ABSORPTION IN A MULTILAYERED MODEL OF MAN. (Eng.) Barber, P. W. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112); Gandhi, O. P.; Hagmann, M. J.; Chatterjee, I. *IEEE Trans Biomed Eng* BME-26(7): 400-405; 1979. (15 refs)

A multilayered planar model was used to examine the dependence of whole-body electromagnetic power absorption on the configuration of surface layers of the human body (skin, fat, and muscle). Surface characteristics of 79 horizontal cross-sections of human tissue were represented by 3- or 5-layer configurations (skin-fat-muscle or skin-fat-muscle-bone-muscle). Numerical calculations were performed using the dielectric characteristics of the various tissue types for frequencies up to and including 10 GHz, with suitable modifications of the characteristics of electrically polarizable molecules used for frequencies above 10 GHz. It was shown that a semi-infinite planar model can accurately predict the layering resonance for a nonplanar geometry. Specifically, the results for multilayered and homogeneous semi-infinite planar models determine a layering enhancement factor that can be applied to whole-body absorption results obtained from nonlayered three-dimensional geometries to predict the absorption characteristics of three-dimensional layered geometries. Calculations for a multilayered prolate spheroidal model of man predict an absorption enhancement over homogeneous muscle tissue of 34% at 1.8 GHz and a reduction of 24% at 5.7 GHz.

6347 SOLAR POWER SATELLITES: MICROWAVES DELIVER THE POWER. (Eng.) Brown, W. C. (Microwave and Power Tube Div., Raytheon Co., Waltham, MA). *IEEE Spectrum* 16(6): 36-42; 1979. (0 refs)

A 2.45-GHz microwave transmission system for delivering the sun's power from space to earth through a network of solar power satellites (SPS) is described. The SPS network, with a 5- x 10-km photovoltaic array on each satellite, would convert the sun's energy to electricity prior to transmission. The microwave transmitting antenna on each satellite would be 1 km in diameter, and the ground stations would have 10- x 13-km elliptical receiving-rectifying antennas (rectennas). The microwave transmission system envisioned is comprised of three stages: the conversion of direct current (dc) power (from the photovoltaic cells on the satellite) to microwave power; the formation and control of microwave beams precisely pointed to fixed locations on the earth's surface; and the collection of the microwave energy and its conversion into dc electric energy at the earth's surface. Safety features such as a pilot beam for the transmitting antenna to track are planned to keep the microwave beams from wandering off target and affecting people. While the microwave beam transfers a large

amount of power, the large-diameter beam has most of its power at the center, where the density is 23 mW/cm<sup>2</sup>. At its edges, the beam's density is 1 mW/cm<sup>2</sup> or only 10% of the continuous exposure standard of 10 mW/cm<sup>2</sup> in the United States. An exclusion area surrounding each rectenna is proposed to hold the risks to humans near the target site to a minimum. Furthermore, the microwave beam focusing system, which employs the pilot beam, has a "fail-safe" feature; in case the beam should untrack, it would defocus to 0.003 mW/cm<sup>2</sup>.

6348 THERMAL DOSIMETRY AND TEMPERATURE MEASUREMENTS. (Eng.) Christensen, D. A. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112). *Cancer Res* 39(6, Part 2): 2325-2327; 1979. (19 refs)

Problems associated with temperature monitoring during tissue heating by electromagnetic radiation are discussed along with some nonperturbing measurement methods for avoiding or minimizing these problems. The use of conventional metallic thermometers can cause severe errors due to reradiated fields, high internal heating, and electronic interference. To avoid these problems, both probes, which use conventional thermistor sensors in conjunction with very high resistance lead wires to reduce interaction, and optical probes, using plastic or glass fibers as the communicating link to a liquid crystal sensor, have been developed. An advantage of high resistance lead probes is that the thermistor sensor is relatively accurate, reproducible, and stable. Disadvantages are the need for highly sensitive electronics, limited length of the probe leads, and the relatively large diameter (about 1-2 mm) of the probe tip. Disadvantages of the optical fiber probes are chemical instability of the sensor material, hysteresis during temperature cycling, and the relatively large diameter of the tip (1.5-2.0 mm). A small semiconductor sensor in conjunction with an optical fiber probe has been developed with the advantages of inherent sensor stability, range, and small tip diameter (0.25 mm, unsheathed but coated), making it attractive for tissue implantation. A new noninvasive approach uses ultrasound-computed tomography and relies on the change in the speed of sound versus temperature to achieve maps of internal tissue temperature. It appears that the eventual temperature resolution of this technique may be about 0.1-0.3 C with a spatial resolution on the order of a few millimeters.

6349 THE MATURING OF ELECTROMAGNETIC RADIATION HAZARD INSTRUMENTS. (Eng.) Aslan, E. (Narda Microwave Corp., Plainview, NY). *Microwave J* 22(5): 83, 84, 88, 90; 1979. (10 refs)

Advances in the measurement of electromagnetic (EM) radiation hazards are reviewed. Isotropic probes, with their independence of polarization, direction of propagation, true square law characteristics, and broad bandwidth, have overcome the uncertainties

associated with field intensity meters with directive antennas. The latter cannot reliably measure complicated EM fields such as those with reactive near field components, multipath reflections, arbitrary polarization, multiple frequency components, complicated modulations, and larger field gradients. Current isotropic radiation monitors cover the frequency range of 10 MHz to 40 GHz. In the high frequency region above 300 MHz, only the electric field is generally measured. Below 300 MHz, both the electric and magnetic fields are measured. Calibration of the probes is accomplished using standard field methods. Above 1,000 MHz, horn antennas corrected for near zone gain and an anechoic sled, which is used to average out multipath interference, are the fundamental components of the calibration system. A calibration cell of the type developed by the NBS is used for calibration below 500 MHz. This cell is essentially a section of extremely large air dielectric 50 ohm rectangular coaxial line. A standard field is generated between the inner and outer conductors as a result of a known power transmitted down the line. At frequencies between 500 and 1,000 MHz, a technique based on propagating the fundamental TE<sub>01</sub> mode in a side wall slotted waveguide section is used. Although a number of personal dosimeters for avoiding exposure to EM energy have been developed over the last 10 yr, no unit exists that can be worn on the body and that meet the requirements of a reliable personal radiation hazard monitor.

6350 EFFECT OF GENERAL ANESTHETICS ON MICE AFTER MICROWAVE IRRADIATION. (Rus.)

Koldaev, V. M. (Vladivostok Medical Inst., Vladivostok, USSR). *Biull Eksp Biol Med* 87(5): 425-427; 1979. (2 refs)

The effects of general anesthetics (sodium thiopental, 60 mg/kg; sodium oxybutyrate, 10, 50, and 500 mg/kg; hexenal, 60 mg/kg; urethan, 800 mg/kg; ftorothan, 1:10,000 concentration; chloroform, 1:5,000; and ethyl ether, 1:1,000) on male and female albino mice irradiated with high doses of microwaves (unspecified doses) were studied. In one experimental series, the anesthetics were administered immediately after microwave irradiation. The survival, determined 3 wk later, was 48% in the controls that were irradiated only and 30% (significantly lower by 1.45-1.6 times) in the groups treated with chloroform, ftorothan, sodium thiopental, and sodium oxybutyrate (500 mg/kg). The reduction in the survival rate was insignificant after microwave irradiation that was immediately followed by ethyl ether, hexenal, urethan, and the lower doses of sodium oxybutyrate. In a second experimental series, the anesthetics were administered 0-10 days after irradiation, and the time elapsing until the animals assumed a lateral position was determined. This time increased by 15-48% compared with the controls when the anesthetics were given immediately after irradiation, but it decreased gradually when they were given at later dates. Compared with the controls, the time increased by 8-14% when ether, ftorothan, hexenal,

and sodium thiopental were administered immediately after irradiation. When ether was administered at later dates, the time increased gradually by 48%. When ftorothan was administered 10 days after irradiation, it decreased by 34%. Hexenal and sodium thiopental administered 2 days after irradiation caused a 28-36% decrease, which reached the control level when the anesthetics were given on day 4. The findings indicate that high-dose microwave irradiation results in varying sensitivities of mice to several general anesthetics.

6351 AN INVESTIGATION OF THE THERMAL AND ATHERMAL EFFECTS OF MICROWAVE IRRADIATION ON ERYTHROCYTES. (Eng.) Peterson, D. J. (Dept. Bioengineering, Univ. Utah, Salt Lake City, UT 84112); Partlow, L. M.; Ghandi, O. P. *IEEE Trans Biomed Eng* BME-26(7): 428-436; 1979. (11 refs)

Rabbit red blood cells (RBC) heated to the same temperature by either microwave irradiation or by conventional techniques were examined for loss of hemoglobin (Hb) and potassium (K<sup>+</sup>). Microwave irradiation was performed at a frequency of either 2.45 GHz or at 0.5-GHz swept frequency regions in the 12.5-18 GHz range. Sample tubes containing RBC were irradiated in the far field of a horn antenna in all cases. A vertical rotating sample holder was used to provide uniform microwave exposure for multiple RBC samples. When rabbit RBC were irradiated with 2.45-GHz microwaves at a power density of 10 mW/cm<sup>2</sup> for 45 min, a temperature rise of 3.7 C was achieved, resulting in a final temperature of 28.7 C. However, no differences in the amount of leakage of either Hb or K<sup>+</sup> were detected among microwave-irradiated RBC, conventionally-heated RBC, and RBC held at room temperature. When RBC were heated to 37 C (power density 86 mW/cm<sup>2</sup> initially, then 35 mW/cm<sup>2</sup> for maintenance) both microwave- and conventionally-heated samples released significantly more Hb (1.7 times) and K<sup>+</sup> (1.4 times) than RBC samples held at room temperature; however, there was no significant difference between the effects of microwave heating and conventional heating. When RBC were heated to and maintained at 41.5 C by either 2.45-GHz microwave (power density 112 mW/cm<sup>2</sup>, then 93 mW/cm<sup>2</sup>) or conventional heating, the leakage of Hb and K<sup>+</sup> from the samples was 22.3 and 7.0 times greater, respectively, than the loss from corresponding samples maintained at room temperature. However, again no differences were observed between microwave heating and conventional heating. At frequencies between 12.5 and 18 GHz, similar results to those obtained at 2.45 GHz were observed for rabbit RBC. When human RBC were warmed to 37 C by 2.45-GHz microwaves or by conventional heating, the amount of leakage of either Hb or K<sup>+</sup> did not differ from that for RBC maintained at room temperature. Human RBC membranes are apparently more resistant to both microwave heating and conventional heating than are rabbit RBC. Any increased loss of either Hb or K<sup>+</sup> from microwave-irradiated rabbit RBC was attributed to thermal effects on erythrocyte membrane stability or permeability.

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6352 SAFETY CODE-6: RECOMMENDED SAFETY PROCEDURES FOR THE INSTALLATION AND USE OF RADIOFREQUENCY AND MICROWAVE DEVICES IN THE FREQUENCY RANGE 10 MHz-300 GHz. (Eng.) Stuchly, M. A.; Repacholl, M. H.; Zuk, W. M.; Waight, P. J.; Ghosh, G. K.; Muc, A. M. (Radiation Protection Bureau, Health and Welfare Canada, Ottawa, Canada). 39 pp.; 1979. [available through Information Directorate, Dept. Natl. Health and Welfare, Brooke Claxton Building, Ottawa K1A 0K9, Canada, Environmental Health Criteria Document No. 79-EHD-30]. (8 refs)

Safety requirements, installation guidelines, and maximum exposure levels for use in Canada with stationary radio frequency devices that operate in the frequency range of 10 MHz to 300 GHz are presented. For microwave radiation workers receiving whole- or partial-body exposure (with exception of the extremities) to either continuous or modulated electromagnetic radiation (EMR) from one or more sources operating in the frequency range of 10 MHz to 1 GHz, the following levels must not be exceeded over a 1-hr period: root mean square (RMS) electric field strength, 60 V/m; RMS magnetic field strength, 0.16 A/m; and power density, 1 mW/cm<sup>2</sup>. When averaged over a 1-min period, these same parameters must not exceed 300 V/m, 0.8 A/m, and 25 mW/cm<sup>2</sup>, respectively. Maximum exposure levels for microwave radiation workers receiving either whole- or partial-body exposure to radiation in the frequency range of 1 GHz to 300 GHz when averaged over a 1-hr period are: RMS electric field strength, 140 V/m; RMS magnetic field strength, 0.36 A/m; and power density, 5 mW/cm<sup>2</sup>. When averaged over a 1-min period, these parameters must not exceed 300 V/m, 0.8 A/m, and 25 mW/cm<sup>2</sup>, respectively. For exposure of the extremities to continuous or modulated radiation at frequencies ranging from 10 MHz to 300 GHz, the following levels must not be exceeded when averaged over a 1-hr period for microwave radiation workers: RMS electric field strength, 200 V/m; RMS magnetic field strength, 0.5 A/m; and power density, 10 mW/cm<sup>2</sup>. For whole- or partial-body exposure of any member of the general public to either continuous or modulated EMR at frequencies ranging from 10 MHz to 300 GHz, the following levels must not be exceeded when averaged over a 1-min period: RMS electric field strength, 60 V/m; RMS magnetic field strength, 0.16 A/m; and power density, 1 mW/cm<sup>2</sup>. Also covered in the safety code are siting and installation requirements for open-beam heating devices, medical devices and electromagnetic interference, microwave ovens, radar and communications systems, and electroexplosive devices. Other topics include safety procedures for operators and maintenance personnel, the protection of the general public, radiation surveys, and the use of warning signs.

6353 INJURY AND RECOVERY OF THE MOUSE AFTER MICROWAVE (2,400 MHz) IRRADIATION. (Rus.) Tichonchuk, V. S. (Inst. Biophysics, USSR Acad. Sciences, Moscow, USSR); Antipov, V. V.; Davydov,

B. I.; Galkin, A. A. *Biull Eksp Biol Med* 88(7): 55-57; 1979. (8 refs)

The relationship between the effects and the duration of exposure at different power densities of microwaves (MW) was studied in 2,200 female mice. Equations are presented to determine, at different power densities, the distribution of deaths in relation to the duration of exposure and the rate of destruction in relation to the rate of regeneration. The animals were exposed to MW irradiation of frequency 2,400 MHz and power densities of 800, 500, 300, 200, 100, 80, or 60  $\mu\text{W}/\text{cm}^2$  for 30 days. With MW power doses under  $40 \pm 10 \mu\text{W}/\text{cm}^2$ , the biophysical mechanisms regulating the heat balance of mice were so effective that heat was eliminated in a shorter time than that of exposure. The relationship between MW power dose and length of exposure can be expressed exponentially and the dependence between the speed ratio of tissue destruction/regeneration and the power density approached the exponential function. Thresholds of power dose and length of exposure were determined for death levels not exceeding 0.1%. The revealed dependencies quantitatively characterize the adaptational capabilities of the mouse to microwave irradiation.

6354 ON THE MECHANISM OF MAGNETIC FIELD EFFECTS IN BACTERIAL PHOTOSYNTHESIS. (Eng.) Haberborn, R. (Institut für Physikalische und Theoretische Chemie, Technische Universität München, D-8046 Garching, W. Germany); Michel-Beyerle, M. E. *Biophys J* 26(3): 489-498; 1979. (39 refs)

The magnetic field-dependence of the primary steps in the bacterial photosynthetic reaction center is analyzed by solving a simple model with only one proton, representing the many magnetic nuclei with which the unpaired electrons in the radical intermediates interact. Analytic expressions are given that can be used to study the influence of the rates of the primary electron transfer reactions and the exchange interaction on the yield of excited triplet states. It is shown that at least the order of magnitude of the reaction rates obtained can be expected to be correct. The triplet recombination rate found in this analysis is larger than the singlet rate; this can be readily understood in view of the different exothermicities of electron transfer reactions. A small value obtained for the exchange interaction in this analysis is somewhat puzzling. It indicates that the overlap of the wave functions of the first excited singlet state of bacteriochlorophyll dimer and the bacteriopheophytin anion is very small; if the interaction between the electrons were mainly of a magnetic nature (a possibility that cannot be excluded), the overlap could be close to zero. On the other hand, the electron transfer step leading to the formation of these radicals proceeds extremely rapidly (within 10 psec). There is some evidence that a geometric change occurs in the reaction center after this fast electron transfer step, which perhaps involves an increase of the distance of the radicals. Another possibility is delocalization of one of the unpaired electrons

and thus the subsequent increase in their average distance in the radical pair state. A model system in which this feature is realized consists of an organic crystal with dye molecules adsorbed at its surface. After excitation by light, a radical ion pair is formed, one charge of which may even diffuse into the crystal bulk. The electric current thus generated and the triplet species formed have been found to be magnetic field-dependent.

6355 TEMPERATURE DEPENDENCE OF THE MICROWAVE PROPERTIES OF AQUEOUS SOLUTIONS OF ETHYLENE GLYCOL BETWEEN +15 C AND -70 C. (Eng.) Macklis, J. D. (Cryogenic Engineering Lab., Massachusetts Inst. Technology, Cambridge, MA 02139); Ketterer, F. D.; Cravalho, E. G. *Cryobiology* 16(3): 272-286; 1979. (21 refs)

The temperature dependence of the microwave properties of aqueous solutions of ethylene glycol (EG) between +15 C and -70 C was investigated in connection with difficulties involved in the microwave thawing of whole organs stored at subfreezing temperatures. Values of the dielectric constant and loss tangent were determined for pure distilled water and for EG at concentrations of 1 molar (M), 2 M, 3 M, 4 M, 5 M, 10 M, and 100% EG. An operating frequency range of 1.40-1.55 GHz was used so that the results could be applied directly to both 0.915-GHz and 2.450-GHz studies. Strong temperature and concentration dependencies were found; low concentration solutions of EG tended to behave similarly to water, while higher concentration solutions were more independent. Peak values and discontinuities occurred at different temperatures, depending on the concentration of the EG solution. A 5-M solution of EG appeared to be a near optimal concentration based on toxicity, cryoprotection, and microwave power absorption considerations. The data suggest that it may be possible to blend two cryoprotectants to increase electric activity while at the same time decreasing toxicity.

6356 ANATOMICAL LOCALIZATION OF HUMAN DETECTION OF WEAK ELECTROMAGNETIC RADIATION: EXPERIMENTS WITH DOWSERS. (Eng.) Harvalik, Z. V. (5901 River Drive, Lorton, VA 22079). *Physiol Chem Phys* 10(6): 525-534; 1978. (16 refs)

Positive responses in the form of dowsing signals were evoked in 14 male dowsers exposed to artificial electromagnetic fields. A total of 691 hits were scored versus 33 misses. During all trials, a high frequency generator (HFG) was mounted on a wooden surface 90 cm above ground level. The 5-cm beam width at the origin dispersed at a cone angle of 17 degrees. Thus at 2.5 m, the distance from the HFG to the path to be followed by the subjects, the axes of the generator coils were horizontally adjusted to point perpendicularly to the path. One subject was sensitive enough to detect microwatt-level signals in the frequency ranges of 42.83 MHz and 58.55 MHz. The other 13 subjects were able

to detect milliwatt-level signals at frequencies ranging from 58.55 MHz to 6 GHz. In experiments where the kidney area was shielded with aluminum, positive responses to the artificial electromagnetic fields were not observed, suggesting that magnetic sensors probably exist in the renal vicinity (hypothetically, the adrenal gland regions). Extinction of response was also observed when the head was shielded, suggesting the existence of an additional magnetic sensory apparatus in the brain. A signature processor is proposed to account for transduction of the magnetic stimulus to a physical response (dowsing signal and L-rod movement) and to explain the apparent discrimination among magnetic signatures when a dowsing responds to the signature for water, for example. Although hard evidence is lacking, numerous measurements and observations during the present experiment suggest that this processor is possibly associated with the sensory mechanism in the pineal region of the brain.

6357 A MICROWAVE COMPATIBLE MIC TEMPERATURE ELECTRODE FOR USE IN BIOLOGICAL DIELECTRICS. (Eng.) Larsen, L. E. (Dept. Microwave Res., Walter Reed Army Inst. Res., Washington, DC); Moore, R. A.; Jacobi, J. H.; Halgas, F. A.; Brown, P. V. *IEEE Trans Microwave Theory Tech* MTT-27(7): 673-679; 1979. (6 refs)

A four-terminal temperature electrode design for in situ use in tissues other than bone during microwave exposure is described. The design is based on hybrid microwave integrated circuit construction; the fabrication methods include a combination of thick- and thin-film techniques. Thick-film techniques are used for the four-terminal transducer subassembly, and thin-film techniques are used for the transmission line. Electrothermal matching is used to prevent artifacts in either of two directions: heat sourcing and heat sinking. The electrode is relatively free from heat sinking or heat sourcing for 2,450-MHz fields at a power level of 250 mW/cm<sup>2</sup> within phantom brain and air environments for the transducer subassembly and flexible hyperthin line, respectively. At the electrode tip, heat sinking is on the order of 0.15 C. Further development will require total system operation in a microwave environment with freedom from radio frequency interference and temperature coefficient effects in the temperature encoding and telemetry electronics.

6358 MICROWAVE APPLICATORS HELP TREAT CANCER. (Eng.) Anonymous. (No affiliation given). *Des News* 35(11): 83; 1979. (0 refs)

The use of localized microwave hyperthermia in cancer therapy is reported, with particular emphasis on the development of new microwave applicators. The principle of microwave hyperthermia in cancer therapy is related to the ability of heat in the range of 42-43 C to destroy malignant cells selectively while sparing normal tissues. In clinical studies involving patients with cancerous lesions on the skin or slightly below its surface, improved

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rates of tumor regression were observed when microwave hyperthermia was used alone or in conjunction with radiotherapy. Recently, coaxial applicators have been developed that can be inserted into body cavities, thus making microwave hyperthermia available for the treatment of certain deep-seated lesions. Initial experiments with animals at frequencies of 2,450 and 915 MHz have been performed with these coaxial applicators (results not specified). The coaxial probes consist of a coaxial cable terminating in a radiating antenna. Heat can be induced within a spherical volume, thus allowing the use of these applicators in a body cavity with the aid of a catheter. To achieve directive heating, a metallic reflector can be used opposite the area treated. Other experimental applicators include dielectric-filled waveguides that are electrically matched to muscle tissue. These minimize reflections of microwave energy from the interface between the applicator and the adjacent muscle. Typically, more than 85% of the microwave energy entering these applicators can be transmitted into the muscle.

6359 AN INVESTIGATION OF ENERGY DENSITIES IN THE VICINITY OF VEHICLES WITH MOBILE COMMUNICATIONS EQUIPMENT AND NEAR A HAND-HELD WALKIE TALKIE. (Eng.) Lambdin, D. L. (Electromagnetic Radiation Analysis Branch, Office Radiation Programs, EPA, P.O. Box 15027, Las Vegas, NV 89114). 52 pp.; 1979. [available through the EPA, Office of Radiation Programs. EPA Report No. ORP/EAD 79-2]. (4 refs)

Electric field energy densities were investigated in and around nine separate vehicles using mobile communications equipment as well as in the near vicinity of a hand-held walkie talkie. The vehicles were equipped with 60- and 100-W transmitters broadcasting at frequencies of 164.45 and 41.31 MHz, respectively. The antennas used were either the ASP 446 base-loaded with 3 dB gain or the Phelps Dodge 551-509 base-loaded whip antenna with 2.5 dB gain. The walkie talkie operated at a frequency of 164.45 MHz with an output power of 1.8 W. The only instance in which the current American National Standards Institute standard of 177 nJ/m<sup>3</sup> was exceeded occurred within 6 inches of an active antenna. In most cases, the antenna was installed at a point on the vehicle where human contact or approach within 6 inches would be minimized (roof mounts). Two vehicles had antennas on or near fenders where exposure levels exceeding 177 nJ/m<sup>3</sup> to part of the body would be possible. In the case of a cowl-mounted antenna on a Chevrolet van, high exposures to the head area would be possible to a person working in the windshield area. Exposures exceeding 177 nJ/m<sup>3</sup> would be most likely to occur with the hand-held walkie talkie (200 nJ/m<sup>3</sup> at the eye). Several other areas, inside and outside of each vehicle as well as near the walkie talkie, showed exposures exceeding 10% of the current standard (17.7 nJ/m<sup>3</sup>). Of the major sites measured and tabulated in the near vicinity of passenger sedans, about 5% of the exposures exceeded 18 nJ/m<sup>3</sup>. Approximately 10% of the measured values close to

and inside two vans exceeded 18 nJ/m<sup>3</sup>, and nearly 40% of those associated with pickup trucks exceeded that value. Exposure levels at 6 feet or greater from any vehicle were much lower than 18 nJ/m<sup>3</sup>. Since the two carrier frequencies investigated (41.31 and 164.45 MHz) were transmitted with 100 and 60 W, respectively, it is believed that these measured exposures represent maximum probable exposure from typical mobile communications systems. The walkie talkie represents the worst possible situation since the antenna is located within 3 inches of the eye.

6360 NUMERICAL STUDIES OF ABSORPTION OF ELECTROMAGNETIC ENERGY BY MAN. (Eng.) Haggmann, M. J. (Ph.D. dissertation, Univ. Utah, 1978); 160 pp. [available from Xerox Univ. Microfilms, Ann Arbor, MI 48106, Order No. 7901556]. (10 refs)

A new synthesis procedure is developed for the design of antenna arrays where stepwise variation is desired in the radiation pattern, and the procedure is used to design a waveguide slot array for use in microwave biologic effects research. The procedure is based on weighted least squares and appears to provide better approximation than is possible with either Fourier synthesis or the Cesaro, Fejer, or Lanczos modifications of Fourier synthesis. Convergence criteria are established for moment-method solutions in electromagnetics, and the criteria are found useful in computations for one-, two-, and three-dimensional problems. Two new procedures are developed for improving convergence of numeric solutions in the two-dimensional electromagnetic problem, and two interpolants are developed that improve convergence of numerical solutions in the three-dimensional electromagnetic problem. It is suggested that interpolants should find general usage as a follow-up to moment-method solutions. A realistic model of man is made using an array of 180 cubical cells to represent the form of the 50th percentile standard man. Calculated values of energy deposition in the homogeneous model are in good agreement with experimental values for homogeneous phantom models. Ground, reflector, and multibody effects are treated numerically with models of man for the first time, and the dependence of energy deposition on frequency and spacing from reflectors is found to be consistent with antenna theory. Multibody effects, first predicted from antenna theory, are confirmed with numerical calculations and animal experiments.

6361 BRAIN INTERACTIONS WITH WEAK ELECTRIC AND MAGNETIC FIELDS. (Eng.) Adey, W. R. (Univ. California, Los Angeles, CA); Bawin, S. M. *Neurosci Res Program Bull* 15(1): 7-129; 1979. (37 refs)

Reports of behavioral, electrophysiological, and biochemical interactions with key regions of the extremely low frequency (ELF), radio frequency, and microwave spectra are discussed in a review of the limited range interactions of weak nonionizing

electromagnetic fields with nervous tissue. In a study on the effects of low-level, low-frequency fields on human circadian rhythms, a weak (2.5 V/m) square wave field at a frequency of 10 Hz shortened the period of human circadian rhythms in 10 experiments by an average of  $1.3 \pm 0.7$  hr. It is speculated that circadian rhythms might be based on a single response to weak electromagnetic fields, with the response having a decay time of the order of 1 day. Recent studies are cited that suggest that the orientational responses of birds, insects, and some other invertebrates are sensitive to magnetic fields. Homing pigeons appear able to detect even minor fluctuations ( $10^{-4}$  to  $10^{-5}$  G) of the magnetic field attributable to solar activity. Birds also appear to exhibit a sensitivity to weak oscillating electric fields (10 Hz, 2.5 V/m square wave), and it is speculated that the capacity of birds to discriminate between electric fields with single frequencies may be related to navigation. Experiments are described in which rabbits exposed for 3 hr/day to 10-cm microwaves (1- $\mu$ sec pulse duration) at a frequency of 400/sec and a power density of 7 mW/cm<sup>2</sup> for a total of approximately 200 hr displayed widespread desynchronization and decreased amplitude of electroencephalogram rhythms. In other experiments on the effects of low-level pulsed and continuous microwave fields (2,950 MHz, 3 mW/cm<sup>2</sup>, pulsed at 1,200/sec, pulse duration 1  $\mu$ sec) on hematopoiesis in rabbits, 74 hr of exposure to pulsed microwaves or 158 hr of exposure to continuous microwaves produced highly significant reductions in iron transport rate, iron turnover rate, quantity of iron incorporated into erythrocytes, and percent erythrocyte production. Cation binding models for the interaction of membranes with electromagnetic fields have shown that very weak electric stimulation (20-50 mV/cm at a frequency of 200 pulses/sec, pulse duration 1 msec) of the cat cerebral cortex increases the release of calcium ion, gamma-aminobutyric acid, and taurine. These results indicate that calcium binding in the cerebral cortex is highly sensitive to small perturbations of the extracellular field. The electric gradient induced by the stimulation is at most 2.5  $\mu$ V across a typical synaptic terminal 0.5  $\mu$ m in diameter. Such high sensitivity is consistent with models of excitable membranes where small stimuli may lead to marked transition in the membrane through cooperative interactions among the membrane components. The bioeffects of electromagnetic fields are also discussed in terms of electromagnetic sensing in fish; effects of weak electric fields on behavior and electroencephalograms of laboratory animals; amplitude-modulated, very high frequency electric fields; and effects of microwave radiation on aplysian ganglion cells. Biophysical characteristics of electromagnetic fields are reviewed through studies on tissue determinants of interactions with electric fields, central nervous system responses to microwave-induced heating, the biologic significance of zero magnetic field conditions, and perturbations of microwave fields by living organisms. In the field of dosimetry and dosimetric techniques, a miniature implantable temperature-measuring device has been developed

that does not interfere with incident microwave fields. This device consists of a small fluid crystal sensor, approximately 1 mm in diameter, connected by a fiber optic system to external photoelectric measuring equipment. The use of scaling techniques is discussed in relation to problems associated with accurately evaluating energy absorption in whole bodies of large test subjects. Molecular and physical bases of tissue interactions with electromagnetic fields are discussed in light of studies on the physical characteristics of electromagnetic field interaction with molecular systems, atomic and molecular mechanisms underlying biologic interaction with electromagnetic radiation, and the possibilities of long- and short-range electric interactions of biologic systems. A formulation of possible modes of long-range interactions at membrane surfaces is presented that proposes conformational changes in proteins by mechanisms of coherence in ferroelectric sheets with associated limit cycles. Realistically specified in these models are the required triggering energies, ranges of transition temperatures, and frequencies of oscillation that would occur in systems physically structured in the fashion of the greater membrane. Observed tissue thresholds are consistent with predictions from these models, even for tissue gradients below  $10^{-7}$  V/cm.

6362 EFFECT OF THE MAGNETIC FIELD COMPONENT OF THE KRAUS-LECHNER METHOD ON THE HEALING OF EXPERIMENTAL NONUNIONS IN DOGS. (Eng.) Blumlein, H.; McDaniel, J.; Perren, S. M. In: *Electrical Stimulation of Bone Growth and Repair*. (New York: Springer Verlag): pp. 41-44; 1978. (8 refs)

The effect of the magnetic field component of the Kraus-Lechner method on the healing of twelve 6- to 10-mo-old experimental bilateral nonunions of the radii in six female beagles was investigated. The radii with the nonunions were placed into magnetic coils that produced a magnetic field of 30 G at a frequency of 22 Hz. The magnetic field treatment was given for a period of 5 hr/day, 5 days/wk, for 3 mo. The magnetic field lines ran parallel to the bone axis. X-rays, microradiographs, and histologic findings failed to demonstrate any effect of the alternating magnetic field on either vascularization or bone formation. During the 3-mo period of magnetic field application, two of the nonunions healed, one in a control group not subjected to the magnetic field and one in the magnetic field group.

6363 RADIOFREQUENCY RADIATION LEVELS AND POPULATION EXPOSURE IN URBAN AREAS OF THE EASTERN UNITED STATES. (Eng.) Athey, T. W.; Tell, R. A.; Hankin, N. N.; Lambdin, D. L.; Mantiply, E. D.; Janes, D. E. (Electromagnetic Radiation Analysis Branch, Office Radiation Programs, EPA, 9100 Rockville Rd., Silver Spring, MD 20910). 42 pp.; 1978. [available through National Technical Information Services, Springfield, VA 22161, Document No. EPA-520/2-77/008]. (19 refs)

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Measurements of nonionizing electromagnetic radiation levels were made at 193 sites in seven cities in the eastern United States. The cities were Atlanta, Boston, Chicago, Miami, New York, Philadelphia, and Washington, DC. The measurements were made in seven frequency bands between 0.01 and 900 MHz. The power density values ranged over five orders of magnitude from 0.0001 to 10  $\mu\text{W}/\text{cm}^2$ , with a median value of about 0.02  $\mu\text{W}/\text{cm}^2$ . The data show that frequency modulated (FM) radio and very high frequency (VHF) television transmitters are the most significant environmental sources of nonionizing radiation. A model for population exposure was applied to the seven areas where measurements were made, and the results show that about 98-99% of the people reside in areas where the levels are less than 1.0  $\mu\text{W}/\text{cm}^2$ . The median exposure level is about 0.01  $\mu\text{W}/\text{cm}^2$ . These levels are quite low compared to the American National Standards Institute and OSHA occupational exposure guides of 10,000  $\mu\text{W}/\text{cm}^2$ . Even the very restrictive environmental guideline of 1  $\mu\text{W}/\text{cm}^2$  proposed in the Soviet Union would be exceeded for only 1 or 2% of the population in these seven metropolitan areas; the actual levels of the latter exposures will have to be determined by examination on a case-by-case basis.

6364 FIFTH REPORT ON "PROGRAM FOR CONTROL OF ELECTROMAGNETIC POLLUTION OF THE ENVIRONMENT: THE ASSESSMENT OF BIOLOGICAL HAZARDS OF NON-IONIZING ELECTROMAGNETIC RADIATION." (Eng.) Anonymous. (NTIA, U.S. Dept. Commerce, 1800 G St., N.W., Washington, DC 20504). *NTIA Report 79-19* 266 pp.; 1979. (488 refs)

Activities of the Federal Government's cooperative multi-agency program to investigate and evaluate biologic effects of nonionizing electromagnetic radiation (0-300 GHz) are summarized. The report covers calendar years 1976, 1977, and early 1978 and includes information on research in progress during fiscal years 1977 and 1978. The primary thrust of the program is to determine whether exposures at low power density levels have an effect, particularly over extended periods of time and with reference to environments that might realistically be encountered by general and occupational populations. Government agency activities and program summaries are presented for HEW, EPA, the Department of Defense, NBS, NSF, the Federal Communications Commission, the Federal Aviation Administration, the Central Intelligence Agency, VA, and the Department of Energy. Additional information, including details of research projects and results of specific experiments, is covered in a variety of technical and conference reports and publications that are cited in the extensive appendix to this report.

6365 EFFECT OF MICROWAVES IN THE NONTHERMAL INTENSITY RANGE ON MICE: RESPIRATION, RECTAL TEMPERATURE, AND MENTAL REACTION. (Swe.)

Criborn, C. O. (Huvudavdelning 5, Forsvarets Forskningsanstalt, 104 50 Stockholm 80, Sweden). 23 pp.; 1978. [available through FOA Rep C 54021-H2, H6]. (7 refs)

The effects of 30-min exposure to microwaves of frequency 2,450 MHz and intensity 10  $\text{mW}/\text{cm}^2$  on the rectal temperature, respiration (minute volume), and reaction to sound (8 kHz, 3-sec pulses, 12 pulses/min) were studied in male CBA mice. No changes in the rectal temperatures of the test animals were observed compared with controls for at least 4 hr after irradiation. The respiratory minute volume increased significantly during the first 15 min of exposure, after which it decreased significantly, reaching its lowest level about 15 min after exposure. Respiration normalized within the first hour after exposure. Irradiation caused a considerable reduction of the sound reaction (reduction of the respiratory minute volume in response to the sound) between 5 and 30 min of the exposure, but the reaction normalized within 30 min after exposure.

6366 MICROWAVES--NEW TOOLS FOR THE MEDIC? (Eng.) Anonymous. (Office of Naval Res. Branch Office, London, England). pp. 27-29; 1979. [available through European Scientific Notes, ONRL Report No. ESN 33-1]. (0 refs)

Research on the diagnostic and therapeutic use of microwaves in cancer therapy is reviewed. Microwave radiometry is being investigated for the detection of tumors. In experiments employing 1.3-, 3.3-, and 6.0-GHz body radiometry, carefully matched waveguide antennas loaded with dielectric were directly placed on the skin of patients. Bandwidths used varied from around 100 to 500 MHz. Excess temperature differences sensed with this tumor detection technique varied from 0 to 4 C. To date, over 4,000 women in a breast cancer detection unit have been examined using this method, and true positive and true negative rates of 70% have been achieved. When infrared mapping was combined with microwave radiometry, the true positive rate increased to 90%. Microwaves are also being used in the hyperthermic treatment of tumors. Prostate tumors have been successfully treated by hyperthermia induced by microwaves from a coaxial probe inserted in the rectum. In other experiments, 433.9-MHz hyperthermia has been combined with megavoltage x-ray treatment in patients with radio-resistant malignant tumors. In these experiments, the tumor temperature was raised to 42 C during irradiation. Favorable responses without noticeable side-effects were observed among 72% of more than 40 patients treated in this manner.

6367 A REVIEW OF MICROWAVE OVEN SAFETY. (Eng.) Osepchuk, J. M. (Raytheon Res. Div., Waltham, MA). *Microwave J* 22(5): 25, 26, 28, 29, 32-37; 1979. (32 refs)

See Current Literature 5784 for description of this article.

- 6368 KEYNOTE ADDRESS AND C. C. JOHNSON MEMORIAL LECTURE. MICROWAVE BIOEFFECTS RESEARCH: HISTORICAL PERSPECTIVES ON PRODUCTIVE APPROACHES. (Eng.) Schwan, H. P. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 1-13; 1978. (0 refs)

The historic development of microwave bioeffects research is reviewed, and a rationale for standards of safe exposure is presented. Biomedical experimental evidence supports the conclusion that significant thermal effects appear somewhere above  $10 \text{ mW/cm}^2$  for man and probably in the  $1\text{-}10 \text{ mW/cm}^2$  range for smaller animals. Over the last 40 yr, no evidence has been discovered that suggests any scientific principles that may be useful in formulating nonthermal standards of exposure. However, it appears that the present exposure standard of  $10 \text{ mW/cm}^2$  in the United States may no longer provide a safety factor of about 10 as originally thought, particularly in light of the resonance effect for man near 100 MHz and the specific absorption rate figures and calculated temperatures in hot spots at 1-2 GHz. On the other hand, it can be argued that at low frequencies the magnetic field contribution is significant, giving preference to surface heating and thus favoring a situation similar to the one above 3 GHz where the effective heating penetration depth is independent of frequency. It has been established that hot spot types of heating patterns appear significant only in the frequency range of 500 MHz to 2 GHz. Taking these data into consideration, it is suggested that the safe standard of  $10 \text{ mW/cm}^2$  for microwave exposure may be lowered between frequencies of 0.3 and 3 GHz, but it may be retained at  $10 \text{ mW/cm}^2$  for frequencies above 3 GHz; as the frequency decreases below 30 MHz, the standard may be drastically relaxed.

- 6369 THE EFFECTS OF LOW POWER DENSITY MICROWAVES ON RAT HYPOTHALAMIC TEMPERATURES. (Eng.) Brainard, G.; Albert, E.; DeSantis, M.; Postow, E.; Parker, J. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 14-31; 1978. (25 refs)

Thermistor measurements of the temperature response of the hypothalamus to 2,800-MHz pulsed microwaves were performed in unanesthetized male Long Evans Hooded rats to determine if neurocytologic and blood-brain barrier effects caused by microwaves are due to associated temperature increases. The microwave signal was pulsed 500 times/sec with a 2- $\mu\text{sec}$  pulse width. The rats were exposed to 0, 5, 10, and  $15 \text{ mW/cm}^2$  power densities for periods ranging from 10-60 min. In control animals, brains showed a slight net temperature decrease during recording ( $-0.17 \text{ C}$ ), whereas in rats exposed to  $5 \text{ mW/cm}^2$ ,  $10 \text{ mW/cm}^2$ , or  $15 \text{ mW/cm}^2$  of pulsed microwaves, there were net increases of  $+0.25$ ,  $+0.65$ , and  $+0.85 \text{ C}$ , respectively. These values demon-

strate a nearly linear relationship between increasing power density and increasing hypothalamic temperatures. In no case was a microwave-induced temperature increase greater than  $1.2 \text{ C}$  observed. Thus, it appears unlikely that the increased permeability of the blood-brain barrier due to low power density microwaves is a result of increased temperature in a macroscopic sense. However, the results presented here do not rule out the possibility that the nonuniform deposition of energy could produce a significant heating at other foci in the rat brain or perhaps at the cell membrane or molecular level.

- 6370 ENDOCRINE FUNCTION IN RHESUS MONKEYS EXPOSED TO PULSED MICROWAVE RADIATION. (Eng.) Lotz, W. G. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 32-51; 1978. (21 refs)

Endocrine function was studied in three adult male rhesus monkeys exposed to 1.29-GHz pulsed microwaves (pulse width 3  $\mu\text{sec}$ , duty cycle 0.001) at a power density of  $20 \text{ mW/cm}^2$ . Hormone levels in sequential blood samples obtained via chronic indwelling jugular catheters were determined. Over a 24-hr period, hourly samples were taken from monkeys restrained in a foamed polystyrene chair before, during, and after an 8-hr exposure to the pulsed microwave radiation. The animals were exposed to far-field conditions in an anechoic chamber. A small, delayed, and transitory depression of circulating thyroxine levels was the only effect on endocrine function produced by microwave exposure. Rectal temperature was elevated an average of  $0.6 \pm 0.1 \text{ C}$  during the exposure. No differences were noted between plasma levels of cortisol or growth hormone during exposure sessions as compared with sham-exposed sessions. These data support the hypothesis that microwave exposure causes a drop in pituitary secretion of thyrotropin that results in a subsequent decline in circulating thyroxine levels.

- 6371 EFFECTS OF MODULATED RF ENERGY ON THE EEG OF MAMMALIAN BRAINS. II. APPEARANCE OF FAST AND SLOW WAVES AFTER CHRONIC IRRADIATIONS. (Eng.) Takashima, S.; Onaral, B.; Schwan, H. P. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 52-75; 1978. (28 refs)

The effects of acute and chronic irradiation with modulated radio frequency (RF) energy on the electroencephalograms (EEG) of rabbit brains were investigated. The frequency of the RF fields ranged from 1 to 10 MHz with two modulation frequencies at 14-16 Hz and 60 Hz. Two large aluminum plates (30 by 30  $\text{cm}^2$ ) were used for the application of the RF fields at a distance of 20 cm. The rabbits

were exposed at field strengths ranging from 60 to 500 V/m for 2-3 hr during acute experiments and for 4-6 wk during chronic experiments. Sequential displays of EEG power spectra were used to analyze the EEG signals. Acute irradiation at a level of 500 V/m did not produce significant changes in the EEG power spectra if the use of intracranial metal electrodes was avoided. Chronic exposures at levels up to about 70 V/m also did not produce any appreciable effects on the EEG patterns. However, at intensities of 80-100 V/m, RF fields (modulated with 14 Hz) stimulated high frequency neuron activities at 10-20 Hz, while chronic irradiation at a level of 500 V/m enhanced low frequency waves (4-5 Hz). These two effects seemed to be competitive in that an increase in low frequency components was usually coupled with the suppression of high frequency activities and vice versa. These changes were reversible, with the EEG returning to normal within several days after irradiation was discontinued.

- 6372 EFFECTS OF 8.6-GHZ PULSED ELECTROMAGNETIC RADIATION ON AN *ESCHERICHIA COLI* REPAIR-DEFICIENT MUTANT. (Eng.) Dutta, S. K.; Hossain, M. A.; Ho, H. S.; Blackman, C. F. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 76-95; 1978. (12 refs)

The effects of pulsed microwave radiation on the growth of *Escherichia coli* strains Pol A<sup>+</sup> (normal) and Pol A<sup>-</sup> (repair deficient mutant) were studied at a controlled temperature of 37 ± 0.1 C in a waveguide exposure system using 8.6-GHz radiation pulsed at a repetition rate of 1 kHz with a pulse width of 1 µsec. The average specific absorption rate of the samples was 12 W/kg, and the samples were exposed for periods of 1, 2, 4, or 7 hr. In one set of experiments, the effects of microwave radiations on actively growing (log phase) *E. coli* strains Pol A<sup>+</sup> and Pol A<sup>-</sup> were investigated, while in another experiment the effects of microwaves on quiescent cells maintained in a non-nutritive salt solution were studied. No significant cellular damage was detected in either experiment at the 95% confidence limit. However, a trend towards microwave-induced growth for actively growing (log phase) *E. coli* Pol A<sup>-</sup> cells was observed at the 90% confidence level.

- 6373 TECHNIQUES FOR PRODUCING STANDARD EM FIELDS FROM 10 KHZ TO 10 GHZ FOR EVALUATING RADIATION MONITORS. (Eng.) Larsen, E. B. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 96-112; 1978. (18 refs)

Techniques used by the NBS for producing standard electromagnetic fields from 10 kHz to 10 GHz are

reviewed. The general approach used for evaluating and calibrating radio frequency radiation monitors is to generate a calculable or standard field and then immerse the probe of the monitor being tested in this known field. The optimum type of field-generating instrumentation depends on the frequency band and desired accuracy. A convenient device at frequencies from 10 kHz to 300 MHz is a rectangular coaxial transmission line known as a transverse electromagnetic mode (TEM) cell. In the frequency range of 300-1,000 MHz, a series of rectangular waveguide transmission lines can be used to generate a field with approximately known intensity. Also, in the frequency range of 100-500 MHz, high-level fields extending over a larger volume can be produced at an outdoor field site in the near zone of open-end waveguide radiators. Calibrating fields between 500 MHz and 10 GHz are produced in an anechoic chamber by a series of standard-gain pyramidal horns. In all of the above cases, it is possible to calculate the electric and magnetic field strengths (and equivalent free-space power density) in terms of the measured power flow through the cell or waveguide or the power delivered to the open-end waveguide or horn antenna. It is concluded that radiation monitors (and other antennas) can be easily calibrated over the entire frequency range of 10 kHz to 10 GHz with an uncertainty of less than ±0.5 decibels. It is possible to produce high-level fields greater than 200 V/m using only low-power radio frequency sources (less than 50 W).

- 6374 TEMPERATURE CONTROLLED CAVITY APPLICATOR FOR RADIO-FREQUENCY WAVE IRRADIATION OF MAMMALIAN CELLS IN VITRO. (Eng.) McEuen, A.; Tanabe, E.; Vaguine, V.; Williams, N.; Li, G. C.; Hahn, G. M. (Radiation Div., Varian Associates, Palo Alto, CA 94303). In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 113-121; 1978. (5 refs)

A cylindrical re-entrant radio frequency (RF) cavity applicator for measuring thermal and nonthermal effects of RF power on an in vitro cell system under controlled temperature conditions is described. The applicator operates over a frequency range of 400-1,000 MHz and is capable of producing absorbed RF power densities up to 180 W/cm<sup>3</sup> in a biologic sample. The cavity is designed to produce a uniform electric field concentrated in the sample between two copper discs. The variation in field strength is about 1% over an area 3 cm in diameter for a 1 mm gap. Typically the sample is 1.6 cm in diameter, and the gap is 0.2 mm. Two separate loops of circulating temperature stabilizing liquid permit independent temperature control of the top and bottom disc-sample interfaces. The temperatures of the top and bottom surfaces of the sample are measured by two thermocouples that are embedded in the copper discs and are located at positions 1 mm from the sample-disc interfaces. The temperature distribution within the sample and sample holder can be obtained by

solving the heat transfer equation. The above system offers several advantages over previously published methods with respect to absorbed power density, field uniformity, accuracy of temperature control and measurement, and efficiency.

6375 EVALUATION OF LYMPHOCYTE FUNCTION IN MICE EXPOSED TO 2450 MHz (CW) MICROWAVES.

(Eng.) Smialowicz, R. J.; Riddle, M. M.; Brugnotti, P. L.; Sperrazza, J. M.; Kinn, J. B. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 122-152; 1978. (24 refs)

Female BALB/c mice were exposed under far field conditions in a temperature- and humidity-controlled environment to 2,450-MHz continuous wave microwaves to investigate possible effects on hematology and lymphocyte function. Exposures were performed at power densities ranging from 5 to 35 mW/cm<sup>2</sup> for periods of 15 or 30 min daily for 1, 4, 6, 8, or 22 consecutive days. Specific absorption rates, determined by twin-well calorimetry, ranged from approximately 4 to 25 mW/g depending on the incident power density. Hematologic variables including complete blood counts were compared between sham and exposed groups. Several techniques were used to assess both cellular and humoral immunocompetence of the exposed mice. Thymus (T)- and bone marrow (B)-derived lymphocyte function was assessed using the in vitro mitogen-stimulated response. Surface receptor assays were used to enumerate T- and B-lymphocytes in the spleens of microwave- and sham-exposed mice. B-lymphocytes were identified using the complement receptor assay, and T-lymphocytes were identified using cytotoxic antisera against the theta surface marker. The antibody response of microwave- and sham-exposed mice to the T-dependent antigen of sheep erythrocytes was measured by the direct plaque-forming cell assay. Colon temperatures were taken prior to and immediately after exposure to assess the possible heat load that exposed animals might experience at different power densities. No physiologically significant increases in colon temperatures were observed in mice irradiated at any of the power densities employed. Exposure of mice to 2,450-MHz microwaves caused no consistent significant alterations in any of the hematologic or immunologic parameters examined.

6376 RADIOFREQUENCY RADIATION ALTERS THE IMMUNE SYSTEM: MODULATION OF IN VIVO LYMPHOCYTE MIGRATION BY WHOLE-BODY HYPERTHERMIC RADIATION. (Eng.) Liburdy, R. P. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 153-174; 1978. (20 refs)

See Current Literature 6177 for description of this article.

6377 ACCELERATION AND DECELERATION OF FETAL GROWTH OF RATS BY 2450-MHz MICROWAVE IRRADIATION. (Eng.) Chernovetz, M. E.; Justesen, D. R.; Levinson, D. M. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 175-193; 1978. (11 refs)

The effect of electrically modulated 2,450-MHz microwave irradiation on fetal growth and development in the rat was investigated. Primigravid albino Sprague-Dawley rats were exposed in a multi-mode cavity for 20 min at average whole-body dose rates of 14 or 28 mW/g to 2,450-MHz microwaves electrically modulated as a bottom-clipped half-wave sinusoid at 60 Hz. On days 8, 10, 12, or 14 of gestation, 48 unrestrained rats were irradiated in pairs. An additional 24 rats were either sham exposed or were maintained as passive controls. Fetuses were delivered by Caesarean section on day 18 of gestation. No gross structural abnormalities were observed as a result of microwave irradiation. However, 330/540 nonresorbed fetuses presented hemorrhagic signs. The number of fetuses with hemorrhages was not associated with the day of gestation, type of treatment, or the interaction of gestational day and type of treatment. Fetal mass was significantly affected by microwave irradiation, but the degree as well as the direction of the effect was dependent on the interaction between the level of energy dosing and the day of gestation during which exposure occurred. Irradiation at the 28 mW/g level on day 8 of gestation resulted in smaller fetal mass, while similar dosing on day 12 or 14 of gestation resulted in larger fetal mass. In contrast, fetal mass was smaller in animals that received 14 mW/g of radiation on day 12 or 14 of gestation. Exposure to 14 mW/g of microwave radiation on day 8 or 10 resulted in no significant difference in fetal mass.

6378 SHUTTLEBOX SIDE PREFERENCE AS MEDIATED BY PULSED MICROWAVE AND CONVENTIONAL AUDITORY CUES. (Eng.) Hjeresen, D. L.; Doctor, S. R.; Sheldon, R. L. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 194-214; 1978. (18 refs)

Rats were exposed in an anechoic chamber to the far field of a 2.88-GHz pulsed microwave beam to test the possibility that preference for the shielded side of a two-compartment shuttlebox as well as increased activity responses are due to audition of the pulsed microwaves rather than to some other aspect of the exposure. The characteristics of the 2.88-GHz microwave beam were as follows: average power density, 9.5 mW/cm<sup>2</sup>; peak power density, 33 W/cm<sup>2</sup>; pulse repetition rate, 100 pulses/sec; pulse width, 3.0  $\mu$ sec; average energy/pulse, 100  $\mu$ J/cm<sup>2</sup>; and absorbed dose rate, 2.1 W/kg. In one

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experiment, a 37.5-kHz tone was substituted for microwave exposure during one of nine test sessions. In a second experiment, microwave audition was masked by pink noise with a suppressed spectrum below 20 kHz, a 60 dB/octave rise from 20 to 40 kHz, and a slow roll-off (11 dB/octave) above 45 kHz. In the first experiment, both microwave audition and exposure to 37.5-kHz tone caused the rats to show an increased preference for the shielded side of a two-compartment shuttle box; side-to-side traverse activity was also increased by both microwave exposure and exposure to the 37.5-kHz tone. In the second experiment, in which microwave audition was masked, no preference for the shielded side of the shuttle box was observed in microwave-irradiated rats; however, the number of traverses made by rats progressively increased with repeated exposures. It appears that while audition of pulsed microwaves may be responsible for the side preference effect, the increased traverse activity among continuously exposed rats may be due to accumulated heat load or an as yet undefined motivating factor.

6379 DISRUPTION OF BEHAVIOR IN MAMMALS OF THREE DIFFERENT SIZES EXPOSED TO MICROWAVES: EXTRAPOLATION TO LARGER MAMMALS. (Eng.) de Lorge, J. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 215-228; 1978. (9 refs)

In three separate studies, four albino rats, three squirrel monkeys, and three rhesus monkeys were exposed to 2.45-GHz microwave irradiation (100% amplitude modulated at 120 Hz) under far field conditions in anechoic chambers to examine the effect of microwaves on the disruption of behavior in mammals of three distinctly different body masses. All animals were performing on operant schedules for food reinforcement during microwave irradiation. Rats worked unrestrained in a response chamber of Styrofoam, while monkeys worked restrained in Styrofoam chairs. Rectal temperature was measured continuously during exposures of the monkeys and immediately after exposures in rats. Exposure sessions lasted 60 min and were usually scheduled during the 5-day work week. The typical result of microwave exposure was a decrement in response rate and an increment in the pause time following a reinforcement. The threshold for disruption of lever responding was 28 mW/cm<sup>2</sup> in rats, 45 mW/cm<sup>2</sup> in squirrel monkeys, and 67 mW/cm<sup>2</sup> in rhesus monkeys. When these thresholds were plotted as a function of body mass (0.3, 0.7, and 5 kg, respectively), a semilog relationship was observed. In addition, power densities associated with behavioral disruption approximated those power densities that produced an increase in rectal temperatures of at least 1°C above control levels. Hence, disruption of behavior may have been caused more by the greater heat load than by any direct action of microwaves on the central nervous system. It

is concluded that scales based on dependent variables other than absorbed energy (or rate of temperature increase) might be more useful for predicting actual effects of exposure to microwave irradiation.

6380 MONITORING OF ARTERIAL WALL MOVEMENT BY MICROWAVE DOPPLER RADAR. (Eng.) Stuchly, S. S.; Goldberg, M.; Thransandote, A.; Carraro, B. (Dept. Electrical Engineering, Univ. Ottawa, Ottawa, Ontario K1N 6N5, Canada). In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 229-242; 1978. (8 refs)

The application of continuous wave microwave Doppler radar for monitoring arterial wall movements is reported. The technique is based on the measurement of the frequency and amplitude of the microwave signal back scattered (reflected) by the arterial wall. The feasibility of this technique was verified by using a low power Doppler transceiver operating at a frequency of 10.525 GHz during several experiments with humans. An open-ended dielectric loaded rectangular waveguide was used as an antenna. The dimensions of the radiating aperture were 10.7 by 4.3 mm, and the dielectric constant of the material filling the waveguide was 5. The input reflection coefficient of the antenna facing the skin was lower than 23 dB (voltage standing wave ratio of less than 1.7). The experiments were performed by placing the radiating aperture directly in contact with the skin over different peripheral arteries. The results indicate that clear, low noise Doppler responses from different peripheral arteries can be obtained. The output signal provides information about the relative movement of the artery during the heart cycle. Although absolute calibration is not possible at this time, it seems that viable diagnostic information can be obtained by comparing the responses from two sides of the body, particularly the limbs, as well as from the relative pattern of the response. The data provided by this technique should generate valuable diagnostic information in the determination of stress-strain characteristics of peripheral arteries.

6381 THERMOGRAPHIC COMPARISON OF TEMPERATURE PROBES USED IN MICROWAVE DOSIMETRY STUDIES. (Eng.) Olsen, R. G.; Hammer, W. C. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 243-270; 1978. (12 refs)

A muscle-equivalent test sphere was used to compare the accuracy and perturbation characteristics

of five readily available temperature probes with thermographic results at two microwave frequencies, 1.7 and 5.95 GHz. The temperature probes were implanted in the sphere that was thermographically analyzed after irradiation for orthogonal probe orientations. The temperature probes tested were the following: a common rectal-type thermistor; a fine-wire, copper-constantan thermocouple; a simple nonmetallic thermocouple; a liquid crystal optical fiber probe; and a prototype four-lead high-resistance thermistor. At 1.7 GHz, thermographic results showed distortion of the internal microwave absorption for probes with either metallic or highly conducting leads. However, the quantitative results at 1.7 GHz showed that all probe-determined specific absorption rate (SAR) data were consistent with thermographically derived SAR data. At 5.95 GHz, the consistency between probe-determined SAR data and thermographically derived SAR data was not as good. In general, wide variations with a rather poor correlation to probe results were seen in the thermographic SARs. Most of the problems contributing to the disparities seen in the 5.95 GHz data concerned technique or physical inadequacy. Implicit in the wide variations for the 5.95 GHz data is the fact that accurate microwave dosimetry becomes more difficult at higher frequencies. At such frequencies, the probes are not as small relative to wavelength; moreover, hot spots or hot regions are formed over smaller areas, making probe size and exact placement more critical.

- 6382 TEMPERATURE PROFILES IN SPHERES DUE TO ELECTROMAGNETIC HEATING. (Eng.) Kritikos, H. N.; Foster, K. R.; Schwan, H. P. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 271-303; 1978. (30 refs)

Theoretical estimates of the temperature rise produced in tissue spheres by microwave irradiation are presented. The results are discussed for the three chief frequency ranges of the microwave absorption properties of the head. For the low frequency or Rayleigh region (<500 MHz for head radii <10 cm), head heating is characterized by electric and magnetic dipole terms. For large spheres (radius of about 10 cm), the magnetic dipole term dominates, and the steady state temperature pattern shows a maximum occurring near the front surface of the sphere; the maximum increase in tissue temperature is <0.03 C for 10 mW/cm<sup>2</sup> incident intensity, with a much lesser temperature increase in the core of the brain. For smaller spheres (5 cm radius), the electric dipole term dominates and the heating pattern is more uniform; the increase in tissue temperature is negligible everywhere. In this low frequency range, significant heating of the entire body occurs, but the purely local model used in this study cannot be used to pinpoint thermal damage in the body. In the res-

onance region (1 GHz for the human head) for spheres with radii of about 5 cm, the absorbed energy is focused in a hot spot near the center with a radius of approximately 1 cm. For a 5-cm radius tissue sphere exposed to an incident field of 10 mW/cm<sup>2</sup> at 1 GHz, the maximum increase in tissue temperature of about 0.6 C occurs in the center of the head. In the high frequency region (greater than 5 GHz), heating occurs only at the front and side surfaces of the sphere, and the calculated temperature increases are similar to those found in a semi-infinite tissue plane irradiated by plane wave energy. Because of thermal conductivity and blood perfusion, the effective heating depth of the energy is about 1 cm, even though the microwave energy might be absorbed much nearer to the surface. For an incident field of 10 mW/cm<sup>2</sup> intensity, the maximum tissue temperature rise is about 0.3 C and is located near the front surface of the tissue.

- 6383 APPROXIMATE CALCULATION OF SAR FOR PLANE-WAVE IRRADIATION OF MAN MODEL NEAR A GROUND PLANE. (Eng.) Iskander, M. F.; Durney, C. H.; Massoudi, H.; Johnson, C. C. In: *Proceedings of the 1978 Symposium on Electromagnetic Fields in Biological Systems held in Ottawa, Canada, June 27-30, 1978*. IMPI and IEEE-Microwave Theory and Techniques Society. (Edmonton, Alberta, Canada): pp. 304-323; 1978. (9 refs)

An approximate analysis for calculating the average specific absorption rate (SAR) of a model of man irradiated near or on a ground plane is presented. The analysis involves two approaches. One approach is based on the equivalent circuit of a receiving antenna. The antenna internal impedance is approximated by the internal impedance of a finite cylinder, while the radiation impedance is calculated by extrapolating available data for a cylindrical antenna. The other approach involves a combination of circuit theory and a curve fitting procedure. A simple series circuit (resistance, conductance, capacitance) is used, with the circuit elements being calculated by curve fitting the available theoretical data for a man in direct contact with the ground plane. In both cases, the introduction of a separation between the feet of the man and the earth (e.g., due to a rubber sole or shoe) is taken into account by introducing a lossy capacitor in the equivalent circuit. Numerical results show that the ground plane effect on the average SAR values is basically important at lower frequencies. For example, at 10 MHz, the average SAR of a man on a ground plane is an order of magnitude larger than its value for the free-space irradiation at the same frequency. This order of magnitude ratio decreases to a factor of 3 at 50 MHz. Furthermore, the ground plane effect decreases rapidly with increasing gap distance. Thus, even for the worst case of a barefoot man placed at a distance from a wet earth, a distance of 7.5 cm is sufficient to restore the conditions of free-space irradiation.

## MEETING ABSTRACTS

- 6384 MICROWAVE LEAKAGE DURING PATIENT TREATMENT (MEETING ABSTRACT). (Eng.) Kopecky, W. J. (Div. Radiation Oncology, Mallinckrodt Inst. Radiology, Washington Univ. Sch. Medicine, St. Louis, MO 63110); Perez, C. A. *Med Phys* 6(4): 353; 1979. (0 refs)

In response to the proposed BRH draft standard for a maximum microwave radiation leakage of 5 mW/cm<sup>2</sup> at 5 cm from the source, measurements of leakage radiation during hyperthermic treatment of patients with two different applicators operating at 915 MHz were made at the Mallinckrodt Institute of Radiology. Some treatments, involving the head and neck region, give rise to large air gaps between the patient surface and applicator, while other treatment sites, including the limbs, present a curved surface. A comparison of these data with data obtained using tissue equivalent phantoms will be presented.

- 6385 EFFECTS OF FOUR NITROSOUREAS WITH LOCAL HYPERTHERMIA ON PRIMARY TUMOR AND LUNG METASTASES (MEETING ABSTRACT). (Eng.) Marmor, J. B. (Dept. Radiology, Stanford Medical Center, Stanford, CA 94305); Mahn, G. M. *Proc Am Assoc Cancer Res* 20: 67; 1979. (0 refs)

The effects of local radio frequency (RF) hyperthermia in combination with four different nitrosoureas on primary tumor development and lung metastases were examined in C3H mice bearing KHT flank tumors. The nitrosoureas were given intraperitoneally, and the flank tumors were locally heated to 42-43 C. Local heat with 1,3-bis(2-chloroethyl)-1-nitrosourea was superior to either modality alone or to both given 24 hr apart (5/40 cures versus 0/40 cures; median growth delay 30 days versus 13 days). In addition, combined therapy was more effective in controlling lung metastases than was chemotherapy alone or chemotherapy plus heat given 24 hr apart (32/47 lungs negative versus 3/38 lungs negative). The effects of chlorozotocin on both primary tumor growth and lung metastases were also markedly potentiated by RF hyperthermia. The effects of 1-(2-chloroethyl)-3-[*trans*-4-methylcyclohexyl]-1-nitrosourea were only slightly enhanced by simul-

taneous local RF heating. The effects of streptozotocin were not enhanced by RF heating. These findings suggest that local RF heating of tumor masses may increase the effectiveness of some, but not all, nitrosoureas and that hyperthermia does not increase the incidence of metastases as suggested by some studies.

- 6386 EFFECT OF MAGNETIC FIELDS ON CHROMOSOMES (MEETING ABSTRACT). (Ger.) Eberle, P. (Fach Humangenetik und Cytogenetik, Technische Universität Braunschweig, Gausstrasse 17, D-3300 Braunschweig, W. Germany); May, C. *Hoppe Seylers Z Physiol Chem* 360(3): 252; 1979. (0 refs)

The effects of 15-min to several-hour exposures of static and homogeneous magnetic fields of 10,000 to 140,000 G on mitotic processes in human blood cultures and in fibroblast cultures (Chinese hamster Vt 79 and human embryonal lung) were studied by light microscopy. The disturbances observed in the mitotic processes included the migration of the chromosomes into the equatorial plane, the migration of the daughter chromosomes to the spindle pole, and multipolar chromosome arrangements. The frequency of chromosome and chromatid mutations did not appear to be significantly affected by the exposure. The disturbances in the mitotic processes observed after the application of magnetic fields may result from interference with the synthesizing processes in the chromosomes, nuclear membranes, and tubular structures of the spindle apparatus. Shifts in the enzyme activities and changes in the orientation of biologically important macromolecules may also play a role.

- 6387 TOLERABLE EXTENT OF MICROWAVE-INDUCED HYPERTHERMIA IN NORMAL AND 5-HTP-TREATED MICE (MEETING ABSTRACT). (Eng.) Nishimoto, Y. (Aichi Cancer Center, Nagoya, Japan); Nakamura, W. *J Radiat Res (Tokyo)* 20(1): 28; 1979. (0 refs)

The effect of 5-hydroxytryptophan (5-HTP) on the tolerance of mice to 2,450-MHz microwave-induced hyperthermia was investigated. In normal mice, the anal temperature for 100% tolerable instantaneous hyperthermia was 43 C. However, when mice were injected intraperitoneally with either 0.1 or 0.4 mg/g of 5-HTP 40 min prior to irradiation, the anal temperature for 100% tolerable hyperthermia dropped to 42 and 40 C, respectively.

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