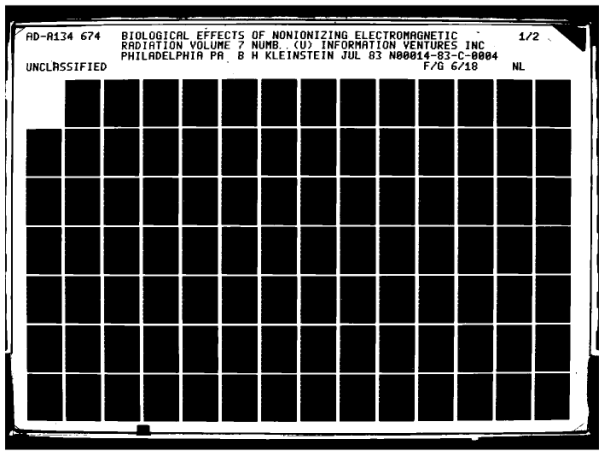
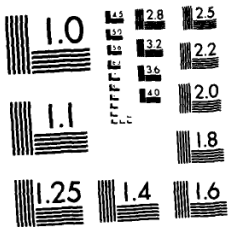

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Biological Effects of Nonionizing Electromagnetic Radiation

Volume VII, Number 2-4
(July Thru December 1982)

July 1983

A Digest of Current Literature

A Quarterly Publication Produced for
Office of Naval Research

INFORMATION VENTURES, INC.

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Biological Effects
of Nonionizing Electromagnetic Radiation

A Digest of Current Literature

A Quarterly Publication Produced for
Office of Naval Research

Literature Selected and Abstracted
by
Information Ventures, Inc.
1500 Locust Street
Philadelphia, Pa 19102

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

The views and conclusions contained in this documentation are those of the author and should not be interpreted as necessarily representing the officials policies, either expressed or implied, of the Office of Naval Research.

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The literature digest contains original abstracts of English and foreign-language research literature, current research su-maries, news items and announcements and information on relevant meetings and conferences. Subject and author indices are provided for all literature abstracts. Original abstracts are prepared based on data presented in the text, tables, and

#20.

density, specific absorption rate, drugs or other stimuli, exposure duration and regime, and end point are included in each abstract.

Biological Effects of Nonionizing Electromagnetic Radiation

July, 1983 Volume VII, Number 2-4

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Preface

Biological Effects of Nonionizing Electromagnetic Radiation is a publication researched and prepared by Information Ventures, Inc. under contract to the Office of Naval Research.

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) is compiled, condensed, and disseminated on a regular basis. The effects of electric and magnetic fields (static and alternating) and research on medical applications of these nonionizing electromagnetic radiations are also included.

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 VII and future volumes will include materials received during the preceding three months. Each issue contains abstracts of current English and foreign-language research literature, current research summaries, news items and announcements, and information on relevant meetings and conferences. Subject and author indices are provided for all literature abstracts to facilitate specific search and reference use. Journals, books and conference proceedings are used as sources for this publication. Materials for which full text is not available will be included as summary abstracts. Announcements and other materials submitted for publication should be addressed to: Dr. Bruce H. Kleinstein, Information Ventures, Inc., 1500 Locust Street, Philadelphia, PA 19102.

The digest was first published in 1974 under the title "Biological Effects of Electromagnetic Radiation." Since 1976 it has been published under the present title. Previous issues can be obtained from the National Technical Information Service.

Abbreviations and Acronyms

A - amp, ampere
ANSI - American National Standards Institute
C - centigrade
cm - centimeter(s)
cps - cycles per second
dB - decibel(s)
EPA - Environmental Protection Agency
eV - electron volt
F - fahrenheit
FAA - Federal Aviation Administration
FDA - Food and Drug Administration
g - gram(s)
G - gauss
GHz - gigahertz
HHS - Department of Health and Human Services
hr - hour(s)
Hz - hertz
ip - intraperitoneal
ISM - industrial, scientific, medical
IU - international unit(s)
iv - intravenous
J - joule(s)
k - kilo-
l - liter(s)
m - meter(s)
m - milli-
M - mega-
u - micro-
min - minute(s)
mo - month(s)
n - nano-
NIH - National Institutes of Health
NIOSH - National Institute for Occupational Safety and Health
NTIS - National Technical Information Service
Oe - oersted(s)
OSHA - Occupational Safety and Health Administration
rad - radiation absorbed dose(s)
R - roentgen(s)
rpm - revolutions per minute
sec - second(s)
sc - subcutaneous
V - volts
VA - Veterans Adminstration
W - watt(s)
WHO - World Health Organization
wk - week(s)
wt - weight
x - times
yr - year(s)

NEWS ITEMS

TERMINAL TEDIUM: CERTAIN CLERKS ARE DENOUNCING THEIR COMPUTERS

(J. Andrew, The Wall Street Journal, May 6, 1983) Workers in automated offices are frequently bothered by backaches and headaches from sitting in front of a terminal for long hours. Such physical complaints seem to be caused by a combination of improper lighting, uncomfortable seating arrangements and insufficient rest periods. Also at issue is whether microwave radiation emitted by the cathode-ray tubes inside terminals might cause illnesses - cancer and cataracts in particular. The tubes generally emit less radiation than television sets, but one sits closer to them. Studies so far have failed to establish any health hazard, although VDTs haven't been in general use long enough for health issues to be resolved conclusively. At least two states, Maine and Massachusetts, are considering legislation addressing some of the health concerns about video display terminals. The proposals would require, among other things, regular inspection of terminals, free eye examinations for frequent users and certain rest breaks during the working day. Rep. Edith Bouillier, the sponsor of the Maine legislation, predicts further controversy over the health effects of video display terminal usage. She believes that in four or five years it will become a workers' compensation issue.

BOOK REVIEW: Environmental Health Criteria 16: Radiofrequency and Microwaves. World Health Organization, Geneva, 1981.

A critical review of this document (see abstract 0066 of BENER Digest vol 6, number 1) is presented. The reviewer comments that the publication is rather unbalanced and does not come up to the high scientific calaber and accuracy of the usual WHO publications.
S. M. Michaelson, Radiat Res, 92:217-219, 1982

TWO SICKLE-CELL RESEARCHERS STUDY ELECTRICAL TECHNIQUE

(L. Herskowitz, Philadelphia Inquirer, May 3, 1983) Researchers at Children's Hospital of Philadelphia and the University of Pennsylvania have developed the first nonchemical approach to treating sickle-cell anemia. The technique uses very short, pulsing electrical charges to alter the shape and consistency of sickle-shaped red blood cells. The technique was reported in the April 22 issue of Science magazine by Dr. Toshio Asakura, a member of the Children's Hospital department of pediatrics and of Penn's departments of biochemistry and biophysics and by Dr. Shiro Takashima, a member of Penn's department of bioengineering and its school of engineering and applied science. To apply electricity to the cells, the researchers attached small electrodes to each side microscope slide that held blood taken from pe with sickle-cell disease. Once a second, a s generator delivered a 200-volt electrical pulse l ing one-thousandth of a second. After three or minutes, the sickle-cell's shape changes to a no round shape. The researchers believe that the e trical field punches holes in the red blood ce membranes allowing water molecules to seep into cells and puff them up. They also say there is liminary evidence that the treatment partially verses the aggregation of the hemoglobin inside cell. The researchers say it is not clear whe the technique will work on humans. The body may be able to withstand the very large voltage requ to treat large amounts of blood. Further, the e trical field may cause irreversible swelling or e tually lead to hemolysis.

CATTLE SEEM UNAFFECTED BY HIGH-VOLTAGE POWER

(K.M. Reese, C&EN News, January 3, 1983) A study of dairy cattle living near a high-vol power line in Minnesota showed no significant eff on milk production and reproduction. The 400, volt line cuts across 180 miles of farmland, Delano to the North Dakota border. The Minne Environmental Quality Board authorized the $89 study to see if ions and electric fields generate the line might harm the health of humans and anim The power line is owned by the Cooperative Power sociation and the United Power Association. C investigator on the project was statistician F Martin of the University of Minnesota. Martin his colleagues studied the records of the Dairy Improvement Association. The data covered 500 h within 10 miles to either side of the power line extended from October 1976, two years before the went into operation, to September 1982. Dairy f within 10 miles of the line were divided into zones. Zone 1 included farms within a quarter of the line; zone 6 included those six to ten m from it.The outer zones, especially zone 6, were sidered control areas, unexposed to the influenc the power line. Over the period of the study, h within a quarter mile of the line showed "an ac table 8% increase in milk production." Times bet births of calves, rates of removal of cows from h because of reproductive problems, and the incid of recorded abortions "were no higher near the p line than at six to 10 miles away." The study sumed that any harmful effects of the power would exist throughout the zone closest to it. the power line affected only a very few of the f within a quarter mile of the line, this study w not have caught it. Farms having serious prob were found both close to and far from the power l Farms showing excellent increases in production were found in both areas.

News Items

HEALTH HAZARDS AND PSYCHOPHYSIOLOGICAL EFFECTS FROM LOW-LEVEL ELECTROMAGNETIC RADIATION SYSTEMS (such as: Video Display Terminals (VDTs/VDUs), Computer programs, Advanced Aeronautics, ELF Transmitters, High-Voltage Transmission Systems). A Transcript of an International Forum. $45.00 (post-paid). Planetary Association for Clean Energy, Inc., 100 Bronson/1001, Ottawa K1R 6G8, Canada; 613/236-6265.

The 1982 Learned Societies Conference in Ottawa presented a discussion by distinguished researchers on the state of advanced knowledge in low-level EM radiation effects on living organisms. Emphasis was on VDTs but their remarks covered research into other similar human/technological interfaces. The subjects discussed included stress symptoms, biologically significant frequency-intensity "windows", pulsed electrostatic fields, magnetic ELF fields, comparative scientific methodology between East European and Western Laboratories, and malignant pregnancy clusters among female VDT operators. Participating in the transcript were: James Beal/Martin Marietta Aerospace; Dr Robert Beck/Alpha Metrics, Inc.; Dr. Robert Becker/SUNY-Syracuse; William Bise/Pacific Northwest Center for the Study of Non-ionizing Radiation; Dr. Eldon Byrd/U.S. Naval Surface Weapons Center; David Eisen/American Newspaper Guild; Claire-Marie Fortin/Canadian Labour Congress; Dr. E. Stanton Maxey/American Board of Surgery; Dr. Russel Jaffe/senior health consultant; Robert DeMatteo/Ontario Public Service Employees Union; Dr. Glen Rein/St. Bartholomew's Hospital-London; Louis Slesin/Microwave News; Professor William Kuhns (moderator) / Communications-University of Ottawa.

VDTs -- A NEW SOCIAL DISEASE

Health problems that have so far been associated with VDTs fall into four broad categories: alleged radiation hazard, visual disturbances, musculoskeletal difficulties, and job stress. A brief essay is presented on the above based on information supplied by Dr. Michael J. Smith of the National Institute of Occupational Safety and Health. In summary, there appears to be no radiation hazard from VDTs. Visual difficulties include irritation, fatigue, or difficulty with focus or accommodation. Minimal criteria for the visual display are: the image should not flicker; the entire display should be in sharp focus; the contrast between light and dark areas should be at least 8 to 1; the characters should be formed in a 5x7 matrix of dots at the very least; all VDTs should have brightness and contrast controls that the operator can find and adjust. Most potential health problems caused by VDTs can probably be averted by planning that takes account of the operators' needs. The Harvard Medical School Health Letter, April 1983

CENTER RESPONDS TO INQUIRIES ON EFFECTS OF VDT'S ON PREGNANCY OUTCOMES

The National Center for Devices and Radiolo Health (NCDRH) recently has been receiving inqu as to whether "clusters" of adverse pregnancy comes among women who work at video display terr (VDT's) could be caused by radiation from VDT's. inquiries have been prompted by news media acc such as one from Canada which reported that VDT's were installed in the offices of a Vanc hospital in 1978, only one of six pregnancies women working at the machines resulted in a n full-term birth. Over the past several years, has tested more than 100 VDT's for radiation lea Results of NCDRH's current testing support the clusion that VDT's should not pose a radiation to those who operate them; no evidence has been that the levels of radiation from VDT's are resp ble for adverse pregnancy outcomes. The Nationa search Council of the National Academy of Sci and the National Institute for Occupational S and health have reached similar conclusions. Ep idologists and statisticians at the NCDRH and a U.S. Centers for Disease Control have noted that "clusters" of adverse pregnancy outcomes would mally be expected on the basis of chance alone fact, evaluation of some of the reported "clus indicated that they did not establish a general tern associating the use of VDT's with problem nancies. Therefore it has been concluded tha reported "clusters" of problem pregnancies amon users would be expected from chance alone, and highly unlikely that they have been caused by th radiation emissionn levels from the machines.

Radiological Health Bulletin, 17(2):3-4,

FDA COMPLETES SEIZURE OF "POCKETDOC" RF SIGNAL GENERATORS

The Food and Drug Administration has seized a n of medical devices called "Pocketdoc," manufac and distributed by Igon Corporation of Minden, Ne The Agency requested the seizure because the d was found to be misbranded under the provisio the Federal Food, Drug, and Cosmetic Act. FDA cials determined that the device was being pro for treatment of such diverse ailments as as hemorrhoids, chronic headache, chest pain, arthr insomnia, and whiplash. Analysis of the device ed it to be a very low power ELF (extremely low quency) generator. A search of the scientific l ature by the National Center for Devices and Radi ical Health's Division of Risk Assessment reveal published data to substantiate the labeled clai the frequencies and power levels at which the d operates.

Radiological Health Bulletin, 17(2):4-5,

DEVELOP EDUCATIONAL GUIDELINES AND RECOMMENDATIONS FOR HYPERTHERMIA OPERATORS

The Food and Drug Administration is seeking a contractor to interview hyperthermia equipment operators, develop methodology, analyze information and develop recommendations and guidelines for the hyperthermia equipment operators. RFP 223-83-6032 is expected to be available o/a June 20, 1983.

Commerce Business Daily, June 20, 1983

SURVEYS OF RADIOFREQUENCY SEALER EQUIPMENT AND OPERATOR EXPOSURE

Sol 223-83-4260. Response date 7/28/83. Radiofrequency (RF) sealers and heaters have been used for more than 30 years, but there are no reliable, documented estimates of the number of units in present use or of the number of workers operating RF sealers. FDA and other government agencies are concerned about the potential health hazards to workers exposed to radiofrequency energy emitted from RF dielectric heaters (more widely known as RF sealers and heaters). FDA is seeking additional information about the use and means to locate this equipment at the state level, and assess the need at each site for effective control technology. The agency is also seeking the identification of suitable populations of exposed persons and is interested in feasibility studies to assess practicable epidemiologic studies. Competition will be limited to state government agencies having the regulatory authority to accomplish the project. The project includes visits to user facilities to conduct measurements of electromagnetic radiation from RF sealers where access to the premises can only be obtained by a duly authorized governmental representative.

Commerce Business Daily, May 19, 1983

SURVEY AND TECHNICAL EVALUATION OF HIGH POWER MICROWAVE SOURCE DEVELOPMENT

The Office of Naval Research is conducting negotiations with Jaycor, 205 South Whiting St., Alexandria, VA 22304 for the above study.

Commerce Business Daily, May 19, 1983

EFFECTS OF LOCAL MICROWAVE EXPOSURE ON LOCAL TISSUE BLOOD FLOW

Contract 68-02-3782. The EPA has contracted with the Univ. of Illinois, 809 South Wright Street, Champaign, IL 61820 for the above study.

Commerce Business Daily, May 18, 1983

AUDITORY MAGNETIC EVOKED FIELDS

Contract N00014-79-C-0383. The Office of Nava
search has contracted with the University of Col
Medical Center, Denver, CO 80220 for the above s

Commrce Business Daily, May 10,

CONTINUATION OF RESEARCH ENTITLED "MICROW
ELECTROMAGNETIC THEORY & INFORMATION PROCESSES (

Contract F49620-82-C-0084-P00003. The Air Forc
fice of Scientific Research his contracted with
technic Institute of New York, 333 Jay St., Broc
NY 11201 for the above study.

Commerce Business Daily, April 18,

ULTRA LOW FREQUENCY FIELDS IN NONHOMOGENEOUS

The Office of Naval Research is conducting neg
tions with Pacific Sierra Research Corp., 12340
Monica Blvd., Los Angeles, CA 90025 for the
study.

Commerce Business Daily, April 6,

EXAMINE THE EFFECT OF RADIO ENERGY ON THE OXIDATION OF ORGANIC SUBSTANCES

The office of Naval Research is conducting neg
tions with SRI International, 333 Ravenswood
Menlo Park, CA 94025 for the above study.

Commerce Business Daily, April 6,

MEETINGS AND CONFERENCES

SHORT COURSE
HYPERTHERMIA FOR CANCER TREATMENT

Date: August 8-10, 1983
Place: Tropicana Hotel, Atlantic, City
Fee: $500 (includes lecture notes, instructional materials, refreshment breaks, and completion certificate; hotel accommodations not included)
Requests for Information: Dana Carpenter, Course Coordinator, Cheung Associates, Inc., 5026 Herzel Pl., Suite 101, Beltsville, MD 20705; (301) 937-5677.
Content: A short course on the principles and practice of radiofrequency, microwave, and ultrasound hyperthermia in the treatment of cancer. The course is designed for physicians, medical physicists, engineers, and medical administrators who are involved or intend to be involved in ultrasound, radiofrequency, and microwave thermotherapy in the treatment of cancer. The course will be taught by Dr. Augustine Y. Cheung. The text to be used is "Physical Aspects of Hyperthermia", AAPM Monograph 8, G. Nussbaum, ed., American Institute of Physics, NY, 1983.

SHORT COURSE: NON-IONIZING RADIATIONS:
BIOPHYSICAL AND BIOLOGICAL BASIS, APPLICATIONS
AND HAZARDS IN MEDICINE AND INDUSTRY.

Date: August 8-12, 1983
Place: Cambridge, MA
Fee: $850
Requests for Information: Dir. of Summer Sessions, Room E19-356, MIT, Cambridge, MA 02139
Content: Topics covered include lasers, microwaves, ultraviolet radiation, magnetic fields, and ultrasound. A detailed reading list and other pertinent materials will be provided. Practical demonstrations will be given of the instruments and techniques used for measurement of the intensity level of each form of energy for implementation of safety programs in the workplace. The discussion on microwaves will include physical characteristics and field measurement, dosimetry, electrical properties of biological tissues in constant and varying fields, absorption, thermal effects, non-thermal effects; results and mechanisms in blood, eye, testes, malignant tumors, growth; applications in diathermy, and in cancer therapy; health hazards of radar, microwave ovens, industrial RF heaters and sealers, Eastern and Western safety standards and their biophysical basis. The discussion on magnetic fields will include geomagnetic environment, static and varying magnetic fields, biological effects; potential hazards and safety in NMR imaging. The course will be taught by Padmakar P. Lele, M.D., Ph.D., Professor of Experimental Medicine, Department of Mechanical Engineering, Harvard-MIT Division of Health Science Technology. Guest faculty include J. J. Galli, Food & Drug Administration, W. P. Hansen, Ph.D. Ortho Diagnostic Systems, J. L. Jones, MIT, and M. A. Pathak, Ph.D., Harvard Medical School.

EIGHTH ANNUAL CONFERENCE OF THE
AUSTRALIAN RADIATION PROTECTION SOCIETY

Date: August 15-17, 1983
Place: Adelaide, Australia
Requests for Information: Mrs. J. Fitch, Conve
1983 ARPS Conference, Private Bag 97, Glenside, 5065, Australia

SHORT COURSE
ENGINEERING TECHNIQUES FOR CLINICAL HY[illegible]

Date: August 29-31, 1983
Place: Washington, DC 20052
Requests for Information: Continuing Eng[illegible]
Education Program, George Washington University (800)424-9773
Fee: $685

TECHNIQUES IN STUDIES OF BIOLOGICAL EFFECTS
LOW-LEVEL MILLIMETER WAVES

Date: September 4-6, 1983
Place: Hotel Alba, Herrsching am Ammersee, Wes Germany (near Munich)
Sponsor: URSI Commission A "Working Group" on surements Related to the Interaction of Electro net.c Fields with Biological Systems"; cosponso by the Bioelectromagnetics Society, Gesellschaf fur Strahlen- und Umweltforschung, and the Max-Planck-Institut fur Festkorperforschung
Requests for Information: Dr. Fritz Keilmann, posium Chairman, Max-Planck-Institut fur Festko forschung, 7000 Stuttgart 80, Germany; Tel.: (0 6860/603 or 6860/651; Telex: 7-255 555.
Subject Matter: The symposium will provide a d cussion platform for scientists studying biolog effects of low-intensity millimeter microwave r ation. Emphasis will be on experimental approa and on experimental details. Specific goals ar (i) which biological systems (which biological points) may be of use, and which requirements d they impose on the microwave system, and (ii) w irradiation configurations may be of use, and h can the microwave fields as well as the microwa induced temperature fields be controlled.
Language: English
Estimated Attendance: 40
Symposium Publications: No publications of pro ings; main results of the symposium will probab be summarized in the form of a detailed report

publication in a journal like Bioelectromagnetics.

FIFTH EUROPEAN CONGRESS ON RADIOLOGY

Date: September 5-10, 1983
Place: Bordeaux, France
Requests for Information: Mme. N. Hargous, Hospital Pellegrin, Service de Radiologie, Place Amelie RabaLeon, F-33076, Bordeaux, France

36TH ANNUAL CONFERENCE ON
ENGINEERING IN BIOLOGY AND MEDICINE

Date: September 12-14, 1983
Place: Hyatt Regency Hotel, Columbus, OH
Sponsor: Alliance for Engineering in Medicine and Biology, 4405 East-West Highway, Suite 210, Bethesda, MD 20814; 301/657-4142
Requests for Information: Mrs. P. I. Horner, AEMB; Conference Chairman is Prof. Herman R. Weed, The Ohio State University; Program Chairman is Baxter Womack, Ph.D., University of Texas
Content: In addition to the traditional topic areas, special sessions will include the following categories: Instrumentation; Bioelectric Phenomena; Medical Imaging; and Standards & Regulations. The deadline for receipt of abstracts is April 15, 1983. Short courses will be held 11 September 1983.

THIRD ANNUAL MEETING OF THE BIOELECTRICAL
REPAIR AND GROWTH SOCIETY

Date: October 2-5, 1983
Place: Gateway Holiday Inn, San Francisco, CA
Requests for Information: Executive Secretary, BRAGS, 425 Medical Education Bldg., 36th and Hamilton Walk, Philadelphia, PA 19104; (215) 898-8653

SHORT COURSE
CURRENT ISSUES AND TRENDS IN CONTROLLING
OCCUPATIONAL EXPOSURES TO RF/MICROWAVE RADIATION

Date: October 11-13, 1983
Place: Salt Lake City, UT
Requests for Information: K. Blosch, Rocky Mountain Center for Occupational and Environmental Health, Univ. of Utah, Salt Lake City, UT 84112; (801) 581-5710

5th COURSE
BIOLOGICAL EFFECTS AND DOSIMETRY OF NON-IONIZING
RADIATION: STATIC AND ELF ELECTROMAGNETIC FIELDS

Date: November 15-25, 1983
Place: Erice, Italy
Requests for Information: Persons from Europe wishing to attend the course should write to Professor Martino Grandolfo, Instituto Superiore di Sanita, Viale Regina Elena 299, 00161 Rome, Italy; persons from other continents should write to Professor Sc M. Michaelson, The University of Rochester, Medica Center, 601 Elmwood Avenue, Rochester, NY 14642. Closing date for application is September 15, 1983
Fee: $500 (covers full board and lodging)
Content: Part of the course will be devoted to studies, both of a theoretical and experimental nature, relating to potential mechanisms of interaction of static and ELF electromagnetic fields with biological systems. After a detailed review of the fundamentals of physics and biology connected with the interaction of these fields with living matter the lectures will provide an updating of the techniques developed for the detection and the dosimetry of these energies and a critical analysis of their biological effects in relation to the establishment of safety standards.

SIXTH INTERNATIONAL CONGRESS OF THE
RADIATION PROTECTION ASSOCIATION

Date: May 7-12, 1984
Place: International Congress Center, Berlin, Germany (DFR)
Sponsor: Int. Radiation Protection Assn. (IRPA)
Requests for Information: R. Neider, Sec General, Bundesanstalt fur Material Prufung, Unter Den Eichen, 87, D-1000 Berlin 45, Germany (DFR)
Content: The scientific sessions of the congress and the exhibit cover all aspects of radiation protection from basic research to practical applications with special emphasis on the risk assessment from ionizing and non-ionizing radiation as compared to risks derived from all other man-made sources (400 papers in English, French, and German

BIOELECTROMAGNETICS SOCIETY
SIXTH ANNUAL MEETING

Date: July 12-17, 1984
Place: Omni Hotel, Atlanta, GA
Sponsor: Bioelectromagnetics Society
Requests for Information: BEMS Headquarters, 1 Bank Street, Gaithersburg, MD 20878; 301/948-5530

EIGHTH INTERNATIONAL BIOPHYSICS CONGRESS

Date: July 29 - August 4, 1984
Place: Bristol, United Kingdom
Sponsor: Int. Union of Pure & Applied Biophysics
Requests for Information: Dr. H. C. Watson, Dept. of Biochemistry, The University, Bristol BS8 1TD, United Kingdom

URSI SYMPOSIUM

Date: August 29 - September 7, 1984
Place: Florence, Italy
Sponsor: URSI

Requests for Information: Contact Professor Sau Rosenthal, Polytechnic Institute of New York, Ro 110, Farmingdale, NY 11735
Note: A joint meeting with the Bioelectromagneti Society is tentatively scheduled for August 27-3

MEETING OF THE EUROPEAN SOCIETY FOR THERAPEUTIC RADIOLOGY AND ONCOLOGY

Date: September 9-15, 1984
Place: Jerusalem Hilton, Jerusalem, Israel
Sponsor: KENES
Requests for Information: Prof. T. Fuks, Head, Dept. of Radiation and Oncology, Hadassah Medic Center, Jerusalem, Israel

TRANSLATIONS FROM FOREIGN LITERATURE

From time to time, Information Ventures, Inc. will prepare full-text translations of foreign research efforts on the biological effects of nonionizing electromagnetic fields for publication in this Digest. The first of these translations is presented below. We welcome your comments and suggestions for future translations.

EFFECT OF MILLIMETER-BAND ELECTROMAGNETIC RADIATION ON BACTERIAL CELLS. (Rus.) A. Z. Smolianskaia. In: Non-Thermal Effects of Millimeter-Band Radiation, N. D. Deviatkov, Editor, published by the USSR Academy of Science, Institute of Radioengineering & Electronics, Research Council on a Problem of "Physical Electronics", Moscow, pp. 132-146, 1981.

Development of millimeter-band generators of the backward-wave-tube type created a natural interest in the biological effects of this type of electromagnetic radiation. From the early 1960's, under the leadership of academician N. D. Deviatkov (1), a number of organizations started to study the effects of this radiation on biological materials and initially on bacterial cells.

Initial interest was associated primarily with an antimicrobial effect. This effect, during the interaction of an electromagnetic field with biological materials, can be caused by either thermal action or by the specific action of radiation on the structure. The specific effect is of greatest interest. Various researchers (2,3) showed that the use of low-intensity radiation that did not cause heating of bacterial cells produced the lethal effect. In addition, it was shown that after exposure to low-intensity radiation in the 6.3-6.9-mm range, some of these waves had an antibacterial effect while others had not.

The data on the antibacterial effect of millimeter-band radiation of nonthermal intensity were used as a basis for the study of the effects of these waves on bacterial systems responsible for lethal synthesis (4). The first experiments with induction of lethal synthesis of colicin in Escherichia coli K12 C 600 (E_T) produced interesting results. Irradiation of this strain with waves in the 5.8-7.1-mm range indicated various interesting characteristics of the interaction of millimeter-band waves with bacterial cells. Firstly, these experiments showed the existence of active and inactive wavelengths, i.e. wavelengths which increase the number of colicin-synthesizing cells and wavelengths which do not. A detailed analysis of 11 neighboring wavelengths with the aid of a special wavemeter capable of measuring wavelengths with a resolution of 0.01% was conducted. The curve obtained (Fig. 1) indicated the markedly resonant type of relationship between the number of colicin-synthesizing bacteria and the wavelength. The resonant type of the effect was confirmed later after irradiation of numerous bacterial and mammalian cells. It should also be mentioned that the system showed a high sensitivity to the wavelength: a shift of 0.02 mm resulted in disappearance of the effect (5).

Secondly, the effect was directly related to the duration of irradiation: maximum effect was observed after 2-hr irradiation; the effect was significantly lower after irradiation for 1 hr, while 30-min irradiation failed to produce the effect.

And, thirdly, the effect was relatively independent of the radiation power within a wide range. After reaching a threshold power of 0.01 mW/cm², a 10-fold change in the power flux density (from 0.01 mW/cm² to 1 mW/cm²) did not affect significantly the biological effect (Fig. 2).

The data obtained in the experiments with colicinogenic bacteria were of paramount importance since they indicated that the lethal effect of millimeter-band electromagnetic radiation of nonthermal intensity can be caused not by direct action of the energy of this radiation which is too low to produce such effects (see below), but rather by the indirect action due to resonant stimulation of the bacterial systems and mechanisms of lethal synthesis.

This conclusion was confirmed in a study of the effects of similar radiation on the lysogenic strain of Staphylococcus aureus No. 962. In our laboratory, A. V. Suslov showed that irradiation with 6.55-mm electromagnetic waves (45.79 GHz) resulted in a 2.2 fold increase in the synthesis of phage particles lethal for the host cell. The critical effect with respect to wavelength was 0.005 (Fig. 3).

These findings thus indicated that the induced genetic systems which regulate lethal synthesis in bacteria, are sensitive to certain wavelengths in the millimeter range and that this effect is of markedly resonant nature.

The observed characteristics of the effect of millimeter-band electromagnetic radiation of nonthermal intensity on functional activity of genetic systems of bacteria cells shed, in our opinion, some light on the multiplicity of effects of millimeter-band waves on various metabolic processes in bacteria detected by various researchers. It was shown, for example, that certain millimeter-band waves change protein metabolism in bacteria (7,8). In other experiments, 6-7-mm waves increased the yield of thrombolytic proteases in Aspergillus and in Nocardia (9,10). The same researchers have found that changes in wavelength and number of irradiation causes changes in functional activity of various systems of bacterial cells producing either caseinolysine or fibrinolysine. The researchewrs from the Leningrad Institute of Antibiotics and Enzymes have found changes in the enzymatic activity of Basidiomyces after exposure to millimeter-band waves (11). We have studied the effects of millimeter-band waves on beta-lactamase (penicillinase) synthesis in penicillin-resistant strains of Staphylococcus aureus and Escherichia coli. It was found

that certain wavelengths (6.468 and 6.478 mm) inhibited the inducible enzyme synthesis in Staph. aureus and did not affect the constitutive enzyme synthesis in E. coli. It is important to note that irradiation did not affect penicillase activity. This phenomenon was verified in experiments with irradiation of exogenous enzyme. The relationship between inhibition of enzyme synthesis and wavelength was of a markedly resonant type: a ± 0.005-mm change in wavelength resulted in a disappearance of the effect (Fig. 3). Another interesting detail was observed in this system: a tenfold decrease in bacterial multiplicity resulted in a fourfold increase in the effect. Since a characteristic morphological feature of a staphlococcal colony is grape-like clustering, the observed data may indicate a shielding effect.

Comparing these data with the results obtained after exposure of colicinogenic strain of E. coli and lysogenic Staphlococci indicated that the most probable application site of millimeter-band radiation energy was the repressor system that blocked the induction of certain metabolic cycles. Since the inducible metabolic processes are widely spread among the living organisms, the possibilities of electromagnetic field effects are also diversified (12).

The observed effects of millimeter-band radiation on enzymatic systems of bacteria can lead to changes in cell division. Webb and Booth (13) studied the effects of millimeter waves in the 4.68-3.94-mm range on division of Escherichia coli B_R cells. Radiation of wavelength 4.41-mm stimulated cell division, while 4.54-mm, 4.19-mm, and 4.11-mm waves inhibited cell division. It was found that radiation of wavelength 4.54-mm inhibited assimilation of amino acids and thiamine by Escherichia coli cells. Waves of wavelength 4.22-mm caused a significant decrease in accumulation of all labeled metabolites, the 4.19-mm waves caused slight decrease in thiamine and amino acid accumulation, and 4.11-mm waves corresponded to the maximum of protein accumulation. All these waves inhibited cell division. Irradiation of this strain with 4.41-mm waves increased accumulation of ^{14}C-uracil and of amino acids and enhanced cell proliferation. It should be mentioned that thiamine assimilation remained unchanged and this can and does lead to the appearance of morphologically altered variants.

The changes in growth rate and appearance of morphological variants after exposure of bacteria to millimeter-band radiation were observed in numerous studies. V. F. Kondrat'eva et al (14) showed the changes in morphology of colonies and cells as well as the changes in biological properties (spore formation, saccharolytic, proteolytic and antigenic properties, pathogenicity) of a number of anaerobic (Clostridium) and aerobic (Prodigiosum) bacteria after irradiation with 7.2-mm waves. Changes in the morphology of bacterial cells were also noted by other researchers (6). The most frequent morphological changes after exposure to millimeter-band electromagnetic radiation were observed in fungi. These changes occurred in saccharomyces cerevisae P^{11-4} after irradiation with a wavelength of 6.0 and a power flux density of 0.25 MW/cm². Simila changes were observed after irradiation of Aspergillus avamory and Endomycopsis fibuliger. In th latter case, the authors noted certain changes biochemical properties of the culture (9,10). Direct observations of the culture growth in a specially designed microscope attached to a generator millimeter waves showed changes in the intensity replication of Rodotorulla rubra (15).

Attempts to induce bacterial mutations by means millimeter-band radiation failed. We could find convincing data in the available literature although various researchers tried to obtain th vaccine strains. But they admitted that the millimeter-band radiation induced very short-term los of virulence. In certain cases the loss of virulence could be explained by selection of pre-existing variants, since in addition to irradiation, th strains were subjected to culturing.

Thus, the results of experiments conducted by different researchers on different microorganisms indicated the presence of biological activity of millimeter-band electromagnetic fields of nonthermal intensity. The type of wavelength-effect curves ar relative independence from the intensity of radiation after reaching a certain threshold value wer indicative of the markedly resonant nature of th effect.

The resonant type of response observed in the inducible bacteria explained and confirmed the data obtained in other biological materials. Simple ar isolated bacterial cells are an extremely valuabl test system for the study of biological effects millimeter-band electromagnetic fields of non-thermal intensity. The clear-cut data obtained durin the study of the effects of this type of radiatio on the extrachromosomal, and therefore on relatively autonomic, inducible bacterial systems (colicinogenic factor, temperate phage, penicillase gene provide a basis for certain generalizations ar theoretical models of the mechanisms of this phenomenon.

It is known that ultraviolet radiation with a wavelength of aproximately 22,550 A and energy of approximately 4.9 ev is the most effective inducer colicin synthesis or of prophage release. It is also known that this is the energy of the same order of magnitude as the energy of C-N, C-C and C-bonds in protein and nucleic acid molecules (2. ev, 2.5 ev, and 4.4 ev, respectively). It is als known that photons with energies of 4-6 ev are selectively absorbed by proteins and nucleic acids This phenomenon probably causes the biological effects of ultraviolet radiation. Ultraviolet radiation can lead to excitation of valent electrons atoms, i.e., to be conducive to their jump int higher energy levels. The molecules with excite electrons enter readily into photochemical reactions. These reactions can cause various biological effects: changes in the genetic code (mutations), breaks and subsequent repair of DNA and R

molecules, which in turn lead to excitation (in case of repressor damage) or inhibition of functional activity of various genetic systems.

But the energy of a millimeter-band electromagnetic field is significantly lower than that of ultraviolet radiation.

It is known that E=hν=h·c/l, where
h = 6.62×10^{-27} erg/sec
c = 3×10^{10} cm/sec
l = 6.5×10^{-1} cm or 7.1 mm.

Therefore,
E = $(6.62 \times 10^{-27}) \cdot (3 \times 10^{10}) / 6.5 \times 10^{-1}$
= 3.06×10^{-16}erg = 1.9×10^{-4}ev,
since 1 ev = 1.60×10^{-12} erg.

Therefore, the energy of the millimeter-band electromagnetic field is approximately 10^4 times lower than the energy of chemical bonds in biological molecules. Energy of this order of magnitude can only cause intramolecular oscillations or rotation of the entire molecule. This was shown by L. G. Koreneva and V. I. Gaiduk (16) for histidine in the hemoglobin molecule. But if these oscillations resonate with the intrinsic oscillations of intracellular molecules, the resultant effect can be equal to that observed after exposure to such powerful agents as ultraviolet radiation or chemical agents, which damage the DNA structure and induce various biological processes. It is possible that the absence of a mutagenic effect from millimeter-band radiation is due to the absence of direct damage to the DNA molecule.

A. M. Makhov (17) calculated the power of electromagnetic radiation required for the resonant effect on one cell of Staphylococcus aureus to inhibit the inducible penicillase synthesis. Stabilization of the effect was achieved with power of approximately 7×10^{-6} W/cm^2 for 1-micron medium layer and 5×10^{-14} W for a single cell. Since the energy of a quantum of electromagnetic radiation is equal to 10^{-4} ev, then the number of quanta per one cell per 1 sec under the condition of saturation of the biological effect is approximately equal to 5×10^9. The relaxation time for the resonating cell structures at a given power flux density can vary from 2×10^{-10} to 2×10^{-7} sec, depending upon the resonating structure. Therefore, the resonant absorption of the millimeter-band electromagnetic field can cause changes in the activity of various functional cell systems. These results showed good agreement with the data on the effects of electromagnetic fields of the same frequency on induction of colicin synthesis. This can indicate the similar mechanism of resonant interactions in different biological systems.

The present communication summarizes the results of experiments of Soviet scientists who initiated the studies of the effects of millimeter-band radiation on bacterial cells.

In recent years, intensive studies of the effects of millimeter-band radiation have been conducted abroad.

In 1977, Grundler, Keilman and Frohlich (18) sho a resonant change in the growth rate of yea which increased or decreased depending upon frequency of radiation (approximately 42 GHz) at irradiation with VHF fields at a power of seve MW/cm^2. Careful regulation of temperature con tions excluded the trivial thermal effect of rad tion. Next year, Grundler and Frohlich (19) c firmed the independence of the effect from tempe ture and showed that the critical frequency 0.01 GHz. In 1977, Webb, Stoneham and Froh (20) studying the Raman spectra of actively rep cating synchronous E. coli culture showed that excitation levels of spectra of a markedly reson type corresponded to the metabolic cycles of t terial cells. These data indicated a relations between coherent millimeter waves and biologi effects.

Italian researchers Dardanoni, Torregrosso, et (21) showed that irradiation with UHF waves pul modulated at 72 GHz reduced the viability of ce ular suspension of Candida albicans, while irrad tion with continuous waves failed to produce s an effect.

A group of U.S. researchers (22) observed an eff similar to that detected in our experiments af irradiating for 1-hr cells of the colicinoge strain of E. coli containing colicinogenic fac E1. Maximum induction of colicin synthesis was served after irradiation at a wavelength of 5.8 and a power flux density of 0.5 MW/cm^2. Simi data on induction of colicin synthesis were obta ed by other researchers.

French scientists Dardalhon, Averbeck and Berte (23) showed that millimeter-band radiation can fect the growth rate of bacteria. The effect pended upon the frequency of radiation. The rad tion did not cause damage to cellular DNA. Th researchers did not observe nuclear-chromosome m ations (experiments with DNA repair-deficient b teria) or cytoplasmic mutations (in mitochondr DNA from diploid yeasts). This confirms our op ion that the basic mechanism of the effect of mi imeter-band radiation is not associated with gr damage to DNA structure but rather with changes configuration of the functional molecule with breakage of intramolecular bonds but with chan in functional activity. In addition, these auth have found that the increase in the number of gotes between two haploid yeast strains was ache ed only after irradiation for at least 330 min a frequency of 70.5 GHz, a power flux density of least 60 MW/cm^2, and a distance from the horn the culture of 2 mm (at a distance of even 10 the effect could not be observed). Comparing t effect with the effects observed after the heat indicated that it corresponded to the heating f 20 C to 23 C. Therefore, irradiation at these p ameters was equivalent to heating by 3 C. Th results confirmed our data and the data obtained Grundler and Keilman indicating that induction

colicin synthesis, release of phage, inhibition of beta-lactamase synthesis and bacterial cell growth required significantly higher temperatures (approximately 40 C). Such increase in temperature can not be achieved at powers lower than 1 MW/cm^2.

Since the effect of millimeter-band waves is associated with the resonant response of the biological system, its detection required a large number of coincidences. It was necessary that the wave hit a cell, that the cell was in an appropiate stage of development, that the wave hit the cellular structures which could resonate with the given wavelength, and finally, that the irradiated population contained a sufficient number of cells meeting all these requirements.

In our opinion, this determines the multiplicity of the effects observed by one and the same authors. For example, Athey and Krop (24) initially observed induction of colicin synthesis in Escherichia coli 3110 Col E1 after irradiation with millimeter-band radiation. But in subsequent experiments, all attempts to induce prophage in lysogenic strain of Escherichia coli BR-475 (1, lac^+) failed. In the latter case, the authors tried to detect production of a free phage not by a conventional plaque method, but rather colorimetrically by lactamase production (in the test strain, lac^+ gene transcribed together with l gene). Since these authors did not observe the radiation-induced increase in the enzyme yield, they doubted the possibilty not only of prophage induction but also of induction of colicin synthesis. They argued that induction of temperate phage and of col factor have similar mechanisms. This statement can not be accepted for several reasons. Firstly, the similarity of the mechanism of induction of temperate phage and that of col factor is quite relative and is limited to observations that such inducers as ultraviolet rays, nalidixic acid, mitomycin C, etc., induce both temperate phage and colicin synthesis. But we have reason to believe that in contrast with the abovementioned inducers, the mechanism of the effect of millimeter-band radiation is not associated with damage to the DNA molecule.

Secondly, the simlarity of derepressors does not mean a similarity in the structure of repressor molecules, which play an important role in response to the effect of millimeter-band radiation. At present we have some data on the protein nature, molecular weight and some other parameters of phage repressor, but nothing is known about the repressor of col factor.

And, thirdly, the detection of similar effects and especially the denial of their existance requires similar experimental conditions. It is especially true for studies of the effects of millimeter-band radiation. In our experiments on the effects of millimeter-band UHF-radiation on bacterial cells we encountered various manifestations of the effect: acceleration and inhibition of the growth rate, potentiation and inhibition of the functional activity of different organells in bacterial cells, and lethal and modification effects. We observed, example, a situation in which the inducible sy of col factor EI in E. coli responded by an crease in colicin synthesis, while the induc synthesis of beta-galactosidase in Staphyloco aureus was inhibited. But in both cases, the g regulating these syntheses were localized in plasmids and showed similar response to such ducers as ultraviolet rays and mitomycin C. In case of Staphylcoccus aureus containing the tem ate phage, the release of free phage after irra tion with a millimeter-band field could be obse in a very narrow wavelength range.

Therefore, we believe that the development of m imeter-band generators provided us with a tool analysis of fine biological processes on a mole lar level. But the mechanism of these interacti still requires a detailed analysis.

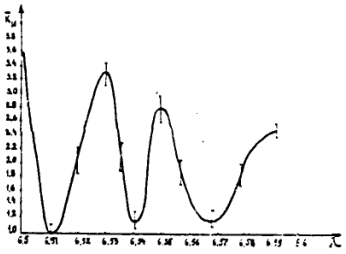


FIGURE 1

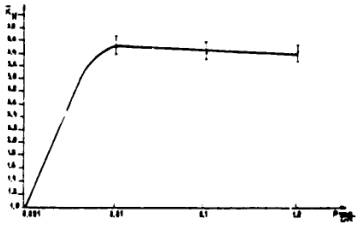


FIGURE 2

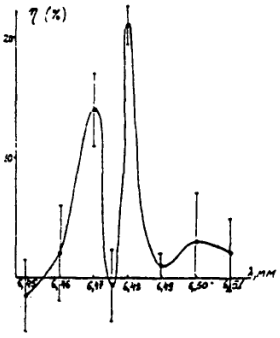


FIGURE 3

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FOR OUR NEXT ISSUE

BIOLOGICAL EFFECTS OF MICROWAVE RADIATION. (Hun Almassy, Gy.; Szabo, L.; and Ballai, L. TKI (1-2):15-45, 1982.

In this paper, the main biological effects microwaves are surveyed, medical applications a outlined, and the draft of a new Hungarian standa on protection against radiation is presented.

NON-IONIZING RADIATION: HEALTH AND SAFETY ISSUES IN THE 98TH CONGRESS. Dodge, C. H. and Kainz, R.; Library of Congress, Congressional Research Service Major Issues System, May 9, 1983.
(The following is excerpted from the above source.)

ISSUE DEFINITION

New technologies and advancements in the electronics, communication, and other industrial and scientific fields have provided many benefits to society. The development of these technologies has also resulted in an increased exposure of the general population to low-level non-ionizing radiations.

This mini issue brief provides a short background on non-ionizing radiation, identifies the common sources of low-level non-ionizing radiations and summarizes available information on the known human health effects associated with non-ionizing radiation exposures.

The effects on human health from these low-level exposures are not well understood. In the 96th and 97th Congresses, two hearings were held on health issues related to occupational exposure to microwave and radiofrequency radiations. Concerns persist in the 98th Congress about the possible health effects of chronic exposure on non-occupational populations to very low-level RF/MW radiations and low-level electric and magnetic fields near power lines. The fact that there remain no formal standards for either occupational or non-occupational exposure to RF/MW radiations is of continuing congressional concern. Currently, there is concern in committees of the House and Senate with oversight authority over the EPA that the Administration has proposed zeroing out the EPA's Health Effects Research Laboratory (HERL) in Research Triangle Park, North Carolina. That laboratory houses the largest non-defense Federal research program on the biological effects of non-ionizing radiations.

Sources of Microwave and Radio-frequency Radiations

Microwave and radio-frequency radiation sources have continued to come closer to major population centers. These sources include a) communication sites; b) navigation devices; c) medical diathermy units; d) food ovens; e) commercial radio; f) television broadcast stations; g) generators; and h) Citizen Band (CB) radios. The Task Force on Research Planning in Environmental Health Sciences has concluded that these microwave sources are responsible for an estimated half of the U.S. population living in some measureable microwave environment. The level of exposure reported by the Task Force is far below the recommended safe level of exposure (10 mW/cm^2) for most normal circumstances. The most rapidly increasing source of public exposure to RF radiation has been the CB radio. The hazard associated with the CB radio is due to the close proximity of the antennas to the individual.

Potential Health Effects of RF and MW Radiation

At sufficiently high levels of field intensity, th effects of RF/MW radiation are thermal in nature The denaturation or "cooking" of biomolecules ca be induced only at field intensities that are s high the temperature of the target tissue is sig nificantly increased. Thus the absorption of R field intensities on the order of 100 mW/cm^2 re sults in rapid tissue heating. If the exposure long enough, there is irreversible tissue damage

In humans, the two organs at greatest risk of RF/M injury are the eye and testicle, because of thei inability to dissipate heat via circulatory syste mechanisms. Accordingly, chronic exposure to hi intensities of RF/MW radiation can result in ma sex cell destruction and thermally-induced cata racts. At very high intensities of RF/MW radia tion (i.e., greater than 100 mW/cm^2) skin burns ca be induced. However, such burns are reversible nature.

Epidemiological studies of human populations in th Soviet Union, Czechoslovakia, Poland, and Swede exposed occupationally to low-level RF/MW radiatio (i.e., below 1 mW/cm^2) have yielded indications changes in human nervous system and cardiovascula function after prolonged exposure (one year more), but these may be reversibly altered. A num ber of behavioral changes have also been reported These studies are subject to controversy in thi country because no comparable data exists for simi larly exposed occupational populations.

At present, the major unanswered question is whe ther there are other mechanisms of interaction be tween RF/MW radiation and biological systems tha can cause reversible or irreversible alterations field intensities, but that do not result in de tectable tissue heating (i.e., below 10 mW/cm^2

Microwave and Radiofrequency Radiation Standards

Exposure standards for microwave and radiofrequenc radiation are usually expressed in terms of th rate at which energy flows through the human body This rate is called power density and is commonl expressed in units of milliwatts or microwatts pe square centimeter.

Title 21, Chapter 1, Subchapter J of the Code o Federal Regulations defines the power density limi for microwave ovens. Ovens shall not exceed 1 mW cm^2 exposure at the oven surface prior to sale initial use. Those ovens which are in active us can not exceed an exposure limit of 5 mW/cm^2

In 1971, OSHA adopted the 1966 version of the Amer ican National Standards Institute (ANSI), C95. Committee, 10 mW/cm^2 exposure standard for workers More recently, ANSI has proposed a reduction this standard to 1 mW/cm^2 for the frequency rang between 30 and 300 MHz. A new OSHA criteria docu ment on occupational microwave and radiofrequenc

radiation exposure may be issued in the near future. Currently, the EPA has announced plans to issue guidance to other Federal agencies to limit exposure of the general public to radiofrequency radiation (Federal Register 47(247):57338-57340, December 23, 1982). The EPA guidance will not address occupational exposure or classes of microwave and radiofrequency sources that can best be controlled by existing performance standards.

Of congressional concern is the fact that the U.S. remains the only country for which there is no formal occupational exposure standard for RF/MW radiation. Occupational exposure standards in most Western countries, which range from 1 mW/cm^2 to 10 mW/cm^2, limit the amount of heat generated when radiation is absorbed in human tissue. Most of these standards do not contain special provisions for exposure of the public. However, Canada has proposed to limit exposure of the public to one-tenth of its occupational exposure limit of 10 mW/cm^2.

In 1979, the Federal Communications Commission (FCC) came out with a Notice of Inquiry (NOI) into possible health hazards of RF at FCC facilities (FR vol. 44, p. 37008, June 25, 1979). Responses to the NOI culminated in a Notice of Proposed Rule Making (NPRM), in 1982 (FR vol. 47, p. 8214, Feb. 25, 1982; FR vol. 47, p. 10871, March 12, 1982; FR vol. 47, p. 27384, June 24, 1982). The NPRM allows FCC to assess possible RF hazards at new FCC facilities. Existing FCC facilities are exempt. There is no standard associated with the NPRM.

The countries of Eastern Europe, including the USSR, Poland, and Czechoslovakia have lower exposure standards for most occupational situations, for example, 0.01 mW/cm^2 for microwave frequencies. Exposure standards for the public at these frequencies are even lower (i.e., 0.005 mW/cm^2 in the USSR). These standards are based on behavioral and clinical studies that have not been repeatable or replicable in the West. Many U.S. experts question the validity of these studies and standards and whether and to what extent the standards are actually enforced.

HEARINGS

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50-60 Hz ISSUES: CONGRESSIONAL PERSPECTIVE

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The Issue

Sharply increased congressional concern about significance of reports listed in Tables 1 an reporting increased incidence of cancers in cert public and occupational populations exposed to 50-60 Hz electric and magnetic fields.

Questions Addressed in 60 Hz, Power Frequency, and COMAR Workshops

1. How significant are the studies epidemiologically?

2. How should CRS evaluate the studies for the Congress and its constituency?

3. How creditable are the experimentors (is there experimental bias?

4. Were the studies adequately designed?
   - sufficiently large populations?
   - "control" populations? (what is a control population?)
   - other factors contributing to the effects reported (ionizing radiations; toxic substances in the air, water and food; personal health histories; personal health habits etc.)
   - prospective and retrospective peer review of epidemiological studies (i.e. New York Power Line epidemiological and experimental studies)
   - does recent experimental work in the 0-100 Hz range compliment the epidemiology? (i.e. T-lymphocyte responses to pulsed RF/MW fields; germ cell changes etc.)

5. What posture should the concerned Federal regulatory and research agencies (EPA, DOE, NIH, NAS, US/USSR Working Group etc.) assume in the wake of the epidemiology studies reported in Tables 1 and 2? (i.e. is it time to hit the panic button or should increased funding be provided for additional epidemiological and experimental studies?

6. In general, where do we go from here?

(Note: Responses regarding the above should be forwarded to C. H. Dodge)

TABLE 1.

PUBLIC EXPOSURE AT 50-60 HZ

Author	Reported Effect (incidence)
WERTHEIMER AND LEEPER, 1979	+ LEUKEMIA, NEOPLASMS (children)
FULTON ET AL, 1980	NO CHANGE IN LEUKEMIA INCIDENCE
PERRY ET AL, 1981	+ SUICIDES
TOMENIUS ET AL, 1982	+ TUMOR CASES (children)
WERTHEIMER AND LEEPER, 1982	+ LEUKEMIA, NEOPLASMS (adults)

Table 2 is presented on the following page

QUESTIONS AND ANSWERS ABOUT BIOLOGICAL EFFECTS
AND POTENTIAL HAZARDS OF RADIOFREQUENCY RADIATIO
(Office of Science and Technology Bulletin No. 5
12 p. July 1982 (3 References)

The Federal Communications Commission (FCC) regu
lates the use of radiowaves and microwaves for co
munications. Because of its responsibilities
this area the Commission often receives inquiri
concerning potential hazards to human health a
safety from radiofrequency (RF) and microwave rad
ation. In recent years there has been a noticeab
increase in public awareness and concern over th
issue. Increased publicity about new uses of
and microwave technology has generated much discu
sion and speculation concerning the alleged "ele
tromagnetic pollution" of the environment. Th
short publication is designed to provide informa
tion on some of the most commonly asked questio
about RF and microwave radiation. Included are r
sponses to the following questions:

- What is Radiofrequency Radiation?
- What is Radiofrequency Radiation Used For?
- What Is Microwave Radiation?
- Are Some Forms Of Radiation More Hazardous Than Others?
- What Biological Effects Can Be Caused By RF Radi ation?
- What Are Safe Levels For Exposure To RF and Mi- crowave Radiation?
- How Safe Are Microwave Ovens?
- Is It Safe To Use AN Electronic Cardiac Pacemek Near An RF Source Such As A Microwave Oven?
- How Safe Is The Radiation Emitted By Radio and Television Broadcasting Towers?
- Is There Any Danger From Microwave Point-To-Poi Relay Towers? What About Microwave Dish Antenn Used For Satellite To Ground Communication?
- Is There Any Hazard Associated With Hand-Held Walkie-Talkies?
- Which Federal Agencies Are Responsible For Pro- tecting The Public From Hazardous Levels Of RF Radiation?
- What Is The Role Of The FCC In Controlling Pote tial RF Hazards?
- Where Can I Go For Help If I Have A Complaint O Question Regarding A Possible RF Hazard?

TABLE 2.

OCCUPATIONAL EXPOSURE TO E AND H FIELDS OF VARIOUS FREQUENCIES

Author	Occupation	Relative Field Strength (freq.)	Reported Effect (incidence)
MILHAM, 1979	ALUMINUM WORKERS	>100 gauss (?)	+ LUNG CANCER: LYMPHATIC AND HEMATOPOIETIC CANCER: BENIGN BRAIN TUMORS: EMPHYSEMA
U.S. NAVY (Sanguine, Seafarer, ELF) 1970-1980	MAINTENANCE PERSONNEL; LINE WORKERS	WEAK (50-75 Hz)	+ BLOOD TRIGLYCERIDES
MILHAM, 1982	VARIOUS (electrical workers)	STRONG TO WEAK (60 Hz-various)	+ LYMPHATIC AND HEMATOPOIETIC CANCERS (lympnoma); LUNG CANCER
WRIGHT ET AL, 1982	VARIOUS (electrical workers)	WEAK (60 Hz-various	+ LEUKEMIA
McDOWALL, 1983	ELECTRICAL WORKERS	WEAK (50 Hz-various)	+ LEUKEMIA
COLEMAN, 1983	ELECTRICAL WORKERS	WEAK (60 Hz-various)	+ LEUKEMIA
NORDSTROM ET AL, 1983	SWITCH YARD WORKERS; LINE WORKERS	STRONG TO WEAK (50 Hz-various)	- FREQUENCY OF "NORMAL PREGNANCY"; + FREQUENCY OF CONGENITAL MALFORMATIONS

0337 MORPHOLOGICAL EFFECT OF ELECTROMAGNETIC STIMULATION ON THE SKELETON OF FETAL OR NEWBORN MICE. (Eng.) Hinsenkamp, M. G. (Service de Chirurgie Orthopedique et de Traumatologie, Hopital Erasme, Brussels Univ., Brussels, Belgium); Rooze, M. A. Acta Orthop Scand 53(S196):39-50; 1982 (25 refs).

Morphological effects of electromagnetic (EM) stimulation on skeletogenesis were studied in Swiss mouse limb buds grown in vitro. Developing limb buds from fetal or newborn mice were incubated in a semi-synthetic culture medium and exposed to an EM signal (duration 63 msec, peak amplitude 16 mV, burst width 4.8 msec) generated by Electro-Biology Inc. coils for 4-6 days. Contralateral limbs served as controls. Skeletal staining with red alizarin and alcian blue showed that EM stimulation selectively influenced the metaphyseal area; distal limb parts were most sensitive. Hematoxylin-eosin staining of paraffin-embedded sections revealed a thicker proliferative layer of chondrocytes, better cartilage configuration, and better trabecular alignment in stimulated limbs than in unstimulated controls. Differences between stimulated and control limbs were more pronounced in distal than in proximal limb segments, but the differences were not statistically significant. The results indicate that EM stimulation can influence the structure of the developing skeleton in mouse limb buds grown in vitro.

0338 HISTOCHEMICAL MODIFICATIONS INDUCED IN VITRO BY ELECTROMAGNETIC STIMULATION OF GROWING BONE TISSUES. (Eng.) Rooze, M. A. (Laboratoire d'Anatomie et d'Embryologie Humaines, Brussels Univ., Brussels, Belgium); Hinsenkamp, M. G. Acta Orthop Scand 53(S196):51-62; 1982 (3 refs).

Histochemical effects of electromagnetic (EM) stimulation on mucopolysaccharide (MPS) content were investigated in mouse embryo limb buds grown in vitro for 4-6 days. Toluidine blue, colloidal iron, and alcian blue (pH 1.0 and 2.5) staining demonstrated that epiphyseal content of carboxylated or sulfated acid MPS was higher in stimulated than in contralateral control limbs. This difference was most pronounced in more distal limb segments, i.e., in the youngest structures. Enzyme analysis showed an increase in beta-glucuronidase activity and a decrease in acid phosphatase activity in stimulated limbs. The enzyme differences suggested that EM stimulation induces cellular changes that modify matrix acid MPS content, possibly by affecting membrane permeability or the biochemical mechanism of transmembrane transfer.

0339 TREATMENT OF NON-UNIONS BY ELECTROMAGNETIC STIMULATION. (Eng.) Hinsenkamp, M. G. (Service de Chirurgie Orthopedique et de Traumatologie, Hopital Erasme, Brussels Univ., Brussels, Belgium); Baillon, J. M.; Danis, A.; de Marneffe, R.; Dozi R.; Tondeur, G. Acta Orthop Scand 53(S196):6: 1982 (20 refs).

Results of electromagnetic treatment of six non-u are reported. Home treatment was performed for hr/day for 3.5 to 12 mo to sites (2 tibia, 2 fem humerus, and 1 scaphoid) in which non-union had present for 12 to 66 mo. Mean length of treatmen 6 mo. The patients (5 male, 1 female, 21-56 yr had undergone 1 to 3 operations before treatment 3/6 cases, spongeous bone grafts were carried None of the patients had undergone surgery with mo prior to the beginning of electric stimulatic Electro-Biology Inc. apparatus. Characteristic the electromagnetic signal were 5 msec width; 13. amplitude; and 66 msec period (15 Hz). Radiol evaluation during treatment revealed softening of union sclerotic edges followed by increasing fuzzi in the non-union line and formation of trabecular bridges. In two atrophic and two hypertrophic unions, clinical progress was faster than radiolo healing. Clinical results suggest that electr netic treatment is indicated for patients who hav dergone several unsuccessful surgical procedure patients for whom surgery is contraindicated.

0340 RESULTS OF NON-UNIONS TREATMENT BY P ELECTROMAGNETIC FIELD STIMULATION. (Sedel, L. (Service de Chirurgie Orthopedique, Ho Saint-Louis, 40, rue Bichat, 75010 Paris, Fra Christel, P.; Duriez, J.; Duriez, R.; Evrard, J. cat, C.; Cauchoix, J.; Witvoet, J. Acta Orthop 53(S196):81-91; 1982 (6 refs).

Bone non-unions in 39 patients (10 females and males, 7-81 yr old) were treated with pulsed tromagnetic fields delivered through Helmholtz (Electro Biology Inc. apparatus) placed on each of the non-union site for 12-14 hr/day for a p of 50 days to 9 mo (average treatment duration, 3 The delays between the initial injury and trea ranged from 2 mo to 25 yr (mean, 11 mo). The n of previous operations was 0 to 6 (mean, 2). of non-union were 17 atrophic, 5 hypertrophic, 4 genital, and 13 infected. The predominant site the tibia (20 cases), followed by the femur (11). 6/37 patients available for follow-up, non-union not heal; in 4 of these cases, treatment was ap incorrectly (insufficient immobilization or sti tion for less than a 2 mo period). Healing occ between 3 mo to 1 yr (mean, 6 mo) in 31/37 pati 21 unions were strong with a large callus and 10 weak. The possibility that factors such as su within 2 mo of treatment or long-term immobiliz may have caused healing in 15/31 unions is consid However, pulsed electromagnetic field stimulatio pears to have played a real role in achieving unions.

0341 IMPACT OF LOCALIZED MICROWAVE HYPERTHERMIA ON THE OXYGENATION STATUS OF MALIGNANT TUMORS. (Eng.) Otte, J. (Dept. Physiology, Univ. Mainz, D-6500 Mainz, W. Germany); Manz, R.; Thews, G.; Waupel, P. Adv Exp Med Biol 157:49-55; 1982 (14 refs).

Oxygenation changes in tumors during hyperthermia induced by microwave (MW) radiation were investigated. DS carcinosarcoma cells implanted in the hind limbs of Sprague-Dawley rats were exposed to localized 2.45 GHz MW heating at 40, 43, or 45 C for 30 min when tumor volumes had reached 1.5-3.0 ml. A cyrophotometric micromethod was used to measure the oxyhemoglobin (HbO_2) saturation of single red blood cells within tumor microvessels. During control conditions (mean tumor tissue temperature of 35 C) the HbO_2 data obtained in tumors were scattered over the whole saturation range. Heating at 40 C resulted in significant improvement of tumor oxygenation, as evidenced by a shift to higher HbO_2 saturation values. In contrast, heating at 43 C resulted in decreasing saturation, and heating at 45 C was followed by a drastic fall in HbO_2 values. No substantial changes were observed in the core temperature of the rats during MW application to the hind foot. Therefore, systemic changes did not mask or enhance alterations in tumor blood flow or tissue oxygenation status. Changes in tumor oxygenation during hyperthermia are apparently mediated through changes in tumor blood flow, which is increased by moderate hyperthermia, but which declines at temperatures higher than 42 C, and ceases almost completely after 45 C. Microcirculation may be affected by heating time as well as by tissue temperature levels. When the heating time was increased from 30 min to 60 min, deterioration of the microcirculation, and thus of the tumor oxygenation, occurred at 40 C.

0342 ADJUVANT HYPERTHERMIA IN THE IRRADIATION OF METASTATIC TUMOR MASSES UTILIZING 2450 MHz MICROWAVES. (Eng.) Fazekas, J. T. (Dept. Radiation Therapy and Nuclear Medicine, Thomas Jefferson Univ. Hosp., Philadelphia, PA 19107); Nerlinger, R. E.; Waterman, F. M.; Leeper, D. B. Adv Exp Med Biol 157: 99-107; 1982 (14 refs).

Microwave (MW) hyperthermia was administered adjuvant to modest doses of radiotherapy to study the response obtained among 87 patients with carcinoma (57 adeno or squamous), melanoma (21), lymphoma (6), and sarcoma (3). Direct contact (MW) applicators operated at 2450 MHz with a maximum power of 100 W were used to deliver hyperthermia treatment (tumor temperature of 42.5-44.5 C in 6-8 40-50 min heating sessions, 2/wk for 3-3.5 wk) prior to electron beam radiotherapy. Effective hyperthermia conditions (42.5 C or beyond) required 5-10 min at an applied power of 30-50 W depending on blood flow, tumor size, and other physiologic factors. Nonperturbing intralesional Luxtron or Vitek probes were used to monitor tumor temperature measurements. Thermostatically controlled c culating water was used for surface cooling. Wa temperature was maintained at 44 C for tumors with overlying tissue. To spare the skin while increas the power output, colder water temperatures were u lized for tumor deposits that were subcutaneous or low. Complete response (CR: absence of all visi and palpable tumor) was seen in 8/15 evaluable me noma patients, and partial response (PR: 50% or m tumor regression) in 3/15. For carcinomas, CR was served in 13/48 evaluable patients and PR in 15/ When tumor response was analyzed by anatomic regi skin overlying chest wall had CR and PR rates of and 60% respectively. It was concluded that 2450 MW hyperthermia is quite effective for tumor depos of melanoma and carcinoma when tumor thickness d not exceed 2.5 cm ; skin cooling by circulating wa prevents serious skin complications and aids in proving the therapeutic ratio; previous therapies not prevent the application of effective combined h and radiotherapy since no serious late skin effe were seen in these patients.

0343 LOCAL IONIZING RADIATION WITH AND WITH MICROWAVE INDUCED HYPERTHERMIA IN SUPERF CIAL MALIGNANT TUMORS IN BRAIN. (Eng.) Lindholm, E. (Lund Univ. Hosp., Lund, Sweden); Kjellen, Landberg, T.; Mercke, C.; Nilsson, P.; Persson, Adv Exp Med Biol 157:145-146; 1982 (no refs).

Patients with superficial brain tumors (less tha cm diameter and less than 3 cm deep) were trea with x-rays, electrons, or ^{137}Cs gamma rays (3 Gray units in 10 fractions) alone or in combinat with 2,450-MHz microwave hyperthermia (42.5-43.5 for 45 min, 1/wk or 2/wk for 2 wk) delivered b computerized system using a 90 mm diameter circu direct contact applicator. The automatic cont system uses a pulsed irradiation technique and re tumor and normal tissue temperature via thermis probes. Results of combined vs single modality tre treatment were evaluated in four patients with m than one superficial tumor. More rapid and more la ing tumor regression occurred in patients treated w the combined modalities than in patients treated w radiotherapy or hyperthermia alone.

0344 EFFECTS OF WEAK AMPLITUDE-MODULATED MIC WAVE FIELDS ON CALCIUM EFFLUX FROM CEREBRAL CORTEX. (Eng.) Adey, W. R. (Res. Serv (151), V.A. Hospital, 11201 Benton Street, Loma Li CA 92357); Bawin, S. M.; Lawrence, A. F. Bioelect magnetics 3(3):295-307; 1982 (33 refs).

The effects of a sinusoidally modulated microw field on the efflux of brain calcium ($^{45}Ca^{2+}$) w studied in awake, intact cats immobilized under lo anesthesia. The cats were exposed for 60 min t

3.0-mW/cm^2 450-MHz field in a horn radiator. A 16-Hz sine wave was used to amplitude modulate the signal to a depth of 85% and its output was applied to a broadband linear power amplifier with a maximum output of 80 W. Tissue dosimetry showed a field of 33 V/m in the interhemispheric fissure (rate of energy deposition 0.29 W/kg). By comparison with controls, efflux curves from field exposed brains were disrupted by waves of increased $^{45}Ca^{2+}$ efflux. These waves were irregular in amplitude and duration, but many exhibited periods of 20-30 min and continued into the post-exposure period. Binomial probability analysis indicates that the field-exposed efflux curves constitute a different population from controls at a confidence level of 0.96. In about 70% of cases, initiation of field exposure was followed by a transient increased end-tidal CO_2 excretion for about 5 min. However, hypercapnea induced by hypoventilation did not elicit increased $^{45}Ca^{2+}$ efflux. Thus this increase with exposure does not appear to arise as a secondary effect of raised cerebral CO_2 levels. Radioactivity measurements in cortical samples after superfusion showed $^{45}Ca^{2+}$ penetration at about 1.7 mm/hr, consistent with diffusion of the ion in free solution.

0345 LOW FREQUENCY AMPLITUDE MODULATED MICROWAVE FIELDS CHANGE CALCIUM EFFLUX RATES FROM SYNAPTOSOMES. (Eng.) Lin-Liu, S. (V.A. Hospital, 11201 Benton St., Loma Linda, CA 92357); Adey, W. R. Bioelectromagnetics 3(3):309-322; 1982 (24 refs).

Calcium ($^{45}Ca^{2+}$) efflux from preloaded rat synaptosomes was studied with a continuous perfusion technique and the rate constants of a biphasic efflux process calculated. When synaptosomes were exposed to 16-Hz sinusoidally amplitude modulated 450-MHz microwave (MW) fields (maximal incident intensity 0.5 mW/cm^2, modulation depth 75%) during the second (slow) phase, the rate constant increased by 38%. Exposure to continuous wave or 60-Hz modulated fields did not produce similar results. The MW field-induced change can be distinguished from $^{45}Ca^{2+}$ efflux stimulated by calcium chloride injection which is most probably derived intracellularly. These data suggest that the MW field-induced change in calcium efflux probably did not involve intracellular calcium. Moreover, the sensitivity exhibited by synaptosomes, which can be regarded as subcellular neuronal elements, provides evidence that whole cells or organized tissue are not required as essential anatomical substrates for field-tissue interaction.

0346 FLUORESCENCE DEPOLARIZATION STUDIES OF THE PHASE TRANSITION IN MULTILAMELLAR PHOSPHOLIPID VESICLES EXPOSED TO 1.0-GHz MICROWAVE RADIATION. (Eng.) Allis, J. W. (MD-74, Experimental Biology Div., Health Effects Research Laboratory, EPA, Research Triangle Park, NC 27711); Sinha, B. L. Bioelectromagnetics 3(3):323-332; 1982 (16 refs).

To investigate the interaction of microwave (MW diation with lipid bilayer vesicles, multilam dimyristoylphosphatidylcholine (DMPC) vesicles exposed to continuous wave 1.0 GHz MW energy in a perature controlled rectangular TEM cell. Befor posure, a fluorescent lipid-seeking molecular p diphenylhexatriene (DPH), was introduced into the membranes. Since chloroform is known to shift transition to a lower temperature, DMPC vesicles als treated with chloroform to serve as positive trols. Fluorescence depolarization measurements made as a function of temperature on control sa and on DMPC suspensions exposed to 1.0 GHz at s fic absorption rates (SAR) of 1, 5, 15, or 30 Measurements were also performed over a series of er levels while the temperature was maintained at and 25.5 C; these temperatures represent the poin which shifts in the phase transition could be det easily. Semilog plots of microviscosity versus perature showed that phase transition temperatu chloroform-treated vesicles was 5 C lower than i treated controls. No shift of the phase trans was found during exposure to 1.0 GHz MW radiati SARs between 1-30 W/kg. No statistically signif difference was found between exposed and control ples as SAR was increased. These results are in trast to those of others using laser Raman spec copy to measure the phase transition in similar tilamellar vesicles exposed to MW radiation.

0347 POSTRESONANCE ELECTROMAGNETIC ABSORPTI MAN AND ANIMALS. (Eng.) Massoudi, H. Electrical Engineering, Univ. Utah, Salt Lake UT 84112); Durney, C. H.; Barber, P. W.; Iskande F. Bioelectromagnetics 3(3):333-339; 1982 (10 r

A surface integral equation (SIE) method is us calculate the specific absorption rate (SAR) in s ically capped cylindrical models of man irradiat an axially incident electromagnetic (EM) plane (K polarization) in the frequency range 80-400 In the SIE method, the EM field equations are f lated in terms of the electric and magnetic cur induced on the surface of the body and the resu integral equation is solved by the method of mom The forward scattering theorem is used to calc the average SAR from the far scattered EM fields. data calculated by the SIE method show good agre with data calculated by the extended boundary c tion method (EBCM) for frequencies up to 80 MHz upper frequency limit of the EBCM) for man mo For rat models exposed to 1-3 GHz radiation, re able agreement was also obtained with the limite perimental data available. The upper frequency for SIE is 400 MHz for man models and 3 GHz fo models. When calculated average SAR values for and H polarizations were plotted with the data fo K polarization, it was found that the three curve tersect just above the E polarization resonance. information may be useful in designing experi where average SAR must be independent of animal tion.

0348 EFFECTS OF 60-Hz ELECTRIC FIELDS ON SPECIFIC HUMORAL AND CELLULAR COMPONENTS OF THE IMMUNE SYSTEM. (Eng.) Morris, J. E. (Biology Dept., Pacific Northwest Laboratory, P.O. Box 999, Richland, WA 99352); Phillips, R. D. Bioelectromagnetics 3(3): 341-347; 1982 (20 refs).

The functional aspects of humoral and cell-mediated immunity in Swiss-Webster mice exposed to 60-Hz electric fields at 100 kV/m (20 hr/day for 30 to 150 days) were investigated. Mice were housed in plastic cages between parallel-plate electrodes (3 animals/cage). The mice were in electrical contact with the wire mesh floors of the cages which constituted the reference ground electrode. After 60 or 90 days, exposed, sham exposed, and cage control mice were immunized ip with keyhole limpet hemocyanin (KLH); assays for precipitating antibodies were taken 14 days after challenge. No significant differences were observed in primary antibody response to KLH among the three groups of mice after 30 or 60 days of exposure. Responses of spleen cells from exposed, sham-exposed, and cage control mice were compared for three mitogens (concanavalin A, pokeweed mitogen, lipopolysaccharide) at various concentrations after exposure periods of 90 and 150 days. No significant differences were observed among the three groups of mice in the 90-day and 150-day exposure. Mean stimulation indexes obtained for phytohemagglutinin-treated spleen cells appeared to be higher for the exposed group than for sham exposed controls; however, statistical evaluation of the data indicated that the difference was not statistically significant.

0349 POSSIBLE EFFECTS OF 1011 Hz RADIATION ON THE OXYGEN AFFINITY OF HEMOGLOBIN. (Eng.) Kondepudi, D. K. (Center for Studies in Statistical Mechanics, Dept. Physics, Univ. Texas, Austin, TX 78712). Bioelectromagnetics 3(3):349-361; 1982 (19 refs).

The possible effect of electromagnetic radiation on the hemoglobin molecule is examined and a simplified model for heme plane oscillations is developed. The binding of oxygen to one of the subunits of hemoglobin greatly enhances the oxygen affinity of the other subunits. This cooperative interaction of the subunits is initiated by the movement of the heme plane toward the proximal side when oxygen binds to the heme. This motion is transmitted to the surface of the globin through a "reaction path" consisting of a group of atoms whose motion is well correlated. A simple model for the heme plane oscillations is presented based on detailed geometry and x-ray diffraction data of the mean square displacement of the atoms surrounding the heme. Using this model, the natural frequency of oscillations is approximately 5×10^{11} Hz. This result, along with recent experimental data on the kinetics of the conformational changes of the heme, points to the possibility that radiation may influence the oxygen affinity of hemoglobin. If such an effect exists, it is likely the oxygen affinity will be enhanced by the radia

0350 LOCAL TUMOR HYPERTHERMIA USING A COMP CONTROLLED MICROWAVE SYSTEM. (Eng.) M R. L. (Dept. Electrical Engineering, Univ. Illi 1406 West Green Street, Urbana, IL 61801); Fu, T Beard, R. E.; Cain, C. A. Bioelectromagnetics 363-370; 1982 (9 refs).

A minicomputer-based system designed to provide heating to tumors in laboratory animals is descr The system was used to treat transplanted subcuta PARA-7 fibrosarcomas in female golden Syrian ham without occurrence of skin burns. A computer was grammed to control the average microwave (MW) delivered to each of four local hyperthermia app tors in accordance with intratumor temperature urements performed at the end of a specified int of time when no MW power was applied. MW power GHz) was delivered through dielectrically loade applicators coupled to the tumors by a temperat regulated water-coupling cuff. Temperature in tumor was measured by thermocouples threaded th the center of the tumor. A temperature-scannin paratus was used to determine the steady-state te ature distribution in tumors. After an initial heating period of 2-3 min when MW power was 20 average power of 4 W was required to maintain a s state temperature of 43 C at the tumor center fo min; duty cycle was 0.78 and circulating water te ature in the water coupling cuff was 41 C. Us the circulating water cuff reduced intratumor te ature gradients and eliminated skin burns.

0351 MEASUREMENT OF BLOOD-BRAIN BARRIER PE TION IN RATS DURING EXPOSURE TO 245 MICROWAVES. (Eng.) Ward, T. R. (EPA, MD-74, Exp mental Biology Div., Research Triangle Park 27711); Elder, J. A.; Long, M. D.; Svendsgaar Bioelectromagnetics 3(3):371-382; 1982 (24 refs).

Adult CD albino rats were injected with a mixtu two radiolabeled saccharides (sucrose and inulin exposed for 30 min to 2450 MHz continuous wave m wave (MW) radiation in the far field of an ane exposure facility at 22 C at power densities of 0. 20, or 30 mW/cm^2 or to an environment at temperat of 22, 30, or 40 C. Following exposure, the brai perfused and sectioned into eight regions, and th dioactivity in each region was counted. Data analyzed both by a series of individual regre analyses to determine the response of each brai gion to each tracer and by profile analysis to for general changes. When the data were analyze 16 independent regression analyses and Bonferr method was applied to prevent false positive re from numerous analyses, no statistically signifi

increase in permeation was found for either tracer in any brain region of MW-exposed rats. When a profile analysis was used to test for a general change in tracer uptake across all brain regions, a significant increase in permeation was found for sucrose but not for inulin. However, no significant increase in permeation due to MW exposure was found after a correction factor derived from the warm-air experiments was applied to the data for the MW-exposed rats. The results suggest that the increase in brain permeation to sucrose observed at higher SAR was due to the thermalizing effect of MW exposure.

0352 ELECTROMAGNETIC DOSIMETRY IN A SITTING RHESUS MODEL AT 225 MHz. (Eng.) Olsen, R. G. (Naval Aerospace Medical Res. Lab., Code 41, Pensacola, FL 32508); Griner, T. A. Bioelectromagnetics 3(3):385-389; 1982 (7 refs).

A 9.5-kg tissue-equivalent rhesus model with an overall sitting height of 73.5 cm was exposed to continuous wave microwave (MW) power at 225 MHz in a horn and waveguide assembly placed inside an anechoic chamber. The model faced the horn at a distance of 228 cm. A nonperturbing temperature probe and a gradient-layer calorimeter were used to determine localized and whole body specific absoprtion rates (SAR). Normalized SARs based on temperature probe measurements showed deep penetration of MW energy, and calorimeter experiments showed an average SAR of 0.285 W/kg per mW/cm^2, a value much higher than the 0.107 W/kg per mW/cm^2 calculated for the same model at 1.29 GHz.

0353 THE VACUOLAR POTENTIAL OF CHARACEAN CELLS SUBJECTED TO ELECTROMAGNETIC RADIATION IN THE RANGE OF 200-8200 MHz. (Eng.) Barsoum, Y. H. (c/o Pickard, Dept. Electrical Engineering, Washington Univ., St. Louis, MO 63130); Pickard, W. F. Bioelectromagnetics 3(4):393-400; 1982 (14 refs).

Single giant cells of Chara braunii and Nitella flexillis were placed in a microstrip exposure apparatus and subjected to bursts of electromagnetic radiation (carrier frequencies from 200 to 8,200 MHz) at a nominal power level of 100 W/m^2. The vacuolar potential was monitored with a micropipette, and offsets as low as 1 mV could be resolved in real time by suitable filtering and signal averaging. At the 100 W/m^2 power level, no visible resting potential offset was detected. However, when the power was increased to a nominal 200 mW/m^2 (i.e., 400 mW delivered to the microstrip or roughly 2.2 V rms on the line), the slow hyperpolarizing ramp reported at lower frequencies could be seen but could not be accurately measured because of insufficient power. It appeared to decay beyond 500 MHz and to be absent at and above 950 MHz. To investigate reports that snail neurons irradiated for 1 hr at 2450 MHz and approximately 15.5 W/kg developed lowered membrane resistivities, electr and nonelectrogenic Chara braunii and nonelectr Nitella flexillis cells were exposed in the micr apparatus for 1 hr at 2450 MHz and 230 W/m^2. Me resistivity decreased 19.3%, 18.9%, and 17.3%, pectively, for each cell type.

0354 SYSTEMS FOR EXPOSING MICE TO 2450-MHz TROMAGNETIC FIELDS. (Eng.) Chou, (RJ-30 Univ. Hosp., Seattle, WA 98195); Guy, Bioelectromagnetics 3(4):401-412; 1982 (13 refs

Two systems for exposing mice to 2450-MHz mic (MW) fields are described. Dosimetry data on t systems are also presented. Laboratory animal placed in individual holders made of a polypro beaker inserted into a low-loss Styrofoam cage f posure. Since the systems are designed for short exposure, food and water are not provided. A are maintained in a constant temperature and h ty environment maintained by forced-air ventil A circular waveguide system is used to expose mice simultaneously to circularly polarized el magnetic fields. For 1-W input power to the guide, the average specific absorption rate (SA determined by twin-well calorimetry to be 3.60 W/kg in 27-g mice. The maximum SAR at the skin face determined thermographically was 8.36 W/ the head of the mouse. A miniature anechoic c is used to expose six mice simultaneously to field plane waves. The inside of the chambe lined with copper shielding and high-temperatur sorbing material to accommodate high input The air ventilation at the location of the mic separately controlled so that any heating in t sorber would not affect the animals. For 1-W power, and when the animals were irradiated wit axis parallel to the E field, the average SAR wa ± 0.01 W/kg and the maximum SAR at the skin s was 0.41 W/kg; when the animals were irradiate pendicular to the E field, the SARs were 0.11 W/kg and 0.64 W/kg, respectively. Although mu scattering among the animals in the circular guide system is larger than in the anechoic cha the circular waveguide system offers some advan over the anechoic chamber system: it is more efficient and less orientation dependent tha miniature chamber and it takes up less space.

0355 EVIDENCE FOR ELECTROSTATIC ENHANCEMEN ODOR RECEPTOR FUNCTION BY WORKER HON ANTENNAE. (Eng.) Erickson, E. H. (Bee Manageme vestigations, US Dept. Agriculture, Science Educ Admin., Russell Lab., Univ. Wisconsin, Madiso 53706). Bioelectromagnetics 3(4):413-420; 198 refs).

Pore plates (placoid chemosensilla) on the ant

of dead worker honeybees (Apis mellifera L.) apparently retained a static electric charge that was significantly different from that of the surrounding cuticle. Residual charge resulted in the concentration of airborne particulate matter over the rim of exposed pore plates to the virtual exclusion of such deposition on surrounding cuticle. Postmortem integrity of polar lipids associated with the pore plate and adjacent sense cells is hypothesized as the source of the static potential. Such a lipoidal matrix, if functioning as an electret and if attracting odorous molecules to receptor cells from outside the odor stream of individual receptors, would greatly enhance receptor efficiency of living bees.

0356 IN VIVO AND IN VITRO DIELECTRIC PROPERTIES OF ANIMAL TISSUES AT RADIO FREQUENCIES. (Eng.) Kraszewski, A. (c/o M.A. Stuchly, Non-Ionizing Radiation Sect., Environmental Health Centre, Health and Welfare Canada, Ottawa, K1A 0L2, Ontario, Canada); Stuchly, M. A.; Stuchly, S. S.; Smith, A. M. Bioelectromagnetics 3(4):421-432; 1982 (12 refs).

The dielectric properties of cat tissues in vivo and in vitro were measured and compared in the frequency range between 100 MHz and 8 GHz. The permittivity of rat tissues in vivo is also reported. An open-ended coaxial line and an improved measurement method employing a computer-controlled network analyzer were used. In vivo measurements were performed on four anesthetized cats; various tissues (muscle, spleen, kidney cortex, liver, and brain cortex) were surgically exposed for dielectric measurements. The cats were euthanized and submerged in a normal saline bath; individual tissues were raised just above the saline bath surface and blotted dry immediately before the measurement probe was applied to the same tissues. The differences between in vivo and in vitro (less than 4 hr after death) measurements of the dielelectric constant and the conductivity of all cat tissues were found to be smaller than the experimental uncertainty limits of 2% for the dielectric constant and 3% for the conductivity. These results provide an experimental confirmation of the predicted behavior of tissues.

0357 FAR-FIELD DOSIMETRIC MEASUREMENTS IN A FULL-SIZED MAN MODEL AT 2.0-GHz. (Eng.) Olsen, R. G. (Naval Aerospace Medical Res. Lab., Code 41, Pensacola, FL 32508). Bioelectromagnetics 3(4): 433-442; 1982 (11 refs).

Electromagnetic dosimetry was conducted in a tissue-equivalent full-sized (1.74 m, 70 kg) model of man irradiated at 2 GHz inside a microwave-anechoic chamber. A nonperturbing temperature probe and a gradient-layer calorimeter were used to determine local and whole-body specific absorption rate (SAR), respectively. Temperature was measured in 9 locat in the body. Dosimetric data were taken at the surface of each location and at 1 cm depths dire behind each location to give a profile of absorp Relatively high SAR values were found in the compared to the axis of the trunk of the model. whole body calorimetric determinations were made. calorimeter experiments yielded an average SAR 3-fold higher than that estimated theoretically prolate spheroidal model of man. It is suggested resonant interactions involving the limbs may be sponsible for the disparity between theory and e iment.

0358 A BEHAVIORAL RESPONSE OF SWINE TO A ELECTRIC FIELD. (Eng.) Hjeresen, (c/o Phillips, Biology Dept., Battelle Pacific N west Lab., Richland, WA 99352); Miller, M. C.; K. W. T.; Phillips, R. D. Bioelectromagnetics 3(4) 452; 1982 (13 refs).

Hanford miniature swine that had been exposed to Hz electric field at 30 kV/m for 20 hr/day, 7 da for up to 3438 ± 45 hr, were tested for their pr ence for the presence or absence of the field dur 21-hr period. During behavioral testing, 4/17 ex swine and 9/15 sham-exposed swine were pregnant. swine were tested in a shuttlebox system consisti a shielded and an unshielded stall connected by a sageway. The location of the pig within the shu box was monitored with two light-beam scanners i passageway. Each of the 32 pigs was subjected single 21 hr test, which included 2 light period a 12-hr dark period (from 5 PM to 5 AM). Known of indirect interaction between swine and 60-Hz were eliminated or reduced to very small values. were analyzed within the two light periods, the period, and the entire 21-hr period. Swine spent nificantly more time in the region shielded from tric field exposure during the sleeping period o diurnal cycle (5 PM-5 AM); when active, they move tween shielded and exposed regions fairly frequ and showed no significant preference for either The response of pregnant and nonpregnant pigs to tric field exposure appeared to be different: exposed nonpregnant swine preferred the shielded while the 4 pregnant swine exhibited no prefere The behavioral response of swine in a 60-Hz ele field is similar to that in rats. It is sugg that the response is a result of a direct intera between the electric field and the animals.

0359 EFFECTS OF X-BAND MICROWAVE EXPOSUR RABBIT ERYTHROCYTES. (Eng.) Cleary, (Dept. Biophys., Med. Coll. Virginia, Virginia Co wealth Univ., Richmond, VA 23298); Garber, P.; L. M. Bioelectromagnetics 3(4):453-466; 1982 refs).

The effects of continuous wave (CW) and pulsed microwave (MW) heating on the permeability of erythrocyte (RBC) plasma membranes were studied. RBC from adult Dutch rabbits were exposed as whole (heparinized) blood suspensions or as washed cells in 1:1 isotonic buffered K^+-free saline suspensions in waveguide exposure chambers or in a temperature-controlled circulating water bath within 20 min after the blood samples were taken; duration of exposure was 2 hr. Temperature distributions within the samples were measured with either a Vitek electrothermia probe or a thermocouple. Statistically significant increases in K^+ efflux compared to water-bath-heated controls were detected when RBC were exposed in whole blood suspensions to either CW or pulse-modulated 3.42-GHz MW energy at specific absorption rates (SAR) resulting in sample temperatures of 24.0 and 24.4 C, respectively. Pulsed MW exposure (5 usec pulses, equivalent peak power density of 14.5 W/cm^2 at the center of the waveguide, pulse repetition rates of 138, 413, or 555 Hz; SAR, 21.6 mW/g) resulted in a small but consistent enhancement of K^+ efflux in 1:1 red cell suspensions and to a lesser extent in whole blood, compared with CW exposure (SAR, 21.7 mW/g). No statistically significant K^+ efflux occurred in the case of 1:1 red cell suspensions under the same exposure conditions. Measured differences in sample heating rates and temperature gradients between MW-exposed and heated control suspensions may account in part for the differential effect of MW exposure, but such effects do not appear to fully explain the results of this study.

0360 ASSESSMENT OF THE IMMUNE RESPONSIVENESS OF MICE IRRADIATED WITH CONTINUOUS WAVE OR PULSE-MODULATED 425-MHz RADIO FREQUENCY RADIATION. (Eng.) Smialowicz, R. J. (Experimental Biology Div., Health Effects Research Lab., EPA, Research Triangle Park, NC 27711); Riddle, M. M.; Weil, C. M.; Brugnolotti, P. L.; Kinn, J. B. Bioelectromagnetics 3(4): 467-470; 1982 (7 refs).

Groups of four female BALB/C mice (8-10 wk old) were irradiated with either continuous wave (CW) or pulse modulated (PM: 1-msec pulse width, 250 pulses/sec) 425-MHz radiofrequency (RF)radiation. Mice were irradiated for 1 hr on each of 5 consecutive days in a rectangular strip-transmission line at average forward powers of 78, 17.7, or 5 W for CW and 17.7, 5, or 1.25 W for PM. The mean specific absorption rate, as measured using twin-well calorimetry was 7.7 W/kg for a forward power of 70 W. No differences in the mitogen-stimulated response of lymphocytes or in the primary antibody response to sheep erythrocytes or polyvinylpyrrolidone were observed between irradiated and sham-irradiated mice, nor between mice exposed to either CW or PM 425-MHz RF radiation. The failure to detect a change in the immune response does not directly answer the question as to whether or not a qualitative difference in biological effectiveness exists between CW and PM modes.

0361 COMPARISON OF BACTERIAL GROWTH TO INTENSITY MICROWAVE EXPOSURE AND CO TIONAL HEATING. (Eng.) Hossain, M. A. (c/o D Dept. Botany, Howard Univ., Washington, DC 20 Dutta, S. K. Bioelectromagnetics 3(4):471-474; (4 refs).

Escherichia coli pol A$^+$ and pol A$^-$ strains wer posed in the far field to 8.8-GHz microwaves pulsed at 1000 Hz (1-usec pulse width) and an S 40 W/kg, which increased the temperature of a bacterial suspension by 7 C. Two-way analysi variance showed no significant difference be the growth rates of MW-irradiated and thermall posed cells beyond that associated with a tem ture increase.

0362 ATTEMPTS TO ALTER $^{45}Ca^{2+}$ BINDING TO TISSUE WITH PULSE-MODULATED MICR ENERGY. (Eng.) Merritt, J. H. (USAF/SAM, Brooks San Antonio, TX 78235); Shelton, W. W.; Chamnes F. Bioelectromagnetics 3(4):475-478; 1982 (8 r

Experiments were designed to test the effect of in vitro and in vivo exposure to pulse-modulate crowave (MW) energy on $^{45}Ca^{2+}$ binding in rat tissue. Six individual samples loaded with ^{45}Ca intraventricular injection were exposed to MW GHz (16 Hz pulse repetition rate, 20 msec pulse w power densities of 1 or 10 mW/cm^2, specific absor rates [SAR] of 0.29 or 2.9 W/kg), or 2.45 GHz (pulse repetition rate, 20 msec pulse width, power sity of 1 mW/cm^2, SAR = 0.3 W/kg), or sham radi for 20 min. No significant differences betwee radiated and sham-irradiated tissues with respe $^{45}Ca^{2+}$ efflux were found. For whole animal expos rats were injected intraventricularly with $^{45}Ca^{2}$ exposed for 20 min to 2.06 GHz in one of 17 diff combinations of power density and pulse repet rate. Pulse width was held constant at 10 msec was 0.24 W/kg per mW/cm^2. There was no signif difference in efflux of $^{45}Ca^{2+}$ between MW- and irradiated groups. The data indicate that net ^{4} efflux in rat brains exposed either in vitro in vivo is not altered by pulse-modulated MW radi under the conditions used in this study.

0363 MICROWAVE ABSORPTION BY FOLDED DNA CH (Eng.) Kohli, M. (Dept. Physics, P Univ., West Lafayette, IN 47907); Van Zandt, Biopolymers 21(7):1399-1410; 1982 (8 refs).

The absorption of microwave radiation by a DNA cule is calculated for a segment of a straight, infinite polymer chain with abrupt, localized b The power absorbed by a segment of chain betwee bends is calculated first. Every length of po

chain is then regarded as lying between bends and the calculated absoprtion can be integrated over the distribution of interbend distances. Contributions to cross section absorption from base pairs outside the bends are estimated separately. Vibrational properties of the bends were parameterized by a transmission and a reflection coefficient. A general Green's function expression for power absorption was studied for different damping rate values and for transmission and reflection coefficients. Detailed expressions for absorption cross sections for longitudinal and optical modes are presented in an appendix. The specific system for which absorption estimates were made is poly(dG)-poly(dC) in B-conformation. Curves of absorption vs frequency (5.0-30.0 GHZ) are shown for various damping parameters and reflection conditions.

0364 ABSORPTION OF MICROWAVE RADIATION BY DNA DOUBLE HELIX IN AQUO. (Eng.) Van Landt, L. L. (Dept. Physics, Purdue Univ., West Lafayette, IN 47907); Kohli, M.; Prohofsky, E. E. Biopolymers 21(7):1465-1468; 1982 (9 refs).

The microwave absorption by DNA double helix in aqueous solution was calculated, and theoretical results were compared with experimental data. Elastic properties of the isolated, dry molecular chain were determined and organized into distinct normal modes characterized by wave number and by one of four eigenvectors in the microwave portion of the spectrum. The behavior of water was treated as a viscous, elastic, inertial continuum extending radially from the surface of a long cylindrical core to infinity. A general expression was obtained for fluid field velocity in the form of a series of independent vector fields. Calculated absorption values agreed strikingly with experimental values for the relative absorption of water and DNA solution at 8-12 GHz. In contrast to simple relaxation time models of molecule-solvent interaction, the theory predicts decreases in absorption at higher frequencies. Data for the narrow frequency range suggest that the drop may be even stronger than predicted, suggesting that additional mechanisms may be involved in the absorption process.

0365 A MICROWAVE RADIOMETRIC METHOD FOR THE STUDY OF THE SEMICONDUCTOR PROPERTIES OF LIVING TISSUE: ITS POTENTIAL APPLICATION TO TUMOR LOCATION. (Eng.) Itigu, J. (Elliot Lake Lab., Mining Res. Lab., PO Box 190, Elliot Lake, Ont., Canada). Biotelem Patient Monit 9(2):98-114; 1982 (26 refs).

A microwave (MW) radiometric technique to enable investigation of the semi-conductive properties of biological tissue is described. The technique makes use of the nonlinear electric properties of tissue in conjunction with its radiative properties as described by blackbody theory. Mixing of the MW power generate a body region illuminated by MW energy with the power generated by an external source results i intermodulation spectrum that can be measured an intermediate frequency radiometer tuned to a determined difference frequency or a sum frequ of the intermodulation spectrum. Preliminary exp mental results are presented. A radiometer operat at 225 MHz with a 10 MHz bandwidth was used in exp ments conducted on rabbits, humans, MW absorbers, dielectrics exposed to 9.3 GHz radiation at power sity levels of 20 mW/cm^2 (less for human subjec No increase in the 225-MHz signal took place specimens illuminated in the 9.3-GHz field rela to the same specimens in the absence of the fi Results were limited by inadequate sensitivity of radiometer; however, it was possible to establish upper quantitative limit for effective semic ductor mixing parameters. Extension of the techn to tumor localization is discussed and described a mathematical model. Radiometric scanning should tect differences in semiconductive properties at boundary of the tumor and surrounding normal tis

0366 HYPERTHERMIA AS A TREATMENT FOR NEOPLA (Eng.) Dreznik, A. (c/o Falk, 1-140 rard Wing, Toronto General Hosp., Toronto, Ont. 1L7 Canada); Falk, R. E.; Howard, V.; Makowka, Venturi, D. Can J Surg 25(6):603-608; 1982 (88 re

A review is presented of the historical background experimental and clinical results of hyperthermia cancer therapy. The reaction of tumor tissue to perthermia differs from that of normal tissue. T cells are more sensitive to heat than normal cells 42-44 C. Selective heating creates a core tumor t perature of 45-50 C with demonstrable tumor and t cular necrosis. The differences in heat accumulat in normal and malignant tissues are apparently lated to tumor blood supply. Thermotherapy can administered by whole body, regional, and local perthermia. Methods of production of hyperther for the treatment of malignant tumors include use of the whole electromagnetic spectrum. Side fects of microwave and radiofrequency hyperther are summarized. Experimental studies suggest t hyperthermia produces an immunological response t plays a prominent role in tumor destruction. mechanism of this effect is not known, but it may volve increases in cell membrane immunogenicity limited number of clinical trials of hyperther alone or in combination with chemotherapy or ra therapy have been reported. Hyperthermia is synerg tic with several chemotherapeutic agents, and th is evidence that it reduces the radiation dose nec sary to cause tumor necrosis. Thermotherapy is eff tive with different histologic tumor types and a deep-seated as well as superficial tumors. Regi hyperthermia induced by radiofrequency offers the s and most controlled form of therapy.

0367 CLINICAL HYPERTHERMIA: RESULTS OF A PHASE I TRIAL EMPLOYING HYPERTHERMIA ALONE OR IN COMBINATION WITH EXTERNAL BEAM OR INTERSTITIAL RADIOTHERAPY. (Eng.) Manning, M. R. (Univ. Arizona Health Sciences Center, Radiation Oncology Div., Tucson, AZ 85724); Cetas, T. C.; Miller, R. C.; Oleson, J. R.; Connor, W. G.; Gerner, E. W. Cancer 49(2):205-216; 1982 (35 refs).

Results of a Phase I trial of hyperthermia (HT) alone or in combination with high-dose-rate external beam or low-dose-rate interstitial radiotherapy in the treatment of 43 patients with advanced, locally accessible neoplasms refractory to conventional therapies are reported. HT alone was used in eleven patients who had reached radiation tolerance levels or were not candidates for radiation for other reasons. Seventeen patients with accessible lesions (who could tolerate general anesthesia) were treated with interstitial thermotherapy in which iridium or radium implants combined with HT produced by localized radiofrequency (RF) current fields using the implant guides or needle casings as electrodes. The remaining 15 patients were treated with externally produced HT and radiation. For all tumor types, HT alone (2-22 fractions, 42.5-44 C for 40 min) resulted in complete response (CR) in 2/11 patients (18%), partial response (PR) in 3/11 (27%); 6/11 patients showed less than 50% reduction in tumor volume. Of the nonresponders, 4/6 experienced growth arrest during treatment concomitant with pain relief. Duration of response was 1-24 mo. Of the patients treated with HT (43-44 C for 40 min at 72 hr intervals) followed by radiotherapy, 8/15 (53%) displayed PR, 4/15 (27%) showed CR, and 3/15 showed no response other than pain relief and central necrosis of tumor. Of the patients treated with interstitial thermotherapy, 5/17 (29%) showed PR lasting 2-3 mo and 12/17 (71%) displayed CR with no tumor regrowth within the treated volume for a 2-12 mo follow-up period. Total response rates based on tumor histology were 1/2 malignant fibrous histiocytoma, 3/5 sarcoma, 11/14 squamous cell carcinoma, 11/14 adenocarcinoma, and 8/8 melanoma. Complications were minimal for all treatment groups and included 1 third-degree burn and 3 second-degree burns from fringing RF fields, 1 vaginal-rectal fistula, a superficial focal soft tissue necrosis, and some minor blistering. The results demonstrate that HT alone or in combination with radiotherapy can be safely applied in the treatment of malignant disease. The data also suggest that HT, especially when combined with interstitial thermoradiotherapy, can yield remarkable results in the eradication of local cancers.

0368 THE TREATMENT OF CONGENITAL PSEUDARTHROSIS OF THE TIBIA WITH PULSING ELECTROMAGNETIC FIELDS: A SURVEY OF 52 CASES. (Eng.) Sutcliffe, M. L. (Orthopaedic Dept., Royal Hallamshire Hosp., Sheffield, S10, 2JF, England); Goldberg, A. A. J. Clin Orthop (166):45-57; 1982 (15 refs).

A survey is presented of European cases of congeni pseudarthrosis of the tibia treated with pulsing el tromagnetic fields (PEMF) using the Bi-Osteogen Sys of Electro-Biology, Inc. Prior disability time of 49 children (1-16 yr old, mean, 6.7 yr) was > 2 yr 78% of the cases and > 5 yr in 35 % of the cases. but 5 patients had undergone at least one unsuccess surgical procedure (mean, 1.76 operations) before P therapy was instituted. Of the 49 patients, a de nite endpoint was reached in 37, and a successful o come (union and progression to full wt bearing w protective orthosis) was achieved in 26 (70.2%). the 37 children who reached a definite endpoint, patients with 30 fractures received an initial cou of PEMF therapy alone; there were 15 successes (av age treatment time, 7.7 mo) and 15 failures (aver treatment time, 12.4 mo). Of the 15 failures, 7 sponded to a bone graft and a second PEMF cou (average treatment time, 8.6 and 8.66 mo, respecti ly, for the first and second treatment courses); patients were awaiting surgery and further PEMF tre ment. In 9 patients, initial PEMF therapy and s gery were carried out concomitantly; union occur in 6 cases (average treatment time, 6.0 mo vs. mo for 3 unsuccessful cases). Analysis of the sults showed that PEMF therapy alone effected un in 60% of cases of Bassett Type I and 57% of Type cases. An average treatment period of 6 mo is in cated before determining whether the coils will s ceed in a given case. Although Type III cases w extreme atrophy and gross mobility do not respond PEMF therapy alone, initial preoperative priming w PEMF is recommended. Because of the importance effective immobilization and a strict, non-weig bearing status, the applicability of PEMF therapy young children (less than 33 mo old) is questionab

0369 REWARMING MICE FROM HYPOTHERMIA BY EX SURE TO 2450-MHz MICROWAVE RADIATI (Eng.) Gordon, C. J. (Physiology Section, Biologi Engineering Branch, Experimental Biology Div., Hea Effects Res. Lab., EPA, Res. Triangle Park, NC 2771 Cryobiology 19(4):428-434; 1982 (12 refs).

Effects of whole-body 2,450-MHz microwave (MW) he ing on survival of hypothermic male AJ and CD-L bino mice (25-40 g) were assessed. Body (colon temperatures were measured with a Vitek probe t provides unperturbed measurements in a radiofreque radiation field (30-3000 MHz). The mice were cold- posed in a cold waveguide system until body tempe ture decreased to an average of 25.7 C (range, 17 C). The MW generator was then activated and incid powers of 10-80 W were directed into the wavegui Of 19 mice, 18 survived rewarming at rates of 0. 0.65 C/sec. MW exposure caused tail burning (spots) in 12/19 animals, but the treatments apparen had no other ill effects. The one death that occur was probably due to cold exposure (body temperatu 16.9 C). A warming rate of 0.65 C/sec is 17-200 ti higher than rates achieved with external heating te niques such as immersion in warm water. Thus, int

nal deposition of electromagnetic radiation permits far faster recovery of experimental animals from hypothermia.

0370 FOOD FORAGING OF HONEY BEES IN A MICROWAVE FIELD (2.45 GHz CW). (Eng.) Gary, N. E. (Dept. Entomology, Univ. California, Davis, CA 95616); Westerdahl, B. B. Environ Entomol 11(1):95-99; 1982 (15 refs).

The effect of exposure to 2.45 GHz continuous wave microwaves (MW) on the foraging behavior of honey bees was investigated. A population of cordovan honey bees was trained to fly 400 m from their colony to foraging arenas in an indoor laboratory containing identical treatment and sham MW chambers. The MW chamber simulated conditions anticipated within and surrounding proposed solar power satellite (SPS) rectennae. A 3-hr MW treatment was carried out on 5 consecutive days at 5 power densities (0, 5, 10, 20, and 40 mW/cm^2). Bees made approximately 20-30 round trips during the 3-hr observation periods and were in the chambers for about half of the time. Mean daily foraging populations did not differ significantly for the MW and sham chambers. Mean round trip times and foraging time were similar for control and MW-treated bees at all power levels. MW-treated bees experienced no detectable alterations in orientation and navigation behavior. The results provide evidence that honey bees readily enter MW fields at power densities similar to and exceeding those expected to be present in the rectennae of the proposed SPS system (23 mW/cm^2 at the antenna center to 1 mW/cm^2 at the edge) and that their behavior is not adversely affected by these fields.

0371 COMMENTS ON THE PAPER "ENVIRONMENTAL POWER-FREQUENCY FIELDS AND SUICIDE." (2 LETTERS TO THE EDITOR). (Eng.) Smith, C. W. (Dept. Electrical Engineering, Univ. Salford, Salford M5 4WT, England); Baker, R. D. Health Phys 43(3):439-441; 1982 (3 refs).

According to Smith, recent work on the effects of low-frequency magnetic fields on bacteria growth rates suggests that there might be a critical onset magnetic field strength or a periodicity in propensity to suicide as a function of magnetic field strength (Perry et al; Health Phys 41:267-277; 1981). Statistical analysis of Perry's raw data confirmed the basic effect, but it neither confirmed nor ruled out the presence of periodicities. If there is any causal relationship between suicide and field strength, the size of the structural entity which should be sought for implication will be at least 360 uM in diameter; local circuit neurons fall within this range. Baker's analysis of Perry's data confirms that the ratio of suicides to controls appears to oscillate with field value indicating that the propensity to suicide a given field value presumably either rises with field, if the apparent oscillation is illusory, does indeed oscillate. More study is needed.

0372 ABSORPTION CHARACTERISTICS OF PROL SPHEROIDAL MODELS EXPOSED TO THE N FIELDS OF ELECTRICALLY SMALL APERTURES. (En Lakhtakia, A. (Dept. Electrical Engineering, Un Utah, Salt Lake City, UT 84112); Iskander,M. F.; O ney, C. H.; Massoudi, H. IEEE Trans Biomed Eng 29(569-576; 1982 (20 refs).

Normalized average specific absorption rate (SAR) v ues were calculated for prolate spheroidal models humans exposed to electrically small aperture sourc The incident electromagnetic fields in the apert were replaced by those produced by equivalent el tric and magnetic dipoles, depending on the charac of the fields incident on the aperture. The indu fields within the spheroid produced by each dip were determined using the extended boundary condit method (EBCM). The orientation of the induced el tric field created by the dipoles at large distan from the aperture was parallel to the spheroid ma axis. From the induced fields, the average SAR the spheroid was calculated. All results were gi in terms of aperture impedance, which is defined the ratio of the incident normal electric field the incident tangential magnetic field at the ap ture. For all calculations, the aperture radius incident power density were equal to .01 wavelen and 1 mW/cm^2, respectively. As the aperture locat (the ratio of aperture-to-spheroid distance to wa length) was increased at 27 MHz, the normalized av age SAR decreased to approximately the same limit value for different values of the aperture impedan Calculations of the SAR were made at 10, 27 and MHz and at an aperture location of 0.15, while aperture impedance was varied in magnitude and pha It is demonstrated that the nature of the near fie of the aperture source is more complex than that elementary sources but that a qualitative understa ing obtained from the study of the irradiation fects of an elementary source accounts for the ne field absorption characteristics of models irradi ed by small aperture fields.

0373 AN ACCURATE PROBE FOR MAPPING STRONG MAGNETIC FIELDS. (Eng.) Oleson, J. (Div. Radiation Oncology, Arizona Health Services C ter, Univ. Arizona, Tuscon, AZ 85724). IEEE Tr Biomed Eng 29(8):581-583; 1982 (11 refs).

The design and use of a high frequency magnetic fi probe with an accuracy of ± 5 percent and precis of ± 1 percent are described. The probe was desig for measuring magnetic fields over small areas and

relatively high field strengths such as those used in hyperthermia treatment. The probe consists of a 1.9 cm diameter wire loop sensor constructed from the leads of a subminiature incandescent lamp. Light from the lamp is transmitted through a 2 m length of multi-fiber-optic cable. The probe measures the average orthogonal magnetic field components over a 2 cm² area. The probe does not allow for simultaneous measurements of orthogonal field amplitudes and relative phases. Since the probe is frequency dependent, its use without frequency spectrum analysis is only possible in fields of a well-defined single frequency such as the field produced by the Magnetrode (13.56 MHz). An expression was derived to relate the lamp intensity to magnetic field intensity, frequency and loop impedance and radius. For calibration purposes, the impedance of the wire loop was measured with the Hewlett-Packard 4815A Impedance Bridge. To test the calibration of the probe, calorimetry experiments were performed and field values were obtained from measurements with a Holiday Isotopic Field Probe at a frequency of 13.56 MHz using the Magnetrode body electrode. Both comparisons agreed to within the ± 5 percent accuracy of the probe.

0374 BLOOD FLOW EFFECTS ON THE TEMPERATURE DISTRIBUTIONS FROM AN INVASIVE MICROWAVE ANTENNA ARRAY USED IN CANCER THERAPY. (Eng.) Strohbehn, J. W. (Thayer Sch. Engineering, Dartmouth Coll., Hanover, NH 03755); Trembly, B. S.; Douple, E. B. IEEE Trans Biomed Eng 29(8):649-661; 1982 (39 refs).

The effects of variations in blood perfusion rates and tissue electrical properties on temperature distributions in homogeneous tissues produced by an array of invasive microwave antennas was studied by numerical simulations. The bioheat equation was solved numerically for a number of symmetrically-spaced antennas forming a circular array in a homogeneous two-dimensional tissue model. The electric field produced by each antenna was expressed as the field at the midpoint of a bare half-wave dipole embedded in a conductive medium. A constant heating of the tissue adjacent to the antenna of +5 C was assumed. The electrical properties of the modeled tissue were varied to simulate muscle, brain, and fat with the same antenna distribution. For a tissue model with the properties of muscle tissue, four antennas equally spaced about a 1.414 cm radius circle, a frequency of 1 GHz, and blood flow rates equal to or less than that in resting muscle tissue, steady state temperatures were reached within .5 min and temperature distributions were governed by heat conduction and were not significantly different from temperature distributions for no blood flow. For blood flow rates 10 times that in resting muscle tissue, steady state temperature distributions were reached within 5 min and the isotherm plots for the therapeutic temperatures were concentrated around the antenna. Temperature distributions were determined by blood flow and were significantly different from temperature distributions for no blood flow. Temperature distributions for different frequencies are shown. For high blood rates, more antennas were needed to create an of therapeutic temperature large enough to be ef tive in treating the tumor.

0375 MICROSTRIP LOOP RADIATORS FOR MEDICAL PLICATIONS. (Eng.) Bahl, I. J. (International Telephone and Telegraph, Electro-Optical ducts Div., 7635 Plantation Rd., Roanoke, VA 240 Stuchly, S. S.; Lagendijk, J. J. W.; Stuchly, M IEEE Trans Microwave Theory Tech 30(7):1090-1 1982 (9 refs).

Three microstrip loop radiators designed for med applications are described. Two of them were desi for inducing local hyperthermia at 433 and 915 and the third was constructed for the detectio breast cancer using microwave radiometry at 1300 The design principles of the loop radiators and t dimensions under various loading conditions are sented together with a diagrammatic representatic their geometry. Return loss measurements with a work analyzer indicated that the radiators were matched in a relatively broad range of frequenc when placed in contact with the human female bre a muscle phantom, and a distilled water bolus lowed by a muscle phantom. Heating patterns of 433 and 915 MHz radiators investigated by thermogr as well as by liquid crystal films indicated that heating patterns of these radiators placed in di contact with the muscle phantom were assymetrical respect to the axis of the radiator. This was at buted to the near-field effect created by the hi order modes. Temperature distribution in the pha along the main axis, after irradiation by a 100-W usec pulse at frequencies of 433 and 915 MHz sh an exponential decrease with the distance from surface. With the water bolus, the heating pat of the radiators was symmetrical with respect to axis. The penetration depth of the heating depe on the frequency of operation and the size of the diator: it was 1.6 cm for the 433-MHz radiator 1.1 cm for the 915-MHz radiator.

0376 CLINICAL RF HYPERTHERMIA BY MAGNETIC-INDUCTION: A NEW APPROACH TO HUMAN CA THERAPY. (Eng.) Storm, F. K. (Div. Oncology, D Surgery, UCLA Sch. Medicine, Univ. California, Angeles, CA 90024); Elliott, R. S.; Harrison, W. Morton, D. L. IEEE Trans Microwave Theory Tec (8):1149-1982; 1982 (43 refs).

Classical methods for raising tissue temperatures reveiwed and the development and clinical use of netrode magnetic-loop induction hyperthermia cancer therapy are described. The magnetrode was signed so that the E-lines run parallel to tissue

terfaces and overheating of fat and skin layers is minimized. The magnetrode is constructed from a conducting sheet rolled so that the two ends overlap but do not touch. The overlap area and distance between the ends determine the capacitance of the applicator. For homogeneous tissue phantoms placed within the magnetrode, peripheral heating of the phantom is much greater than the central heating. When high-dose hyperthermia was quickly applied to anesthetized dogs, temperature distributions within the abdominal cavity were similar to those in homogeneous phantom models. Moderate dose hyperthermia heated the central and peripheral tissues more evenly with a temperature gradient of less than 1 C. The effect of blood flow was demonstrated by applying moderate dose hyperthermia to the same dog when alive and dead which resulted in even heating and preferential peripheral heating, respectively. Deep heating with little surface heating was produced in a human thigh placed within the magnetrode. Of 89 tumors treated in clinical trials, 78% were heated to temperatures equal to or greater than 42 C, 36% to temperatures over 45 C and 25% to temperatures over 50 C without raising normal tissue temperatures beyond physiological limits. Success rates for reaching therapeutic temperatures are also given according to malignancy type and tumor size. Larger tumors had greater success rates which may reflect a decrease in their vascularization and thermoregulation. The clinical trials indicated that increasing the treatment time, temperature, and number of treatments increased the chance of tumor necrosis. Magnetic-loop induction hyperthermia producing 500-1000 W of absorbed power resulted in physiological changes which did not exceed physiologically tolerable limits. Surface tissue injury occurred in 0.3% of the of the treatments.

0377 HEAT TRANSFER IN SURFACE-COOLED OBJECTS SUBJECT TO MICROWAVE HEATING. (Eng.) Foster, K. R. (Dept. Bioengineering, Univ. Pennsylvania, Philadelphia, PA 19104); Ayyaswamy, P.; Sundararajan, T.; Ramakrishna, K. IEEE Trans Microwave Theory Tech 30(8):1158-1166; 1982 (15 refs).

A model to predict the thermal characteristics of a biological sample uniformly heated by an electromagnetic (EM) field and cooled by an unbounded, laminar fluid flow around the sample is described. The homogeneous biological sample was initially at a temperature equal to that of the coolant before EM heating began. The coolant was assumed not to be heated by the EM field. Objects of three geometries (sphere, cylinder, and rectangular slab) were analyzed. For each case, the solution of the appropriate non-dimensional differential equation for heat conduction with convective boundary conditions was presented. Actual temperature can be found assuming that the sample density, material thermal properties of the sample and the Biot and Reynolds numbers that characterize the flow and convective cooling, are known. Plots of nondimensional temperature as a function of nondimensional time are shown for different locations within the three differently shaped objects and for different Reynolds numbers of flow. An optimum flow rate beyond which no more effective cooling of the sample possible exists for each situation and depends on thermal conductivity of the object and coolant, Prandtl number. Bounds were formulated for the imum temperature difference produced within a sa that are possible for various flow situations function of sample size and thermal conductivity. results are of general applicability and are also id where the coolant is a gas or liquid different water with the only restriction being the Reyn number of flow.

0379 HUMAN WHOLE-BODY RADIOFREQUENCY ABSORP STUDIES USING A TEM-CELL EXPOSURE SYS (Eng.) Hill, D.A. (Radiation Biology Section, fence Res. Establishment Ottawa, Ottawa, Canada 0Z4). IEEE Trans Microwave Theory Tech 30(11):1 1854; 1982 (31 refs).

A transverse electromagnetic (TEM)-cell exposure tem constructed for the measurement of whole-body sorption in humans of radiofrequency radiation at quencies of 3 to 20 MHz is described. Human vo teers were exposed to 11 uW/cm^2 for up to 1 hr, and never absorbed more than 1 W. The exposure ber was a large (6.1 x 7.3 x 13.0 m) low-loss angular-coaxial TEM mode transmission line sha tapered at each end to form a cell. The cell a irradiation of subjects in any orientation with pect to the propagating TEM mode under simulated space or grounded conditions. The absorbed power termined from 3-min signal-averaged measurement incident, reflected, and transmitted power, was ured to a precision of 0.06% of incident power dB in insertion loss). Analysis of systematic rors in the method showed that a directional-co directivity approaching 50 dB is necessary for accuracy in absorbed-power measurements and tha dielectric-loading effect of the subject on the absorption is undetectable. The total systemati ror in determining absorption rate per unit exp rate was about ±35% of the measurement. Oper frequencies are currently limited to 3-20 MHz d occurrence of the first cell resonance, assoc with the TE_{01} mode, at 20.7 MHz. The first set o man whole-body absorption results is presented subjects exposed in free space to 11 uW/cm^2 at MHz in six different body orientations with respe the TEM wave. The measured absorption rates fo two principal E orientations are larger than the lished predictions by a factor of 2-3.

0379 A BROAD-BAND TEMPERATURE-CONTROLLED S FOR THE STUDY OF CELLULAR BIOEFFECTS O CROWAVES. (Eng.) Riazi, A. (Dept. Electrical neering, Univ. Utah, Salt Lake City, UT 84112); W.; Hagmann, M.J.; Gandhi, O.P.; D'Andrea, J.A.

Trans Microwave Theory Tech 30(11):1996-1998; 1982 (5 refs).

A broad-band temperature-controlled microwave (MW) exposure system designed for the study of cellular bioeffects of MW radiation is described. The dual-circuit apparatus allows simultaneous testing at frequencies in the E-band (65-75 GHz) and in the U-band (38-48 GHz). A waveguide switch is used in both circuits to allow accurate measurement of incident power levels with thermistor detectors. Continuous monitoring of both incident and reflected power is done with SWR meters connected to the broad-band diodes attached to directional couplers in the two circuits. A schematic of the irradiation system is presented together with diagrams of the system's thermally insulated housing and sample holders. The system coupling efficiency is greater than 99% over all usable frequencies, which allows use of relatively inexpensive low-power sources, and it is simple to operate. Opposing thermocouples allow measurement of temperature differences as small as ±0.01 C. Compensatory heating of the control sample holders suggests that temperature differences over the course of 30 min exposures can be kept within ±0.02 C by appropriate feedback circuits. The system has been successfuly used to investigate the effects of MW radiation on cell suspensions of several bacterial strains. A limitation of the apparatus is that it exposes biological samples during their time of transit past the waveguide.

0380 MICROWAVE DIFFRACTION TOMOGRAPHY FOR BIOMEDICAL APPLICATIONS. (Eng.) Bolomey, J. C. (Laboratoire des Signaux & Systemes, Ecole Superior d'Electricite, Plateau du Moulon, 91190 Gif-Sur-Yvette, France); Izadnegahdar, A.; Jofre, L.; Pichot, C.; Peronnet, G.; Solaimani, M. IEEE Trans Microwave Theory Tech 30(11):1998-2000; 1982 (11 refs).

A method for rapid microwave tomography for biomedical imaging applications is described. Electromagnetic energy scattered from the target was measured using a modulated scattering technique, which employed an array of probes that were loaded by nonlinear elements. Modulating the load resulted in a diffracted signal that was proportional to the field being measured and was collected by an auxiliary antenna. The image was calculated as the convolution product of the pointspread function of the focusing system and the equivalent current distribution function induced by the target which in turn was related to the scattered field intensity distribution. The experimental equipment consisted of a 10 mW generator with standard S-band waveguide, a linear probe array of 64 dipoles loaded by diodes and separated from each other by λ/5 at 3 GHz, a network analyzer, a minicomputer and a low-noise amplifier. Results were given for a target consisting of two plexiglass rods surrounded by water, a plexiglass rod surrounded by sponge and a plexiglass cylinder filled with water. This m allowed measurements of the field on a measur line within one-half sec and calculation of the in 50 sec. Incident power levels were less th mW/cm^2 and a spatial resolution of λ/2 was poss where λ is the wavelength of the microwave ener water (1.16 cm at 3 GHz).

0381 NUMERICAL AND EXPERIMENTAL RESULTS NEAR-FIELD ELECTROMAGNETIC ABSORPTI MAN. (Eng.) Chatterjee, I. (Dept. Electrical neering, Univ. Utah, Salt Lake City, UT 84112); dhi, O. P.; Hagmann, M. J.; IEEE Trans Microwave ory Tech 30(11):2000-2005; 1982.

An empirical formula for the mass-normalized w body-average electromagnetic energy (SAR) was de for a 180-cell block model of man exposed to fields with N-polarization (E-field directed a arm). A similar formula for P-polarization (no ponent of the E-field directed arm to arm) ha ready been derived. The SAR predicted from the e ical formulas agreed well with experimental re obtained by exposing reduced-scale models of h to leakage fields similar to those from an RF se Saline-filled figures were exposed to fringing f from two metal parallel plates separated by Styr and connected to a RF power generator producing W of power at simulated frequencies of 71-176 The SAR was determined from the average temper rise in the figure. In another set of experim a tissue phantom made of water, polyethylene pc Superstuff (a gelling agent) and salt was p in the figure. The internal E-fields in the fi measured with an implantable probe at three simu frequencies (77, 110 and 150 MHz) were an ord magnitude less than the incident E-field and a well with the calculated E-fields. For 180-cell models of man exposed to a 1 V/m RMS and 27.1 vertical electric field, the model in contact wit ground plane had an SAR that was 8.5 times larger the SAR for a model isolated by 5 cm from the g plane.

0382 MICROWAVE POWER ABSORPTION IN A BIOLO SPECIMEN INSIDE A STANDING-WAVE IRRADI WAVEGUIDE. (Eng.) Fujiwara, O. (Dept. Elect Engineering, Faculty of Engineering, Nagoya U Furo-cho, Chikusa-ku, Nagoya 464, Japan); Amemiy IEEE Trans Microwave Theory Tech 30(11):2008-1982 (15 refs).

Expressions for the total absorbed power and the tial distribution of absorbed power were derive a prolate spheroidal model of a biological s irradiated by standing waves in a rectangular guide. Three orientations of the spheroid were ined: the major axis of the spheroid parallel t

electric field, parallel to the magnetic field and perpendicular to the electric and magnetic fields. The power absorption due to electric and magnetic fields were analyzed separately. Calculations from the theoretical expressions were made for a spheroidal model of a pupa with a major axis and radius of 15 and 5 mm, respectively, and a relative permittivity of 30-13j at a frequency of 2450 MHz. For all orientations of the spheroid, the power absorption produced by the electric field was larger than that produced by the magnetic field. The largest occurred when the electric field was parallel to the major axis of the spheroid. For all cases, the absorbed power was much less than the forward waveguide power. Exposure to electric fields did not create any spatial variation in power absorption, but exposure to magnetic fields did. The theoretical results for total absorbed power were compared with experimental results from pupa of Tenebrio molitor irradiated in a WRJ-2 waveguide (forward power, 10 W; frequency, 2485 MHz). The temperature increase of the pupa was measured with a chromel-alumel thermocouple to find the total absorbed power. The calculated values for total power absorption agreed well with the experimental values.

0383 EFFECT OF CHRONIC MICROWAVE RADIATION ON RABBIT ERYTHROCYTES. (Eng.) Nageswari, K. S. (Dept. Physiology, GSVM Medical Coll., Kanpur 208 002, India); Tandon, H. C.; Varma, S.; Bhatnagar, V. M. Indian J Exp Biol 20:13-15; 1982 (11 refs).

The effects of chronic microwave (MW) exposure (2.1 GHz, continuous wave, 5 mW/cm^2, for 3hr/day, 6 day/wk for 3 mo) on peripheral blood were investigated in 13 rabbits. Blood samples from 8 irradiated and 5 control animals were collected preirradiation, at 1 and 2 mo, at the termination of the irradiation period, and 1/wk for 2 wk. The mean rectal temperature which was measured before and after each MW exposure during the entire 3 mo period did not increase more than an average 0.8 C after each session of MW irradiation. Erythrocyte counts declined 4.27%, 8.08%, and 8.46% following 1, 2, and 3 mo exposure, respectively. Although recovery was seen in the 2 wk post-irradiation period, the cell count did not return to its initial value. Decreases in erythrocyte number were paralleled by increases in mean corpuscular volume and hemoglobin which became statistically significant at the end of 2 and 3 mo of MW exposure. These findings suggest that the animals may have been protected from hypoxia by the increases in size and hemoglobin content of the red cells.

0384 EFFECT OF PROLONGED LOW POWER MICROWAVE RADIATION ON PERIPHERAL LEUCOCYTE COUNTS IN RABBITS. (Eng.) Nageswari, K. S. (Dept. Physiology, GSVM Medical Coll., Kanpur 208 002, India); Tandon, H. C.; Varma, S.; Bhatnagar, V. M. Indian J Med Res 75: 453-459; 1982 (15 refs).

The effects of chronic exposure to low power (continuous wave microwave (MW) radiation (2.1 mW/cm^2, 3 hr/day, 5 days/wk for 3 mo) on rabbit peripheral leukocytes were studied. Blood samples from irradiated and 5 control animals were collected preirradiation (PRI), at 1 and 2 mo, at the termination of the irradiation period, and 1 wk for 2 wk. The rectal temperature was measured before and after MW exposure during the entire 3 mo period and did not increase more than an average 0.8 C after each session. After 3 mo exposure, total leukocyte counts increased 50% from PRI values of 6621 to 9825, and differential leukocyte counts revealed a threefold increase (from 5.75 to 14.13) in large lymphocytes and a significant decrease (from 53.5 to 45.25) in small lymphocytes. However, the counts returned to normal within 2 mo after termination of exposure. MW irradiation for 2 mo produced significant neutropenia which was corrected after exposures were continued for another mo. A significant but reversible leucocytosis was observed in rabbits after chronic exposure to low level MW irradiation. In the absence of a thermal effect, the possibility of a specific cumulative effect at MW power levels is considered.

0385 LOCALIZED HYPERTHERMIA IN THE TREATMENT OF CANCER. (Eng.) Storm, F. K. (Div. Radiology, Dept. Surgery, UCLA Sch. Medicine, Univ. of California, Los Angeles, CA 90024); Morton, D. L. Adv Surg Oncol 5:261-275; 1982 (58 refs).

Experimental and clinical studies of localized hyperthermia in cancer therapy are reviewed. Localized hyperthermia techniques include hot water bath, isolated limb perfusion, low frequency current fields, inductive magnetic coupling, ultrasound, microwaves (433, 915 and 2,450 MHz), and radiofrequency waves (13.56 MHz) using capacitive electrodes, induction coils, and magnetrode magnetic loop applicators. Recent clinical trials suggest that potentially effective hyperthermia can be achieved in most superficial and visceral solid human tumors regardless of histopathologic type, although it is most effective for large tumors. Local toxicity depends on the heat dose and the method of hyperthermia. Future hyperthermia potentials as adjuvant therapy in surgery, and in combination with radiotherapy and with chemotherapy is summa

0386 DEMONSTRATION OF A THERMAL EFFECT OF MICROWAVES DURING LOW-LEVEL RADI
(Eng.) Klein, M. S. (Div. de Neurophysiologie Appliquee, Centre D'Etudes et de Recherches de Medecine Aerospatiale, 26 boulevard Victor, 75996 Paris A France); Steru, L.; Milhaud, C. L. IRCS Med Sci (6):455-456; 1982 (10 refs).

Effects of low-level microwaves (MW) on hypothermia induced by oxotremorine (OX: 125 mg/kg) or by

phine (AP: 16mg/kg) and on the blood-brain barrier (BBB) were studied in male C57BL mice. In one experiment, the anti-cholinergic agent methylatropine (which nomally does not pass through the BBB) was injected simultaneously with OX. The mice were irradiated for 30 min at 2,450 GHz (continuous wave; 2 and 5 mW/cm^2). MW exposure resulted in significant heating of mice made hypothermic by OX or AP; rectal temperatures in irradiated mice were significantly higher than those of control mice. MW did not antagonize OX-induced hyperthermia and, therefore, could not have crossed the BBB. These results are inconsistent with the existence of nonthermal MW effects at power densities lower than 10 mW/cm^2.

0387 AUDITORY PERCEPTION OF RADIO-FREQUENCY ELECTROMAGNETIC FIELDS. (Eng.) Chou, C.-K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine, Sch. Medicine, Univ. Washington, Seattle, WA 98195); Guy, A. W.; Galambos, R. J Acoust Soc Am 71(6):1321-1334; 1982 (55 refs).

Research on radiofrequency hearing, including psychological studies of human subjects, physiological and behavioral observations on animals, and physical measurements on materials is summarized. Humans with normal high-frequency hearing experience an auditory sensation when exposed to pulsed microwaves (MW) of sufficient energy content. A clicking, buzzing, or hissing sound is heard, depending on modulation characteristics of the MW. The perceived sound (for pulses less than 50 usec) seems to originate at the central, posterior aspect of the head. The threshold energy density per pulse is very low (2-40 uJ/cm^2) and the maximal rise in temperature of the exposed tissue is 10^{-5}-10^{-6} C for exposure of an individual pulse at the threshold energy density. Experimental data on cochlear potentials, single-unit nerve fiber responses, and brainstem evoked responses suggest that pulsed MW radiation produces cochlear microphonic responses similar to those elicited by other stimuli. Results of single unit recording of extra-cellular potentials in cats are consistent with human perceptions when pulse widths are long. Electrophysiological recordings from mammals have confirmed the mechanical nature of the MW hearing effect and are consistent with a mechanism of hearing based on thermoelastic expansion. Behavioral studies indicate that rats can perceive pulsed MW energy; results may be attributed to the hearing effect. However, the low threshold of the MW hearing phenomenon makes it essential to differentiate the hearing effect from other biological effects of pulsed MW radiation.

0388 POSTNATAL FUNCTIONAL ANALYSIS OF PRENATAL EXPOSURE OF RATS TO 915-MHz MICROWAVE RADIATION. (Eng.) Jensh, R. P. (Dept. Anatomy, Jefferson Medical Coll., Thomas Jefferson Univ., 1020 Locust St., Philadelphia, PA 19107); Vogel, W. H.; Brent, R. L. J Am Coll Toxicol 1(3):73-90; 1982 refs).

The effects of chronic prenatal continuous wave crowave (MW) exposure (915 MHz, 10 mW/cm^2, for 6 day, days 1-21 of gestation) on postnatal neurologi and neurobehavioral development were studied in Wis albino rats. Animals delivered and raised their o spring (F_{1a}) until weaning at 30 days of age. days after weaning, the mothers were rebred and lowed to deliver again (F_{1b} offspring). Irradia neonates (F_{1a}) were given four perinatal reflex te (surface righting, air righting, auditory start visual placing) and a physiological test (eye op ing). At 60 days of age, F_{1a} offspring were gi behavioral tests and at 90 days half of them w bred to determine reproductive capability and h were killed for histopathological studies. Pre tal irradiation significantly accelerated onset reflex achievement. However, eye opening did differ in experimental and control groups, sugge ing that the acceleration may not have been sim a whole-body acceleration. Auditory startle was celerated by 4.2 days. There were no signific differences between irradiated and control anim in 5/6 behavioral tests (water T-maze, open fie activity wheel, forelimb hanging, swimming); resu of conditioned avoidance response tests revealed decrease in long-term memory in exposed animals, the variation in individual animals was quite hi Irradiation did not significantly affect maternal gan wt or organ-body wt ratios, and it did not al neonatal and young adult growth rates. The resu indicate that chronic prenatal exposure to low po density levels of 915 MW radiation did not result any significant alterations of postnatal behavior of growth and development.

0389 TREATMENT OF THERAPEUTICALLY RESISTANT N UNIONS WITH BONE GRAFTS AND PULSING EL TROMAGNETIC FIELDS. (Eng.) Bassett, C. A. L. (De Orthopaedic Surgery, Columbia Univ. Coll. Physici & Surgeons, 630 West 168th St., New York, NY 1003 Mitchell, S. N.; Schink, M. M. J Bone Joint S [Am] 64(8):1214-1220; 1982 (18 refs).

The results of the combined and concomitant use bone grafts and pulsing electromagnetic (EM) fie as a means of achieving bone union in 83 adults reported. The patients consisted of 38 individu with wide gaps, synovial pseudarthosis and malali ment who had not undergone previous EM treatment (dian disability time, 16 mo; 100 unsuccessful earl surgical attempts at repair prior to treatment) 45 individuals who had initially been unsuccessfu treated with pulsing EM fields alone (median disab ity time, 17 mo; 101 previous operations, includ 38 bone grafting procedures). The majority of lesions in both groups were tibial (45/83) and f oral (25/83) non-unions. Home treatments (10 hr/d using a pulse generator that produced a 5 msec

burst of 200 usec wide (positive-going) pulses, repeating at 15 Hz began 2-4 wk postoperatively. Successful bone healing was seen in 33/38 (87%) patients without prior EM treatment and in 42/45 (93%) patients exposed to EM fields before and after grafting. The median time from start of EM-field treatment to healing was 4 mo in both groups. No complications of surgery or of pulsing EM fields were reported. Pulsing EM fields should receive strong consideration as an adjunct to any bone graft of the extremities, whether in a primary or a salvage situation.

0390 THE TREATMENT OF FIBROUS NON-UNION OF FRACTURES BY PULSING ELECTROMAGNETIC STIMULATION. (Eng.) Sharrard, W. J. W. (Royal Hallamshire Hosp., Glossop Rd., Sheffield S10 2JF, England); Sutcliffe, M. L.; Robson, M. J.; MacEachern, A. G. J Bone Joint Surg [Br] 64(2):189-193; 1982 (15 refs).

Results of pulsed electromagnetic (EM) stimulation in the treatment of 53 fibrous non-unions in 52 patients (25 male, 17 female, 13-79 yr old, mean age 37 yr) are reported. Median time from injury to start of treatment was 28.2 mo (range 1-25 yr). The tibia was the most commonly affected bone. An electric current of highly specific shape, magnitude and repetition rate was generated in the bone by a pair of externally-placed oval air-cored electromagnets driven by a small portable generator producing a 5-msec burst of quasi-rectangular assymetrical pulses repeated at 15 Hz. Patients were instructed to use the equipment for 12 to 16 hr/day. Union was achieved in 38/53 cases (71.7%) including 26/30 (86.7%) tibia fractures. The median time taken to reach union was 6 mo (range 3-16 mo). The results were not affected by patient age, previous or active sepsis, presence of plates or nails, or the time since injury. Inadequate immobilization, a gap between bone ends in excess of 5 mm, or a screw in or very near the fracture non-union site were the most important factors in the 15 failures. The results indicate that EM stimulation applied in conjunction with adequate immobilization promotes bone union in a high proportion of extremely refractory cases of ununited fractures or surgical insults.

0391 CYTOGENETIC CONSEQUENCES OF MICROWAVE IRRADIATION ON MAMMALIAN CELLS INCUBATED IN VITRO. (Eng.) Yao, K. T. S. (Bureau Radiological Health, FDA, Rockville, MD 20857). J Hered 73(2): 133-138; 1982 (33 refs).

A 2450-MHz microwave (MW) oven was converted into an incubator that also served as a MW exposure chamber. The effects of continuous MW exposure on growth and on chromosome structure of rat kangaroo RH16 cells (normal euploid chromosome number) and RH5 cells (hypoploid) were investigated. The cells were grown in the incubator at 35-37 C and simultaneously exposed to MW irradiation for 320 days (50 passages) at a energy absorption dose rate of 15.2 ± 1.82 mW/g. were then returned to a conventional incubator an lowed to grow for another 30 passages. MW-incu and control cells were examined for chromosome rations at about 10, 20, 30, 40, and 50 passag subculture. MW incubation resulted in a signif reduction of cell growth rates and an increase in doubling time. These effects appeared to be cu tive, with 15-passage irradiated cells exhib greater growth retardation and longer cell dou time than 7-passage cells. Chromosome aberration peared after 20 passages (124 days) under irradia The number of chromosome breaks/cell reached a ma of 0.84 in RH5 cells and 0.10 in RH16 cells. The mer was hypoploid at the beginning of the experi which may have contributed to the greater suscept ity of this cell line to MW exposure. After the cultures were returned to the conventional incu and maintained for 30 passages, the number of ch some breaks was greatly reduced. MW irradiatio tered the chromosome number of the cells. Afte irradiation, RH5 and RH16 cell cultures had 35 31% polyploid cells, respectively. After long irradiation, 41% of RH5 cells which originally h chromosomes became 10-chromosome cells. When th radiated cells were returned to the conventional bator, the percent of 10-chromosome cells reached The missing chromosome was usually chromoson

0392 EVIDENCE FOR GENETIC CONTROL OF MICRO INDUCED AUGMENTATION OF COMPLEMENT R TOR-BEARING B LYMPHOCYTES. (Eng.) Schlagel, (Armed Forces Inst. Pathology, Washington, DC 20 Ahmed, A. J Immunol 129(4):1530-1533; 1982 (14 r

The genetic control of microwave (MW)-induced inc in complement receptor-bearing B lymphocytes (CRL studied in congenic, backcross, and recombinant i (RI) strains of mice. Mice were exposed to 245 MW radiation (0.6 W; 10-14 W/kg) in an environmen controlled waveguide and assayed for CRL on days 6 postexposure. Genetic studies of responder X responder F_1 mice and backcross analysis of nonre der X (responder x nonresponder)F_1 mice indicated MW susceptibility was controlled by a single, d ant Mendelian gene. Crosses between two nonresp strains failed to restore the responder state. dichotomy in MW susceptibility between two st congenic at the H-2_T1a region on chromosome 17 responder and B.6-H-2k) confirmed the noninvolv of the Crl-1 gene and indicated that the esse gene was located outside the H-2 region. The s distribution of MW responsiveness in the BXH RI demonstrated that the MW-induced increase in CR controlled by a single regulatory gene locate chromosome 5. MW responsiveness was studied i congenic strains of mice which possess different HeJ segments of chromosome 5 inserted into a C57 background. The JGBF/LeTy strain exhibited ar crease in CRL indicating possession of the se of C3H/HeJ chromosome 5 that controls MW respon

ness. The C57BL/6JTy-le strain remained nonresponsive. This places the essential regulatory gene to the right of the PgM-1 locus and to the left of the rd locus on chromosome 5. The data confirm the genetic control of the transitory increase in CRL frequency induced by a single exposure to 2450 MHz radiation and demonstrate that genetic control was due to a single regulatory gene that was functional in the heterozygous as well as the homozygous state.

0393 A GENERALIZED MODEL FOR THE INTERACTION OF MICROWAVE RADIATION WITH BOUND WATER IN BIOLOGICAL MATERIAL. (Eng.) McClean, V. E. R. (Physics Dept., Queen Elizabeth Coll., London W8 7AH, England); Sheppard, R. J.; Grant, E. H. J Microwave Power 16(1):1-7; 1981 (17 refs).

Calculations of the deposition of microwave (MW) energy in bound water surrounding a biological macromolecule are based on a previous model of a hydrated macromolecule consisting of a spherical core surrounded by a concentric shell of bound water immersed in a continuum of free water with dissolved ions. Ideally the dielectric properties of the bound water would be considered to vary smoothly across the shell, ranging from the water most tightly bound to the relaxation time of free water; however, to facilitate the calculations, the change is considered to take place in 5 steps for most cases. The average energy deposited per unit volume of the bound water shell was calculated from 100 MHz to 10 GHz for various assumed relaxation frequencies. Sub-shells were assigned the following frequencies: 100-900 MHz in increments of 200; 5-50,000 MHz in multiples of 10; a homogeneous layer of bound water of relaxation frequency 500 MHz; 1000-9000 MHz in increments of 2000; 10-90 MHz in increments of 20; 100-1000 MHz in increments of 100; and free water with a relaxation frequency of 26 GHz. The calculations were carried out for a low value of ionic conductivity of 0.001 S/m for both the free and the bound water. Calculations were also carried out for the first three cases (all which assume a central relaxation frequency of 500 MHz) for conductivities of 1 S/m. At equal but low conductivities, MW energy deposition was greater in bound water (sometimes by at least one order of magnitude) than in free water at frequencies of a few hundred MHz to a few GHz. This effect decreased with increases in ionic conductivity; and at conductivities equal to those of physiological saline, specific energy deposition in bound water was no more than twice that in the electrolyte continuum over the same frequency range. The results show that the biological effect of MW radiation at a given power density is enhanced in tissues with a high bound water content. For tissues of high ionic conductivity and containing 20% bound water, overall energy absorption would be 25% greater at certain frequencies than if all the water were in the free state. For tissues of low ionic conductivity, the increase would be more than one order of magnitude.

0394 EVIDENCE FOR MICROWAVE-INDUCED ACOUS RESONANCES IN BIOLOGICAL MATERIAL. Olsen, R. G. (Naval Aerospace Medical Res. Lab., sacola, FL 32508); Hammer, W. C. J Microwave Pow (3&4):263-269; 1981 (7 refs).

Resonant stress waves were induced by microwave energy in two biological models: a rectangular equivalent mass of 15 kg and a spherical brain alent model of 5 cm radius. The rectangular model was irradiated using a horn antenna at 5.0 energy with a peak power of 200 kW and pulse se tion of 380 usec. Pulses were repeated to produ inforcing. The spherical model was irradiated b gle pulses or short bursts of 1.10 GHz energy peak power of 4 kW and pulse durations of 10-90 Stress waves were monitored by hydrophone transd at the center of each model. In the rectangular the amplitude of the induced stress wave was greater for four properly spaced radiofrequency than for a single pulse. In the spherical mo single pulse of energy produced a resonant res which decayed exponentially with a time consta about 500 usec. A burst of three pulses i stress waves of greater peak amplitude than thos duced by a single pulse. A burst frequency of generated the largest effect with a doubling o amplitude of the induced stress waves compared t from a single pulse. These experiments showed t portance of pulse width and pulse repetition ra the generation of sonic energy in biological mate with MW energy. The specific absorption rates spherical model were determined calorimetrical be 824 W/kg at the center and 653 W/kg at the su closest to the MW source.

0395 LOCAL HYPERTHERMIA USING MICROWAVES THERAPEUTIC PURPOSES - EXPERIMENTAL ST OF VARIOUS APPLICATIONS. (Eng.) Guerquin-Kern, (Lab. Thermologie Biomedicale, Faculte de Medicir rue Humann, 67085 Strasbourg Cedex, France); P L.; Priou, A.; Gautherie, M. J Microwave Power 4):305-311; 1981 (5 refs).

The electromagnetic heating of biological tissu studied using physical models and infrared crystal, or thermistor probe thermography. A pr inary study was also reported in which the tran heating of a one-dimensional tissue slab is calcu subsequent to heating by 2,450 MHz or 434 MHz wave radiation. The models consisted of excised pose and muscular tissue from animals, human ad tissue from a surgical procedure, and phantoms posed of a gel and a polyester resin to simulate pose and muscle tissue. The effects of surface ing and use of multiple apertures on the heating tern were examined using these models and two of applicators operating at 2,450 and 434 MHz. experimental results are consistent with the c lated values and demonstrate the need for su cooling and the advantage of a "cross-fire" conf

ation in producing local hyperthermia.

0396 TEMPERATURE PROFILES IN SPHERES DUE TO ELECTROMAGNETIC HEATING. (Eng.) Kritikos, H. N. (Dept. Electrical Engineering, Univ. Pennsylvania, Philadelphia, PA 19104); Foster, K. R.; Schwan, H. P. J Microwave Power 16(3&4):327-344; 1981. (33 refs).

The steady state temperature increase in a tissue sphere (modeling the human head) irradiated by plane wave microwave energy was estimated for different frequency regions. The heat transport in the tissue was modeled by a differential equation to include heat conduction, heat convection by blood flow and heat transport from the tissue surface into space. For each frequency range, the heat transport equation was solved using an analytic approximation of the heating potential. The steady state increase in tissue temperature and the specific absorption rate (SAR) are plotted as functions of distance from the center of the sphere. The steady state temperature increase resembles the SAR but, for physiologically reasonable values of blood flow, the temperature increases are averaged over approximately 1 cm. The convection length is defined as a function of blood flow. This quantity estimates the distance over which temperature variations occur and allows for an approximation of the distance over which the fine structure of the SAR may be averaged. The maximum steady state temperature increase and its location are summarized for each frequency range and a field intensity of 10 mW/cm^2. For frequencies less than 500 MHz and a sphere radius of about 10 cm, the maximum steady state temperature increase is less than 0.03 C and is located close to the front surface of the sphere. For frequencies less than 500 MHz and a sphere radius of about 5 cm, no significant temperature is produced. For frequencies of around 1 GHz and a sphere radius of 5 cm, the maximum steady state temperature increase is 0.6 C and is located at the center of the sphere. For frequencies above 5 GHz, only surface heating is produced. The maximum steady state temperature is produced at the front surface of the sphere and is about 0.3 C.

0397 MICROWAVE AND RF HAZARD STANDARD CONSIDERATIONS. (Eng.) Schwan, H. P. (Dept. Bioengineering, Univ. Pennsylvania, Philadelonia, PA 19104). J Microwave Power 17(1):1-9; 1982 (49 refs).

Microwave (MW) and radiofrequency exposure safety hazards are reviewed. Considerations for establishing a 10 mW/cm^2 standard for MW radiation are outlined. Recent results are surveyed and basic mechanisms and appropriate exposure limits examined for four frequency ranges: below resonance, resonance, hot spot, and surface heating. Below several hundred MHz, human bodies can resonate with electric fields. Maximum average specific absorption rate (SAR) around 80 MHz for man. In the resonance range absorption can quadruple if the direction of the electric field is parallel to the long axis of the An exposure standard of less than 10 mW/cm^2 is essary in this frequency region. Above the res range to about 3 GHz, hot spots may be produ portions of the body. Temperature elevations head of up to 0.5 C at power densities of 10 have been predicted from numerical calculations frequencies below the resonance range (< 30 MH above the hot spot range (> 3 GHz), only surface ing is produced. The 10 mw/cm^2 standard prov safe margin for these frequencies. Tolerable loads are functions of environmental conditio well as of incident radiation intensity and ex time. Recent studies support a time constant ur as the limit separating short and long term sures.

0398 THE DEVELOPMENT OF MICROWAVE POWER AP TIONS IN CHINA. (Eng.) Chen, H.-K. crowave Res. Lab., E. China Normal Univ., Sha China); Shen, Z.-Y.; Fu, C.-S.; Wu, D. J Micr Power 17(1):11-15; 1982 (3 refs).

Applications of microwave (MW) power in China ha creased gradually since China began manufacturin tinuous wave (CW) magnetrons in 1973. The larg magnetrons made in China are 10 kW at 2450 MHz kW at 915 MHz. Principal applications are MW h in food processing, timber drying, paper drying netic tape drying, and drying of traditiona nese medicines. Thermotherapy research, with sis on combining local MW heating with cancer therapy or radiotherapy, is being conducted in s hospitals. Other research areas include the co tion of MW therapy at 1000 MHz and traditiona puncture, male birth control, silkworm breedin plant germination (using 3-cm, 30-cm, and 1-m Theoretical work has involved box-type MW applic uniformity of temperature distribution in appli and improvement of magnetron performance. T the following standards were recommended in Ch power density of 50 uW/cm^2 (6 hr/day) as the sional safety standard for MW exposure and 300 as the maxiumum allowable dosage per day.

0399 ERROR SOURCES AFFECTING THERMOCOUPLE OMETRY IN RF ELECTROMAGNETIC FIELDS. Chakraborty, D. P. (Dept. Radiation Oncology, Alabama in Birmingham, Birmingham, AL 35233); vich, I. A. J Microwave Power 17(1):17-28; 19 refs).

The errors resulting from use of thermocouple measuring temperature in the presence of the

frequency (RF) electromagnetic fields used for clinical hyperthermia are analyzed. RF currents capacitively or inductively coupled into the thermocouple-detector circuit produce incorrect temperature readings called "pick-up" errors as well as errors due to RF heating at the junction of the thermocouple. A filter between the thermocouple and detector and an aluminum foil shield around the detector eliminate the pick-up errors. The heating effects at the thermocouple junction were divided into three categories: junction current heating, tissue heating, and eddy current heating. The magnitude of each error was estimated and necessary conditions for minimizing errors were outlined. At 13.56 MHz and voltage levels below 100 V rms, errors are shown to be less than 0.1 C if the thermocouple is properly insulated and recommendations for reducing error are followed.

0400 PECAN WEEVIL CONTROL BY DIELECTRIC HEATING. (Eng.) Nelson, S. O. (U. S. Dept. Agricultural Res. Service, Richard B. Russell Agricultural Res. Center, Athens, GA 30613); Payne, J. A. J Microwave Power 17(1):51-55; 1982 (13 refs).

The use of 43 or 2450 MHz electromagnetic energy was examined for killing pecan weevil larvae in intact pecans or in pecan pieces. Samples were irradiated for various periods between the parallel plates of a power oscillator at 40 or 43 MHz with an average electric field intensity of 1.0 or 1.3 kV/cm or in a microwave oven operating at 2450 MHz with 800 W total power output. The temperatures were measured immediately after exposure. Pecan weevil larvae in intact pecans were all killed after 25 sec of parallel plate exposure at 40 MHz after which the temperature of the pecans was 62 C. Germination of the pecans with a 3% moisture content was not significantly reduced by 43 MHz treatment until the kernels were heated to 50 C; a temperature of 75 C completely prevented germination. The differences in moisture content for the whole pecans and the pecan pieces and its effect on heat conductivity and larvae mortality are discussed.

0401 MICROWAVE THERMOGRAPHY - CHARACTERISTICS OF WAVEGUIDE APPLICATORS AND SIGNATURES OF THERMAL STRUCTURES. (Eng.) Robillard, M. (Centre Hyperfrequences et Semiconducteurs, Univ. Sciences et Techniques de Lille I., B t P4, UER IEEA, 59655 Villeneuve, D'ASCQ Cedex, France); Chive, M.; Leroy, Y.; Audet, J.; Pichot, C.; Bolomey, J. C. J Microwave Power 17(2)97-105; 1982 (29 refs).

A method based on the antenna reciprocity principle permits computation of thermal signals emitted by biological tissues measured by microwave (MW) thermography. The computation requires knowledge of the temperature distribution and the electrical field distribution in the lossy medium when the probe, or applicator, is radiating a MW signal. Computed thermal signals were verified in experiments with a MW radio including a low noise preamplifier, a heterodyne receiver, and a microprocessor for numerical filte operating at a central frequency of 3.2 GHz and width 1.0 GHz. The resultant data can be consi as thermal signatures of a given thermal stru which is defined by a set of parameters descr its shape, position, depth, and temperature. Qu tative determination of temperature distributi tissues can be obtained if experimental and com thermal signatures are identical.

0402 OBSERVATIONS OF SYRIAN HAMSTER FETUSE TER EXPOSURE TO 2450-MHz MICROWAVES. (Berman, E. (EPA, MD74C, Res. Triangle Pk, NC 27 Carter, H. B.; House, D. J Microwave Power 1 107-112; 1982 (11 refs).

The teratogenic potential of microwave (MW) radi was investigated in Syrian hamsters exposed to MHz continuous wave MW energy (power densities or 30 mW/cm^2) for 100 min/day on gestation days Exposure to 20 mW/cm^2 at a specific absorption (SAR) of 6 mW/g caused no significant changes i tal survival, body wt, or skeletal maturity. sure to 30 mW/cm^2 (SAR of 9 mW/g) resulted in sig cant increases in fetal resorption and in decr in body wt and skeletal maturity. Incidences o jor and minor anomalies in the two exposure group not differ significantly. After exposure to 20 m and 30 mW/cm^2, rectal temperatures of pregnant sters increased 0.4 C and 1.6 C, respectively, those of sham irradiated dams. However, maternal icity was not observed at either exposure even t maternal rectal temperatures rose to almost 40 30 mW/cm^2. Thus, the loss of body wt observed i tuses irradiated at 30 mW/cm^2 was not seconda general maternal toxicity. Fetotoxic effects irradiation were compared in mice and hamsters mice, decreased fetal body wt and skeletal immat were not observed at an SAR lower than 16 or 22 In hamsters, an SAR of 9 mW/g causes similar ch and also causes a significant increase in fetal (resorptions). The results suggest that the ha fetus is more susceptible to MW radiation tha mouse fetus.

0403 ASSESSMENT OF IMMUNE FUNCTION DEVELO IN MICE IRRADIATED IN UTERO WITH 245 MICROWAVES. (Eng.) Smialowicz, R. J. (Immunob gy Section, Cellular Biophysics Branch, Healt fects Res. Lab., EPA, Res. Triangle Pk, NC 27 Riddle, M. M.; Rogers, R. R.; Stott, G. A. J M wave Power 17(2):121-126; 1982 (17 refs).

Immune responses at age 3 and 6 wk were studi male mice born to time-bred CD-1 mice irradiated

2,450-MHz microwaves (MW) at an incident power density of 28 mW/cm² for 100 min/day from day 6 to day 18 of pregnancy. The average specific absorption rate (SAR) was 15.5 W/kg, more than twice the basic metabolic rate of the mouse. In contrast to recent reports of MW-induced stunting in mice, no consistent growth retardation was observed. Primary antibody responses to sheep red blood cells (SRBC) were similar in irradiated and sham-irradiated mice. There was also no difference in hemagglutination or hemolysin titers to SRBC. In utero MW exposure did not increase blastogenic responses of T or B lymphocytes to mitogens. Natural killer (NK) cell activity against YAC lymphoma cells was reduced in 6-wk-old mice, but there was considerable variability in NK activity among mice in a given group. Differences in NK activity between irradiated and control mice were not marked. Further studies are needed to corroborate growth-retarding effects of MW exposure and to determine whether neonatal stunting is related to impaired development of NK cell activity.

0404 COAXIAL NONMETALLIC THERMOCOUPLE WITH ELECTRONIC ICE POINT FOR DOSIMETRIC USE IN ELECTROMAGNETIC ENVIRONMENTS. (Eng.) Olsen, R. G. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32598); Hammer, W. C.; Taylor, J. C. J Microwave Power 17(2):137-143; 1982 (11 refs).

An improved nonmetallic thermocouple (NMT) that can provide multiple simultaneous temperature measurements in irradiated subjects at modest cost is described. The NMT is relatively non-perturbing, stable, and linear in output in microwave (MW) environments. The temperature sensitive portion of the coaxial NMT is the tip junction between a carbon-bearing fluorocarbon wire and an outer coating of conductive elastomer. A slightly modified, commercially available electronic ice point provides compensation for the effects of changes in ambient temperature. Specific absorption rates (SAR) measured by the NMT and the more sophisticated Vitek probe in tissue-equivalent material were compared in two MW irradiation tests. A 9-cm diameter muscle-equivalent sphere was exposed for 60-300 sec periods to 5.655 GHz MW energy produced by a military type radar transmitter with a peak output power of 200 kW (0.5 usec pulses at 240 pulses/sec). A 4-kg mass of muscle-equivalent material was placed in a large MW irradiation chamber and exposed in the far field of a horn antenna to continuous wave 2.0 GHz MW energy generated by a Singer 6600 sweeper/oscillator and amplified to 300 W by a MCL Model 10270 Klystron. Essentially no difference was seen in the SAR determined by either probe at 5.655 GHz. At 2.0 GHz, a small difference was seen which was probably the result of the two probes being slightly misplaced during irradiation. The results show that the coaxial NMT offers a useful alternative to more sophisticated and costly temperature probes in certain MW dosimetric configurations.

0405 EFFECTS OF AMBIENT TEMPERATURE AND EX
TO 2450-MHz MICROWAVE RADIATION EVAPO
HEAT LOSS IN THE MOUSE. (Eng.) Gordon, C. J.
engineering Branch, Experimental Biology Div.,
Effects Res. Lab., EPA, Res. Triangle Park, NC 2
J Microwave Power 17(2):145-150; 1982 (25

Effects of ambient temperature and microwave (M
posure on physiologic heat dissipation were stud
4 mo old male CBA/J mice. Whole-body evaporativ
loss (EHL) was measured as whole-body evaporati
ter loss (EWL) in mice exposed individually to c
uous wave 2,450 MHz MW radiation for 90 min and
bient temperature of 20 C and in nonexposed mice
tained at ambient temperatures of 20-35 C. The
ent temperature threshold for increasing EWL w
33 C. At an ambient temperature of 20 C, a sp
absorption rate (SAR) of 29 W/kg was required
significant increase in EHL. Above 29 W/kg, a
elevation in EHL was seen with increasing SAR
mouse dissipated 65% of the total absorbed heat
ter evaporation; the remainder was dissipated pa
ly. Extrapolation of a threshold SAR in a labo
animal to man necessitates a logarithmic scalin
tor. Thus, a SAR of 29 W/kg in a 0.0034-kg mo
equivalent to an SAR of 0.25 W/kg in a 70-kg

0406 TWO-DIMENSIONAL TECHNIQUE TO CALCULA
EM POWER DEPOSITION PATTERN IN THE
BODY. (Eng.) Iskander, M. F. (Dept. Electric
gineering, Univ. Utah, Salt Lake City, UT 84112)
ner, P. F.; DuBow, J. B.; Kao, J. J Microwave
17(3):175-185; 1982 (15 refs).

A numerical procedure using the method of mome
determine the heating patterns in two-dimension
dels of human cross sections irradiated by ap
sources is described. X-ray computerized axial
graphic scans are used to determine the size,
and location of internal tissues for the two-
sional model. The incident electric field is a
to be directed perpendicularly to the cross sec
area and to be a half wavelength cosine functio
its maximim at the aperture center. The cros
tional model is divided into cells of a size
of the wavelength inside the dielectric. The s
each cell was chosen according to the permittiv
the tissue; it was smaller for high permittivit
sues (heart and muscle) and larger for low perm
ity tissues (bone, fat and lung). The electric
and power density distribution at 70 MHz is sho
a human thorax divided into 201 cells and irra
by eight aperture sources in an annular array.
power deposition is shown in the central area
the heart is located. Experimentally measure
perature increases in a homogeneous tissue phant
posed to over 1,000 W for 10 min and a sacrific
exposed to 1,500 W for 10 min agreed with theor
results from the two-dimensional model.

0407 AN EMPIRICAL TIME-INTENSITY RELATIONSHIP FOR THERMAL BIOELECTROMAGNETIC EFFECTS. (Eng.) Miller, T. M. (Dept. Civil Engineering, Northwestern Univ., Evanston, IL 60201); Brodwin, M. E.; Zember, H. J Microwave Power 17(3):195-202; 1982 (26 refs).

An empirical formula relating the exposure time needed to induce a biological effect to the specific absorption rate (SAR) was based on an analysis of published experimental data on laboratory animals and on pain threshold studies on humans. The bioelectromagnetic effects considered were lethality, cataractogenesis and threshold pain sensation in a frequency range from 2.45 GHz to that of visible light. For each effect, a critical organ was chosen as the anatomical location where absorbed radiation produces the specific effect. The critical organs for lethality, cataractogenesis, and threshold pain are the whole body, the crystalline lens of the eye, and skin, respectively. The exposure time needed to induce an effect is reciprocally related to the exposure intensity as measured by the SAR for the critical organ. From regression analysis of each set of data, a general relationship was found giving exposure time as an inverse power function of the SAR. The exponent of the power function is different for each type of experiment. The SAR values of the experimental data ranged from 1.6 to 4700 W/kg, while the exposure time ranged from 0.25 to 18,000 sec. It is suggested that these empirical relationships may prove useful in representing time-intensity relationships for thermal/harmful biological effects.

0408 RADIOFREQUENCY-INDUCED HYPERTHERMIA IN THE PROSTATE. (Eng.) Scheiblich, J. (Medikonzept Ltd., PB 1629, D-5190 Stolberg/Rhld., W. Germany); Petrowicz, O. J Microwave Power 17(3):203-209; 1982 (7 refs).

A microwave applicator developed for heat treatment of prostate cancer is described. The 20-mm diameter applicator is insertable into the rectum (insertable length of 175 mm). A high frequency (432.9 MHz, maximum output power, 120 W) slot antenna inside the applicator is cooled with distilled water. To avoid gaps filled with air between the inserted applicator and the rectum, a balloon is filled with water as soon as the applicator is placed correctly. Protective circuits cut off radiation when preselected limiting temperatures (e.g., 41 C on the surface and 46 C in the prostate) are reached. This control system prevents damage to tissue around the prostate, especially the rectal mucosa and tissue between rectum and prostate. Short-term (20 min) and long-term (several treatments in a few wk) experiments were conducted in male dogs at mean power rates of 55 W and 51 W and cooling-liquid temperatures of 2.5 C. Rectoscopic, macroscopic, and micromorphologic examinations showed no damage to the canine rectum, and local heat damage in prostate tissue demonstrating that local hyperthermia of the prostate can be achieved safely with new applicator.

0409 EXPOSURE OF RATS TO 425-MHz (CW) RADIO QUENCY RADIATION: EFFECTS ON LYMPHOCY (Eng.) Smialowicz, R. J. (Experimental Biology I Health Effects Res. Lab., Enviromental Res. Cer EPA, Res. Triangle Park, NC 27711); Weil, C. M.; R J. B.; Elder, J. A. J Microwave Power 17(3):211-1982 (31 refs).

The effects of chronic low-level exposure to 425 continuous wave (CW) radiofrequency (RF) radiatic lymphocyte response in rats were studied. Four ex iments were performed in which six time-bred pre rats were irradiated from day 12 of pregnancy to turition for 4 hr/day in a temperature controlled posure system consisting of a rectangular strip tr mission line. An AIL 135 power generator capabl supplying 80 W output was used to excite the sys Temperature was maintained at 22 C during irradiat Four male pups born to each dam were subsequently radiated under the same conditions for 20-21 or 4 days and euthanized. In 3/4 experiments, forwardi er was 20 W; irradiated dams were inadvertently posed at 6.6 W forward power in the fourth experi In a fifth experiment, pregnant rats were exposed 16 hr/day from day 6 to day 19 of gestation to 42 CW RF radiation at a forward power of 20 W. Pups not irradiated. At 22 and 42 days, two pups from litter were euthanized. No difference was obse in the wt of irradiated compared with sham irradi rats. Specific absorption rates for rats of dif ent ages derived by twin-well calorimetry or extr lated from power meter readings ranged from 3.1 t mW/g. No consistent change in the peripheral b picture was observed between irradiated rats and trols. In the first two experiments, a consiste significant increase in the mitogen-stimulated sponse of lymph node lymphocytes of irradiated was observed. The blood lymphocyte response of 4 day old irradiated rats displayed an increased sponse to stimulation by phytohemagglutinin (PHA compared with controls in experiments 3 and 4. change was seen in the hematologic pictures of irradiated in utero for 16 hr/day at 22 or 42 day age. However, node lymphocytes from 42-day-old irradiated only in utero incorporated significa greater amounts of tritiated thymidine than cont following stimulation by PHA and concanavalin A. increased responsiveness was similar to that see rats irradiated bot e- and postnatally. The sults suggest that prenatal exposure of rats to MHz RF radiation may be a factor in the lymphop ferative responses of older rats. The possibi that the increased activity of lymphocytes from radiated rats was due to a thermally induced st reaction is noted.

0413 A RADIO-FREQUENCY MONITOR FOR PROTECTION AGAINST OVEREXPOSURE FROM RF HEATERS. (Eng.) Bini, M. (I.R.O.E., National Research Council, Florence, Italy); Ignesti, A., Millanta, L.; Rubino, N.; Vanni, R. J Microwave Power 17(3):223-229; 1982 (5 refs).

A simplified radiofrequency (RF) hazard monitor is described that meets the requirements of isotropy, flat frequency response, simplicity and ease of use, low cost, and includes three indicator lights corresponding to existing safety standards. A green light indicates a field lower than the limit allowed for exposure during an entire working day; a red light indicates a limit beyond which exposure is not permitted; and a yellow light is activated at intermediate levels where part-time exposure is allowed. In the 3-30 MHz band, the monitor has been calibrated to switch from green to yellow at 20 V/m (which corresponds to the USSR standard) and from yellow to red at 150 V/m (which corresponds to a value where 1 min of exposure is allowed in the USA according to ANSI and NIOSH). The limits appear to be compatible with any RF heating machine that is performing reasonably well. The RF monitor has a wide range of potential applications in electromagnetic pollution control.

0411 ULTRASTRUCTURAL CHANGES AND DIFFUSION OF ACETYLCHOLINE IN RAT BRAIN AFTER MICROWAVE IRRADIATION. (Eng.) Kasa, P. (Central Res. Lab., Medical Univ., Szeged, Hungary); Bansaghy, K.; Gulya, K. J Neurosci Methods 38(3):749-752; 1982 (10 refs).

Neuron ultrastructure in different regions of the central nervous system was investigated in 9 control and 20 microwave-(MW) irradiated rat brains. CFY rats were sacrificed by decapitation (controls) or by focused high power 2450 MHz MW irradiation to the head for 0.4, 0.8, or 1.0 sec (output power 5 kW, reflected power, 100-150 W). Acetylcholine (ACh) diffusion was examined in cryostat and Vibratome-prepared tissue sections (cortex, striatum, hippocampus, nucleus interpaeduncularis, archicerebellum). Little change in neuron ultrastructure was seen after 0.4 sec irradiation. However, the fine structure of neurons was markedly affected by 0.8- and 1.0-sec irradiation. Surface membranes were ruptured and rough endoplasmic reticulum was disorganized in the perikarya. Synaptic vesicles were aggregated, and mitochondria were badly damaged in axon terminals. Cortex and striatum ACh levels were lower in Vibratome than in cryostat sections. This reduction was attributed to diffusion of ACh into the Krebs-Ringer buffer solution.

0412 PULSING ELECTROMAGNETIC FIELD TREATMENT (2 Letters to the Editor). Irvine, R. D. (Hilo, HI); Bassett, C. A. L.; Mitchell, S. N.; Easton, S. R. JAMA 248(8):921; 1982 (1 ref).

Since most fractures with delayed unions heal spo eously with time and adequate immobilization, I advocates a double-blind controlled study to eva the efficacy of pulsing electromagnetic fiels (treatment described by Bassett et al. [See BENER abstract # 0068]. Bassett et al. point out tha of the patients treated with PEMF could not be cl as having delayed union: they had an average dis ity time of 4.7 yr (range, 2-22 yr) and an av number of 3.4 unsucessful surgical procedures to PEMF treatment; more than one third of thes tients were or had been actively infected and at one recommendation for amputation had been made i of the cases. Of these patients, 75% were heal PEMFs without further operative intervention. agreed that a double blind approach would be u to fully substantiate claims for PEMF efficacy if ficient numbers of matched or paired cases ca found for statistical significance to be establi such a study is in progress in the United Kingdom is also pointed out that the method is approp only for delayed or non-united fractures, as op to fresh fractures.

0413 MAGNETIC AND ELECTRIC FIELDS PRODUCED ING PULSED-MAGNETIC-FIELD THERAPY FOR UNION OF THE TIBIA. (Eng.) Lunt, M. J. (Dept. cal Electronics, St. Bathalomew's Hosp., London 7BE, England). Med Biol Eng Comput 20(4):501 1982 (13 refs).

A theoretical model is described that can be us predict magnetic and electric fields produced in during pulsed-magnetic-field (PMF) treatment of unite fractures. The electric field induced by rent pulses through two square coils separated b length of their sides is proportional to the ra change of magnetic field. A calculation of the s density at points along the bone/tissue interfac dicates that the insulating boundary has modifie field, especially near the coil axis. In the co tor, the field lines circulate; at the insulating face, they are parallel to the interface. Whil model is based on the assumption that bone acts insulator it can be extended to allow for the f resistivity of bone as the effect of resistivi the surface charge density is small. When a si rectangular cross section immersed in a conductor way between two coils is used as a model of the etry of bone in tissue, field lines are parall the boundary but in opposite directions on each of the slab; further from the boundary, currents culate in the tissue, again in opposite directio each side of the slab. A comparison of theore and experimental results (measurements of mag fields in air and in tissue, electric fields n single interface, around a slab, and around a showed good agreement. While the model cann used quantitatively to predict the magnitude o fields produced in a clinical situation, it can dict the effect of changing coil size and separ and can be used to compare the fields from diff

current waveforms. The model may also help to elucidate the physical and biochemical mechanisms involved in the healing effects of PMF.

0414 USE OF MICROWAVE TECHNIQUES TO INACTIVATE BRAIN ENZYMES RAPIDLY. (Eng.) Galli, C. (No affiliation given); Racagni, G. Methods Enzymol 86: 635-642; 1982 (33 refs).

A technique for sacrificing small laboratory animals using high-intensity microwave (MW) radiation is described, which allows rapid inactivation of metabolic brain enzymes. MW instrumentation has been designed to control the intensity and duration of the incident power and to minimize the reflected power. General specifications are: current, 15 A; power consumption, 3500 W; power output, 1300 W; frequency, 2450 MHz. For adult rats (body wt = 150-300 g), irradiation periods of 2-4 sec are adequate, while for adult mice (body wt = 20-40 g), the values should be 0.7-1.5 sec. For newborn animals the irradiation times should be about 0.5-1.0 sec. The use of focused MW irradiation for animal sacrifice prevents postmortem changes of various neurochemical parameters and gives virtually the same results as the freeze-blowing technique. When samples obtained from animals sacrificed by MW irradiation were compared with those obtained by decapitation, increased levels of cyclic AMP, 3-methoxytyramine, normetanephrine, GABA, and choline and decreased levels of DOPA were seen in the samples obtained by decapitation. Levels of free arachidonic acid (FAA) in brain areas of animals sacrificed by focused MW irradiation were much lower than those measured by decapitation followed by a time interval before analysis; they were not statistically different from levels measured after decapitation and immediate analysis (<30 sec between decapitation and homogenization in organic solvent), or analysis after decapitation and immediate freezing. Levels of prostaglandin (PG) F and thromboxane (Tx), derived through PGH synthase, and HETE, derived through lipoxygenase, were much lower in the brain of animals sacrificed by MW irradiation than in those sacrificed by decapitation followed by a time interval before analysis and were of the same order as those measured in brain tissue frozen in liquid nitrogen immediately after sacrifice. In synthesis, the use of focused MW irradiation prevents both the release of FAA occurring after decapitation followed by a time interval before analysis and the accumulation of PG and Tx observed in the brain even if the interval between decapitation and analysis is less than 30 sec.

0415 ^{3}H-NORADRENALINE RELEASE POTENTIATED IN A CLONAL NERVE CELL LINE BY LOW-INTENSITY PULSED MAGNETIC FIELDS. (Eng.) Dixey, R. (Dept. Medical Electronics, St. Bartholomew's Hosp., West Smithfield, London EC1A 7BE, England); Rein, G. Nature 296 (5854):253-256; 1982 (25 refs).

A model system is described for studying effec extremely low-frequency (ELF) magnetic fields on ronal functions. Clonal PC12 cells, derived f transplantable rat pheochromocytoma, were expos a pulsing low-frequency magnetic (LFM) field gene between a pair of concentric coils wired in par to a pulse pulse generator and driving circuit si to one used in clinical trials for treatment of union fractures. For these experiments, pulse of 0.6 msec was used with 1.4 msec between each giving an overall frequency of 500 Hz. Maximu minimum fields applied to the sample were 8.5 1.6 G. Release of ^{3}H-noradrenaline (^{3}H-NA) from cells was monitored for 12 sequential 15-min pe in 10 trials. Values obtained at 105 and 120 mi cell cultures were exposed for 13 min to LFM were always higher than values obtained from th preceding 15-min time periods. Expressing the s lated release as the difference between the co and experimental values relative to the control for a given time period, a stimulation of 27.5% was obtained for both experimental time periods 9 further trials in which 15 mM Mg^{2+} was includ the medium at the 105 and 120 min time periods rate of release in control washout curves was no tered, but the stimulated release was abolished. stimulated release values in the presence of ele Mg^{2+} were not significantly different from the trols. The results indicate that PC12 cells c used as a model system for studying the effec LFM fields on neuronal functions.

0416 DIELECTRIC PROPERTIES OF ANIMAL TISSU VIVO AT RADIO AND MICROWAVE FREQUEN COMPARISON BETWEEN SPECIES. (Eng.) Stuchly, (Nonionizing Radiation Section, Radiation Prote Bureau, Health and Welfare, Ottawa, Canada); Kra ski, A.; Stuchly, S. S.; Smith, A. M. Phys Med 27(7):927-936; 1982 (17 refs).

An open-ended coaxial line sensor was used to me the dielectric properties of various tissues of thetised cats and rats at frequencies between 0. 10 GHz. The measurement method is based on deter tion of the input reflection coefficient of the ial line when placed against the test tissue. Thi efficient depends on tissue permittivity, frequ and dimensions of the coaxial line. Dielectric stants and conductivities are reported for ske muscle, brain cortex, spleen, and liver and com with previously published in vivo data for cat rats and for dogs. The differences in the diele properties of the same tissue for these species found to be very small (less than 10%) in the fre cy range from 0.1 to 10 GHz, suggesting that nonaquatic animals can be used for modeling huma ings in developing microwave hyperthermia techni At frequencies above 1 GHz, tissue properties c lated well with water content. A comparison of culated and measured tissue water content indi that the tissue water in muscle has the diele properties of free water while a varied but cons able amount of water in other tissues is in a fo

bound water.

0417 THE COMPLEX PERMITTIVITY OF HUMAN TISSUE AT MICROWAVE FREQUENCIES. (Eng.) Hey-Shipton, G. L. (c/o Mathews, Dept. Electrical and Electronic Engineering, Leeds Univ., Leeds, Yorkshire, England); Matthews, P. A.; McStay, J. Phys Med Biol 27(8):1067-1071; 1982 (8 refs).

The complex permittivity and emissivity of the human body and attenuation coefficient of skin were determined from simple measurements made on living tissue over the frequency range 8 to 18 GHz. The experimental setup consisted of a rectangular waveguide terminated by a semi-infinite flange. The medium inside the waveguide was considered to have a permittivity value identical to that of free space. To create a flat geometry in the plane of the waveguide flange, a plug of expanded polystyrene was inserted into the end of the waveguide. Measurements were made by pushing the waveguide up against the palm of the hand. Power in the waveguide was kept below 10 mW/cm^2. The VSWR and phase shift of the reflected wave were measured using a precision slotted line, the phase being compared with the reflected wave produced from a flat metal plate pushed up against the flange. The absolute values of VSWR and phase angle for the biological sample were then entered into a computer program whose output gave the value of the complex permittivity of the sample necessary to produce such a VSWR and phase angle. Measurements of real permittivity were about a factor or two lower than those predicted by theory, while the measurements of imaginary permittivity correlated well with existing measured values at about 10 GHz. Emissivity values agreed closely with calculated emissivity values at 8-18 GHz for skin of infinite thickness. Possible sources of error in the measurements of complex permittivity included accurate determination of both VSWR and phase shift, contact of skin with the waveguide flange, and the assumption that the skin could be considered infinitely thick in the area of measurement.

0418 A MICROWAVE HEATING TECHNIQUE FOR THE HYPERTHERMIC TREATMENT OF TUMOURS IN THE EYE, ESPECIALLY RETINOBLASTOMA. (Eng.) Lagendijk, J. J. W. (Univ. Hosp. Utrecht, Dept. Radiotherapy, Catharijnesingel 101, 3500 GG Utrecht, The Netherlands). Phys Med Biol 27(11):1313-1324; 1982 (12 refs).

A 2450-MHz microwave (MW) stripline applicator for hyperthermic treatment of eye tumors, especially retinoblastoma, is described. The applicator is placed directly on the eye beneath the eyelids so that the geometry can be fixed. The only parameters influencing temperature distribution which cannot be regulated are differences between patients in eye diameter and blood flow. Temperature distributions in human and rabbit eye resulting from absorbed MW power distribution c culated with a thermal finite difference computer m el were verified experimentally on rabbit eyes. Ac racy was better than 0.3 C when the anterior part the eye was heated to 43-44 C. Accuracy was lower the posterior half of the eye because of differen in blood flow, but was still better than 0.5 C. retinoblastoma patients were treated with x-radiat followed by hyperthermia up to 44 C for 1 hr. 3 tumors regressed and no cataracts were induced by heating. The complete computer-controlled MW hyp thermia system is described.

0419 MICROWAVE IMAGING OF CEREBRAL EDEMA. (En Lin, J. C. (Bioengineering Program, Un Illinois, Chicago, IL 60680); Clarke, M. J. Proc I 70(5):523-524; 1982 (2 refs).

A microwave (MW) transmission technique for detect and monitoring cerebral edema was demonstrated o model of the human head. The skull and brain tis were simulated by a 7.4 cm radius glass sphere fil with 1150 ml of ethanol containing a rubber ball filled with 550 ml of water to stimulate the cerebr spinal fluid. Ethanol and water could be added to removed from both compartments. A beam of 2.4 GHz energy (at a power level <10 uW/cm^2) was transmit through the head model and compared with a refere signal. Relative amplitude and phase were measu by vector voltmeter. The phase change in the MW s nal was correlated with changes in fluid volume the head model. It is shown that volume changes less than one percent of the total fluid volume co be detected.

0420 A NEW ITERATIVE PROCEDURE TO SOLVE SCATTERING AND ABSORPTION BY DIELECTRIC JECTS. (Eng.) Iskander, M. F. (Dept. Electri Engineering, Univ. Utah, Salt Lake City, UT 8411 Lakhtakia, A.; Durney, C. H. Proc IEEE 70(11):13 1362; 1982 (4 refs).

A new technique, the Iterative Extended Boundary C dition Method (IEBCM), is presented to calculate scattering and absorption of electromagnetic ene by homogeneous highly conductive dielectric objec This method increases the solution stability of Extended Boundary Condition Method which may bec unstable at resonant and postresonant frequenci The IEBCM begins by replacing the lossy dielectric ject with a perfect conductor and calculating curr densities on the surface; the surface current is u to compute the internal fields inside the dielect body. The interior of the object is partitioned to overlapping spherical subregions to produce a n efficient convergence. To obtain internal field pansion coefficients, the surface currents obtai from the solution of the external problem are pe

matched with the surface currents obtained from the internal expansion, while maintaining the continuity of the magnetic field in the overlapped regions. This procedure yields a zero-order estimate of the internal fields. Further iterations are used to improve the initial estimate of the surface current density. Calculations are presented for the internal field in a spheroidal model of man composed of nine overlapping spheres at 27 MHz.

0421 RADIO-FREQUENCY HAZARDS IN THE VLF TO MF BAND. (Eng.) Gandhi, O. P. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112); Chatterjee, I. Proc IEEE 70(2):1402-1464; 1982 (5 refs).

The external electric (E) fields necessary to generate threshold perception and let-go currents for a human in conductive finger contact with ungrounded metallic bodies (car, station wagon, truck, fence, and roof) were calculated for frequencies from 10 kHz to 10 MHz. The calculated external E-fields for threshold perception were below the proposed ANSI guideline of 100 mW/cm^2 (E = 615 V/m for 0.3 to 3.0 MHz). The human body was modeled as a resistance which varied with frequency and a capacitance which was assumed to be 100 pF at all frequencies. The current through the human body in conductive contact was calculated as a function of resistance, capacitance, frequency, and the short circuit current induced in the metallic object by a vertical E-field. The calculations assume that the E-field lines terminating in the human body and the ungrounded metallic object were not affected by the presence of the other and that object length was smaller than 1/15 or 1/10 of the free space wavelength. Experiments on reduced scale models of a car and a jeep using a 0.1 wavelength monopole-above-ground antenna produced results comparable to the calculated values for a simulated frequency of 0.765 MHz.

0422 STUDIES ON ACUTE IN VIVO EXPOSURE OF RATS TO 2450-MHz MICROWAVE RADIATION. III. BIOCHEMICAL AND HEMATOLOGIC EFFECTS. (Eng.) Galvin, M. J. (Natl. Inst. Environmental Health Sciences, P.O. Box 12233, Research Triangle Park, NC 27709); Ortner, M. J.; McRee, D. I. Radiat Res 90:558-563; 1982 (22 refs).

The hematologic and biochemical effects of acute microwave (MW) radiation were examined at incident power levels resulting in undetectable thermal stress (as determined by colonic temperature). Male Charles River rats were divided into three groups of 8 animals each (wt = 300 ± 35 g, 10-wk-old) were exposed for 8 hr to continuous wave (CW) 2450 MHz MW radiation in the far field at intensities of 0, 2, and 10 mW/cm^2 (estimated average specific absorption rates of 0, 0.44, and 2.2 mW/g, respectively). Rats were then decapitated, and blood samples were collected for determination of hematocrit, hemoglobin, red blood (RBC) and white blood cell (WBC) counts, and differential WBC percentages. No differences in deep col temperature, which averaged 38 C for all three gr were noted when measured immediately after termina of exposure. Serum levels of protein, beta-glucu dase, alkaline phosphatase, cholinesterase, and tic dehydrogenase were not altered by exposure t ther MW power density. In addition, MW radiatio no effect on sodium and potassium levels. No ch in the hematocrit or RBC number were noted for e exposure group. There were no differences be the sham and either group of MW-exposed rats i total number of circulating WBC or percentage o types. It is postulated that the differences i matologic effects between this study and that by previous investigators most likely resulted differences in frequency, mode of delivery (p versus CW), and duration of exposure.

0423 PULSE MICROWAVE EFFECTS ON NERVE VITA (Eng.) McRee, D. I. (Lab. Environm Biophysics, Natl. Inst. Environmental Health ences, P.O. Box 12233, Research Triangle Park 27709); Wachtel, H. Radiat Res 91:212-218; 19 refs).

The effects of pulsed microwave (MW) radiation o vitality of frog sciatic nerves were investigate compared with effects of continuous-wave (CW) M diation. Isolated sciatic nerves of frogs (Ran piens) were exposed to 2.45-GHz pulse-MW radiati a waveguide exposure system. In previous studi CW MW radiation at a specific absorption rate (SA 10 mW/g, survival time of the irradiated nerve s lated to fire at a high rate (50 twin pulses/sec shortened significantly. In this study, 3 sets o periments were carried out using 10-usec-wide p at 50 pulses/sec, with an average SAR of 10 mW/g asynchronous pulsing wherein the MW pulse was d ered at varying times in the firing cycle; (2) chronous pulsing during the peak of the nerve a potential; and (3) synchronous pulsing during the escient period between nerve firings. In all a significant decrease occurred in the survival of the exposed nerves, as compared with the unex nerves. Statistical analysis indicated that the of vitality of the exposed nerve was highly sig cant compared with that of the control nerve. H er, the magnitude of this effect was essentiall same in all three cases and was also comparable the effect seen earlier with CW MW radiation of e alent SAR. It is suggested that the MW effec nerve vitality may result from an interference long-term regulatory processes (such as interf with maintenance of adequate ionic concentration dient across the membrane) rather than interfe with the mechanism for action potential firing.

0424 CHANGES IN TUMOR OXYGENATION AFTER LOCALIZED MICROWAVE HEATING. (Eng.) Vaupel, P. (Dept. Physiology, Univ. Mainz, Saarstrasse 21, D-6500 Mainz, W. Germany); Otte, J.; Manz, R. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 65-74; 1982 (27 refs).

Microwave-(MW) induced changes in tumor oxygenation were investigated by determining the oxyhemoglobin saturation (HbO_2) of single red blood cells within tumor capillaries after MW hyperthermia. Local hyperthermia was induced for 30 min in tumor-bearing Sprague-Dawley rats (270-400 g) of both sexes using 2.45 GHz MW radiation delivered through a special applicator (15 mm outer diameter). Three hyperthermia levels were employed: 40 C, 43 C, and 45 C. Mean tissue temperature for controls was about 35 C. The intracapillary HbO_2 was studied during respiratory normmoxia by a cryophotometric micromethod. Upon heating at 40 C, oxygenation of tumor tissue improved significantly ($p < 0.00005$). Directly after 40 C hyperthermia, the mean saturation increased to 66 sat% (median, 70 sat%). However, tumor oxygenation decreased significantly after 43 C hyperthermia compared with control conditions ($p < 0.02$). After a further rise of the mean tumor temperature to 45 C, tumor oxygenation decreased drastically ($p < 0.00005$). The results were thought to reflect changes caused by localized hyperthermia within the tumor tissue itself since no host systemic effects were detected and all tumor biopsies were taken at comparable values of mean arterial blood pressure and of respiratory gas parameters in arterial blood. These results clearly indicate that local hyperthermia has profound effects on tumor tissue oxygenation.

0425 BLOOD FLOW AND TEMPERATURE EVOLUTION OF RHABDOMYOSARCOMA-BEARING MICE DURING NORMAL GROWTH AND DURING SEQUENTIAL HYPERTHERMIA TREATMENT. (Eng.) Robert, J. (Lab. Biophysique, Faculte Medicine, 18 rue Lionnois, 54000 Nancy, France); Escanye, J. M.; Marchal, C.; Thouvenot, P. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 85-95; 1982 (8 refs).

The effects of microwave (MW) induced hyperthermia on tumor blood circulation were investigated in male C3H mice with chemically-induced rhabdomyosarcomas transplanted in the left thigh. Hyperthermia treatment (13 min/day, 5 day/wk for 2 wk) began on day 15 after tumor transplantation when mean tumor size was 1.4 cm and ended on day 29 when mean tumor size was 2.3 cm. Hyperthermia was induced by a a 434-MHz MW generator with a high frequency output of 5 W, delivered by a coaxial-type applicator with a contact diameter of 5 mm on the tumor surface. Blood flow and temperature measurements were made on days 15, 22, and 29 after transplantition. Tumor blood flow, as determined Xenon .33 clearance, decreased when tumor diameter creased. Blood flow in the normal right thigh comparable to that in the tumor-bearing left t when tumor diameter was 1.0-1.5 cm. However, it creased perceptibly as tumor size increased. Rec temperature and temperature at the tumor surface, its center, and sc in the normal right thigh was corded. A significant decrease was seen in int and extratumoral temperatures in tumors measuring 2.0 cm; the decrease was less significant in tur larger than 2.0 cm. Temperature at the tumor cer was about 1 degree higher than at the surface. R tal temperature was consistently higher than t measured temperatures. Rectal and normal tissue t perature decreased 2.5 C as tumor size increased 1.4 to 2.0 cm and 0.5 C as tumor size increased 2.0 to 2.5 cm. The results suggest that the thei regulatory system of the mice was not altered by irradiation of small tumors (diameter = 1.4 cm) wh mice bearing big tumors (diameter = 2.0 and 2.5 appeared to loose their thermoregulatory mechanis Observed changes are a function of measurement te nique, tumor age, existence and extent of previ hyperthermia treatments, and of measurement ti

0426 EFFECTS OF LOCAL MICROWAVE HYPERTHERMIA LIVER TUMORS: AN EXPERIMENTAL STUDY RATS. (Eng.) Hafstrom, L. O. (Dept. Surgery, U Lund, S22185 Lund, Sweden); Hugander, A.; Jonss P.-E.; Bolmsjo, M.; Persson, B.; Stenram, U. Biomedical Thermology. Proceedings of an Internati al Symposium held in Strasbourg, France, June July 4, 1981. Gautherie, M.; Albert, E., eds. York: Alan R. Liss, Inc.): pp. 97-102; 1982 refs).

An experimental model for local microwave-indu hyperthermic (HT) treatment of liver tumors is p sented. Inbred Wistar rats bearing transplant chemicallyinduced hepatic adenocarcinoma were divi by size of tumor into five separate groups that w subdivided into a control group and one subjected local HT induced by a 2.45 GHz Siemens magnetron diotherm 305 generator operating at 20 W. The t perature for HT treatment was preset at 42 C. Tu size was measured 6-8 days after treatment. No d ference in growth ratio (size at day of measuren divided by size at day of treatment) was seen in c trol and treated tumors smaller than 50 mm^2. Tur between 50 and 150 mm^2 treated with HT exhibite slower growth rate than controls. For tumors betw 150 and 200 mm^2 there was no difference in tumor s between the two groups. Microscopic examination the tumor-bearing lobe 14 days after local HT reve ed an increase in tumor necrosis with increasing mor size, indicating that the tumoricidal effect HT was increasing although the difference in tu size between treated and control tumors decreas Thus the edema and osmotic effect of necrosis disguise good tumor response to HT if the respo is expressed as change in tumor size.

0427 BIOLOGICAL EFFECTS OF MICROWAVES AND THE QUESTION OF COHERENCE. (Eng.) Frolich, H. (Dept. Physics, The University, P.O. Box 147, Liverpool Lo9 3BX, England). In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 189-195; 1982 (8 refs).

Nonthermal biological effects of microwave (MW) radiation at fields that are weaker than those which give rise to thermal effects and their prediction from theory are discussed. Two possibilities for the trigger action of external electromagnetic waves are presented. One theory refers to coherent electrical vibrations excited by metabolic energy. A small external energy supply may be sufficient to trigger the excitation and the subsequent biological effects. Another refers to a metastable state of large molecules (such as enzymes) with a very high dipole movement. Interaction between the dipoles of activated enzymes may lead to oscillations with a definite frequency and amplitude. This so-called limit cycle may be destroyed by a relatively weak external field with the same frequency thus leading to the liberation of stored energy. In general, frequencies in the second case are much lower than in the first case. The observed nonthermal effects from MW radiation amplitude-modulated at low frequencies may result if the two frequencies work together to yield a stronger biological response than each one individually. This suggests simultaneous application of high and low frequency fields that would arise if the MW energy triggered the excitation of the high frequency vibration while the low frequency acted on the limit cycle. Specific investigations should be performed to determine at which stage in cell development a particular frequency becomes effective. It is speculated that carcinogenesis could occur if foreign chemicals or electrons caused a cell to lose its correct frequency. The vibrational properties of tissues will have to be studied to investigate this speculation.

0428 THERMAL ASPECTS OF BIOLOGIC EFFECTS OF ELECTROMAGNETIC FIELDS AT THE CELLULAR AND MOLECULAR LEVEL. (Eng.) Berteaud, A.-J. (CNRS GR 35, 2 rue Henri Dunant, 94320 Thiais, France). In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 197-208; 1982 (20 refs).

Various mechanisms involved in thermal energy transfer into living systems from electromagnetic (EM) fields are reviewed. Cell suspensions have been used to compare the effects of microwave (MW) and conventional heating. Results of studies using zygote formation in Saccharomyces cerevisiae to determine global temperature resulting from MW irradiation indicate that heating was due mainly to the dielectric absorption of MW energy by free or loosely bound water molecules inside the cytoplasm. Thermal stress induced b irradiation has been detected by cytoplasmic micro cosity measurements based on fluorescence depolar tion. Possible molecular effects of exposure to intensity EM fields have been proposed. At radio MW frequencies, a permanent excitation of metast states due to thermal noise is present. Long r interactions of EM fields and biomembranes may mo the equilibrium in cooperatively bonded systems ex ing in periodic structures such as cellular membra Direct effects of EM fields on synthetic or nat membranes have been postulated. Mechanisms invo in dielectric losses at radio and MW frequencies outlined. For water molecules with different chem bonds at room temperature, dielectric loss can va a function of frequency. Heating and thermaliza mechanisms in hydrated media such as living matte discussed. Hydration water bound to specific biop mer substrates absorb more energy from inciden fields than free water regardless of the freque Additional research on the mechanisms of interac of EM radiation with living systems at cellular molecular levels is needed.

0429 ACTION OF 2.45-GHz MICROWAVES ON THE THESIS OF PROTEINS IN SACCHAROMYCES CE SIAE. (Eng.) Dardalhon, M. (Institut Curie, Sec Biologique, 26 Rue d'Ulm, Paris 75231, France); A beck, D.; Berteaud, A.-J. In: Biomedical Thermol Proceedings of an International Symposium hel Strasbourg, France, June 30-July 4, 1981. Gauthe M.; Albert, E., eds. (New York: Alan R. Liss, In pp. 209-218; 1982 (20 refs).

Protein synthesis was examined in yeast exposed t crowave (MW) radiation to investigate the exist of specific thermal effects. The haploid strain of Saccharomyces cerevisiae was grown in an anec chamber in the presence of MW radiation pulsed 10 msec at a frequency of 2.45 GHz or in the pres of conventional heating. For MW power levels of 170, 220, 270, 330, and 400 W, incident power v were 10, 20, 30, 40, 50 and 60 mW/cm^2, respecti Protein synthesis was determined after treatmen different MW power levels. After 30 min, the of protein synthesis (measured by [^{3}H]-leucine i poration) in MW-irradiated cultures did not di significantly from that of cultures grown under ventional heating methods. No significant diffe was seen in the rate of protein synthesis after exposure to either conventional or MW-induced hy thermia, taking into account a temperature equili tion period of 30 min for the sample. These resu which are consistent with previous findings, su that MW action at higher power levels may produc perthermia that is not different from that pro by conventional means. The possible contributi specific MW action to the overall thermic effect relatively small, if at all present, in these ex ments.

0430 INTERACTIONS OF NONIONZING RADIATION WITH THE NERVOUS SYSTEM. (Eng.) Albert, E. N. (Dept. Anatomy, George Washington Univ. Medical Center, 2300 I St. N.W., Washington, DC 20037); Sherif, M. F. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 219-225; 1982 (35 refs).

Literature dealing with the effects of nonionizing electromagnetic radiation (EMR) on the nervous system is reviewed. Russian and Eastern European literature includes reports of a neurasthenic syndrome in individuals occupationally exposed to EMR. Early animal experiments performed to assess the effects of EMR on the nervous system were carried out at high intensities of EMR which resulted in increased body temperature and death. Observed effects could be attributed to thermal stress. However changes have also been reported in the nervous system and brain of experimental animals exposed to lower power densities which appear to be well tolerated and which probably do not produce hyperthermia. Histopathologic changes in the brains of experimental animals subjected to acute exposures to microwave radiation at low power densities (10 and 25 mW/cm^2) have been reported. However, unpublished studies showed that chronic exposure to EMR (2450 MHz at 10 mW/cm^2 for 14 hr/day for 10 wk) did not induce any remarkable morphologic changes in most of the exposed animals. Increased blood-brain barrier permeability has been reported after exposure to EMR at low power density. Most of the research on the effects of EMR on the developing brain has dealt with gross observations on brain. There is very little literature on the effects of low-level EMR on changes in brain cells during development. Similar changes in cerebellar Purkinje cells have been reported after prenatal and neonatal exposure to different EMR frequencies (100 and 2450 MHz) at similar specific absorbed energy levels. The literature in general supports the observation that low-level EMR produces reversible morphologic changes in the nervous system. However, the significance of such morphologic changes is not known at the present time and more research is needed.

0431 IMMUNOLOGICAL RESPONSE OF MAMMALS TO MICROWAVES. (Eng.) Szmigielski, S. (Center for Radiobiology & Radioprotection, 128 Szaserow, 00-909 Warsaw, Poland). In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 227-246; 1982 (42 refs).

Data on the effects of microwave (MW) and radiofrequency (RF) radiation are grouped into the following categories: alterations in immunocompetent cells irradiated in vitro; response to low-level, short-term exposure in vivo; response to whole-body MW hyperthermia; and alterations in natural, nonspecific (anti terial, antiviral, antineoplastic) resistance in exposed animals. Tabulated experimental data inc details of irradiation conditions and periods. literature does not contain any convincing evid that metabolic and/or functional alterations occu immunocompetent cells irradiated in nonthermal M fields in vitro, until thermal effects occur. S term irradiation of animals in low level and the genic MW fields may enhance immune response as denced by increased antibody levels, faster mat tion of B lymphocytes, and enhanced delayed hyper sitivity reactions. The observed effects are tr ient and inconsistent and may be explained in t of nonspecific stress reaction and/or thermal after irradiation at higher power densities. term irradiation in nonthermal MW and RF fields not provide any convincing evidence for specific mune system response to nonionizing radiation. T may be slight and transient immunosuppression tha not directly related to interaction with MW energy is explainable in terms of chronic, nonspecific st reaction. An increase of field power density tha sufficient to increase body temperature by 2 to evokes distinct responses of hematopoiesis and lym poiesis. Results of MW hyperthermia experiments reported. A biphasic reaction was observed in exposed to daily sessions of 2450 MHz MW hyperth mia: stimulation of cell-mediated immunity du the first 4 days of treatment was followed by tr ient but pronounced immunosuppression. Reduced sistance to staphylococcal infections was obse in mice exposed to low-level or thermal MW fie Significantly lower clearance of ^{32}P-labeled sta lococci from peripheral blood of rabbits tre with 2-hr daily sessions of MW hyperthermia was s After iv injection of viable cancer cells, mice posed for 1 to 3 mo to 2450 MHz (2 hr/day, at 15 mW/cm^2) and mice treated with daily session MW hyperthermia for 14 days developed significa more cancer nodules than controls. Accelerated velopment of spontaneous breast tumors and 3,4- zopyrene-induced skin cancer has been reported MW-irradiated mice. The results suggest that u the tested conditions MW radiation lowers both a bacterial and antineoplastic resistance and tha radiation may possess cocarcinogenic properties.

0432 INFLUENCE OF THE NEOFORMATION OF BONE SUE BY MEANS OF LOW-FREQUENCY PULSED NETIC FIELDS. (Eng.) Haimovici, N. (Dept. Hand gery & Operative Rheumathology, Herder Clinic Dobben 103, 2800 Bremen 1, W. Germany). In: Biom cal Thermology. Proceedings of an Internati Symposium held in Strasbourg, France, June 30- 4, 1981. Gautherie, M.; Albert, E., eds. York: Alan R. Liss, Inc.): pp. 247-255; 1982 refs).

To determine the effect of low-frequency pulsed netic fields (PMF) on bone healing, a compara study was performed in 32 patients with a severe

lateral metatarsus primus varus who underwent simultaneous osteotomies on both feet. The left foot of all the patients (2 male, 30 female; 15-55 yr old) was subjected to two daily PMF treatments (0.5 hr/day for 12 wk; at 10 Hz and 50 G), using low frequency pulsed magnetic field equipment supplied by ELEC. The right foot was not subjected to electrophysical therapies and was shielded from electromagnetic fields. Clinical, radiographic, tomographic and scintigraphic examinations were performed after 1,2,4,6, and 12 mo. The average time for clinical and biologic bone healing was 16 wk for magnetic field-treated cases and 26 wk for the untreated cases. Macroscopically, a solid osseus callus with regenerated bone structure was observed in the magnetic-field treated cases 4 mo after surgery. With the exception of a single case, no complete and definitive bone regeneration was observed in the untreated contralateral feet after the same interval. Microscopic examination revealed that regeneration of the spongious and cortical structure reached a state comparable to normal in most cases treated with PMF. Formation of bone units, stratification, osseous lamellation, ossification, and calcification of the callus were accelerated in PMF-treated cases and improved blood distribution was observed. No temperature increase in joints, bone or adjacent tissue was induced by PMF treatment and there were no signs of irritation or side effects.

0433 HEATING BLOOD IN EXTRACORPORAL CIRCULATION WITH A HIGH-FREQUENCY ELECTROMAGNETIC FIELD: EFFECT OF MICROWAVES ON BLOOD. (Eng.) Andre, J. (Centre de Technologie Biomedicale, INSERM SCN 13, Toulouse, France); Barthelemy, R.; Lefeuvre, S.; Priou, A.; Morucci, J. P. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 257-268; 1982 (13 refs).

Microwave (MW) blood heating devices are considered as an alternative to the heat exchangers currently used to heat blood during heart surgery and in some cancer treatments using general hyperthermia. The effect of MW heating during extracorporal circulation (ECC) was studied in 12 40-kg dogs. One group of 6 dogs was treated by conventional techniques for ECC blood heating; a second group of 6 dogs was used for MW blood heating tests. The MW device consisted of a 2450 MHz generator capable of delivering a maximum steady power of 1 kW. The standing wave ratio was 1.02 over a 10-MHz frequency range centered at the working frequency of 2450 MHz. A rectangular waveguide coupled the irradiation cavity to the MW generator. In the conventionally treated dogs, blood temperature was lowered to 29 C at the begining of the treatment and was returned to 38 C after 30 min by use of a 41 C thermostated bath and maintained at a constant temperature thereafter. In the dogs used for MW blood heating tests, blood was heated to 38 C after being cooled to 32 C (4 dogs) or 29 C (2 dogs). The input power levels (continuous wave) required for temperature elevation by 6 C and by 9 C were 450 650 W, respectively. Blood samples were taken both groups of dogs at T_1= 0 min, T_2=30 min and 90 min; T_1 was taken 20 min after the start of A fourth blood sample was taken after 5-8 wk. B flow rates used for the dogs were about 1000 ml/ Biochemical and hematologic investigations were ried out. No significant differences between the heating methods were seen in polynuclear neutrophi average globular value, leukocytes, hematocytes, hemoglobin. No significant variation occurred in tabolic activation during phagocytosis, expresse the trazolium nitroblue reduction test, or in cell gration capability, measured in the chemotaxis t Blood biochemical analyses established that no si ficant differences resulted from either heating m od or were found as a function of sampling t

0434 DIELECTRIC PROPERTIES OF BIOLOGICAL SUE. (Eng.) Grant, E. H. (Dept. Phys Queen Elizabeth Coll., Campden Hill Rd., Londo 7AH, England). In: Biomedical Thermology. Proc ings of an International Symposium held in St bourg, France, June 30-July 4, 1981. Gautherie, Albert, E., eds. (New York: Alan R. Liss, Inc.): 475-484; 1982 (25 refs).

The motion of ions and the relaxation of water m ecules both contribute to the production of hea biological material which occurs when microwaves or radio waves are used to treat cancer. The rela contribution of these processes is examined in a cussion of dielectric properties. The four dis sion regions that characterize the dielectric be ior of typical biological material are described mechanisms of heat dissipation are discussed. At quencies below the MW region (300 MHz-300 GHz), e gy absorption is due mainly to ionic conductiv However, at MW frequencies, energy dissipation ari from the relaxation of water becomes increasingly portant, especially as the water content of most logical tissues is so high. For tissues of high ter content, there is nothing to be gained by hea at frequencies higher than 2.45 GHz which can ach a penetration depth of several cm. However, bec of the shortness of wavelength in tissue, 2.45 radiation can produce standing waves in the subc neous layers of fat or other tissue, and the ma of electric field produce localise heating or spots. All factors considered, it appears that optimum frequency for cancer treatment is around 900 MHz. The dominant factor determining the en absorption when MW energy interacts with biolog material is the water content. Deposition of en in free or bulk water and bound water or water of dration are compared. The dispersion region of b water occurs at the low-frequency end of the MW gion while free water relaxation takes place at quencies about 10 times greater. Thus bound wate heated differentially at the low-frequency end of MW region, and tissues with high bound water con will absorb more energy at frequencies from a few

MHz up to several GHz than they would absorb if all the water were bulk water. Differential heating of malignant tumors over normal tissue could therefore be achieved over a certain frequency region if malignant tissue had a higher bound water content. Recent studies indicate that malignant tissue has a higher total water content than normal tissue and that the state of water binding may also be different. If the indications can be confirmed by using dielectric methods, it may be possible to identify a frequency region where malignant tissue absorbs more energy than normal tissue.

0435 MICROWAVE RADIOMETRY AND THERMOGRAPHY:PRESENT AND PROSPECTIVE. (Eng.) Leroy, Y. (Centre Hyperfrequences et Semiconducteurs, Lab. Associe au CNRS 287, Universite des Sciences et Techniques Lille I, 59655 Villeneuve D'Ascq Cedex, France). In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.):pp. 485-499; 1982 (80 refs).

A review of microwave (MW) radiometry and thermography is presented. Physical principles underlying MW thermography are summarized and advances in radiometry and thermography are described. Studies of clinical applications of MW thermography undertaken between 1974 and 1980 in the US and France are tabulated. A method to compute thermal patterns based on the antenna reciprocity principle is presented which permits quantification of the subsurface temperature distribution for defined physical conditions (the geometric, thermal, and electrical charcateristics of the lossy material, band width of the receiver, and characteristics of the probe) when the probe scans the surface of the lossy material. The use of two (or more) probes to investigate overlapping subvolumes may result in better control over the measurement process. This method is called correlation MW thermography.

0436 MICROWAVE THERMOMETRY IN INTRACRANIAL PATHOLOGY. (Eng.) Thouvenot, P. (Laboratoire de Biophysique, Faculte de Medecine, 18 rue Lionnois, 54000 Nancy, France); Robert, J.; Mamouni, A.; Renard, C. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 501-508; 1982 (8 refs).

Results obtained by microwave thermometry for imaging intracranial lesions are presented. A radiometer sensitive to 9 GHz and thermographs working at 68, 30, and 11 GHz were used to study 9 healthy subjects and 31 patients with tumors or vascular intracranial lesions. The radiometer was formed by a dielectric loaded waveguide of rectangular cross section (10 x 5 mm) placed perpendicularly in contact with the scalp. Measurements were made for 15-20 sec at distance 1-2 cm, 2-4 sec being the theoretical response Thermographic measurements were performed at a distance from the scalp unidirectionally and perdicularly to the saggital, frontal, or horiz plane. Recordings were made continuously foll sweep lines at a speed of 10-20 cm/min. Results tained in 9 normal individuals showed good right symmetry and absence of sharp variations of local peratures. Temperatures genrally ranged from C, the higher values corresponding to the post temporal and parietal regions. Of the 31 pat with tumors or vascular lesions, 26 showed the fo ing types of intracranial thermic distribution alies: hyperthermia associated with the lesion; perthermia associated with the lesion and accomp by a peripheral hypothermia; hypothermia loca at the lesion; extended hypothermia. No relatio was seen between lesion size and the absence or ence of thermic anomalies. Thermic distributio modified by 21/22 superficial lesions; however, 5/9 deep lesions caused any modification. In of the high proportion of lesions detected, the diometry could not be considered as a diagnostic od. The technique seems to be promising for fo up of lesions and perilesion edemas and for pro tic information on vascular pathology.

0437 THERMOGRAPHIC DETECTION OF HUMAN CANCE MICROWAVE RADIOMETRY. (Eng.) Shaeffe (Radiation Oncology and Biophysics, Eastern Vir *Medical Sch., 600 Gresham Drive, Norfolk, VA 23* El-Mahdi, A. M.; Carr, K. L. In: Biomedical The ogy. Proceedings of an International Symposium in Strasbourg, France, June 30-July 4, 1981. Ga rie, M.; Albert, E., eds. (New York: Alan R. Inc.): pp. 509-521; 1982 (14 refs).

A microwave thermometry system operating at a fre cy of 4.7 GHz was evaluated in patients with a va of biopsy-proven cancers. Temperature differen consistent with known malignancies were found often in patients with primary and recurrent b carcinoma and lymphoma. Little success was rea in detecting more deeply seated tumors which se be beyond the detection capabilities of an ext antenna.

0438 NEAR-FIELD CHARACTERISTICS OF ANTENNA SORS FOR MICROWAVE DIAGNOSIS: PRELIM RESULTS OF MULTISPECTRAL RADIOMETRIC EXPERIM (Eng.) Edenhofer, P. (Institut fur Hoch- und Ho frequenztechnik, Univ. Bochum, 463 Bochum 1, W. many); Gruner, K.; Steiner, R.; Suss, H. In: Bio cal Thermology. Proceedings of an International posium held in Strasbourg, France, June 30-Ju 1981. Gautherie, M.; Albert, E., eds. (New York: R. Liss, Inc.): pp. 523-537; 1982 (13 refs).

Microwave radiometry is used for remote sensing of spatial temperature distribution in biologic tissue. Broadband antenna sensors are preferred for deriving temperature profiles. Computational results based on a full TE, TM mode analysis are presented for an aperture antenna sensor modeled by an open-ended, rectangular waveguide in direct contact with a multilayer composite biologic tissue (skin-fat-muscle). An undisturbed H_{10} mode within the aperture plane is assumed. The spacial distribution of power received by the sensor was reduced in penetration depth to values of about 19 mm at 1 GHz and 7 mm at 3 GHz, within the muscle tissue and within the fat layer, respectively. These values in a typical inhomogeneous biologic medium were significantly less than those known for homogeneous plane waves, e.g., at 1 GHz for skin 32 mm (60%) and fat 164 mm (12%). Lateral resolution was about 20% less than the aperture width and exceeded aperture height by 30% at 1 GHz (fat-muscle interface) and by 10% at 3 GHz (within the skin layer). The radiation pattern for an alternative antenna sensor system consisting of an elliptical offset-reflector (distance of foci 1000 mm) and a corrugated horn feed was calculated for 32 and 90 GHz. The power of resolution was 20 mm at 32 GHz and 7 mm at 90 GHz with a focal displacement of 0.75 degrees or 16 mm. Preliminary radiometric images of surface temperature in two test subjects conformed to predicted values.

0439 AN INTERFEROMETRIC METHOD FOR DETERMINING THE ELECTRIC FIELD SCATTERED BY AN OBJECT. (Eng.) Floyrac, R. (Lab. Biophysique Medicale, Fac. Medicine Grenoble, 38700 La Tronche, France); Dubois, F.; Kom, M.; Baribaud, M.; Bouthinon, M. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York:Alan R. Liss, Inc.): pp. 539-545; 1982 (5 refs).

A method to determine the amplitude and the phase of a diffracted electric field which is applicable in microwave imaging is described. This interferometric method is based on the application of the equivalence theorem to Maxwell's equations. In any point in space, the diffracted electric field is the same as the field produced by currents distributed in the illuminated object at a given density. However, the real field that can be measured with a network analyzer is the vectorial sum of the diffracted and incident electric fields which exists at each point when the object has been removed from the incident field. Four measurements are recorded: the intensity of the incident field without the illuminated object, the intensity of the total field with the object, and the intensities obtained by adding the incident field and the total field to the reference field. The time required for the four recordings is about 1 hr.

0440 FLUOROPTIC THERMOMETRY: A NEW RF-IM TECHNOLOGY. (Eng.) Wickersheim, K (Luxtron Corp., 1060 Terra Bella Ave., Mountain V CA 94043); Alves, R. V. In: Biomedical Thermol Proceedings of an International Symposium held Strasbourg, France, June 30-July 4, 1981. Gauthe M.; Albert, E., eds. (New York: Alan R. Liss, In pp. 547-554; 1982 (3 refs).

Fluoroptic thermometry is an electrically isolata nonperturbing technique for the measurement of perature in strong radiofrequency (RF) environm using optical sensors. The model 1000A Fluoro Thermometer, developed by Luxtron Corp., is a sin probe system designed for use in a variety of lab tory applications. It is small in diameter and av able in a choice of lengths, with cabling for e strength, if required; sterilization of probes by toclaving appears practical. An absolute accurac ± 0.1 C is achievable over the biomedical range highly conforming (biomedical grade) probe is care ly calibrated before use. A modification of the for biomedical applications is planned. One or stable high precision temperature references can be preset to selected temperatures in the hy thermia range will be added to the instrumenta system. An optional calibration mode will als provided. Availability of a multisensor system allows the use of three to six sensors is expe by late 1982.

0441 THERMAL DOSIMETRY DURING HYPERTHER (Eng.) Cetas, T. C. (Div. Radiation cology, Univ. Arizona Health Sciences Center, Tuc AZ 85724). In: Biomedical Thermology. Proceed of an International Symposium held in Strasbo France, June 30-July 4, 1981. Gautherie, M.; Alb E., eds. (New York: Alan R. Liss, Inc.): pp. 561- (49 refs).

The present clinical status of thermal dosimetry reviewed. Static phantoms are used for determi power disposition patterns of various heating mo ities and applicators. During actual treatment, a few invasive temperature probes are used to de mine subsurface temperatures; surface temperat are frequently measured with a thermographic cam Microwave (MW) heating of a surface lesion of mela and interstitial thermoradiotherapy of advanced mors are cited as illustrations of conventional t mometry methods and instruments. Inherent prob with conventional electrical thermometers in the p ence of strong electromagnetic fields have led to development of special thermometer probes designed use in that environment. Current research activi include investigation of temperature measurement tumors and surrounding normal tissues by using a invasive three-dimensional scanning technique an gous to a computed tomography scan but where the pendent variable is temperature, or by using numer analysis to compute temperatures everywhere within

field. Several studies have investigated the application of the Pennes bio-heat equation to thermal dosimetry problems in hyperthermia, e.g., thermal conductivity and power deposition. Volumetric maps of temperature vs time and specific absorption rate vs time would provide information upon which to base thermal dose determinations. Good agreement between experimental and numerical calculations was obtained in a preliminary experiment that involved heating of the thighs of a mini-pig with 915 and 2450 MHz fields. Equipment required for adequate thermal dosimetry includes an automated data-acquisition system that can display information in real time and record it in computer-readable format for later numerical analysis.

0442 EXPERIMENTAL STUDIES OF VARIOUS HEATING PROCEDURES FOR CLINICAL APPLICATION OF LOCALIZED HYPERTHERMIA. (Eng.) Dutreix, J. (Dept. Radiation Therapy, Institut Gustave Roussy, 94805 Villejuif, France); Cosset, J. M.; Salama, A.; Brule, J. M.; Damia, E. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 585-596; 1982 (27 refs).

The characteristics of various heating procedures that are currently in use are reviewed. Their limitations in clinical hyperthermia are discussed. Thermal contact methods are characterized by superficial heating with a steep temperature gradient. In radiative diathermy, microwave radiation is usually applied as a beam arising from a waveguide; the heat distribution resulting from the beam and its low penetration in tissues is restricted to a small superficial volume corresponding to the central part of the beam. Improvement of the temperature distribution can be achieved using multiple beams. In inductive diathermy, superficial heating is produced by the the eddy currents arising in tissues exposed to a high frequency magnetic field. However, tumors with a low blood flow have been heated at depth using a powerful generator operating at 13.5 MHz. In capacitive diathermy, the conventional method of medical diathermy, two flat electrodes are applied on the opposite sides of the region to be treated and supplied with a radiofrequency voltage (usually 27 or 13.5 MHz). Tissues between the electrodes act as a high-loss dielectric in which heat is generated by the electric field. Heat deposition is maximum at the surface under the central region of the electrodes and diminishes at depth and with distance to the axis. Heat distribution is complicated by tissue inhomogeneity. The sc fatty layer is at risk of overheating. In conductive diathermy, heating is produced by local currents passing through tissues between electrodes applied around or implanted within the treated region. For electrodes placed or inserted at a short distance, temperature is fairly uniform in the volume surrounded by the electrodes. Ultrasonic heat deposition in the tissues results from the absorption of ultrasound. Tissue inhomogeneity is a problem. No heating modality currently in use meets all of the requirements for achieving satisfactory hyperthermia.

0443 DESCRIPTION AND TEST OF A 1.3-GHz MICR HYPERTHERMIA GENERATOR. (Eng.) Escany M. (Laboratoire de Biophysique, Faculte de Mede 18 rue Lionnois, 54000 Nancy, France); Itty, C. bert, J. In: Biomedical Thermology. Proceedin an International Symposium held in Strasbourg, Fr June 30-July 4, 1981. Gautherie, M.; Albert, E., (New York: Alan R. Liss, Inc.): pp. 597-604; 19 refs).

A local hyperthermia system that can be adapted previous 434-MHz generator is described. Resul experiments using the apparatus are presented. apparatus consists of a frequency tripler, ampli and applicator. Power input comes from an inexpe 434 MHz/12 W hybrid communication amplifier and o lator. The continuous duty cycle power output o tripler-amplifier unit is 20-25 W at 1.3 GHz app 600-V anode voltage. The waveguide is entirely f with dielectric load for compactness and good t matching. Experiments on tissue equivalent tran ent polyacrylamide gel indicated that the maximum perature was more than twice as deep at 434 MHz at 1.3 GHz. A comparison of temperature increas tumor-bearing mice placed either parallel or perp cular to the electric field indicated that there body shape effect. However, effective penetr depths in tumor-bearing rats were affected princi by vascular and diffusive heat transport.

0444 PRODUCTION AND CONTROL OF 2,450-MHz MI WAVE-INDUCED HYPERTHERMIA. (Eng.) Bor G. (Centre d'Etudes d'Electronique, Univ. Sci at Techniques du Languedoc, Place E. Bataillon, Montpellier Cedex, France); Richard, J. P.; Dela J. P.; Dubois, J. B.; Hay, M. In: Biomedical mology. Proceedings of an International Symp held in Strasbourg, France, June 30-July 4, Gautherie, M.; Albert, E., eds. (New York: Ala Liss, Inc.): pp. 605-610; 1982 (2 refs).

Dogs were exposed to 2450 MHz radiation to dete whether controlled heat can be delivered to a of 2 cm without risk to superficial tissue. H thermia was applied with a standard generator f with a helicoidal antenna. When theoretical c for the induction of superficial (0.2 cm) and (1.5 cm) temperatures were obtained for two o power levels (100 mW/cm^2 and 200 mW/cm^2), cons able heating of superficial tissue was seen at higher dose. The curves rose linearly, event reaching a steady state. The results of in viv periments in dogs showed that a relatively smal crease in beam strength can lead to a surge in perature which is difficult to control. Tissue

perature also varied with applicator position. The results suggest that a 2450 MHz source can be used to generate and control hyperthermia for the treatment of superficial and/or deep tumors up to a depth of 2 cm if a precise protocol to modulate output power levels can be defined.

0445 434-MHz MICROWAVE HYPERTHERMIA APPLICATORS: EXPERIMENTAL RESULTS IN PHANTOM AND PRELIMINARY CLINICAL RESULTS. (Eng.) Gaboriaud, G. (Institut Curie, Section Medicale, 26 rue d'Ulm, Paris 75231, France); Jaulerry, C.; Bataini, J. P.; Michel, D.; Dardalhon, M.; Averbeck, D. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 611-620; 1982 (7 refs).

The efficacy of heating with 434-MHz microwaves (MW) was investigated in a phantom and in patients with relatively superficial tumors. A Remy Co. generator (maximum power 100 W) connected to external radiating applicators filled with cooling water was used to induce hyperthermia. MW power was interrupted to perform temperature measurements at sampled intervals. In gel, peak temperature rise was proportional to MW incident power for the same water cooling temperature. Peak temperature rise moved from 0.5 cm to 2.0 cm and the superficial layers were protected from excessive heating when the cooling temperature decreased from 20 to 5 C for the same incident power. Incident MW power must be increased to maintain the same temperature level or to obtain a higher level. Patients presenting with incurable recurrent cancer or with sc metastatic nodules underwent six sessions of hyperthermia alone or in combination with radiotherapy. Sessions were 45 min long with a plateau at 43 to 45 C reached in 2-6 min. There was a large variation of MW power between sessions for the same patients (40-83 W); average temperatures ranged from 40 to 46 C. Tolerance to hyperthermia treatment varied with tumor localization. Partial regression was observed in 3/4 patients treated with hyperthermia alone. Among the 5 patients treated with combined radiotherapy-hyperthermia, one large regreassion was seen. The results suggest that good hyperthermia at 0.5 to 2.0 cm can be achieved by heating superficial tumors with 434-MHz MW.

0446 434-MHz MICROWAVE GENERATOR FOR LOCALIZED HYPERTHERMIA. (Eng.) Escanye, J. M. (Lab. Biophysique, Faculte de Medecine, 18 rue Lionnois, 54009 Nancy, France); Itty, C.; Robert, J. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 621-626; 1982 (4 refs).

A low-cost microwave hyperthermia system is described which includes a 16-W 434-MHz generator, a 150-W er amplifier, and a dielectric filled TE_{01} wave applicator. High-frequency power output is incre from 30 to 150 W by switching the high voltage 600 to 1600 V. A tuner stub is placed between the plicator and the generator. Distance between the and the applicator could be increased to 1 cm wi affecting the results. In clinical tests, skin perature was comparable to tumor temperatures at 2 cm in depth, after an initial 15 min rise, in no contact condition. Stray radiations did not ceed 30 mW/cm^2 when the applicator was 1 cm fro skin, at maximum power; 5 mW/cm^2 was the highest ue recorded in a 50 cm radius. Single applicator limits the system to sc or close-to-skin surface nor positions.

0447 DEEP AND LOCALIZED HYPERTHERMIA WITH A MICROWAVE SURFACE APPLICATOR. (Eng.) mar, A. (Lab. Thermoregulation L.A. 181 CNRS, Fac de Medecine Lyon-Nord, 8 Avenue Rockefeller, Lyon Cedex 2, France); Delhomme, G.; Bourdon, Schmitt, M. In: Biomedical Thermology. Proceed of an International Symposium held in Strasbo France, June 30-July 4, 1981. Gautherie, M.; All E., eds. (New York: Alan R. Liss, Inc.): pp. 627- 1982 (10 refs).

A direct-contact coaxial applicator developed for at 2450 MHz is described. The end of the coaxial is enlarged and shaped like a door knob. The appl tor is cooled by water circulating in several cir that can be monitored separately. Temperature di bution at the applicator surface can be controlle the amount of heat absorbed by the superficial l of the model or tissues can be regulated. Tempera measurements were performed in a model consistin polyacrylamide gel exposed to 2450-MHz microwave radiation emitted by a magnetron generator with able power output from 0-200 W. Localized hyperthermias that differed in shape, depth, and intensity obtained by varying the MW power and the cooling in the applicator. Maximal hyperthermia depth of 4 cm from the surface was determined by the MW p Surface temperatures did not exceed 36 C with temp tures of 42 or 43 C at depth. The temperature gr ent between the maximal hyperthermia and the sur depended on MW power and applicator cooling. Sim results obtained with inert biologic tissues sug that the applicator is suitable for obtaining fo hyperthermic areas.

0448 A COAXIAL APPLICATOR FOR INTRACAVITARY PERTHERMIA OF CARCINOMA OF THE CE (Eng.) Hand, J. W. (MRC Cyclotron Unit, Hammers Hosp., Ducane Rd., London W12 OHS, England); Blake R.; Hopewell, J. W.; Lambert, H. W.; Field, S. B. Biomedical Thermology. Proceedings of an Internat

al Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 635-639; 1982 (7 refs).

A 915-MHz microwave (MW) applicator designed to induce hyperthermia after conventional intracavitary radiotherapy of cervical cancer is described. The complete antenna fits in a conventional cesium afterloading tube (internal diameter, 0.5 cm). Increases in cervical, rectal, and urethral temperatures were measured after insertion of the applicator into the cervix of anesthetized pigs. A MW power level of 10-12 W was required to to achieve peak temperatures of 43-44 C. Temperatures recorded in the rectum and urethra at about 1 cm from the applicator agreed with the radial fall-off in temperature observed in previous liquid phantom studies. No increase in rectal temperature was observed 2 cm from the applicator.

0449 HYPERTHERMIA BY IMPLANTABLE APPLICATORS. (Eng.) Arcangeli, G. (Dept. Radiation Therapy, Istituto Medico e di Ricerca Scientifica, Via S. Stefano Rotondo 6, 00184 Rome, Italy); Barni, E.; Dividalli, A.; Lovisolo, G.; Nervi, C.; Mauro, F. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 641-647; 1982 (10 refs).

Thermal dosimetric studies were performed in vivo to study the temperature distribution obtained with an implantable applicator operating at 500 MHz. Uniform temperature distribution was obtained in the thigh of an anesthetized lamb with a 5.5-cm applicator and a power ranging from 7-12 W after 20 min heating. The area of therapeutically useful heating had a diameter of approximately 3 cm. Larger areas were heated homogeneously by employing several applicators inserted in different positions at about 3 cm from each other to encompass different tissue shapes and volumes. A new needle applicator has been designed with thermocouples located in the applicator cavity for continuous temperature monitoring and employing a frequency of 1 to 30 MHz.

0450 LOW-FREQUENCY (0.5-MHz) CONTACT AND INTERSTITIAL TECHNIQUES FOR CLINICAL HYPERTHERMIA. (Eng.) Cosset, J. M. (Dept. Radiation Therapy, Inst. Gustave Roussy, 94805 Villejuif, France); Brule, J. M.; Salama, A. M.; Damia, E.; Dutreix, J. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 649-657; 1982 (3 refs).

Heating of tissues by low-frequency currents p between electrodes placed around or inserted in treated volume was studied. Computed values electric field magnitude and current density for taining a constant temperature in tissue were i agreement with values measured in patients. Pre ary clinical results of low-frequency contact a terstitial hyperthermia are presented. Twenty-s tients with intractable superficial metastatic current tumors were treated with 0.5 MHz techn 21/26 were treated with contact electrodes (tu plates, usually with water cooling) and 5 were with implantation of special needles. A minimu or temperature of 42 C was reached for 13/21 pa treated with contact electrodes and temperatu 43-44 C were obtained frequently. Significant thermia was not achieved in 3/21 patients, pr because of the thickness of the fatty tissues the electrodes. With the interstitial techni temperature of about 44 C was reached easily. thermia was combined with chemotherapy in 5/26 Analysis of treatment results suggested that a response was obtained in the patients treated interstitial technique and in those who recieve bined therapy.

0451 E- AND H-FIELD SENSOR SYSTEM. (Eng.) one, B. (Equipment Group, Aeritalia selle Torinese, 10072 Torino, Italy); Bolla Gerbi, G.; Gabriele, P. In: Biomedical Therm Proceedings of an International Symposium hel Strasbourg, France, June 30-July 4, 1981. Gaut M.; Albert, E., eds. (New York: Alan R. Liss, pp. 659-672; 1982 (11 refs).

Characteristics of electromagnetic (EM) field that have been designed, constructed and teste discussed and tabulated. Sensors in the devel phase include instruments that can cover the fr cy ranges of 20 Hz to 18 GHz for electric field urement and 10 Hz to 100 MHz for magnetic field urement. Design goals include accurate measu of all polarizations, isotropic probes, balanc sensitivity to continuous wave as well as mod field signals. Improvements in repeater unit proposed. A study to improve the accuracy of calibration techniques is underway.

0452 STUDIES ON THE BIOLOGICAL EFFICIENCY PERTHERMIA PRODUCED BY A MICROWAVE AP TOR (434-MHz) FOR THERAPEUTIC MEANS USING AN E OTIC CELL SYSTEM AS INDICATOR. (Eng.) Dardalh (Inst. Curie, Section Biologique, 26 Rue d'Ulm, 75231, France); Averbeck, D.; Gabortaud, G.; M D.; Jaulerry, C.; Bataini, J. P. In: Biomedical mology. Proceedings of an International Sym held in Strasbourg, France, June 30-July 4, Gautherie, M.; Albert, E., eds. (New York: Al Liss, Inc.): pp. 673-686; 1982 (22 refs).

The effects of 434-MHz microwave (MW) radiation on biological samples were studied in yeast cells. A MW applicator designed for medical use was filled with water; its surface could be cooled with a thermostated pump-driven water circulation system. The frequency of the 434 MHz generator was stable and the power could be varied from 0 to 100 W. Samples of hyperthermia-sensitive Saccharomyces cerevisiae were positioned in a block of muscle tissue in a thermostated water bath and exposed for 1 hr to MW radiation after irradiation with 700 or 1000 Gray (Gy). Results were not significantly different from those obtained with conventional hyperthermia treatment for 1 hr in a thermostated water bath. When the temperature of MW-treated samples was increased gradually, the decrease in cell survival observed was less than with conventional hyperthermia. When the samples were placed in a pre-heated muscle block, rates of cell survival and induction of cytoplasmic "petite" mutations were unaffected by variations in ouput power or applicator water temperature when sample temperature remained constant and were comparable to those obtained with conventional heat treatment. Cells were maximally sensitized at 1.5-1.8 cm with MW or conventional heating.

0453 EXPERIENCE WITH DIATHERMIA-INDUCED WHOLE BODY HYPERTHERMIA. (Eng.) Neumann, H. (Dept. Hematology and Oncology, Medizinische Klinik der Albert-Ludwig Univ., Hugstetterstrasse 55, 7800 Freiburg, W. Germany); Fabricius, H. A.; Burmeister, P.; Stahn, R.; von der Tann, M.; Engelhardt, R.; Lohr, G. W. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 697-704; 1982 (24 refs).

Whole-body hyperthermia was induced in 24 cancer patients with disseminated malignancies using a Siemens diathermy cabinet. Treatment temperatures of 40-41 C were induced by 27 MHz radiation; generator output was 400 W. Chemotherapy was administered iv when a temperature of 40 C was reached. Side effects of cytostatic drugs did not exceed the range observed under nonthermic conditions. An enhancement of metastasis rate was not observed. Changes in hormone levels corresponding to endocrine system response to exercise or stress were observed. Immune parameters that appeared to be affected normalized after treatment; the effects were not correlated with hyperthermia. A patient receiving Adriamycin showed tachyarrhythmia during the fourth hyperthermia treatment, confirming previously reported enhancement of cardiotoxicity of Adriamycin by hyperthermia.

0454 COMBINED WHOLE-BODY AND LOCAL HYPERTHERMIA FOR CANCER TREATMENT: CMT SELECTOTHERM TECHNIQUE. (Eng.) von Ardenne, M. (Res. Inst. Manfred von Ardenne, 8051 Dresden, Zeppelinstrasse 1 Germany); Kruger, W. In: Biomedical Thermology. ceedings of an International Symposium held in St bourg, June 30-July 4, 1981. Gautherie, M.; All E., eds. (New York: Alan R. Liss, Inc.): pp. 713; 1982 (28 refs).

The cancer multistep therapy (CMT) concept is bas a combination of hyperthermia and tumor overacidi tion. Systemic long-term glucose infusion caus selective drop in tumor pH. The excess glucose tributes to a rise in core temperature through bolic heat generation which is further elevate whole-body radiofrequency (RF) heating. The tum then heated locally by RF. The limitations of co tional RF heating are overcome by the CMT Selecto technique which introduces a movable applicator to deliver RF to induce whole-body hyperthermia. ter core temperature is elevated to 41 C by sca the body with high RF amplitudes parallel to the surface, the RF power is reduced and energy foc on the tumor area. Target tissue temperatures 42.5 C. Draining lymph nodes can also be heate cally in a third step, if necessary. Temper courses during CMT Selectotherm treatment of tient with inoperable lung sarcoma are shown.

0455 MODERATE-TEMPERATURE WHOLE-BODY HYPER MIA IN THE TREATMENT OF MALIGNANT DIS (Eng.) Wallach, D. F. H. (Dept. Therapeutic Ra ogy, Tufts-New England Medical Center, 171 Har Ave., Boston, MA 02111); Madoc-Jones, H.; Sternic S.; Santoro, J. J.; Curran, B. In: Biomedical The ogy. Proceedings of an International Symposium in Strasbourg, France, June 30-July 4, 1981. Gau ie, M.; Albert, E., eds. (New York: Alan R. Inc.): pp. 715-720; 1982 (29 refs).

Results of a Phase I trial of whole-body radi quency (RF) hyperthermia at moderate temperatur the treatment of cancer are reported. The hyper mia unit was constructed after the Siemens proto Core heating to 40-41 C was achieved within 30-4 by deposition of 27-MHz RF energy primarily int great vessels of the trunk and abdomen. As he is concentrated in the body core, many physiolo compensatory mechanisms are minimized and heati well tolerated. Nine patients with either dis nated or locally advanced and uncontrollable di have been treated with hyperthermia 3/wk for 3 w gether with conventional radiotherapy 5 days/wk. of these patients completed eight or more course hyperthermia. Three patients did not complete schedule because of complications unrelated to h thermia. There were no serious side effects.

0456 LOCALIZED HYPERTHERMIA BY RADIOFREQ WAVES IN THE TREATMENT OF CANCER.

Israel, L. (Oncology Unit, CHU Avicenne, 125 route ie Stalingrad, 93000 Bobign , France); Besenval, M.; Breau, J. L. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 721-729; 1982 (31 refs).

The differential and preferential thermal sensitivity of malignant tumors and possible mechanisms of action of hyperthermia are discussed. Methods of producing radiofrequency (RF) hyperthermia are reviewed. Results of a phase I-II study of the efficacy of RF hyperthermia in the treatment of large, localized, deep-seated tumors are reported. Fifty-five patients with various deep-seated inoperable, metastatic tumors refractory to conventional treatment were treated by capacitive hyperthermia at 13.56 MHz generated by two soft electrodes. Total heating time ranged from 1 hr to 55 hr; sessions were 45 min to 3 hr long, and patients underwent 1 to 27 sessions. Available energy was increased so that a single field rather than the initial three alternate fields could be used for large tumors. A complete response was seen in 2 patients, a partial response in 15; stabilization for more than 3 wo in 20, and unmodified progressive disease in 18. No systemic toxicity associated with treatment was observed; however, skin burns due to a border effect occurred. It is concluded that localized RF wave hyperthermia is selective, nontoxic, and effective against large, poorly vascularized, deep-seated tumors not responsive to standard therapeutic procedures.

0457 RADIOFREQUENCY THERMOTHERAPY (RFTT) IN THE TREATMENT OF CANCER. (Eng.) LeVeen, H. H. (Dept. Surgery, Medical Univ. South Carolina, 171 Ashley Ave., Charleston, SC 29425); Pontiggia, P. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 731-738; 1982 (7 refs).

A radiofrequency (RF) generator utilizing a frequency of 13.56 MHz and employing multiple portals through which energy is introduced into the body was designed for the treatment of cancer. Multiple electrode pairs are successively energized for brief intervals with constant heating of the tumor, providing penetrating heat without excessive skin heating. The electrodes are refrigerated to further prevent skin overheating. Results obtained in a series of about 60 patients with advanced tumors treated in Italy with RF thermotherapy are reported. RF thermotherapy was effective in the treatment of tumors of different types that were generally in advanced stages; few complications were observed.

0458 SHORTWAVE REGIONAL HYPERTHERMIA OF THE PELVIS. (Eng.) Sidi, J. (Dept. Clinical Dermatology, Hopital Saint Louis, Place Alfred Fou 75010 Paris, France); Jasmin, C.; Convert, G.; D J.; Azam, G.; Huber, H.; Leger, J. In: Biome Thermology. Proceedings of an International sium held in Strasbourg, France, June 30-July Gautherie, M.; Albert, E., eds. (New York: Ala Liss, Inc.): pp. 739-744; 1982 (8 refs).

An apparatus for shortwave regional hyperther the pelvis is described, and a protocol emplo the treatment of chronic urogenital infections resist conventional modalities is presented. T paratus features a three-electrode capacitive h system and a 1000 W generator operating at 27.1 Patients with bacteriologically proven chronic genital infections were treated every other day wk; treatment sessions lasted at least 2 hr. Te tures slightly higher than 41 C were tolerated rectal and vaginal level level without a signi increase in buccal temperature and with no risk taneous burns. A total generator power of up t W may be needed for certain patients with a larg vic volume. Even in cases where treatment cou be completed, a noted painkilling effect was obs A generator of lower frequency than 27.12 MHz used in cases where the patient is resistant t type of heating.

0459 HYPERTHERMIA FOR HEAD AND NECK MAL TUMOR. (Eng.) Kijima, T. (Dept. Otol gology, Kobe Univ. Sch. Medicine, 7-5-20 Kusunoki Chuo-ku, Kobe 650, Japan); Hohki, A.; Masuda, M. natani, K. In: Biomedical Thermology. Proceedi an International Symposium held in Strasbourg, F June 30-July 4, 1981. Gautherie, M.; Albert, E., (New York: Alan R. Liss, Inc.): pp. 745-749; 1 refs).

Results are reported in the treatment of 15 pat with head and neck cancer using local radiofre (RF) hyperthermia alone (in 2/15 patients), with gery (1/15), chemotherapy (1/15), radiotherapy (or combined chemotherapy and radiotherapy (7/15). perthermia was induced by 13.56 MHz RF applied surface electrode that could be cooled by circul cool water. Treatments took place 2/wk. Tumor perature was controlled between 42 and 45 C. Pa remission was seen in 1/2 patients treated with hyperthermia alone; complete remission was seen patient treated with hyperthermia and chemothe 2/4 patients treated with hyperthermia and radi underwent complete remission; 7 patients treated combined therapy seem to have responded with co remission. There was no evidence of central ne system dysfunction when hyperthermia was appli nasopharyngeal and mesopharyngeal cancer, and no effects were reported.

0460 CLINICAL EXPERIENCES WITH COMBINED HYPERTHERMIA AND RADIOTHERAPY IN THE TREATMENT OF CANCER. (Eng.) Friedenthal, E. (Radiotherapy Dept., Montefiore Hosp. and Medical Center, Bronx, NY 10467); Mendecki, J.; Botstein, C.; Sterzer, F.; Paglione, R.; Nowogrodzki, M. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 751-760; 1982 (12 refs).

Clinical experience with microwave (MW) and radiofrequency (RF) induced hyperthermia at Montefiore Hospital and Medical Center in New York City is summarized. Patients with tumors of various histological characteristics in a variety of stages and anatomical sites have been treated. MW hyperthermia is induced by apparatus operating at 2450 or 915 MHz, which permits heating of tissue up to 2-3 cm in depth. A modified Burdick MW generator and a Mictron 10-W generator are used as the power sources at 2450 MHz and at 915 MHz, respectively. For deeper-seated tumors plane-wave RF heating at 27 MHz is employed. The power source is a Henry Radio generator containing provisions for measuring incident and reflected power. Standardized applicator designs do not exist, and variants of applicators have been developed for particular tumor sites or treatments. Hyperthermia is administered as soon as possible following radiotherapy to ensure higher therapeutic gain (1-hr sessions 2/wk, at 48-72 hr intervals) with tumor temperatures targeted at 42-43 C. In general, no systemic ill effects have been experienced by patients treated with MW-induced hyperthermia. At 27 MHz, control of the heated volume is more difficult, and systemic effects are more pronounced. The effect of heating certain vital organs (e.g., heart, large bowel) must be considered when hyperthermia is applied. Results of treatment in over 100 cases are summarized.

0461 PRELIMINARY RESULTS IN THE TREATMENT OF OAT CELL CARCINOMA OF THE LUNG BY COMBINED APPLICATION OF CHEMOTHERAPY (CT) AND WHOLE-BODY HYPERTHERMIA. (Eng.) Engelhardt, R. (Dept. Hematology and Oncology, Medizinische Klinik der Albert-Ludwigs Universitat, Hugstetterstrasse 55, 7800 Freiburg, W. Germany); Neumann, H.; von der Tann, M.; Lohr, G. W. In: Biomedical Thermology. Proceedings of an International Symposium held in Strasbourg, France, June 30-July 4, 1981. Gautherie, M.; Albert, E., eds. (New York: Alan R. Liss, Inc.): pp. 761-765; 1982 (12 refs).

Preliminary results are reported for 15 patients with small cell carcinoma (SCC) of the lung treated by multidrug therapy and whole body hyperthermia induced by a Siemens unit. Chemotherapy consisted of Adriamycin and Oncovin administered iv on Day 1 and Cyclophosphamide po on Days 2-5, repeated up to 6 x at 3 wk intervals. Two to five cycles of chemotherapy were administered together with whole body hyperthermia on Day 1; injections of Adriamycin and Oncovin were given the treatment temperature of 40.4 ± 0.5 C which maintained for 1 hr. Complete remission (disappe ance of all signs of measurable disease for at le 1 mo) was obtained in 8 patients, partial remiss (shrinkage of all measurable tumors by at least for at least 1 mo without new tumor growth) in 5 tients, no change in 1, and progressive disease observed in 1 patient. Survival rates, calcula from life table analysis, are 87% at 6 mo, 53% at mo, 22% at 18 mo, and 22% at 24 mo. A 50% survi rate is now at 53 wk (12.3 mo). Whole body hyperth mia was well tolerated by the patients. There was evidence for the accelaration of disease or the s mulation of metastasis by hyperthermia. Given poor prognosis for patients with SCC (median survi time of 6-8 wk without treatment and 7.6 mo with m tidrug therapy), the results are encouraging.

0462 INTRAARTERIAL INFUSION CHEMOTHERAPY IN C BINATION WITH 2450-MHz MICROWAVE HYPERTHI MIA FOR CANCER OF THE HEAD OF THE PANCREAS. (En Miura, T. (Dept. Surgery, Hanzomon Hosp., Tokyo Japan); Haida, K.; Haida, S.; Wada, T. In: Biomedi Thermology. Proceedings of an International Sympos held in Strasbourg, June 30-July 4, 1981. Gauther M.; Albert, E., eds. (New York: Alan R. Liss, Inc pp. 767-774; 1982 (no refs).

Results of intraarterial infusion chemotherapy in c bination with 2450-MHz microwave (MW) hyperthermia the treatment of 25 patients with advanced cancer the head of the pancreas are presented. MW radiat was applied to the primary tumor site of each pati for a 10-min period. When the tumor site was hea to a peak local temperature, chemotherapeutic age were infused through an indwelling catheter in the tery. Of the 25 patients, 17 (68%) survived > 6 and 36% > 1 yr, and 1 patient was alive 46 mo af treatment. These survival rates are uncommon in tients with advanced pancreatic cancer; patients conventional systemic chemotherapy would have had 2-3 mo life expectancy. The results indicate t the effects of the intraarterial chemotherapy w potentiated by MW hyperthermia.

0463 MEDICAL USE OF NONIONIZING ELECTROMAGNE WAVES IN THE RADIO AND SUPERHIGH FREQUE RANGE: HAZARDS AND STANDARDS. (Eng.) Stuchly, M. (Radiation Protection Bureau, Health & Welfare Cana Rm. 233 Environmental Health Centre, Ottawa, Ontar K1A OL2 Canada). In: Biomedical Thermology. P ceedings of an International Symposium held in Str bourg, France, June 30-July 4, 1981. Gautherie, Albert, E., eds. (New York: Alan R. Liss, Inc.): 851-863; 1982 (66 refs).

The biophysical basis of the interactions of radiof

quency (RF) and microwave (MW) radiation with living systems is briefly outlined. The sound base of dosimetric data established since the concept of the specific absorption rate was adopted allows better quantification of experimental studies and hazard assessment. Studies investigating thermogenic, genetic, teratogenetic, cardiovascular, endocrinological, immunologic, behavioral, auditory, and blood-brain-barrier effects of RF and MW radiation are summarized. Epidemiological studies have failed to produce reliable evidence of detrimental effects of occupational exposure to RF and MW radiation. Exposure levels recommended in both the 1979 Canadian exposure standard and the proposed US standard take into account the dependence of the absorbed dose on frequency. The potential health risk associated with all diagnostic medical applications is small. In hazard assessment for therapeutic uses of RF energy, both the patient and the operator must be considered. Promising medical applications of RF and MW radiation include cancer diagnosis by MW radiometry, NMR imaging, and cancer treatment. Areas requiring further research are outlined.

0464 EFFECT OF LOCALIZED MICROWAVE HYPERTHERMIA ON PHYSIOLOGICAL RESPONSES. (Eng.) Bicher, H. I. (Div. Radiology, Henry Ford Hosp., 2799 W. Grand Blvd., Detroit, MI 48202); Sandhu, T. S.; Vaupel, P.; Hetzel, F. W. Natl Cancer Inst Monogr 61: 217-219; 1982 (21 refs).

Measurements of pH, local blood flow, and tissue oxygen tension (TpO_2) were performed in normal cat brain and in muscle of the hind leg of C3H Sed-BH mice. Determinations were obtained in both controls and in animals bearing an implanted mammary adenocarcinoma. Modifications in these parameters as a function of temperature and the differential responses observed between normal and tumor tissues were also investigated. Microwave radiation (2,450 MHz) was delivered through a specially-designed applicator loaded with low-loss dielectric material having a dielectric constant of 6. Responses to hyperthermia were similar in both normal tissues except that the temperature at which TpO_2 began to fall (the breaking point) was significantly lower for the tumor. Blood flow in mice increased significantly up to approximately 41 C. In addition, there was a correlation between decreases in TpO_2 and blood flow as the temperature was increased to 43 C. The mean value of tissue pH was 6.8 ± 0.2 pH U in C3H mammary tumors. With heating for 1 hr at 43 C, pH decreased 0.5-1 U to 6.2 ± 0.2. It is concluded that the therapeutic effectiveness of hyperthermia may partially result from several induced physiological modifications: moderate (41 C) hyperthermia in combination with ionizing radiation may result in improved tumor response by increased oxygenation and, hence radiosensitivity coupled with a decrease in tumor pH; hyperthermia at 42 C and above may be directly tumoricidal because tumor micro blood flow is eliminated and tumor pH is sharply reduced, whereas normal tissue is properly perfused.

0465 THERAPEUTIC POTENTIATION OF cis-DICH DIAMMINEPLATINUM(II) AND RADIATION TERSTITIAL MICROWAVE HYPERTHERMIA IN A MOUSE (Eng.) Douple, E. B. (Norris Cotton Cancer C Dartmouth-Hitchcock Medical Center, Hanover 03755); Strohbehn, J. W.; de Sieyes, D. C.; Albo D. P.; Trembly, B. S. Natl Cancer Inst Monog 259-262; 1982 (8 refs).

An interstitial microwave (MW) system for proc local hyperthermia in deep-seated tumors was alone and in combination with cis-dichlorodia platinum(II) (cis-PT(II)) chemotherapy and/or tion in the treatment of mouse mammary tumor planted in the thighs of C3H/HeJ female mic small needle-like coaxial monopole antenna (active length) operating at 1 GHz was inserted the center of 0.5- to 1.0-cm diameter tumors temperatures were monitored and controlled either 44 or 45 C maximum at the antenna for min. Both MW and conventional heating induced tinct histological changes signifying pyknosis sence of mitoses, and necrosis. Histological sis indicated that microwave heating destroyed cells in the center of tumors, whereas water-ba mersion produced cell killing only in the per of the tumor near the skin. Both microwave and bath heating resulted in severe damage to the i.e., swelling followed by desquamation, nec and eventual leg loss. Compared with water heating, less damage to mouse normal leg tissue sulted when microwave heating was used. Analys tumor diameter doubling time values for cis-P radiation, heat, and combination treatments su that this method of local heating potentiates t fects of these agents. The results suggest single microwave coaxial antenna may serve as propriate system for producing local hyperther tumors in small laboratory animals.

0466 FRACTIONATED RADIOTHERAPY AND SHOR MICROWAVE HYPERTHERMIA. (Eng.) Dietz (Radiologisches Institut, Stadtische Krankenan en, 8580 Bayreuth, W. Germany); Linhart, G.; Gr B. R. Natl Cancer Inst Monogr 61: 267-269; 1 refs).

Experimental groups of 30 to 50 female NMRI mic solid Erlich neck tumors of 1-ml, were irradiat cally with 5 Gray (Gy) of X-rays followed immed by localized microwave hyperthermia to 42 C for Localized hyperthermia was delivered by a 2,4 Philips generator. Cell loss rate (CLR) was me by the loss of radioactivity of [^{125}I] deoxyur labeled tumor cells. CLR of hypoxic and oxyg cells was nearly identical in untreated tumors. perthermia alone had little influence on the l oxygenated cells, but it resulted in a signi loss of hypoxic cells. Hyperthermia in combi with irradiation significantly enhanced cell l hypoxic cells compared with irradiation alone.

hypoxic cells, a thermal enhancement ratio of 3.3 and a super-additive factor of 1.22 was obtained. Repeated hyperthermia retarded tumor growth only for a few days, whereas fractionated radiation therapy delayed tumor growth according to the dose applied. With combined treatment, the tumor was under control for the complete treatment time and even for a long period after the last treatment. Eight treatments of 5 Gy each combined with hyperthermia reduced tumor growth more than 8 fractions of 8 Gy alone. Whereas all animals given radiotherapy treatment died before day 100, 13.3% of the animals given the combined hyperthermia treatment survived more than 100 days without recurrence. Whereas 8 Gy given 8 x leads to severe skin reactions, the combination of this amount of radiation with hyperthermia induced almost no skin damage. The thermal enhancement ratio of the fractionated radiotherapy combined with microwave hyperthermia was more than 1.6.

0467 EFFECTS OF HEAT ON WOUND HEALING IN MICE. (Eng.) Martinez, A. (Div. Radiation Therapy, Dept. Radiology, Stanford Univ. Sch. Medicine, Stanford, CA 94305), Faria, S. L.; Flores, S.; Hahn, G. M. Natl Cancer Inst Monogr 61:307-309; 1982 (7 refs).

The effects of hyperthermia on wound healing in C3H/K mice were studied in order to develop an easy and reproducible model of wound healing; to assess the effects of hyperthermia on wound healing; and to compare the effects of water bath and radiofrequency (RF) heating. Skin and underlying muscle from the right hind thighs of C3H/K male mice, 11-25 wk old, weighing 30-40 g were excised leaving a surgical defect 1 cm in diameter. Five minutes prior to excision, hyperthermia treatments were given at a fixed temperature of 45 C, either in a water bath or with 13.56 MHz radiofrequency, for periods of 10, 20, 30, and 40 min. Microscopic measurements of the excised area were recorded, and the percentage of mice with 50% of the wound healed versus days of follow-up was plotted for analysis. For controls in which an incision was performed without prior hyperthermic treatment, one-half of the mice had 50% of their wounds healed in 8.5 to 9.5 days. In a water-bath control group (temperature kept constant at 37 C) the healing time ranged from 7.5 to 10 days. However, as the water bath temperature was increased to 45 C and kept constant for 10, 20, 30 and 40 min, a delayed healing time was noted as treatment time increased. In the RF group, no significant difference was observed between the control, group treated at 37 C and the mice treated at 45 C.

0468 INTERSTITIAL THERMORADIOTHERAPY. (Eng.) Manning, M. R. (Div. Radiation Oncology, Dept. Radiology, Univ. Arizona Health Sciences Center, Tucson, AZ 85724); Cetas, T. C.; Gerner, E. W. Natl Cancer Inst Monogr 61:357-360; 1982 (9 refs).

The results of a phase I clinical trial in which h was combined with interstitial (low dose rate) rad tion are described with emphasis on response technical and physical aspects of heating. Twen five patients (27 lesions) were treated using int stitial implants to locally recurrent, accessi tumors heated by 0.5 MHz radiofrequency currents 43-45 C for 30 min, with needle guides as electrod They were subsequently irradiated with either 19 or ^{226}Ra. All patients had failed previous conv tional treatments. In all but one, a single hyp thermic treatment was given and the average dose low dose irradiation was under 3,000 rad over 60 No patient failed to respond, 63% achieved a compl disappearance of tumor in the treated volume, and had partial response (50%<volume reduction<100 Duration of response varied from 2-30 mo and no tient showed regrowth at the site treated. A cumu tive summary of responses based on histology an comparison of treatment results obtained using h alone, external heat + external radiation, and int stitial radiation are presented. All but one of complications observed were considered minimal; one serious complication was a vaginal-rectal fist that developed 1 mo after the implant. Other comp cations including soft tissue vaginal necrosis, fa liquefaction, and proctitis healed spontaneously. is concluded that interstitial thermoradiotherapy both a safe and an effective means of treatment advanced or recurrent accessible disease. The te nique of implantation, subsequent heating, and rad active after-loading make this procedure applica to intraoperative approaches in such diseases as resectable pancreatic carcinoma, tumors of the g trointestinal tract, and unresectable ovarian d ease.

0469 HYPERTHERMIA EFFECTS IN ANIMALS WITH SP TANEOUS TUMORS. (Eng.) Gillette, E. (Comparative Oncology Unit, Dept. Radiology & Rad tion Biology, Colorado State Univ., Ft. Collins, 80523). Natl Cancer Inst Monogr 61:361-364; 1982 refs).

Results of investigators who have used spontane canine tumors for evaluation of hyperthermia reviewed for the purpose of designing appropri therapeutic protocols for treatment of animal tum or use of that information as a basis for human c cer therapy.

0470 MICROWAVE HYPERTHERMIA AND ELECTRON B THERAPY OF SUPERFICIAL TUMORS OF HUMAN O IN IN THE NUDE MOUSE. (Eng.) Cunningham, D. (Dept. Radiology and Specialized Cancer Res. Cent Pennsylvania State Univ. Sch. Medicine, Hershey,