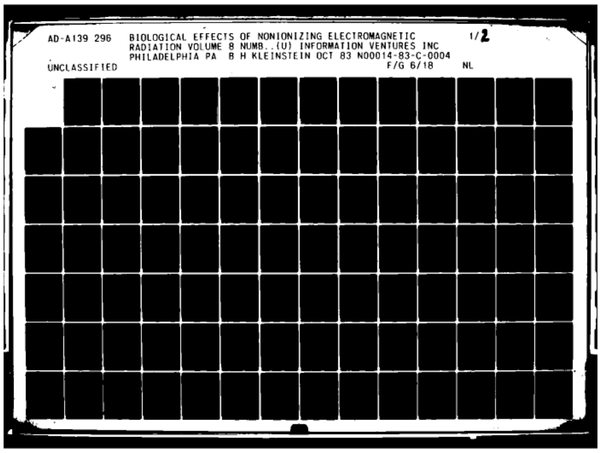

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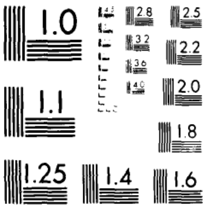

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Biological Effects of Nonionizing Electromagnetic Radiation

Volume VIII, Number 1

October 1983

A Digest of Current Literature

A Quarterly Publication Produced for
Office of Naval Research

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Nonionizing radiation, electromagnetic fields, literature digest, bibliography, electric fields, magnetic fields, microwaves, radiofrequency radiation

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 summaries, 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 figures in the document. Where appropriate, quantitative data such as

#20 Cont.

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

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Block 8. Contract or Grant Number*(s)*. For a contractor or grantee report, enter the complete contract or grant number*(s)* un which the work reported was accomplished. Leave blank in in-house reports.

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Block 10. Program Element, Project, Task Area, and Work Unit Numbers. Enter here the number code from the applicable Department of Defense form, such as the DD Form 1498, "Research and Technology Work Unit Summary" or the DD Form 1634. "Research and Development Planning Summary," which identifies the program element, project, task area, and work unit or equival under which the work was authorized.

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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."

Biological Effects of Nonionizing Electromagnetic Radiation

October, 1983 Volume VIII, Number 1

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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
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
NTIA - National Telecommunications and Information Administration
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
USAF/SAM - U. S. Air Force School of Aerospace Medicine
V - volts
VA - Veterans Adminstration
W - watt(s)
WHO - World Health Organization
wk - week(s)
wt - weight
x - times
yr - year(s)

NEWS ITEMS

EPA RF/MW BIOEFFECTS REPORT

The EPA's draft report on the biological effects of radiofrequency/microwave radiation will undergo revision with respect to its assessment of thermal risk. The Science Advisory Board Subcommittee met on September 22-23, 1983, at EPA Headquarters in Washington, DC to discuss the draft report. Revisions are expected to be completed by December 83. Copies of the draft report may be obtained from David Janes, Office of Radiation Programs, EPA Headquarters, 401 M Street, SW, Washington, DC; (703)557-8217. Minutes for this meeting can be obtained by contacting Dr. Terry F. Yosie, Director, Science Advisory Board (202)382-4126 or Dr. Douglas Seba, Executive Secretary, Science Advisory Board (202)382-2552. A transcript of the entire proceedings is available for $0.40 per page from the Executive Court Reporters, 8525 Colesville Road, Silver Spring, MD 20910; (301)565-0054. The transcript is approximately 300 pages.

CRITICAL APPRAISAL OF THE BIOLOGICAL EFFECTS DUE TO EXPOSURE TO ELECTRIC AND MAGNETIC FIELDS AT LOW FREQUENCIES

Contract 68-02-3845. The Environmental Protection Agency, Research Triangle Park, NC has contracted with the National Council on Radiation and Measurements, 7910 Woodmont Avenue, Suite 1016, Bethesda, MD 20814 for the above study.
Commerce Business Daily, October 18, 1983

COMPUTER MODELLING OF 60 HZ ELECTRIC FIELD COUPLING TO BIOLOGICAL TISSUE

Sol DE-RP01-84CE76236. The U.S. Dept. of Energy is seeking proposals from qualified organizations for the above study. Proposals are due by 11/16/83.
Commerce Business Daily, October 14, 1983

THEORETICAL AND NUMERICAL STUDIES OF AN INTENSE MICROWAVE SOURCE

The Naval Research Laboratory, Washington, DC, is negotiating with Science Applications, Inc. McLean, VA 22102 for the above study.
Commerce Business Daily, July 29, 1983

HYPERTHERMIA QUALITY ASSURANCE PROGRAM

Contract N01-CM-37512. The National Cancer Institute has contracted with Allegheny-Singer Research Corp., 320 East North Ave., Pittsburgh, PA 15212 for the above five year incrementally funded study.
Commerce Business Daily, July 7, 1983

NEW BOOKS:
NUCLEAR MAGNETIC RESONANCE IMAGING: BASIC
PRINCIPLES. Young, Stuart W.
176 p., 80 figures, $19.00 (November 1983) ISBN 0-89004-998-X. Published by Raven Press, NY, NY

ALL-UNION SYMPOSIUM IN PUSHCHINO

An All-Union Symposium on the "Biological Effects of Electromagnetic Fields" was held in Puschino, USSR, in 1982. One hundred sixty eight papers were presented in the following areas: I. Biological Effects of Radio Frequency Electromagnetic Radiation (40); II. Biological Effects of Millimeter-Band Electromagnetic Radiation (14); III. Biological Effects of Low-Intensity Electromagnetic Fields (20); IV. Biological Effects of Constant Magnetic Fields (30); V. Biological Effects of Electric Fields (11); VI. Clinico-Hygienic Aspects of Electromagnetic Radiation (29); VII. Effects of Combined Exosures (10); and VIII. Physical Fields of Biological Materials (14). Figures in parentheses indicate the number of papers presented in each category. Translated titles and author names will appear in the next issue of the Digest. Author affiliations include:

DUBNA
- Joint Inst. Nuclear Research

IVANO-FRANKOVSK
- Medical Inst.

KARAGANDA
- State Medical Institute

KAZAN
- Res. Inst. Traumatology and Orthopedics

KHARKOV
- Res. Inst. Industrial Hygiene and Occupational Diseases

KIEV
- P. M. Buiko Res. Inst. Pediatrics, Obstetrics and Gynecology
- A. N. Marzeev Inst. General and Communal Hygiene
- Inst. Molecular Biology and Genetics, Ukrainian

SSR Acad. Sciences
- A. V. Palladin Inst. Biochemistry, Ukrainian SSR Acad. Sciences
- Inst. Microbiology, Virology, Parasitology
- T. G. Shevchenko Kiev State Univ.

KUPAVNA
- Res. Inst. Biological Testing of Chemical Compounds

LENINGRAD
- A. A. Ukhtomskii Physiological Inst.
- Sanitary-Hygienic Medical Inst.
- B. P. Konstantinov Inst. Nuclear Physics
- Res. Inst. Industrial Hygiene and Occupational Diseases
- Res. Inst. Radiation Hygiene

MAKHACHKALA
- Dagestan Polytechnical Inst

MINSK
- Byelorussian State Inst. Advanced Medical Training

MOSCOW
- All Union Res. Inst. Cable Industry
- All Union Res. Inst. Electric Current Sources
- A. N. Sysin Res. Inst. General and Community Hygiene
- Inst. Higher Nervous Activity and Neurophysiology
- Inst. Medico-Biological Problems
- Central Res. Inst. Balneology and Physical Therapy
- Inst. Radio Engineering and Electronics
- All Union Cancer Res. Center
- Inst. Biophysics, USSR Ministry Public Health
- Inst. Chemical Physics, USSR Acad. Sciences
- Inst. Biological Physics Pushchino, Moscow Region

OBNINSK
- Res. Inst. Medical Radiology

ROSTOV-ON-DON
- Res. Onkological Inst.

SARATOV
- State Univ.

SIMFEROPOL
- M. V. Frunze State Univ.

TOMSK
- Res. Inst. Biology and Biophysics, State Univ.
- Polytechnical Inst.

VLADIVOSTOK
- Medical Inst.

WORKSHOP [illegible] IN
ELECTROMAGNETIC INTERACTIONS WIT[illegible]

On November [illegible], [illegible] a workshop was held at t University of Maryland, College Park Campus. T Workshop was sponsored by the U.S. Office of Na Research and the Bureau of Radiological Healt the U.S. Food and Drug Administration. The purp of the meeting was to promote exchanges between r searchers in this field and those in other clos related disciplines, provide a forum for critic assessment of theoretical ideas, and to identi problem areas and research priorities. The two a one-half day program included a dozen invited t torial lectures from leading authorities in the fields, a poster session for contributed paper and a general review and discussion session. A though the proceedings of the meetings will not published, it is expected that a short report wi be prepared which will attempt to summarize t principal ideas presented at the Workshop and wi include the abstracts of the poster papers.

MEETINGS AND CONFERENCES

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 Sol M. Michaelson, The University of Rochester, Medical 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.

RADIATION AND ENERGY: CONFRONTING THE CHALLENGES OF THE EIGHTIES - LAW, REGULATION, RISK LIABILITY, LITIGATION AND COMPENSATION

Date: December 8-9, 1983
Place: New York, NY
Requests for Information: James Lawrence, Lloyd's of London Press, 817 Broadway, New York, NY 10003; (212)673-4700

8TH ANNUAL IEEE INTERNATIONAL CONFERENCE ON INFRARED AND MILLIMETER WAVES

Date: December 12-17, 1983
Place: Carillon Hotel, Miami Beach, FL
Requests for Information: Dr. K. J. Button, National Magnet Laboratory, Building NW-14, MIT, Cambridge, MA 02139; (617)253-5561

MICROWAVE SIGNATURES IN REMOTE SENSING

Date: January 16-20, 1984
Place: Toulouse, France
Requests for Information: Dr. Richard Moore, Remote Sensing Laboratory, Univ. of Kansas, Center for Research, 2291 Irving Hill Drive, Lawrence, KS 66045; (913)864-4836.

SYMPOSIUM ON NMR IMAGING

Date: January 27-29, 1984
Place: Fontainebleau Hotel, Miami Beach, FL
Requests for Information: American College of Radiology, 6900 Wisconsin Ave., Chevy Chase, MD 20815; (301)654-6900.

28TH ANNUAL MEETING OF THE B YSICAL SOCIETY

Date: February 19-23, 1984
Place: San Antonio Convention San Antonio, TX
Requests for Information: Biopl .c Society, 9650 Rockville Pike, Bethesda, MD 20: [illegible] .301)493-6114

BIOLOGICAL EFFECTS OF ELF ELECTROMAGNETIC FIELDS AND THERAPEUTIC APPLICATIONS

Date: February 23-25, 1984
Place: Venice, Italy
Requests for Information: Dr. Luigi Zecca, Associations for Biomedical Applications of Electromagnetism, Via Gentilino, 9/A, 20136 Milano, Italy; Tel. 02-8321655 or 8391867
Content: Topics of the meeting will be the physical aspects, the biological effects, the medical implications and the therapeutic applications of extremely low frequency (ELF) electromagnetic fields. Attention will be focused on the following items: Physics: field generation devices, field characterization, dosimetry; Biology: cellular effects, developmental effects, physiology, hematology, immunology, neurology, tissue-vascular relationships; and Therapeutics: rheumatology, traumatology, angiology, dermatology, neurology. Abstracts in English must be submitted by December 31, 1983.
Invited lectures by W. R. Adey, V. M. Bogoliubov, G. Cheng, J. M. R. Delgado, R. W. Farndale, F. Lechner, A. R. Liboff, V. V. Poltoranov, and L. Zecca
Fee: Registration will be $150 up to December 31, 1983. Late registration will be $180.
Publications: An abstract book will be provided to all registered participants. The proceedings will be published by an International Publishing House.

SIXTH INTERNATIONAL CONGRESS OF THE RADIATION PROTECTION ASSOCIATION

Date: [illegible], 1984
Place: International Congress Center, Berlin, [illegible]
Sponsor: Int. Radiation Protection Assn. (IRPA)
Requests for Information: R. Neider, Sec General, Bundesanstalt fur Material Prufung, Unter Den [illegible], 87, D-[illegible] Berlin 45, Germany (DFR)
Note: 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 [illegible] papers in English, French, and German)

4TH INTERNATIONAL SYMPOSIUM ON HYPERTHERMIC ONCOLOGY

Date: July 2-6, 1984
Place: Aarhus, Denmark
Requests for Information: Jens Overgaard, M.D., Symposium Chairman, The Institute of Cancer Research, Radiumstationen, DK-8000 Aarhus C, Denmark

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 [illegible]

EIGHTH INTERNATIONAL BI[illegible]

Date: July 29 - August 4, 1984
Place: Bristol, United Kingdom
Sponsor: Int. Union of Pure & Appl[illegible]
Requests for Information: Dr. R. C. [illegible] of Biochemistry, The University, Bri[illegible] United Kingdom

URSI SYMPOSIUM

Date: August 29 - September 7, 198[illegible]
Place: Florence, Italy
Sponsor: URSI
Requests for Information: Contact [illegible] Rosenthal, Polytechnic Institute of New [illegible] L.I., Farmingdale, NY 11735
Note: A joint meeting with the B[illegible] Society is tentatively scheduled [illegible]

MEETING OF THE EUROPEAN SOCIETY [illegible] THERAPEUTIC RADIOLOGY AND [illegible]

Date: September 9-15, 1984
Place: Jerusalem Hilton, Jerusalem, [illegible]
Sponsor: KENES
Requests for Information: Prof. Z. [illegible] Dept. of Radiation and Oncology, Hada[illegible] 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 second of these translations is presented below. It is an excerpt from the following article:

BIOLOGICAL EFFECTS OF MICROWAVE RADIATION. (Hun.) Almássy, Gy. (Scientific Council, TKI - Telecommunications Research Inst. - Hungary); Szabó, L.; Bailai, L. *A Tavkozlesi Kutato Intezet Kozlemeyei*, Vol. 27(1-2):15-45; 1982 (46 refs).

Literature data on the biological effects of microwave radiation are reviewed. The discussion covers the physical properties of microwave radiation, its absorption by living organisms, and systemic effects of microwave radiation. Microwave thermography for medical diagnostic purposes is described and apparatus for centimeter- and millimeter-wave thermographic examinations is illustrated. The draft of a new Hungarian microwave radiation safety standard is presented.

..... "In the draft of the new Hungarian standard, different safety regulations are specified for the general population and for persons who are occupationally exposed to microwave radiation. The permissible exposure level for occupationally exposed persons can be higher by 10 dB than that for the general population. Occupationally exposed personnel must undergo periodic medical check examinations.

In the draft of the standard, occupationally exposed persons are defined as follows:

- persons operating, repairing, and measuring equipment emitting electromagnetic energy, who are adequately trained;
- persons using and operating energy-generating equipment who are adequately trained for these tasks;
- persons who are at the site of equipment radiating electromagnetic energy during performance of their jobs, regardless of professional training.

Permissible radiation levels in the draft of the Hungarian radiation safety standard are summarized in Table I, below. The safety levels shown in the table are averages. No distinction is made between exposure to continuous wave or pulse modulated signals. The levels in the table are illustrated in Figures 13, 14, 15, and 16 (from the article).

During extraordinary work conditons, occupationally exposed persons can stay in areas with a high-frequency radiation hazard for a short time period (maximum of 20 minutes) and can perform work. Protective apparatus to be used is specified in separate regulations. To reduce the harmful effects of the microwave field, protective goggles absorbing microwave energy must be worn.

Radiation safety regulations of the socialist countries are summarized in Table II. "

The measurement of microwave radiation is discussed.

Table I.

Frequency range		0.03-30 MHz	30-300 MHz	0.3-300 GHz
Lower limit values of hazardous radiation	General population	20 V/m	10 V/m	0.01 mW/cm^2
	Occupational exposure	50 V/m	20 V/m	1.0 mW/cm^2
Upper limit values of harmless radiation	General population	480/t	240/t	0.24/t mW/cm^2
	Occupational exposure	1200/t	480/t	2.4/t mW/cm^2
Forbidden areas: general population + occupational exposure		1000 V/m	500 V/m	10 mW/cm^2

Note: t = exposure time in hours (t > 1 hour).

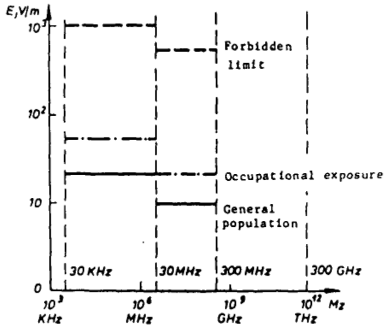

Figure 13.
Safe limits of electric field intensity for continuous exposure (Hungarian draft standard).

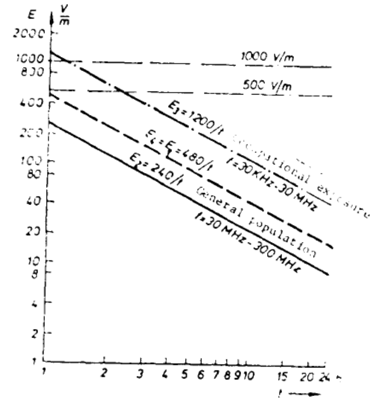

Figure 14.
Safe limits of electric field intensity for intermittent exposure (Hungarian draft standard).

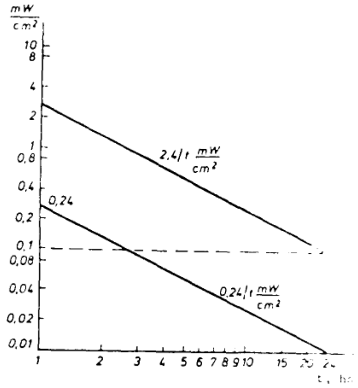

Figure 16.
Permissible values of microwave power density for intermittent exposure (Hungarian draft standard).

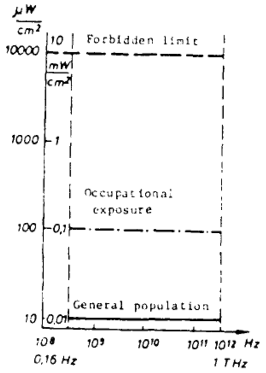

Figure 15.
Permissible values of microwave power density for continuous exposure (Hungarian draft standard).

Table 11.

Standard	Scope	Frequency	Exposure limit	Exposure duration	Continous/ pulsed mode	Fixed/rotary antenna
Soviet standard 1974	Occupa-tional Exposure	10-30 MHz	20 V/m	Work day	Both	Both
		30-50 MHz	10 V/m	Work day	Both	Both
			0.3 A/m	Work day	Both	Both
		50-300 MHz	5 V/m	Work day	Both	Both
		0.3-300 MHz	10 uW/cm^2	Work day	Both	Fixed
			100 uW/cm^2	Work day	Both	Rotary
			100 uW/cm^2	2 hours	Both	Fixed
			1 mW/cm^2	2 hours	Both	Rotary
			1 mW/cm^2	20 minutes	Both	Fixed
Soviet standard 1978	General Popu-lation	0.3-300 MHz	1 uW/cm^2	24 hours	Both	Both
Polish standard 1972	Occupa-tional Exposure	0.3-300 MHz	0.2 mW/cm^2	10 hours	Both	Fixed
			0.2-10 mW/cm^2	32/P^2/hour/	Both	Fixed
			1 mW/cm^2	10 hours	Both	Rotary
			1-10 mW/cm^2	800/P^2/hour/	Both	Rotary
	General Popu-lation	0.3-300 MHz	10 uW/cm^2	24 hours	Both	Fixed
			0.1 mW/cm^2	24 hours	Both	Rotary
Polish recommended standard 1975	Occupa-tional Exposure	10-300 MHz	20 V/m	Work day	Both	Both
			20-300 V/m	3200/E^2/hour	Both	Both
	General Popu-lation	10-300 MHz	7 V/m	24 hours	Both	Both
Czech standard 1970	Occupa-tional Exposure	10-30 MHz	50 V/m	Work day	Both	Both
		30-300 MHz	10 V/m	Work day	Both	Both
			25 uW/cm^2	Work day	Continuous	Both
			10 uW/cm^2	Work day	Pulsed	Both
		0.3-300 GHz	1.6 mW/cm^2	1 hour	Continuous	Both
			0.64 mW/cm^2	1 hour	Pulsed	Both
	General Popu-lation	30-300 MHz	1 V/m	24 hours	Both	Both
		0.3-300 GHz	2.5 uM/cm^2	24 hours	Continuous	Both
			1 uW/cm^2	24 hours	Pulsed	Both
		30-300 MHz	1 V/m	24 hours	Both	Both
		10-30 MHz	2.5 V/m	24 hours	Both	Both

P - Power density W/m^2 E - Electric field density V/m

BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION DIGEST welcomes contributions from its readers. Information on meetings, news, current research and current literature is actively sought for publication in the DIGEST. Forms for submission of notices of current research projects are included at the back of this issue.

0655 TECHNIQUE FOR MICROWAVE-INDUCED HYPERTHERMIA IN SUPERFICIAL HUMAN TUMORS. (Eng.) Nilsson, P. (Dept. Radiation Physics, Univ. Hosp., S-22185 Lund, Sweden); Persson, B.; Kjellen, E.; Lindholm, C.-E.; Landberg, T. Acta Radiol Oncol 21(4):235-239; 1982 (16 refs).

A hyperthermia system consisting of a microcomputer-controlled 2450 MHz microwave (MW) generator is described. MW power is delivered via a circular direct contact applicator. Up to 8 thermistor probes connected to a temperature registration unit can be used simultaneously to measure tumor and skin surface temperature; digitized temperature signals are sent to the microcomputer for calculation of temperature and for control of the heating. One of the thermistors (usually the one inserted in the center of the tumor) is chosen as the master probe, and the temperature recorded at this probe is compared with a preset temperature value. Heating is started via a signal from the computer to the MW generator when temperature at the master thermistor is at least 0.2 C lower than the preset temperature. The power of the generator (maximum output power of 200 W) is selected manually to achieve a temperature increase of approximately 0.5 C during a 15-sec MW pulse. All probes are read 2 sec after MW energy is shut off by the computer, eliminating the problem of incorrect temperature measurement during MW irradiation due to interaction between the metallic wires of the probes and the electric field. When the preset temperature value is reached, the length of the pulse is adjusted by the control program so that temperature at the master thermistor does not fluctuate more than ± 0.5 C. This automatic control system has proven to be very reliable in clinical work.

0656 MICROWAVE-INDUCED HYPERTHERMIA AND IONIZING RADIATION. PRELIMINARY CLINICAL RESULTS. (Eng.) Lindholm, C.-E. (Dept. Oncology, Malmo Allmanna Sjukhus, S-21401 Malmo, Sweden); Kjellen, E.; Landberg, T.; Nilsson, P.; Persson, B. Acta Radiol Oncol 21(4):241-254; 1982 (70 refs).

Local hyperthermia induced by a computer controlled 2450 MHz microwave (MW) system was used alone or in combination with ionizing radiation to treat superficial tumors that were refractory to other therapy. Thermistor probes were placed within the tumor and on the skin surface; temperature of the probe designated as the master probe was maintained at 42.5 ± 0.5 C via the computer control system. The effects of hyperthermia alone, ionizing radiation alone (30 Gray in 10 fractions over 12 days), or hyperthermia (45 min 1/wk or 2/wk for 2 wk) with radiation were compared. Of 8 evaluable tumors given combined hyperthermia and radiation, 5 showed a complete and 3 showed a partial response while no response was seen in 3 tumors treated with ionizing radiation alone or in 1 tumor treated with heat alone. Combined therapy was effective even in sites that had been irradiated previously. The MW applicator allowed heating of lesions less than 7 cm in diameter and 3 cm deep. The preset temperature at the master probe could be maintained at ± 0.5 C but differences of up to 3.5 C were observed between the different thermistors at a given treatment session. Side effects of hyperthermia included pain and skin burns.

0657 USE OF RADIO-FREQUENCY PULSED ENERGY IN THE CONTROL OF POSTOPERATIVE REACTION IN BLEPHAROPLASTY. (Eng.) Nicolle, F. V. (30 Harley St., London W1N 1AB, England); Bentall, R. M. Aesthetic Plast Surg 6(3):169-171; 1982 (9 refs).

Clinical results obtained with a portable device used to apply small pulses of radiofrequency (RF) energy to surgical wounds are reported. The device consists of a small oscillator tuned to 27.12 MHz with a timer switching the oscillator so that small pulses of RF energy (square, 100-usec long pulses; 1000 pulses/sec) are emitted from the single turn coaxial coil. The unit is powered by a small nickel-cadmium battery that can be used for 5 days without recharging. The area of the coil is approximately 6 cm in diameter. In order to adapt the device to fit over the eyelid region, two wire loops were designed in the shape of an eyeglasses frame and held in place with light padding and a bandage. Only one loop was electrically active; the other provided a control. The device was applied for 24 hr to one eye in 21 consecutive patients after bilateral blepharoplasty. No device-related complications were observed. Improvement was apparent in 11/13 cases where sufficient ecchymosis and edema existed for comparison; ecchymosis and swelling were so slight in 6 cases that no difference was visible between treated and untreated sides. Two cases were judged to be worse on the treated side and 2 were excluded because of displacement of the dressings by the patients. A similar device with larger loops to cover the neck and sides of the face is being used in face and neck lifts.

0658 REACTION OF NORMAL EQUINE EYES TO RADIO-FREQUENCY CURRENT-INDUCED HYPERTHERMIA. (Eng.) Neumann, S. M. (Dept. Clinical Sciences, Coll. Veterinary Medicine and Biomedical Sciences, Colorado State Univ., Fort Collins, CO 80523); Kainer, R. A.; Severin, G. A. Am J Vet Res 43(11): 1938-1944; 1982 (4 refs).

The long-term effects of treatment of equine ocular tumors with radiofrequency (RF) current-induced hyperthermia were studied. The eyes of 13 horses and 8 ponies were subjected to a 30-sec application of RF current (2 MHz, 7 or 10 W); the eyes of 3 horses were sham-treated. The electrodes of a localized current field device were applied horizontally to the central cornea in the right eye and horizontally and vertically to 2 separate limbal sites in the left eye. Mean temperatures at the 2 corneal sites was 48.7 C; at the 4 limbal sites, 56.0 C. In eyes observed from 1 to 6 mo after treatment, scars persisted at 1 central corneal site (4.5%) and 6 limbal sites (27.3%) where electrodes were positioned vertically. Pathologic changes observed up to 1 wk after treatment included transient ulcerative keratitis and anterior uveitis. Vision was not compromised in any of the animals permitted to live beyond 1 wk.

0659 ACCELERATION OF THE DEVELOPMENT OF BENZOPYRENE-INDUCED SKIN CANCER IN MICE BY MICROWAVE RADIATION. (Eng.) Szudzinski, A. (Dept. Dermatology, Postgraduate Centre, Military Medical Acad., Szaserow 128, PL-00-909 Warsaw, Poland); Pietraszek, A.; Janiak, M.; Wrembel, J.; Kalczak, M.; Szmigielski, S. Arch Derm Res 274(3-4):303-312; 1982 (20 refs).

The possible co-carcinogenic activity of long-term low-level microwave (MW) radiation was studied in Balb/c mice. Skin cancer was induced in the mice by chronic exposure to 3,4-benzopyrene painted on the dorsal skin every 2 days for up to 6 mo. Mice were exposed to 2450 MHz MW energy (from a Lucz 58 generator with maximum output power of 150 W) in a temperature and humidity controlled anechoic chamber at incident power levels of 5, 10, or 15 mW/cm^2 (specific absorption rates of 2, 4, and 6 mW/g, respectively) for 2 hr/day, 6 days/wk, for up to 6 mo. Mice were divided into six experimental groups of 100 animals each. Mice in groups 1 and 2 were simultaneously exposed to benzopyrene treatment and MW energy (5 mW/ cm^2 or 15 mW/cm^2) for 6 mo. Mice in groups 3-5 were irradiated for 1, 2, or 3 mo before the beginning of benzopyrene treatment. Control animals were exposed to benzopyrene treatment for 6 mo and sham-irradiated for 2 hr/day for 1, 2, 3 or 6 mo. All MW irradiation protocols resulted in significant stimulation of the development of benzopyrene-induced skin cancer and in shortening of the life span of the tumor bearing hosts. The effect was more pronounced both after exposure to higher power densities and after longer exposure periods. When benzopyrene treatment was preceded by or concomitant with MW irradiation, skin reactivity to dinitrofluorbenzene was markedly inhibited, suggesting that long-term exposure to low-dose 2450 MHz MW radiation may suppress cellular immune reactions.

0660 INTERRELATIONSHIPS BETWEEN WATER AND CELL METABOLISM IN ARTEMIA CYSTS. X. MICROWAVE DIELECTRIC STUDIES. (Eng.) Clegg, J. S. (Lab. Quantitative Biology, Univ. Miami, Coral Gables, FL 33124); Szwarnowski, S.; McClean, V. E. R.; Sheppard, R. J.; Grant, E. H. Biochim Biophys (4):458-468; 1982 (50 refs).

The dielectric properties of cysts of Artemi primitive crustacean known as the brine shrimp, measured over the frequency range 0.8-70 GHz. mia cysts are composed of about 4 000 closely-pa cells surrounded by an acellular shell and ca dergo cycles of hydration-dehydration without of viability. Measurements were performed on with various water contents, primarily 1 g H_2O g dried cysts. Complex permittivity measure were made at 0.8, 2, and 4 GHz with a coaxial apparatus; those at 15, 35, and 70 GHz were with a waveguide apparatus. At each frequency cept 70 GHz, the permittivity showed an increas the water content of the cyst was increased. At high hydration values, the permittivity leveled At 70 GHz, permittivity was linearly dependen cyst water content. The permittivity of the i cellular water at 35 GHz was estimated as 16 is 30% below that for pure water at 34 GHz. authors assumed that water exists as bulk and bulk fractions in the cysts and calculated that of the cellular water had a permittivity equa that of pure water.

0661 MICROWAVE MODULATION OF NEURAL ACTIV (Eng.) Wachtel, H. (Dept. Electr Engineering, Univ. Colorado, Boulder, CO). B Sci Instrumen 18:45-50, 1982 (6 refs).

A mathematical model is presented which can be to predict optimal microwave (MW) pulse parame for perturbing neural activity with minimal ris damage due to temperature rise or excessive cur density. The model, which is based on the obse tion that low levels of MW power can rapidly pr changes in the firing patterns of isolated Apl pacemaker neurons and that MW pulses may be equ lent to injected transmembrane DC pulses, sugg that a distinct minimum pulse energy exists pulse duration (in sec) equals 1.2 x the memb time constant. Noninvasive modulation of neur activity by MW pulses could have numerous bi ical applications.

0662 MICROWAVE ABSORPTION OF DNA BETWEEN 12 GHz. (Eng.) Swicord, M. L. (Burea Radiological Health, 12721 Twinbrook Parkway, ville, MD 20857); Davis, C. C. Biopolymers 21(2453-2460; 1982 (11 refs).

The microwave (MW) absorption coefficients of a ous solutions of DNA extracted from Escherichia li were measured over the frequency range 8-12 The phase fluctuation optical heterodyne tech was used to monitor the temperature rise induced in *a sample by pulsed* MW irradiation. In this technique, a single frequency He-Ne laser beam traverses the sample while the sample is heated with 10 mJ pulses of MW energy. The heating of the liquid sample when it absorbs MW energy induces a phase chirp in the laser beam. The absorption coefficient of the sample is determined from a plot of optical heterodyne signal as a function of the distance of the laser beam from the surface of the liquid. The maximum random error in the system was less than 2% as determined from measurements on deionized water and other media such as saline solutions and methanol. The attenuation coefficient of the DNA solution was greater than that of water and saline solution. The absorption coefficient of the DNA solution was 40% higher than water at 8 GHz, decreasing to 10% higher at 12 GHz. At 6 GHz, the absorption coefficient of the sample, which had a measured dc conductance of 0.67 mmhos/cm, was 25% higher than that of a saline solution of 20 times greater dc conductance. Thus, the absorption in the DNA solution does not arise from ionic behavior but is in agreement with absorption by the longitudinal acoustic mode of the double helix.

0663 FALSE CLAIMS FOR MAGNETOTHERAPY (LETTER TO EDITOR). (Eng.) Orpin, J. A. (Bureau Medical Devices, Health Protection Branch, Dept. National Health and Welfare, Ottawa, Ont., Canada). Can Med Assoc J 126(12):1375; 1982 (no refs).

In response to many requests from physicians regarding medical applications of magnetic fields, the author states that there is no scientific evidence of any usefulness of magnetotherapy. The units used for this therapy consist of a coil through which direct current passes and may be pulsed 1 to 50 times per sec. The magnetic field, which can reach a value of 10 mT, approximates that found near a small 100-W transformer. He further states that findings in the literature concerning magnetotherapy often conflict and that no properly controlled trial has been conducted.

0664 CLAIMS FOR MAGNETOTHERAPY (TWO LETTERS TO EDITOR). (Eng.) Bassett, C. A. L. (Orthopaedic Res. Labs., Coll. Physicians and Surgeons, Columbia Univ., New York, NY); Orpin, J. A. Can Med Assoc J 127(11):1079-1080; 1982 (no refs).

Regarding Orpin's letter to the editor in Can Med Assoc J 126:1375, 1982 [see Abstract No. 0663], it is necessary to differentiate between electromagnetic devices for which unfounded claims have been made and those which have been thorougly investigated in controlled laboratory and clinical conditions such as the use of highly specific pulsed electromagnetic fields in fractures that fail to heal, failed arthrodeses and congenital pseudarthroses. Orpin responds that his letter referred to magnetic equipment currently advertised in Canada and not to devices used in research that are not yet available for clinical use. A more precise terminology and a classification system for devices that deliver diagnostic or therapeutic energy based on their levels of acceptance and authenticity are proposed.

0665 *NEUROPHYSIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS.* A CRITICAL REVIEW. (Eng.) Hansson Mild, K. (National Board Occupational Safety and Health, Dept. Occupational Health, Box 6104, S-900 06 Umea, Sweden); Oberg, P. A. Electroenceph-algr Clin Neurophysiol [Suppl] 36:715-729; 1982 (58 refs).

The neurophysiological effects produced by exposure to 0-300 GHz electromagnetic (EM) fields at levels considered to be non-thermal are reviewed. Occupational exposure to near- and far-field radiation is discussed. The effects of constant and alternating magnetic fields at the cellular level of the nervous system have been studied in giant axons of lobsters, frog nerve-muscle preparations, frog retina and sciatic nerves, cat saphenous nerves, rabbit vagus nerves and superior cervical ganglia, and the abdominal ganglia of aplysia californica. At the organ level, calcium fluxes in cat and chick brain tissue exposed to modulated EM fields and heart rate changes in isolated perfused rat hearts exposed to microwave (MW) irradiation have been reported. The results of studies of EM field effects on different mammals are reviewed. Effects observed in humans exposed to EM fields include deep heating in tissue during shortwave and MW diathermy, a faint flickering visual sensation when the head is exposed to electric currents or magnetic fields, and auditory perceptions when the head is exposed to pulse-modulated MW energy above a certain intensity level. The neurasthenic syndrome (headache, irritability, dizziness, loss of appetite, sleeplessness, sweating, difficulties in concentration or memory, depression, emotional instability, dermographism, thyroid gland enlargement, and tremor of extended fingers) has been reported in epidemiological studies of workers exposed to radiofrequency (RF) and MW radiation. There appears to be a general consensus that the majority of biological effects of RF and MW fields can be explained by thermal energy conversion. For frequencies in the kHz range the possibility exists of direct nerve excitation by induced eddy currents at very high magnetic field strengths. Modulated fields appear to have a greater ability for interfering with biological material than do continuous waves. Both amplitude modulated ultra high frequency fields and extremely low frequency fields with frequencies in the range 6-30 Hz have been shown to affect brain tissue and bioelectrical activity. However, the level of knowledge of the mechanisms behind EM field effects on biological systems is still low.

0666 RADIOFREQUENCY AND MICROWAVE RADIATION. (Eng.) Hileman, B. (No affiliation given). Environ Sci Technol 16(8):442A-444A; 1982 (no refs).

The environmental effects of radiofrequency and microwave radiation are reviewed. Results of animal studies are outlined briefly. Standards and guidelines for exposure to microwave radiation vary by 3 orders of magnitude (up to 100, 1000, or 10,000 uW/cm^2). The U.S. has no federal standards adopted by the government through the regulatory process for the protection of workers or the general population from either microwave or radiofrequency radiation.

0667 AN INCREASE IN COLONY-FORMING CAPACITY OF THE BONE MARROW STEM CELLS AFTER MICROWAVE IRRADIATION IN VITRO. (Eng.) Rotkovska, D. (Inst. Biophysics, Czechoslovak Acad. Sciences, 612 65 Brno, Czeckoslovakia): Vacek, A. Folia Biol (Praha) 28(2): 138-141; 1982 (7 refs).

The effect of microwave (MW) radiation on bone marrow cell suspensions in vitro was investigated in mice. Bone marrow cell suspensions in Hanks' solution were irradiated for 5 min (2450 MHz, 65 mW/cm^2, temperature increase of 6 C) and injected iv into x-irradiated isogenic recipients 10, 30, or 45 min after MW exposure. On day 10 after transplantation, a significant increase in the number of colony forming units was observed for the bone marrow cell suspension transplanted within 10 min of MW exposure but no difference was observed for the suspension transplanted 45 min after MW irradiation. In a control experiment, the colony forming capacity of bone marrow heated in a water bath was not affected by a rise in temperature comparable to that reached during MW irradiation. The repopulation activity of bone marrow cells added to MW-irradiated Hank's solution and transplanted after 20 min incubation at room temperature was almost equal to that of MW-irradiated bone marrow suspensions. The results suggest that the effect of MW radiation on the colony forming capacity of the bone marrow may be indirect and may be mediated by alterations in the MW-irradiated solution.

0668 CHANGES IN CARDIAC-CELL MEMBRANE NOISE DURING MICROWAVE EXPOSURE. (Eng.) Seaman, R. L. (Biomedical Res. Div., Georgia Tech Engineering Experiment Station, Atlanta, GA 30332); [illegible]r, R. K.; DeHaan, R. L. 1982 IEEE MTT-S Digest: 436-438; 1982 (11 refs).

The membrane voltage noise of cardiac-cell aggregates was studied during microwave (MW) irradiation as a probe of the molecular mechanism of interaction between electromagnetic (EM) energy and an excitable cell membrane. Aggregates of embryonic white Leghorn chicken heart cells in culture were placed in an open-ended coaxial exposure device connected to a source of continuous wave, 2450 MHz MW energy. Temperature of the medium was maintained at [illegible] ± [illegible]. During irradiation at specific absorption rates 122 to 237 mW/g, the local temperature of the aggregates increased by no more than 0.8 C. Membrane voltage noise was recorded from 5 different aggregates in a total of 8 exposures. Average pre-exposure value of power for the 8 exposures was -8[illegible] ± 3.12 dB; during the beginning of exposure, it was -82.36 ± 4.25 dB. Average powers for the first [illegible] exposures were -83.39 ± 3.87 dB and -81.44 ± [illegible] dB for pre-exposure and beginning epochs, respectively. The average increase in power during the beginning of exposure was 0.99 ± 3.93 dB over [illegible] 8 exposures and 1.94 ± 3.81 dB for the first 5 exposures. Because of the large variability, this result is inconclusive and further experiments are in progress.

0669 A SELF-BALANCING MICROWAVE RADIOMETER [illegible] NON-INVASIVELY MEASURING THE TEMPERAT[illegible] *OF SUBCUTANEOUS TISSUES DURING LOCALIZED HYPERTHER*MIA TREATMENTS OF CANCER. (Eng.) Sterzer, F. ([illegible] Labs., Princeton, NJ 08540); Paglione, R.; [illegible] F.; Mendecki, J.; Friedenthal, E.; Botstein, [illegible] IEEE MTT-S Digest:438-440; 1982 (6 refs).

The use of a self-balancing radiometer operating [illegible] 2350 to 2550 MHz to non-invasively measure subcutaneous tissue temperature during localized radiofrequency (RF, 27 MHz) and microwave (MW: 2450 MHz) hyperthermia treatments for cancer is described. When 2450 MHz contact applicators are used for treat[illegible] cutaneous and subcutaneous tumors, the applicator serves as the antenna of the radiometer and receives the thermal radiation from the heated tissues. [illegible] 27 MHz applicators are used to heat deep-seated tumors, tissue temperatures are measured by removing the applicator after heating and then measuring the thermal noise power emitted by the heated tissues [illegible] a ceramic filled waveguide applicator usually serves as the antenna of the radiometer. Current limitations of radiometers of this type are that only average rather than point temperatures are measured by this method, and the depths at which tissue temperatures are measured are relatively shallow.

0670 THERMAL DRIFT IN MICROWAVE THERMOGRAPH[illegible] (Eng.) Shaeffer, J. (Dept. Radi[illegible]

Oncology and Biophysics, *Eastern Virginia Medical* Sch., Norfolk, VA 23507); El-Mahdi, A. M.; Bielawa, R.; Regan, J. F.; Carr, K. L. 1982 IEEE MTT-S Digest:441-443; 1982 (3 refs).

During microwave (MW) thermography for the measurement of subcutaneous tissue temperature, prolonged contact between the MW antenna at one temperature and a subject at a different temperature results in thermal drift, the apparent change in the subject's temperature. Thermal drift may be positive or negative depending on the nature of the thermal mismatch between antenna and subject. It can be eliminated or minimized by appropriate thermal matching of subject and antenna and improvement in antenna design.

0671 DYNAMIC IN VIVO PERFORMANCE OF TEMPERATURE CONTROLLED LOCAL MICROWAVE HYPERTHERMIA AT 2.45 GHz. (Eng.) Knochel, R. (Philips Res. Lab., Vogt-Kolln-Strasse 30, D-2000 hamburg, W. Germany); Meyer, W.; Zywietz, F. 1982 IEEE MTT-S Digest:444-447; 1982 (4 refs).

A temperature-controlled 2.45 GHz microwave (MW) system for local heating of small animal tumors is described which consists of a Philips MW 127 generator (25 or 200 W maximum output power) operating in a pulsed power mode, micro-thermocouple temperature monitoring equipment and three different applicators: commercially available non-contact spiral antenna, ceramic-filled waveguide and cross-fire arrangement of two ceramic-filled antennas in cophase. It was capable of inducing an intratumor temperature of 43 C within 3 min and maintaining it within ± 0.1 C during 15-min treatment sessions. Comparison of the control-loop response in phantom tissue and in solid tumors (rhabdomyosarcoma R1H) in anesthetized rats showed significantly different heat distributions during both transient and stationary phases of heat control. Interference between thermocouples and electromagnetic fields was reduced by orthogonal positioning of the thermocouples and by at least a 1 sec interval between turning off MW power and temperature sampling. The ceramic-filled waveguide antennas exhibited better coupling between the tumor and the antenna than the spiral antenna. Although *positioning* of the rat was not as easy as with a single applicator, the crossfire arrangement of applicators was the most efficient: less power per applicator was applied and faster heating to the final temperature was obtained.

0672 BIOLOGICAL EFFECTS AND MEDICAL APPLICATIONS OF RF ELECTROMAGNETIC FIELDS. (Eng.) Gandhi, O. P. (Dept. Electrical Engineering, *Univ. Utah, Salt Lake City, UT* 84112). IEEE Trans Microwave Theor Tech 30(11):1831-1847; 1982 (113 refs).

Current knowledge about the biological [illegible] al effects of exposure to radiofrequency [illegible] tromagnetic fields is summarized. Ocular, [illegible] and behavioral effects, enhanced efflux [illegible] ions from chick and cat cortex tissues, [illegible] gistic effects between microwave radiation [illegible] choactive drugs have been reported. A [illegible] with exposures lasting up to 16 wk have [illegible] ducted. Results of the first 15 mo of a [illegible] simulating human exposure to the Air Force [illegible] system are discussed. Factors affecting [illegible] absorption of electromagnetic radiation are summarized. A lower, frequency-dependent safety standard has been recommended by the ANSI C95 committee. [illegible] allowed power densities are calculated to [illegible] whole-body averaged specific absorption rate [illegible] than or equal to 0.42 W/kg over the frequency [illegible] 3-100,000 MHz. Medical applications of [illegible] netic fields include hyperthermia as an [illegible] cancer therapy, biomedical imaging, and [illegible] wave heating of the animal head as a [illegible] sacrificing animals and inactivating brain [illegible] Areas that need further investigation are [illegible]

0673 UN-UNITED FRACTURES. PART I. [illegible] ELECTROMAGNETIC FIELDS: A NON[illegible] WAY TO PRODUCE BONY UNION. (Eng.) [illegible] L. (Dept. Orthopaedic Surgery, Columbia [illegible] Physicians & Surgeons, 630 W. 168 St., New [illegible] 10032). Instr Course Lect 31:88-94; 198[illegible]

The first article of a three-part series [illegible] ed fractures describes the use of pulsed [illegible] magnetic fields (PEMFs) to stimulate the healing [illegible] un-united fractures. A study of 1078 [illegible] patients with un-united fractures or failed [illegible] deses treated with PEMFs revealed a success [illegible] 77% for the first attempt to produce union [illegible] method [see Abstract No. 0068]. A success [illegible] 92% was seen in a series of 53 un-united [illegible] of the tibial diaphysis treated at [illegible] terian Center in 1979. Contraindications [illegible] method and procedures that are important [illegible] the success are outlined. PEMFs and bone [illegible] pear to work synergistically to assure [illegible] PEMFs are used in clinical evaluations [illegible] vascular necrosis, looosened prostheses, [illegible] osteoporosis, and Paget's disease, and, [illegible] oratory, they have proved effective in [illegible] repair of peripeheral nerve lesions.

0674 UN-UNITED FRACTURES. PART II. CONSTANT DIRECT CURRENT IN THE [illegible] OF NONUNION. (Eng.) Brighton, C. T. [illegible] paedic Surgery, Sch. Medicine, Univ. Penn[illegible] Philadelphia, PA 19104). Instr Course [illegible] 103; 1982 (36 refs).

[illegible] second part of a three-part series on un-united fractures describes the use of a semiinvasive percutaneous constant direct current method to treat bony nonunions. In clinical studies, 316 patients with [illegible] well-established nonunions secondary to trauma were treated with constant direct current delivered [illegible] a power pack consisting of field-effect transistors and resistors in circuit with a 7.5 V battery [illegible] constant current was delivered regardless of changing resistance. During the course of the study, the current was increased from 10 to 20 [illegible], the number of cathodes from one to four, and the duration of the electrical treatment from 9 to 12 wks. Stainless steel cathodes were inserted in the operating room. In most cases, the patients were discharged from the hospital 1 day post-operatively. Of the 324 nonunions treated with constant direct current 238 (73.4%) healed. Inadequate electricity accounted for 11/86 failures, synovial pseudarthrosis for 10, and the presence of a large gap (greater than half the diameter of the bone at the level of the nonunion) for 8. Thus of 295 nonunions treated properly, bony union was achieved by 80.7%. The most common nonunion in the series, the tibia [illegible] achieved an 86% heal rate; the worst results were seen in the humerus (24/29[illegible]) with a heal rate of [illegible]. The advantages of this method include: [illegible] of the apparatus; a low risk benefit ratio; presence of a metallic fixation device at the nonunion site does not compromise the use of direct current; even when the procedure fails to achieve solid bony union, usually some bone is formed in the vicinity of the cathode.

[illegible] UN-UNITED FRACTURES. PART III. CLINICAL USE OF THE OSTEOSTIM, AN IMPLANTED BONE GROWTH STIMULATOR, FOR IMPAIRED BONE HEALING. (Eng.) Paterson, D. (Dept. Orthopaedic Surgery, Adelaide Childrens' Hosp., 72 King William Rd., N. Adelaide [illegible], South Australia). Instr Course Lect 31:103-11[illegible], 1982 (27 refs).

The final part of a three-part series on un-united fractures describes the use of the Osteostim, a surgically implanted bone growth stimulator, which has been used to achieve union of long bones in > 250 cases in Australia with an overall success rate of [illegible]%. The unit consists of a hermetically sealed titanium casing incorporating the power source, the anode [illegible] the platinized hemispherical end of the [illegible] and a silicone-insulated stainless steel lead [illegible] to the titanium cathode. The surgical [illegible] for implantation of the unit [illegible] the [illegible] and the detachable cathode are removed [illegible] of approximately 6 mo [illegible] surgical [illegible]. The efficacy of this method of electrical stimulation is illustrated in [illegible] reports. The [illegible] time for union is [illegible] wks. [illegible] has been successfully used in all [illegible] of both upper and lower limbs and has stimulated [illegible] cases where other techniques have failed. [illegible] treatment has been used [illegible]

cases of [illegible] in [illegible] be attributed [illegible] technique, [illegible] existing [illegible]

[illegible] NEAR [illegible] (Dept. [illegible] Preventative Med[illegible] C-245, Univ. Medical Center, [illegible] Denver, CO 8[illegible] (4): 345-3[illegible], 198[illegible]

The association between [illegible] adults and [illegible] wiring was [illegible] comprised [illegible] who had died [illegible] life-threatening [illegible] without known [illegible] age, age [illegible] economic [illegible] could be [illegible] yr prior to cancer diagnosis [illegible] study; the addresses [illegible] of the [illegible] dress [illegible] configurations around the addresses [illegible] according to the number of current [illegible] near the house, [illegible] the wires [illegible] house. The results [illegible] incidence of cancer in adults [illegible] addresses with high current [illegible] suggest a possible dose-relationship [illegible] the proportion of homes with [illegible] the majority of the cases studied, there [illegible] nificant difference between males [illegible] degree of association [illegible] under [illegible] yr of age exhibited [illegible] sociation between HCCs and [illegible] The [illegible] subjects with [illegible] [illegible] level [illegible] members of [illegible] [illegible] the [illegible] sistent with [illegible] fields [illegible] promote [illegible]

[illegible] METABOLIC AND [illegible] RESPONSES [illegible] MONKEY [illegible] TO MICROWAVES. [illegible] Naval Aerospace Medical Res. [illegible] Naval Air [illegible] R. P. [illegible] refs).

[illegible] microwave [illegible] was similar in [illegible] to that observed [illegible] mammalian species, rectal temperature [illegible] levels of cortisol, thyroxine (T_4), [illegible] (GH) were measured in 6 rhesus [illegible] to pulsed MW power (1.29 GHz; pulse [illegible] pulse repetition rate, 337/sec) pro[illegible] type AN/TPS-1G radar. Whole-[illegible] of the chair-restrained monkeys [illegible] far-field conditions. Intensities of [illegible], 28, and 38 mW/cm² with corresponding specific absorption [illegible] W/kg. Blood samples [illegible] indwelling jugular venous [illegible] period before, during, and [illegible] exposure. Rectal temperature [illegible] average of [illegible], and 1.7 C [illegible] for the three intensities used. [illegible] GH were observed. Only the 38 [illegible] resulted in marked increases in [illegible]. The results indicate that whole-[illegible] rhesus monkeys to 1.29 GHz pulsed [illegible] increase in circulating cortisol [illegible] a threshold intensity of exposure [illegible] 38 mW/cm². It was concluded [illegible] temperature and adrenocortical responses to MW [illegible] the rhesus monkey are comparable to [illegible] responses in other animal models.

[illegible] REPAIR WITH SE[illegible] ELECTROMAGNETIC FIELDS. [illegible] C. A. L. [illegible] Res. Labs., [illegible] Physicians and Surgeons, 630 W. [illegible], New York, NY [illegible]; Valdes, M. G.; [illegible] Bone Joint Surg [Am] 64(6): 888-[illegible]

[illegible] electromagnetic [illegible] biomechanical and histological [illegible] of the radius [illegible] Dawley rats. [illegible] osteotomies were [illegible] in additional re-[illegible] of round, [illegible] exposed to [illegible] for 2 wk. [illegible] battery, [illegible] width, [illegible] repetition rate was [illegible], or 15 Hz. [illegible] treated with PEMF were killed on Day 14; [illegible] 8 wk. [illegible] mechanical testing was [illegible] Histolo-gical tests included examination of general morpho logical features and measurement of fibrocartila and fibrous-tissue width at the level of the osti tomy and diameter of the callus. Animals expos [illegible] 5 msec, 5 Hz pulse produced a [illegible] value that was 2.45-fold greater than the contr value and a 30-sec value that was [illegible] greate [illegible] load decay was 15% less. Histological da were compatible with the load data. The resul suggest that total energy is not a major factor pulse effectiveness and that specific waveform cha acteristics may be required to trigger selecti biological responses.

0679 STUDIES OF LONG-TERM EXPOSURE OF THE PO CINE BRAIN TO RADIATION FROM TWO-WAY POR ABLE RADIOS (MEETING PAPER). (Eng.) Sutton, H. (Div. Neurosurgery, Univ. South Florida Col Medicine, Tampa, FL 33612); Balzano, Q.; Garay, O Carroll, F. B. J Microwave Power 17(4):280-28 1982 (2 refs).

To assess the effect of prolonged exposure to i termittent microwave (MW) energy on the brain, 200-lb pigs were fitted with a leather harness hol ing a standard two-way portable radio (Motorol Model MX350, 452 MHz, 6.4 W) so that the antenna r mained at a distance of 1.5 cm from the frontal mi line of the scalp. After a 1-mo training period habituate the pigs to the headgear, 8/15 pigs we irradiated for 8 hr/day for 90 days. To simula intensive use of a radio by a human operator, MW e posure was composed of repeated 10-min cycles (1 m continuous-wave radiation, 9 min pause). After days, all animals were sacrificed. Each animal w injected with Evans Blue 1 hr prior to sacrific No areas of blood brain barrier disruption were e countered and there was no evidence of brain edem In addition to routine processing of brain tiss for hematoxylin and eosin stains, neurohistologic special stains were prepared and several enzyme hi tochemical incubations were carried out. There w no evidence of injury to brain tissue in either t 8 irradiated pigs or the 7 non-irradiated pigs. T results indicate that repeated daily exposure to 4 MHz MW energy does not produce detectable brain i jury in pigs and that it is unlikely that simil usage of two-way portable radios in humans will pr duce any brain injury or blood-brain barrier disru tion.

0680 SYNERGISTIC EFFECTS OF MICROWAVES A PENTOBARBITAL IN LABORATORY RATS (MEE ING PAPER). (Eng.) De Witt, J. R. (Dept. Ele trical Engineering, Univ. Utah, Salt Lake City, 84112); D'Andrea, J. A. J Microwave Power 17(4 [illegible] 283; 1982 (5 refs).

The effects of combined doses of pulsed microwave (MW) radiation and sodium pentobarbital on the acquisition of shuttle-box avoidance responses were studied in 24 male Long-Evans rats. Six groups of rats were given different combinations of sodium pentobarbital (0, 10, or 15 mg/kg, ip) followed by MW radiation (0 or 1 mW/cm^2, 3-GHz carrier wave, 500 pulses/sec, 2-usec pulse width, for 30 min). After actual or sham radiation, rats were removed to a shuttle box and given 10 min to explore and adapt before training was begun. The conditioning stimulus (CS) was a combination of sound from a speaker [illegible] and illumination from the 24-V lamp in the chamber that the rat happened to occupy at the onset of the CS. During the training trials, the CS preceded the unconditioned stimulus (US: 0.73 mA scrambled shock of constant current delivered to the grid floor of the shuttle-box) by 10 sec and stayed on until the rat made an avoidance, escaped from the shock, or 120 sec of footshock had been given. A training session consisted of 50 trials with an average 30-sec intertrial interval. The effect of drug dose and the interaction between drug dose and radiation treatment were statistically significant. Increases in drug dose were associated with increased latencies to escape or avoid for both irradiated and nonradiated rats. There was no difference between radiated and nonradiated rats receiving [illegible]. However, radiated rats given either 10 or 15 mg/kg were slower than nonradiated rats given the same dose suggesting that there was a *synergism* between pulsed MW radiation and drug doses of 10 and 15 mg/kg pentobarbital.

[illegible] RF HYPERTHERMIA APPLICATOR WITH MOVING ELECTRODES (MEETING PAPER). (Eng.) Cur[illegible], T. [illegible] (Dept. Electrical Engineering, Univ. Alberta, Edmonton, *Alberta, Canada T6G 2G7*); Voss, [illegible] J Microwave Power 17(4):284-285; 1982 (2 refs).

[illegible] agar phantoms and capacitive electrodes [illegible] through an 80 degree arc were submerged [illegible] heated in a saline water bath to 22.1 C. Small [illegible]-plated *electrodes provided* 200 W at a frequency [illegible] MHz for 10 min. Temperature gradients [illegible] the agar cylinder are illustrated. Extrapolation of the data suggests that this technique [illegible] achieve a tumor temperature of 45- [illegible] maintaining all other body temperatures [illegible].

[illegible] SIMPLE PRECISE METHOD TO MEASURE PD AND [illegible] FOR BIOLOGICAL SAMPLES (MEETING PA[illegible] Shen, Z.-Y. (Microwave Res. Inst., [illegible] Inst. New York, 333 Jay St., Brooklyn, [illegible] J Microwave Power 17(4):287-289; [illegible].

The transmitted power method [illegible] power density (PD) on the surface of [illegible] ples is presented. The method [illegible] liquid sample in a quartz [illegible] power behind a sample, which [illegible] disturbing the field at the [illegible] proportional to the PD at the [illegible] To determine the proportion[illegible] [illegible] is placed in a [illegible] cross section as the sample [illegible] the sample is used to measure [illegible] The PD is determined by measuri[illegible] er with the same small [illegible] keeping the surface of the sam[illegible] the incident wave. In a [illegible] cident power and reflected power [illegible] the input waveguide [illegible] for calculating the specific [illegible] gives the value of the SAR [illegible] electrical conductivity, dielectr[illegible] loss tangent of the sample.

0683 EFFECT OF LOW LEVEL [illegible] ON THE DUODENAL [illegible] UNANESTHETIZED RAT. (Eng.) [illegible] tologie-Pharmacologie, Bat. [illegible] bert Einstein, 69621 Villeurbanne [illegible] Microwave Power 17(4):329-334; [illegible]

Chrome-nickel insulated electrodes [illegible] in the duodenal wall of 7 male wistar [illegible] the effects of 2.45 GHz microwave (MW) [illegible] smooth muscle. Rats [illegible] were irradiated in a multimode cavity [illegible] mW/cm^2 or 1-4 hr. Specific absorption rates measured by readings of forward and re[illegible] at 5, 7.5, and 10 mW/cm^2 were 5.[illegible] mW/g, respectively. During irradiation [illegible] slow-wave frequencies accelerate[illegible] MW exposure began (by 9% at 5 mW [illegible] cases and by 19% at 7.5 mW/cm^2 in 9[illegible] and disappeared 10-15 min after termi[illegible] posure. Duodenal action potentials were [illegible] by radiation; the effect was more marked [illegible] at 5 mW/cm^2. The results show that [illegible] trical activity is affected by MW irrad[illegible] accelerating effect on duodenal [illegible] dependent on thermal activity while [illegible] effect on action potentials is [illegible] cific MW effect.

0684 LACK OF MUTAGENIC EFFE[illegible] ASPERGILLUS AMSTEL[illegible] 8.7175-GHz CW MICROWAVES. (Eng.) (Dept. Biology, Coll. Science, [illegible] Habash, R. W. Y.; Al-Hafid, H. T. [illegible] er 17(4):345-351; 1982 (3[illegible] refs).

The mutagenic effects of 8.7175 GHz continuous wave (CW) microwave (MW) radiation were studied in conidia of Aspergillus amstelodami. Conidia were exposed in the near field of a horn antenna for 3 or 6 hr at an estimated incident power density of 2.09 mW/cm^2. Exposures were carried out in the dark at temperatures ranging between 28 and 30 C. During irradiation, the suspension was continuously stirred by a rotating magnetic stirrer (rate of rotation, 14 Hz; a 16.87 x 10^{-3} tesla magnetic field was induced by the stirring device). The frequencies of conidial color variants and of 8-azaguanine resistant mutants in treated and untreated populations were compared. Both treated and untreated conidial populations gave similar frequencies in morphological and in drug-resistant mutants. The response was not affected by exposure duration or by temperature elevation (2.2 C and 2.4 C higher than controls after 3- and 6-hr exposures, respectively). The results demonstrate a lack of genetic response of conidia of A. amstelodami to 8.7175 GHz CW MW radiation.

0685 PSYCHOLOGICAL SYMPTOMS AND INTERMITTENT HYPERTENSION FOLLOWING ACUTE MICROWAVE EXPOSURE. (Eng.) Forman, S. A. (Navy Environmental Health Center, Norfolk, VA 23511); Holmes, C. K.; McManamon, T. V.; Wedding, W. R. J Occup Med 24 (11):932-934 (11 refs).

Psychological symptoms and hypertension following accidental, acute, high-level exposure to X-band microwave (MW) radiation are reported in two healthy men operating a portable high-power MW radar tracking system during military field maneuvers. The exposures occurred in the radiating near field and were from a continuous wave beam from a uniformly illuminated circular aperture antenna. The worst case, a 54 yr old man who was exposed continuously for 80 sec, showed an electric field strength of 475-580 V/m (corresponding to an equivalent plane wave power density of 60-90 mW/cm^2). Immediate effects were severe chest pain, vertigo, and a heating sensation of the chest and head. Rapid onset of recurrent, severe headaches, insomnia, irritability, and emotional lability were also experienced. Peak severity of the subjective complaints occurred 3 mo after the exposure, coincident with a diagnosis of arterial hypertension in the range of 160/105 which was controlled with medication. After 1 yr of follow-up, blood pressure readings were normal but psychological problems of varying severity persisted. A 21-yr-old man sustained intermittent exposure to the MW beam over a period of 5 min (total time of irradiation, approx. 75 sec). Immediate effects included a heating sensation of the head and chest and a headache. Irritability, insomnia, headaches, photophobia, and visual blurring were experienced subsequently. Hypertension of 140/105 was detected 4 mo after the incident; it was controlled with medication. Blood pressure was normal at the 12-mo follow-up; emotional lability and insomnia persisted. No organic basis was discovered for the psychological problems or the hypertension ex[illegible] men; a diagnosis of acute post-traumatic [illegible] order was given in both cases. Tw[illegible] men, aged 30 and 39 yr, were exposed [illegible] power density for 5-10 sec. They re[illegible] vertigo, and a heating sensation, but [illegible] did not persist beyond 3 wk after [illegible]

0686 DEVELOPMENT AND USE OF A NONRESTRAINING WAVEGUIDE CHAMBER FOR RAPID MICROWAVE RADIATION KILLING OF THE MOUSE AND NEONATE RAT. [illegible] Schneider, D. R. (Dept. Pharmacology, [illegible], Wayne State Univ., 540 East Canfield, Detroit, MI 48201); Felt, B. T.; Rappaport, M. [illegible] J Pharmacol Methods 8(4):2[illegible]

A nonrestraining waveguide chamber design[illegible] with focussed 2450 MHz microwave (MW [illegible] kill small rodents rapidly and without stress [illegible] animals is described. The design is based on the observation that a rodent will preferentially enter a darkened hole (e.g., in the broad face of the waveguide chamber device) with a delay time [illegible] sec after being placed on a lighted platform adjacent to the chamber. The MW generator to which the waveguide chamber is attached must have a minimum 3.5 kW output power to properly heat the mass of the small rodent head within the time limit of [illegible] msec required for the accurate measurement of basal concentrations of rapidly modulated neurochemical indices. For maximum coupling of MW energy to the rodent brain, animal placement must be at a distance of 1/4 wavelength from the closed end of the waveguide. To insure accurate positioning of a standing wave of MW radiation at this location, a triple screw tuner waveguide section is inserted into the waveguide system between the magnetron and the chamber. A positioning cup, consisting of a plastic cylindrical tube with a rounded end, is placed through the waveguide to optimally position the animal head within the energy field. Two versions of the waveguide have been extensively tested: a small WR-284 chamber suitable for either the neonate mouse or rat (up to 10 g), and a WR-430 chamber for use with the adult mouse and small rats (to 50 g). The center of the entrance hole is positioned at distances of [illegible] and 3.69 in from the terminal end of the WR-284 and the WR-430 chambers, respectively.

0687 PULSING ELECTROMAGNETIC FIELDS IN THE TREATMENT OF NON-UNION OF FRACTURES. (Eng.) Caullay, J. M. (Orthopaedic and Accident Unit, Royal Infirmary, Glasgow, Scotland); [illegible] S. J R Coll Surg Edinb 27(2):102-[illegible] refs).

Four cases of non-union of the tibia treated [illegible] fully with pulsing electromagnetic fields (PEMF) [illegible]

[illegible] site [illegible] external [illegible] of brain and [illegible] ected [illegible] will [illegible] the start [illegible] the tibia [illegible] was [illegible]

[illegible] IMPLANTED [illegible] PACEMAKER [illegible] St. [illegible] A.; Chen, [illegible] refs).

[illegible] electric [illegible] to 20 [illegible] of modern, [illegible] multi- [illegible] pacemakers [illegible] human [illegible] Spectrax [illegible] cardiogram [illegible] electric field [illegible] repeated [illegible] fibrillated [illegible]

[illegible] EFFECT [illegible]
A. [illegible] EGAP 4EB, England [illegible] refs).

Literature report [illegible] electric field [illegible] occupational [illegible] and [illegible] kV substations [illegible] human health [illegible] of the research [illegible] has produced negative [illegible] major health [illegible] sons undertaken [illegible] and Sweden suggests [illegible] give rise to chronic [illegible] performed in Germany [illegible] 1-20 kV/m fields for period [illegible] negative results. [illegible] significant but [illegible] fields [illegible] that [illegible] function [illegible] was [illegible] logical [illegible] relations have [illegible] However neither [illegible] Effects reported in the [illegible] out on the exposure [illegible] are probably due to [illegible] taken in the U.S., [illegible] pational disease [illegible] from among high voltage [illegible] physiological changes [illegible] consistent with causes such [illegible] ception of the presence of the [illegible] study reporting on congenital [illegible] progeny of exposed male [illegible] malformations [illegible] tion studied regardless [illegible] 120-300 kV, or [illegible] kV substations [illegible] evidence to modify the view [illegible] harmless up to transmission [illegible] are probably harmless [illegible]

[illegible] THE EFFECT [illegible] DURATION [illegible]
[illegible] MEMBRANE COMPONENTS. [illegible] lar Biophysics [illegible] Health Effects [illegible] Park, NC [illegible] refs).

A model of the cell surface is developed to determine the effect of an externally applied electric field on the interaction between negative charges embedded in the cell membrane and positive ions (counter-ions) trapped near the surface. The cell is assumed to be an immovable hemisphere with a continuous distribution of charges on the surface. A homogeneous electric field is applied parallel to the surface on which the hemisphere is affixed. At a time period after the application of an external electric field that is long compared to the relaxation time of the surrounding ions but short compared to the time needed for movement of the charged molecules within the surface, the electric field due to counter-ion polarization can be estimated at any point on the cell surface. The electric field was evaluated at each point on the surface under the assumption that $qaE_0 << kT$ where q is the charge of the ion near the surface, a is the radius of the cell, E_0 is the external electric field, k is Boltzman's constant, and T is the absolute temperature. Plots of the electric field are given as a function of cell surface potentials from 10 to 80 mV, temperatures from 5 to 37 C, and electrolytes. The solution for the electric field due to ion polarization is independent of the cell radius for small applied fields (approx. 1 V/cm); if $qaE_0 < kT$, it will depend on the cell radius and polar spherical coordinate. A more refined model would include distributions of discrete charges on the cell surface instead of a continuous distribution, allowance for redistribution of surface charges with the field, and the effects of bound water. The model presented does predict a force due to counter-ion distribution polarization that could significantly affect the charges that are embedded in the membrane.

0691 LEUKEMIA IN WORKERS EXPOSED TO ELECTRIC AND MAGNETIC FIELDS (LETTER TO EDITOR). (Eng.) Wright, W. E. (Dept. Family and Preventive Medicine, Univ. Southern California Sch. Medicine, Los Angeles, CA 90033); Peters, J. M.; Mack, T. M. Lancet 2(8308):1160-1161; 1982 (11 refs).

Leukemia incidence in Los Angeles County from 1972 to 1979 in white males occupationally exposed to electrical and magnetic fields was studied following reports suggesting an increased risk for leukemia with exposure to electrical and magnetic fields. There were 35 cases of all leukemias among occupationally exposed men; the proportional incidence ratio (PIR=observed/expected x 100) was 128.6. For acute leukemias, the number of cases was 23 and the PIR 172.6. For acute myelogenous leukemias (AML), the number of cases was 22, and the PIR 207.1. The data indicate that there is a trend toward increased PIRs in occupationally exposed males and that the risk is greatest for AML. AML in power linemen and telephone linemen and the cumulative PIRs for all electrical jobs for acute leukemia and AML are significant.

0692 EFFECTS OF LOW-LEVEL MICROWAVE RADIAT ON THE EYE OF THE CRAYFISH [illegible] Munemori, J. (Dept. Electrical Engineering, [illegible] Inst. Technology, Gokiso, Showa-ku, [illegible] Japan); Ikeda, T. Med Biol Eng [illegible] 1982 (4 refs).

The biological effects of low-level microwave [illegible] radiation were investigated in the [illegible] crayfish (procambarus clarkii). Optic [illegible] were inserted into a waveguide and irradiated at a pow- er of 1 mW for 1 min. MW power was provided by HP Model 8620C sweep oscillator operating at 9 GHz (continuous wave). Electrodes were inserted i to the the optic nerve from the side of the wav guide to measure the spontaneous discharge with disturbing the electromagnetic field. The spont neous discharge was recorded for 1 min before irr diation, during 1 min of irradiation, and after t power was turned off. Although the amplitude of t waves and the mean value of the interspike interva were not significantly changed by irradiation, t distribution of the intervals (variance) [illegible] gradually at the beginning of exposure and then [illegible] creased and approached pre-irradiation [illegible] T calculated power density at the crayfish eye irr diated under these conditions was [illegible] the calculated temperature increase in the eye [illegible] 1 min of irradiation was 0.01 C. Thus the [illegible] response, which was obtained at a power level low than Japanese maxiumum permissible exposure level was not due to a thermal effect.

0693 MORTALITY FROM LEUKEMIA IN W[illegible] POSED TO ELECTRICAL AND MAGNETIC FIE (LETTER TO EDITOR). (Eng.) Milham, S. (Washington State Dept. Social and Health Services, [illegible] 98504). N Eng J Med 307(4):249; [illegible]

When proportionate mortality ratios (PMR=observed/ expected x 100) standardized by age and year of dea were calculated for 158 cause-of-death groups in 2 occupational classes in Washington [illegible] through 1979, leukemia mortality [illegible] w found to be greater than expected [illegible] old whose occupations required them to work [illegible] tric or magnetic fields. The PMR for leukemia rang from 67 (welders and flame cutters) [illegible] station operators) in the 11 [illegible] sumed exposure to electric and magnetic [illegible] averaged 137. The PMR was elevated [illegible] tions. For acute leukemia, [illegible] (streetcar and subway motormen) [illegible] and radio repairmen) and averaged [illegible] of expected total and acute [illegible] from 1.7 to 37 and from [illegible] The author states that the available literature occupational exposure to electrical and magnet fields has not mentioned carcinogenesis. Howeve these findings suggest a causal relationship betwe electric and magnetic fields and leukemia.

[illegible] New [illegible] Medical [illegible]

[illegible] literature dealing with ele[illegible] [illegible] in laboratory [illegible] reviewed [illegible] a review of the litera[illegible] electromagnetic radiation [illegible] data accumu[illegible] to provide evidence [illegible] occupational exposure to electric [illegible] fields and the incidence of [illegible]

[illegible] MECHANISMS IN INTERA[illegible] [illegible] AND [illegible] A. [illegible] Neural [illegible]

[illegible] electromagnetic [illegible] fields from [illegible] fields in [illegible]

[illegible]

[illegible] and [illegible] has been [illegible] without [illegible] agent [illegible] multiple [illegible] cal treatment [illegible] human patient [illegible] therapy [illegible] When [illegible] therapy [illegible]

[illegible] Further [illegible] of an [illegible] and [illegible] resulted [illegible] as the [illegible] time of the mice to MW radiation was assessed by measuring the interval between the onset of exposure and the time for EHL to reach a point corresponding to (1-1/e) of the total change (approx. 63% above baseline). The response time decreased as a power function with increasing SAR, from 9 min at 19 W/kg to 3.9 and 3.4 min at 68 and 194 W/kg, respectively. When deep-body temperature was measured in restrained mice during exposure to MW radiation (incident power of 1 to 10 W), a direct correlation between the rate of increase in deep body temperature and SAR was observed: the temperature increased by 0.0004 C/sec for each W/kg elevation in SAR. The results suggest that control of EHL in the mouse is highly sensitive to the rate of heat absorption and support the hypothesis that the mammalian heat-dissipating system is highly affected by the rate of temperature increase (i.e., temperature regulation as opposed to thermoregulation).

0699 EFFECTS OF ELECTROMAGNETIC STIMULI ON BONE AND BONE CELLS IN VITRO: INHIBITION OF RESPONSES TO PARATHYROID HORMONE BY LOW-ENERGY LOW-FREQUENCY FIELDS. (Eng.) Luben, R. A. (Div. Biomedical Sciences and Dept. Biochemistry, Univ. California, Riverside, CA 92521); Cain, C. D.; Chen, M. C.-Y.; Rosen, D. M., Adey, W. R. Proc Natl Acad Sci USA 79:4180-4184; 1982 (35 refs).

The effects of clinically useful pulsed electromagnetic fields (PEMF) on cultures of the osteoblast-like mouse cell line MMB-1 were studied and the responses of the cells to hormones that either do or do not appear to act primarily via plasma membrane receptors were examined. PEMFs were produced by the paired square Helmholtz coils of the Bi-Osteogen clinical field generator. In one configuration, a continuous train of single pulses was produced at a frequency of 72 Hz. The second system consisted of bursts of 4-kHz pulses lasting 5 msec and repeated at a 15 Hz rate. Both fields generated an electrical gradient of 1.0 mV/cm. Exposure to both PEMFs inhibited accumulation of cAMP stimulated by parathyroid hormone (PTH) or osteoclast-activating factor (OAF) by decreasing the hormonal effects on adenylate cyclase in the cell membrane. Inhibition of PHT and OAF responsiveness persisted after the cells were removed from the fields. The catalytic activity of adenylate cyclase, as determined by fluoride activation, was not changed by exposing cell cultures to either PEMF. The inhibition of cAMP levels was attributed to field effects on cell surface receptors for the hormones. Neither field altered the effects on collagen synthesis of 1,25-dihydroxyvitamin D_3, a hormone with a cytoplasmic receptor. Another cell surface effect was the blocking of PTH inhibition of collagen synthesis by the fields. No significant difference was seen in the effects of the two PEMFS. These experiments substantiated the hypothesis that field effects are mediated through the osteoblast cell membrane by interferences with hormone-receptor binding or receptor coupling with adenylate cyclase.

0700 LOCAL HYPERTHERMIA FOR TREATMENT
CINOMA OF THE PROSTATE: A PRELIMINA
REPORT. (Eng.) Yerushalmi, A. (Radiation Uni
Weizmann Inst. Science, Rehovot 76100, Israel); S
vadio, C.; Leib, Z.; Fishelovitz, Y.; Rokowsky,
Stein, J. A. Prostate 3:623-630; 1982 (28 refs

After extensive animal experiments, 15 patients wi
prostatic carcinoma received a total of 146 trea
ments of local deep microwave hyperthermia (LDMW
2.45 GHz) either alone or in combination with radi
therapy (6,200 rads) or hormonal therapy (DES, 3 m
day). LDMWH was delivered from a probe inserted i
to the rectal cavity. Tumors were heated to 42-4
while non-invaded tissues were maintained at a te
perature below 32 C. A total of 6 to 9 60-min LDM
treatments were given at 2-3 day intervals. Trea
ments were well tolerated by all of the patients a
subjective and objective improvements were record
in all cases.

0701 INTERACTION OF MICROWAVE RADIATION WI
TURKEY SPERM. (Eng.) Hall, C. A. (La
Environmental Biophysics, Natl. Inst. Environment
Health Sciences, Research Triangle Park, NC 2770
Galvin, M. J.; Thaxton, J. P.; McRee, D. I. Bart
Environ Biophys 20(2):145-152; 1982 (17 refs).

Mature turkey sperm were exposed in vitro to 2
GHz continuous wave microwave (MW) radiation in
temperature controlled waveguide apparatus. Tem
perature was maintained at 40.0 ± 0.5
suspensions were exposed for 30 min at an avera
specific absorption rate (SAR) of either 1, 10,
50 mW/g. Samples were stirred during exposure
magnetic stirrers mounted below the waveguide
eliminate variation in intrasample temperature
The following parameters were examined before a
after MW exposure: percentage viability, percenta
abnormal sperm, and release of the enzymes lacta
dehydrogenase (LDH) and glutamic oxalic transam
nase (GOT). Removal of the seminal plasma had no e
fect on spermatocyte viability; thus, the resul
are from washed spermatocytes only. The time
perform the experiments and the stirring of t
samples produced no observed changes in viabili
of the sperm or enzyme release. Viability was 9
or above for all exposed and control groups and w
not significantly affected by in vitro exposures
SARs of 1, 10, or 50 mW/g. There were no signif
cant differences between treatment groups in t
percentage of abnormal sperm. Release of the cyt
plasmic enzymes LDH and GOT was not significant
altered by MW radiation.

[illegible] OXYGENATION OF MALIGNANT TUMORS AFTER LOCALIZED MICROWAVE HYPERTHERMIA. (Eng.) [illegible], F.W. (Physiologisches Inst. Univ. Mainz, [illegible]strasse 21, D-6500 Mainz, W. Germany); Otte, [illegible], R. Radiat Environ Biophys 2[illegible](4):289-3[illegible]; [illegible] refs).

[illegible] in the oxygenation of tumor tissue during localized microwave (MW) hyperthermia treatment of [illegible]-carcinosarcoma tumors in rats were studied. Tumors were grown on the hind feet of 27[illegible]-[illegible]0 g inbred Sprague-Dawley rats of both sexes until tumor volumes reached 1.5-5.0 ml (10-17 days after implantation). Observations were performed on a total of 4[illegible] tumor-bearing rats anesthetized by ip injection of sodium pentobarbital. Tumors were heated to 40, 43, and 45 C for 30 min by application of 2450 MHz MW radiation produced by a Radarmed type 12 S 20 generator. Tumor temperatures were monitored with miniaturized thermocouples and the power of the generator was adjusted as required to maintain tumor temperatures constant to within 0.1 C. Core temperatures, mean arterial blood pressure, and blood gases of the left carotid artery were also monitored. After heating, tumor tissue biopsies were taken to measure the oxygenation state which was determined by the oxyhemoglobin (HbO_2) saturation of single red blood cells within tumor microvessels with diameters up to 12 um using a cryophotometric method. HbO_2 saturation varied from 0 to 100 saturation percent with a mean value of 51 sat.% in 1[illegible] control tumors. After 40 C-hyperthermia, mean saturation increased to 56 sat.% (11 tumors). However, mean tumor oxygenation decreased to 47 and 24 sat.% after 43 and 45 C hyperthermia, respectively. No changes in core temperature, blood pressure, or blood gases were recorded. Lower HbO_2 saturation values at 45 C were attributed to decreased nutritive blood flow. Metabolic needs of the tumor tissue such as oxygen consumption seem to have a minor effect on the intercapillary HbO_2 saturation distribution.

0703 SCIENTIFIC AND HYGIENIC ISSUES IN BIOLOGICAL RESEARCH ON MICROWAVES: TOWARD RAPPROCHEMENT BETWEEN EAST AND WEST. (Eng.) Justesen, D. R. (Dept. Psychiatry, Univ. Kansas Sch. Medicine, Kansas City, Kansas 66103). Radio Science 17(5S):1S-12S; 1982 (74 refs).

Many issues and controversies separate the experimental radiobiologist and the hygienist from the goal of attaining a concordant view of biological effects of exposure to microwaves and other radiofrequency electromagnetic (RFEM) fields. Although the strongest notes of discord are struck by East-West differences (e.g., recommended limits with respect to exposure of human populations to RFEM fields are generally orders of magnitude more stringent in the USSR than in the U.S.), there are discordant notes as well within national boundaries. Selected problems are addressed in terms of semantic, tactical, logistic, and strateg[illegible] of which in some measure have import [illegible] community of radio scientists. Semant[illegible] include the false agreement or disagree[illegible] from failure to achieve common def[illegible] The tactical issues are those of [illegible] ment: field strength, densitometry, and [illegible] The pitfalls of interdisciplinary resea[illegible] the logistical burden and problems of [illegible] two or more disciplines. Strategic [illegible] deserving of study on a global level are [illegible]

0704 COHERENT OSCILLATIONS IN BIOLOGICAL [illegible]TEMS: INTERACTION WITH EXTREMEL[illegible] FREQUENCY FIELDS. (Eng.) Kaiser, F. (Inst. [illegible]retical Physics, Univ. Stuttgart, Pfaffenwald[illegible] 57, D-7000 Stuttgart 80, W. Germany). Radio [illegible] 17(5S):17S-22S; 1982 (27 refs).

Frohlich's concept of coherently excited [illegible] length electric vibrations in the 10^{11} [illegible] region associated with metastable states with a high dipole moment in biological membranes has [illegible] the basis for explaining the extraordinary high sensitivity of certain biological systems to extre[illegible] weak electromagnetic signals. In this model, [illegible] range collective interactions within the memb[illegible] may lead to oscillatory biochemical reactions. [illegible] resulting slow chemical oscillation is connected [illegible] a corresponding electric vibration by means of large dipole moments of reaction-activated enzy[illegible] Thus a macroscopic oscillating polarization is b[illegible] up, causing large regions to oscillate coherentl[illegible] the 10 to 100-Hz region (e.g., EEG activity). [illegible] remaining (unscreened) polarization causes the [illegible]tem to exhibit a ferroelectric instability. [illegible] nonlinear kinetic equations describing the s[illegible] are discussed. Extremely low frequency fields [illegible]teract with the limit cycle oscillation, whi[illegible] caused to collapse for certain frequencies an[illegible]tensities of the stimulation. This leads to the [illegible]set of propagating pulses even for an extremel[illegible] stimulation. There is increasing experimental [illegible]port for the rather speculative model and for [illegible] existence of biological effects when systems are [illegible]posed to electromagnetic waves. Furthermore, [illegible]respondence between this model and nerve [illegible] generating models has been established.

0705 QUANTUM SOLID STATE MECHANISMS [illegible]ICAL EFFECTS OF ELECTROMAGNETIC RADIA[illegible] WITH EMPHASIS ON LOCAL SUPERCONDUCTIVITY. [illegible] Achimowicz, J. (*Military Inst. Aviation Me*[illegible] Warsaw, Poland). Radio Science 17(5S):[illegible] (36 refs).

Quantum solid state mechanisms of nontherm[illegible] fects of nonionizing electromagnetic radia[illegible] reviewed, and an hypothesis concerning mechanisms based on biological superconductivity is presented. Classical and quantum mechanisms of bioeffects are compared, stressing the necessity of not only considering quantum absorption, transfer, and conversion of radiant energy in biological systems, but also of appropriate systems modeling. There is a need for developing quantum models of the biological solid state on the supramolecular level to fill the gap between molecular and cell biology. The supramolecular models of macromolecules and enzyme complexes are reviewed. The high-temperature superconductivity problem in organic systems is discussed, with stress on the importance of system structure and the excitation quasi-particle (phonon and electron) spectra relationship. New mechanisms of enzymatic activity assuming enzyme-substrate complex electron spectrum instability induced by electron-and phonon mediated electron-electron interaction are proposed. Since this quantum cooperative phenomenon is the possible origin of specificity and etticiency of enzyme action, it is extremely sensitive to system-generated electromagnetic fields, which gives the possibility of enzymatic regulation and also may explain some nonthermal resonant bioeffects. In systems containing superconducting regions, the processes of electron transport depend strongly on magnetic and electromagnetic fields which can be the origin of biological effects of nonionizing radiation. Local superconductivity coherent electron states) and the Josephson effects are discussed as the possible mechanisms of bioeffect, such as the observed sensitivity of small animals to very weak magnetic fields.

0706 MEASUREMENTS OF ELECTRIC AND MAGNETIC STRAY FIELDS PRODUCED BY VARIOUS ELECTRODES OF 27-MHz DIATHERMY EQUIPMENT. (Eng.) Kalliomaki, P. L. (Inst. Occupational Health, SF-00290 Helsinki 29, Finland); Hietanen, M.; Kalliomaki, K.; Koistinen, O.; Valtonen, E. Radio Science 17(5S):29S-34S; 1982 (5 refs).

To investigate the exposure of the physiotherapist and to unprescribed tissues, electric and magnetic stray fields were measured around 3 types of commercially available diathermy units (3 Siemens Ultratherm 608 units, 3 Curapulse Curamed 418 units, and 1 Diapulse D 401 unit) with 4 typical electrodes in 6 routine therapeutic treatments. The subjects were 2 men and 2 women. Field strengths were determined at the point of treatment and at 14 locations close to the patient's body, and as a function of distance from the electrodes. The radiation dose setting was at position 1 for continuous wave power and at positions 5-7 for pulsed power. At a distance of 0.6 m from the diathermy units, the power density was less than 10 W/m^2. The results showed that the diathermy devices are very similar with respect to stray fields, but there are great differences between the electrodes during specific treatments. When the unit was well tuned, the relative output power of the equipment [illegible] tional to the dose scale readings. [illegible] cles were found to be only 7 [illegible] the respective instruction manual [illegible] The measured values of electric [illegible] strengths are tabulated. The [illegible] to select proper electrodes for each [illegible] treatments, as they indicate which [illegible] have minimum stray fields.

0707 ELF MAGNETIC FIELDS IN ELECTROSTEEL A WELDING INDUSTRIES. (Eng.) Lovsund, (Dept. Biomedical Engineering, Linkoping Univ., 581 85 Linkoping, Sweden); Oberg, P. A.; Nilsson, E. G. Radio Science 17(5S):35S-[illegible]; 198[illegible] [illegible]

In order to obtain a realistic basis [illegible] studies of the bioeffects of low-frequency magnet fields present in industrial environments, magnet fields were mapped for a number of welding and ste processes. All of the measurements were perform at points selected to obtain the closest possib impressions of the fields to which the workers a exposed. Measurements were carried out with the a of a F W Bell 610Z gaussmeter operating within [illegible] kHz and the dynamic region 0.1 mT-[illegible] 10^4 G. The industrial measurements comprised on the magnetic component of the field as the process studied require high currents even though low vol age is used. Field flux densities in the range [illegible] 10 mT at mostly 50 Hz were found in both the ele tric welding and electric steel industries. [illegible] the magnetic flux density and the frequency may very high (up to 10 kHz) near induction heater and a study which will include electric field mea urements is planned. In order to improve knowled on how low-frequency magnetic fields affect man industrial environments, it is important to simula the flux density data measured in industry in t laboratory. As understanding of how the magnet field influences biological structures at the cell lar level increaes, it will be possible to predi effects at higher levels and to establish more r liable threshold values.

0708 POPULATION EXPOSURE TO VHF AND UHF BROA CAST RADIATION IN THE UNITED STATE (Eng.) Tell, R. A. (Office of Radiation Program Electromagnetic Radiation Analysis Branch, EPA, [illegible] Vegas, NV 89114); Mantiply, E. D. Radio Science [illegible] (5S):39S-47S; 1982 (13 refs).

Nearly 11,000 individual broadcast signal field [illegible] tensities were determined at 374 measurement sit distributed throughout 12 large cities (Boston, A lanta, Miami, New York, Philadelphia, Chicago, [illegible] Vegas, Washington, San Diego, Portland, Houston, [illegible] Los Angeles) to estimate population exposure [illegible] radiofrequency (RF) and microwave radiation. The cumulative population of the 12 cities represents 18% of the total U.S. population. It included 38,548 census enumeration districts (CED) with an mean population per CED of 993 persons. The 373 sites comprised 193 FM radio stations, 26 low VHF and 31 high VHF TV stations, and 31 UHF stations. VHF and UHF broadcast service is the main source of ambient RF exposure in the U.S. A computer algorithm using the measurement data to estimate the broadcast exposure at the CEDs within the metropolitan boundaries of the 12 cities was developed. The results provide information on the fraction of the population that is potentially exposed to various intensities of RF radiation. A median exposure level of 0.005 uW/cm^2 time-averaged power density was determined for the population of the 12 cities. Approximately 1% of the population studied, or about 380,000 persons, is potentially exposed to levels greater than 1 uW/cm^2, the suggested safety guide for the population of the USSR. Alternative techniques of using the measurement data to estimate population exposure are examined and future extensions of this work are discussed.

0709 MEASUREMENT OF INDUCED ELECTRIC FIELDS IN A PHANTOM MODEL OF MAN. (Eng.) Chen, K.-M. (Dept. Electrical Engineering & Systems Science, Michigan State Univ., East Lansing, MI 48824); Rukspollmuang, S.; Nyquist, D. P. Radio Science 17(5S): 49S-59S; 1982 (8 refs).

An inexpensive and rugged implantable electric field probe with an interference-free lead wire system was constructed to measure the induced electric fields in a phantom model model of man irradiated by waves of various frequencies. The probe consisted of a short dipole loaded with a zero-bias microwave (MW) diode, and the interference-free lead wires were constructed with two series of lumped resistors of 3 kohm. Characteristics of the probe were checked by measuring the induced electric fields in irradiated, electrically small cubes filled with phantom material. The measured results agreed well with theoretical results obtained from the tensor integral equation method. A phantom model of man scaled to 1/5 dimensions of a typical man made of thin *Plexiglas* was filled with phantom material of appropriate conductivity and permittivity and placed in a large MW anechoic chamber and exposed to 500-3000 MHz traveling electromagnetic waves incident normally from front to back. Induced electric fields were probed over 28 locations in one side of the model and the distribution of the measured electric fields was compared with the distribution of theoretical results obtained numerically from the tensor integral equation methods. While a qualitative agreement was obtained between experiment and theory, the agreement tended to deteriorate at lower frequencies. This may be due to the fact that the magnetic mode of induced electric field starts to *dominate* the electric mode as the frequency becomes lower than 1000 MHz, and there [illegible] theoretical convergence with the [illegible]

0710 EDDY CURRENTS [illegible] FIELDS IN [illegible] Lee, J.-H. (Dept. Electrical [illegible] Science, Michigan State Univ., [illegible] M. Radio Science 17(5S) [illegible]

A theoretical method [illegible] eddy currents induced by [illegible] magnetic fields of up to [illegible] in biological bodies [illegible] sented. The body is [illegible] circular rings of various [illegible] areas. The induced electric [illegible] in each ring is numerically determined [illegible] of the theory of vector potential [illegible] method. A computer program [illegible] calculate induced eddy currents [illegible] cal bodies yielded numerical results [illegible] significantly from the [illegible] utions. A series of experiments [illegible] measure the electric field [illegible] frequency magnetic fields [illegible] models constructed with [illegible] phantom biological material. [illegible] fied by the experimental [illegible] results.

0711 IRRADIATION OF [illegible] OF HUMANS AND ANIMALS [illegible] OF A SMALL LOOP ANTENNA. [illegible] (Dept. Electrical Engineering, [illegible] Lake City, UT 84112); Iskander, M. F.; [illegible] H.; Massoudi, H. Radio Science [illegible] 1982 (23 refs).

Absorption characteristics [illegible] els of humans and animals [illegible] of a small coaxial loop antenna [illegible] near fields of the antenna [illegible] used to identify the suitable [illegible] volved in the spheroidal models. [illegible] mulated in terms of an integral [illegible] transverse dyadic Green's function [illegible] diated by the current [illegible] the vector spherical harmonics [illegible] ue problem is solved by the [illegible] tion method. The specific [illegible] distribution and the average [illegible] lated as a function of the [illegible] different frequencies [illegible] of an average [illegible] medium rat. For instance [illegible] the average SAR values [illegible] value. In particular [illegible] an increase in the average SAR values was generally observed. In spite of the complicated nature of the near fields, the absorption characteristics can be explained in terms of the incident radiation. At all frequencies, excessive heating occurs at the surface of the spheroid while a limited absorption occurs in the central region around the major axis. This result is of particular importance in hyperthermia, where efforts are being directed towards achieving deep-tissue heating by a coaxial coil carrying radiofrequency power at about 27 MHz.

0712 STUDIES OF MICROWAVE ABSORPTION IN LIQUIDS BY OPTICAL HETERODYNE DETECTION OF THERMALLY INDUCED REFRACTIVE INDEX FLUCTUATIONS. (Eng.) Davis, C. C. (Electrical Engineering Dept., Univ. Maryland, College Park, MD 20742); Swicord, M. L. Radio Science 17(5S):85S-94S; 1982 (6 refs).

A new technique is described for performing microwave (MW) absorption spectroscopy of transparent or translucent media, particularly liquids, which directly measures the frequency dependence of power absorbed in the sample. In this technique, called phase fluctuation optical heterodyne spectroscopy, the refractive index fluctuation produced in a sample when its temperature rises as a result of absorption of MW radiation is measured. This refractive index fluctuation produces a phase fluctuation in a single-frequency laser beam passing through the sample. For a small temperature increase, the magnitude of the induced phase fluctuation is directly proportional to the temperature increase, and is a direct measure of the amount of absorbed power. The phase fluctuation is measured by heterodyning the laser beam which traverses the sample with a reference beam derived from the same single-frequency laser. Preliminary experiments on water and ethanediol yield absorption spectra that are consistent with those obtained in previous investigations using conventional techniques.

0713 THERMOGRAPHIC ANALYSIS OF WAVEGUIDE-IRRADIATED INSECT PUPAE. (Eng.) Olsen, R. G. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508); Hammer, W. C. Radio Science 17(5S):95S-104S; 1982 (8 refs).

A high-resolution thermographic imaging system was used to study radiofrequency (RF) absorption patterns in the yellow mealworm, Tenebrio molitor L., for waveguide irradiation situations. Early-stage pupae (1-3 days old) of the yellow mealworm without visible defects were mounted inside a right-angle, waveguide E bend and irradiated through longitudinal slots cut in the broad wall of the E bends. Use of the E bends was required by the addition of a closeup lens assembly mounted on the front of the thermographic imaging device, a Spectotherm M 900, which was used to obtain the magnitude spatial distribution of absorbed microwave Mw ergy at three frequencies. At 1.3 and 5.95 MHz, MW source was a sweeper/oscillator (A that was used to drive traveling wave t ets (Semidyne); at 10 GHz, a Gunn oscillator tral Microwave CMF-420AE) supplied the power. M ured power levels were 25 W, 1.0 W, and 23 mW, pectively, at 1.3, 5.95, and 10 GHz. The ther graphic images show good resolution of the irra ated pupae; many of the thermograms clearly s the head, legs, and other features. Distinct d ferences in electrical properties exist between various sections of the insect, particularly betw the abdomen and the other two sections. These th mographic measurements suggest that more theoret work is needed to properly model the nonhomoge nature of the actual pupa.

0714 MILLIMETER WAVE IRRADIATION AND MEAS MENT SYSTEM FOR CELL SUSPENSIONS. (E Tamburello, C. C. (Inst. Elettrotecnica & Elettr ica, 90128 Palermo, Italy); Zanforlin, L. Ra Science 17(5S):105S-110S; 1982 (6 refs).

The high water content of cell suspensions, wh is necessary for cell survival, creates cert problems in the measurement of electric paramet in the millimeter wave band. By feeding microw energy through the sample holder bottom, it been possible to make accurate measurements of sample mismatch using a highly sensitive null terferometer. Two measurement systems have b developed; the first, which utilizes a tuna klystron in the 65-73 GHz range, allows prec measurements at fixed frequencies; the second, wh utilizes two swept impact avalanche transit t (IMPATT) sources covering the 66-85 GHz range, lows rapid parameter measurements over a wide f quency range but with reduced precision. Refl tion characteristics of a cell sediment can be curately derived in the 60-90 GHz frequency ba These results may then be utilized in cooperat with biologists for analyses of correlations betw electrical and biological effects, in an effort better understand the mechanism of microwave int action at the cellular level and to help defin physical model of these phenomena.

0715 A MICROWAVE METHOD FOR ESTIMATING AB LUTE VALUE OF AVERAGE LUNG WATER. (En Iskander, M. F. (Dept. Electrical Engineering, Un Utah, Salt Lake City, Utah 84112); Durney, C. Bragg, D. G.; Ovard, B. H. Radio Science 17(111S-117S; 1982 (21 refs).

The ability to measure lung water is an essential diagnostic technique for the diagnosis of virtually all lung diseases. A microwave (MW) transmission method for calculating the absolute value of the water content of the lung has been developed, using computerized axial tomography to obtain a transverse cross-sectional image of the thorax showing the dimensions and the relative positions of the organs and the MW applicators. The electromagnetic field problem is then solved numerically using the method of moments. The numerical procedure was evaluated by carrying out detailed calculations for a human cross-section, and the cross-section of a dog's thorax. The transmission coefficient can be directly related to the average amount of total water content in the lung since the mismatch between the MW applicators and the patient's skin is found to be highly insensitive to the changes in the underlying lung parenchyma.

[illegible] A CLASS OF NEW MICROWAVE THERAPEUTIC APPLICATORS. (Eng.) Lin, J. C. (Bioengineering Program, Univ. Illinois, Chicago, IL 60680); Kantor, G.; Ghods, A. Radio Science 17(5S):119S-[illegible]; 1982 (11 refs).

A class of new direct-contact microwave (MW) applicators for hyperthermia and diathermia applications is described. *The applicators consist of three concentric, circular, cylindrical tubes.* The inner cylinder may serve as a port for circulating coolant to reduce surface temperature, as a port for introducing ionizing radiation in combination therapy for cancer, or to insert a temperature or field sensor for monitoring purposes. The coaxial waveguides formed by the inner and middle cylinders and by the middle and *outer* cylinders can be used to propagate TE_{11} and TE_{21} modes, respectively, for dual-beam, single *frequency operation*, or may be designed to permit two frequencies to propagate with the same TE_{11} *mode. The dual-beam 2450 ± 50-MHz* applicator has an an overall diameter of 10.4 cm at the output aperture. The annular regions formed by the middle and outer cylinders are loaded with high-density polyfoam to give added structural support. Dielectric loading may be used to maintain a small aperture diameter and still permit the propagation of TE_{11} and TE_{21} modes at lower frequencies. The applicator has a measured voltage standing wave ratio of 1.25. At the therapeutically effective specific absorption rate of 235 W/kg, the net forward power required is only 26 W; the maximum leakage at distances of 5 cm from the applicator surface in contact with a fat-muscle phantom is 4 mW/cm². These results compare favorably with the best designs available and are superior to the noncontact applicators currently in clinical usage. Thus the new applicator may be a good candidate for safe and efficacious use in diathermy and in hyperthermia for combination cancer therapy.

0717 IMPLANTABLE MICROWA[illegible] ICAL HYPERTHERMIA. [illegible] (Dept. Radiation Oncology & Elect[illegible] Univ. Maryland Sch. Medicine, Balti[illegible] Samaras, G. M.; Cheung, A. Y.; [illegible] P. M. Radio Science 17(5S):[illegible] refs).

Microwave (MW) induced hyperthermia [illegible] nally located radiators promises a [illegible] provement in therapy for neoplasia in the [illegible] brain and other organs which are accessible [illegible] body orifices. Coaxial MW radiators [illegible] to pass through standard bronchoscopes [illegible] scopes have been constructed, permitting [illegible] ual control of radiator position. A [illegible] is combined with an antenna consisting [illegible] array of half-wave dipoles which, instead [illegible] connected by an external line that would interfere with the radiation pattern, are connected by an [illegible] ternal cable whose outer conductor is simultaneous[illegible] ly used as the radiating element. The [illegible] formed by cross-connecting the inner and [illegible] conductors of the cable at intervals, [illegible] in the needle antenna. When the radi[illegible] in a phantom material with the same dielectric [illegible] mittivity and loss tangent as human muscle at [illegible] MHz, test results show more than [illegible] of [illegible] at the radiator is absorbed by the phantom. [illegible] der to obtain realistic estimates of the temper[illegible] distributions induced by the coaxial radiators [illegible] live tissues, steady state in vivo heating [illegible] were measured in feline esophagus and brain. [illegible] *heating and cooling times were short.* The MW [illegible] diation was confined to the target volumes with[illegible] *detectable leakage.*

0718 BIOLOGICAL AND BEHAVIORAL EFFECTS OF [illegible] NATAL AND POSTNATAL EXPOSURE TO 245[illegible] ELECTROMAGNETIC RADIATION IN THE SQUIRREL M[illegible] (Eng.) Kaplan, J. (SRI International, Menlo Par[illegible] CA 94025); Polson, P.; Rebert, C.; Lunan, K.; [illegible] M. Radio Science 17(5S):135S-144S; 198[illegible]

The effect of chronic microwave (MW) irradiat[illegible] or below the ANSI-recommended radiation [illegible] guide for human exposure on prenatal and [illegible] development of the squirrel monkey (Saimiri [illegible] reus) was studied. Pregnant squirrel monkeys [illegible] were exposed to 2450 MHz radiation in [illegible] cavity at whole-body average specific [illegible] rates equivalent to those resulting [illegible] to plane wave irradiation at 0, 0.034, [illegible] W/kg (8, 5, 6, and 4 monkeys, respectively[illegible] births occurred, exposed animals were [illegible] signed to groups for which exposures were [illegible] terminated or continued. In both cases, [illegible] were treated together with their mothers [illegible] and then alone for an additional 6 m[illegible] occurred 3 hr/day, 5 days/wk throughout [illegible] No differences were found between irrad[illegible] control adult monkeys with respect to the number of live births produced, or to measures of locomotor activity, maternal care, urinary catecholamines, plasma cortisol, phytohemagglutinin-stimulated response of peripheral blood lymphocytes, or electroencephalographic (EEG) activity. Offspring exposed at 3.4 W/kg both before and after birth had a high mortality rate (4/5) before 6 mo of postpartum age. These results suggest that MW radiation at power densities to 3.4 W/kg might have little direct effect on the monkey fetus when exposures occur in utero during the latter half to two-thirds of pregnancy but that continued exposure after birth may be harmful. No differences were found between exposed and nonexposed offspring in the same blood, urine, and EEG parameters; growth rate and most aspects of behavioral development were not altered by exposure. In a follow-up study, pregnancy outcome and offspring survival were compared between a group of 31 monkeys irradiated at 2450 MHz beginning in the first trimester of pregnancy and a group of 34 sham-treated controls. After parturition dams and their offspring were treated under the same conditions; then offspring were treated alone through 9 mo of age. The results of the latter study did not support those obtained in the initial experiment: no differences were found between irradiated and sham-exposed monkeys in the number of abortions, stillbirths, or livebirths that occurred or in the number of offspring that died.

0719 CONSTANT-DOSE MICROWAVE IRRADIATION OF INSECT PUPAE. (Eng.) Olsen, R. G. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). Radio Science 17(5S):145S-148S; 1982 (4 refs).

The effects of a constant total dose of 5.95 GHz microwave (MW) energy on pupae of the yellow mealworm Tenebrio molitor L. were investigated. Pupae were irradiated in the standing wave of a continuous MW beam. The standing wave configuration produced alternating planes of electric field (E) and magnetic field (H) intensities, and the pupae were mounted in either the E field or the H field plane. Exposure duration was 1.5, 3.0, 6.0, 12, or 24 hr with specific absorption rates (SAR) of 208, 104, 52, 26, and 13 W/kg, respectively. Irradiations were conducted both with and without a ventilating fan that limited the rise in chamber temperature to less than 4.5 C for all irradiations; without ventilation, the temperature increased about 11 C at the highest power level. Abnormal development as a result of the MW exposure was seen only in the high-power, short-duration experiment without chamber ventilation. It is proposed that a predominately thermal interaction mechanism operates in abnormal insect development, which hypothesis necessarily precludes the existence of cumulative effects. For this configuration and frequency, 40 C appears to be the threshold for effects.

0720 BINDING AND [illegible] LOW-LEVEL [illegible] VIEW. (Eng.) Adey, W. [illegible] California, [illegible] Radio Science [illegible]

Studies of brain tissue [illegible] tromagnetic fields are reviewed [illegible] experiments testing the [illegible] ence of lanthanum may modif[illegible] lated chick brain exposed [illegible] tromagnetic fields are reported. [illegible] rebral hemispheres were [illegible] solutions of different ionic content and pH, and exposed to a 450 MHz field [illegible] ulated at 16 Hz to a depth [illegible] 0.75, 0.375, and 2.0 mW/cm [illegible] ation was vertical. [illegible] efflux was compared for [illegible] bonate, increased levels of calcium, [illegible] bonate, without calcium, with pH [illegible] solution containing lanthanum [illegible] hemisphere was tested against the [illegible] brain with left and right sides serving [illegible] and test samples. Efflux of [illegible] solution was the control in the experim[illegible] ing calcium concentration, pH, [illegible] solutions. Efflux in the [illegible] medium served as reference in the experiments with lanthanum. The results of the experiments [illegible] previous findings that radiofrequency fields [illegible] tude-modulated at brain wave frequencies increase calcium efflux from isolated chick cerebral tissue. New observations include an absence of sensitivity of the response to variations of calcium concentration (0 to 4.16 mM) in the bathing solution, [illegible] hancement by addition of hydrogen [illegible] hibition in the absence of normal [illegible] els. Addition of lanthanum [illegible] solution restored field sensitivity, [illegible] ulus decreased calcium efflux. It [illegible] that weak extracellular electric [illegible] ating at low frequencies or [illegible] quency modulation on a radiofrequency carrier wave may be transduced in a specific class of extra[illegible] lar negative binding sites, normally [illegible] calcium ions and susceptible to [illegible] gen ion binding. The [illegible] so far defined for field interactions with [illegible] calcium binding strongly suggest [illegible] teraction based on long-range interactions [illegible] length of a coherently organized charge system. The cooperative aspects of the interaction [illegible] in frequency and power windows may arise [illegible] different role for hydrogen ions, with proton tunneling occurring between [illegible] across the boundary between coherent and [illegible] charge zones.

0721 COMPARISON OF MEASURED AND PREDICTED CHARACTERISTICS OF MICROWAVE INDUCED SOUND. (Eng.) Lin, J. C. [illegible] puter Engineering and Neurology, Wayne State Univ., Detroit, MI 48202); Meltzer, R. J.; Redding, F. K. Radio Science 17(5S):159S-163S; 1982 (16 refs).

The thermoelastic theory of microwave (MW) auditory effect was compared with new measurements obtained in cats and with previously available measurements. The theory describes the acoustic waves generated in the head as functions of the size of brain spheres, and characteristics of impinging and absorbed MW energies. Anesthetized cats were placed in a stereotaxic head holder using hollow ear bars. During the experiments, the animals' body temperature was maintained between 36 and 39 C. The dorsal aspect of the skull was exposed and insulated stainless steel electrodes were advanced to various brain stem nuclei and fixed to the skull. The reference gold pin electrode was always located near the lowest part of the right pinna. A small direct contact applicator (Elmed 15) was used to deliver short rectangular 2.5-25 usec-wide pulses produced by an Applied Microwave Lab. MW pulsed signal source (2450 MHz) at a rate of 10-100/sec. Peak incident power varied from 0 to 10 kW. Bioelectric activity extracted from the vertex and from each depth electrode was amplified by Grass (RM 122) amplifiers with a band pass of 80 Hz to 10 kHz and summated on-line using a Nucelar Chicago computer of average transient. The first 10 msec of the averaged response were displayed on the cathode-ray tube and also photographed. The thermoelastic theory correlated well with experimental measurements regarding the frequency of sound and threshold of sensation, width of impinging MW pulses, independence from MW frequency, and specific absorption rate distribution.

0722 THE EFFECT OF MICROWAVE RADIATION (1.0 GHz) ON THE BLOOD-BRAIN BARRIER IN DOGS.

(Eng.) Chang, B. K. (Div. Hematology & Oncology, Dept. Medicine, Electrical Engineering & Neurosurgery, Duke Univ. Medical Center, Durham, NC 27710); Huang, A. T.; Joines, W. T.; Kramer, R. S. Radio Science 17(5S):165S-168S; 1982 (10 refs).

The integrity of the blood-brain barrier (BBB) was evaluated in dogs following exposure to continuous wave microwave (MW) radiation at 1.0-GHz (20 min at power densities ranging from 2 to 200 mW/cm^2). The MW source was an AIL 125 generator. A Plexiglas apparatus for suspension of a double-ridged waveguide horn antenna was used to deliver near-field MW radiation directly onto the top of the head of anesthetized 15-20 kg mongrel dogs. Control (11) and exposed (21) dogs were injected with 25-30 uCi/kg of ^{131}I albumin as a tracer. Cannulation of the cisterna magna and the femoral vein permitted simultaneous sampling of cerebrospinal fluid (CSF) and plasma every 20 min for 5 hr. Measurement of the CSF/plasma distribution ratio of ^{131}I revealed no effect on the BBB at power densities of 2, 4, 10, 50, or 200 mW [illegible] However, 4/11 dogs exposed at [illegible] increased penetration [illegible] the BBB [illegible] compared to controls [illegible] in 2 dogs, and 2-4x greater [illegible] Two patterns were [illegible] the CSF:plasma ratio [illegible] rise with subsequent [illegible] standard deviation [illegible] rise to a level well outside the [illegible] A possible explanation for the res[illegible] 30 mW/cm^2 is that a MW window [illegible] ing very near this value.

0723 EFFECTS OF HIGH-INTENSITY [illegible] EXPOSURE OF RAT BRAIN. [illegible]

(Bioelectromagnetics Res. Lab., [illegible] tion Medicine, Univ. Washington [illegible] Seattle, WA 98195); [illegible] (5S):169S-178S; 1982 [illegible]

The heads of female Wistar [illegible] to 915-MHz microwave (MW) [illegible] (1 usec-360 msec) and power [illegible] the threshold for the [illegible] sciousness. The exposure [illegible] lindrical waveguide with [illegible] in a region of high magnetic [illegible] field. The thresh[illegible] correspond to a [illegible] regardless of the [illegible] Based on thermographic data, [illegible] to a change in temperature [illegible] brain temperature of [illegible] el) or a peak specific [illegible] Rats exposed to pulses with [illegible] sponding to energy levels [illegible] appeared to be normal [illegible] to pulses with energies [illegible] generally displayed petit [illegible] lasting for 1 min after exposure, [illegible] min of unconsciousness. [illegible] els corresponding to the [illegible] the threshold curve, the rats were [illegible] stunned, but displayed a lethargy [illegible] The period of unconsciousness [illegible] with the amount of exposure energy [illegible] old level. The temperature [illegible] to the baseline level within [illegible] rats began to move when the temperature [illegible] within 1 C of their normal temperature [illegible] ical examination was [illegible] the rats: 1 control; [illegible] pulses (below the threshold [illegible] to 10-kW, 0.1-sec pulses [illegible] level). Macroscopically, there was [illegible] difference among the [illegible] (10 kW at 100 msec and [illegible] ation indicated some [illegible] and microfocal [illegible] to demyelination of [illegible] bral cortex [illegible] pathological findings in 2 exposed rats 1 mo after exposure were that the brains appeared swollen and microfocal glial nodules were present in the brain.

0724 INTERACTION OF AMBIENT TEMPERATURE AND MICROWAVE POWER DENSITY ON SCHEDULE-CONTROLLED BEHAVIOR IN THE RAT. (Eng.) Gage, M. I. (Neurotoxicology Div., MD-74B, Health Effects Res. Lab., EPA, Research Triangle Park, NC 27711); Guyer, W. M. Radio Science 17(5S):179S-184S; 1982 (15 refs).

The interactive effects of microwave (MW) power density and temperature on behavioral changes measured immediately after termination of exposure were investigated in 64 adult male Long-Evans rats trained to insert their heads into a food cup to obtain a 45 mg food pellet on a 1-min variable-interval schedule of reinforcement. Exposure to 2450 MHz continuous wave MW energy took place in an anechoic chamber under far field conditions; relative humidity was 50% during all exposures, and air velocity was 0.07 m^3/sec. Two groups of 4 rats each were exposed for the 15.5 hr period from 1630 to 0800 hr under one of the following combinations of power density and air temperature: 8 or 14 mW/cm^2 at 22 C; 0, 8, or 14 mW/cm^2 at 26 C; or 14 mW/cm^2 at 30 C. Before MW exposure, 3 daily behavioral testing sessions followed a sham exposure at 22 C to acclimate the rats to the housing conditions during exposure. The last sham exposure also served as the 0 mW/cm^2 at 22 C exposure. The night following exposure, each group was given a sham exposure at the ambient temperature of the previous night. Rectal temperature was measured in 1 rat of each group before and after each MW or sham exposure. Behavioral testing occurred approximately 10 min after termination of exposure. MW irradiation was found to reduce rates of responding in direct proportion to the power density at each ambient temperature. This decrease of rate was most pronounced after exposures at 30 C. During sessions 1 day after MW exposure many rats showed behavioral overcompensation as response rates exceeded those measured the day before irradiation. When response duration was measured, increases in response duration were seen after exposures at 14 mW/cm^2 and 26 C and after exposure at both 8 and 14 mW/cm^2 when the temperature was 30 C. There were no significant increases in response duration after any exposures at 22 C. The results indicate that the intensity of MW irradiation and ambient temperature interact to increase decrements in rates of behavioral responding measured at the termination of irradiation.

0725 EFFECTS OF CONTINUOUS AND PULSED CHRONIC MICROWAVE EXPOSURE ON RABBITS. (Eng.) Chou, C.-K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine, Univ. Washington Sch. Medicine, Seattle, WA 98195); Guy, A. W.; McDougall, J. A.; Han, L.-F. Radio Science 17(5S):185S-[illegible] (18 refs).

The effects of exposure to continuous wave (CW) and pulsed microwave (MW) fields for a 3-mo period were investigated and compared in 18 New Zealand rabbits (3 mo old; 9 male, 9 female). Animals were placed in Plexiglas cages and exposed singly in miniature anechoic chambers to CW, pulsed, or sham 2450-MHz plane wave fields for 2 hr/day, 5 days/wk [illegible] days. An S band standard-gain horn was located [illegible] above the animal. Because of the limited low average power output (10 kW peak power) of the [illegible] generator (Applied MW Lab. PH40K), maxiumum average power density at the animal location was 1.5 mW/cm^2. To maximize the animal exposure, rabbits were exposed singly to 1.5 mW/cm^2 pulsed fields (pulse width, 10 usec; repetition rate, 100 pulses/sec). The same average power density was used for CW exposure. Sagittal specific absorption rate (SAR) patterns were obtained thermographically; the peak sagittal SAR for 1.5-mW/cm^2 incident power density was 2.1 W/kg in a rabbit's back and 1.6 W/kg in the head region. Carbon loaded Teflon wires were used for the electroencephalogram (EEG) recording. To control for possible effect of circadian rhythms, the schedule of exposure for each group of 3 animals was rotated. No significant differences were observed between the exposed and sham rabbits in body wt (measured every other day); EEG and evoked potentials (recorded 1/wk); blood tests (hematological, chemical, and morphological studies, 1/mo); or cataract examination before and after the 3 mo exposure. At the end of the 3-mo period, all 18 rabbits were injected with various dosages (1, 2, 4 mg/kg) of apomorphine to study drug induced hyperthermia and behavioral hyperactivity. However, 5 (1 exposed to CW, 3 pulse-exposed, and 1 sham-exposed) animals died during the experiment indicating that the animals were very sensitive to the apomorphine (normal young rabbits can tolerate up to 8 mg/kg dosage). The remaining rabbits (5 each exposed to CW or sham-exposed, 3 pulse-exposed) were sacrificed and detailed histopathological examinations were carried out. No consistent, significant differences in tissue damage were seen in the histopathological study.

0726 THE RESPONSE OF MOUSE MAMMARY TUMOR TO MICROWAVE HEATING AT 2.45 GHz. (Eng.) Robinson, J. E. (Div. Radiation Therapy, Univ. Maryland Sch. Medicine, Baltimore, MD 21201); Cheung, A. Y.; Harrison, G. H.; Samaras, [illegible] Radio Science [illegible] (5S):195S-199S; 1982 (8 refs).

The response of mammary carcinomas implanted in the flanks of female C3H mice to microwave (MW)-induced hyperthermia was studied and compared with water bath heating. Tumor regrowth time, i.e., the time for the treated tumors to regress and to grow to a vol twice that at the time of treatment was as a criterion of tumor response to treatment. In order to minimize the size and shape dependence of the 2.45 GHz MW heating, the tumors were immersed in a bath of tissue equivalent bolus. Two types of bolus were used: a semisolid gel and a temperature controlled liquid bolus made up of 20% ethanol in isotonic saline. In order to reduce energy deposition gradients, two parallel opposed MW applicators dielectrically loaded to support a simulated transverse electromagnetic wave were energized alternately at a rate which was fast in comparison to that of tumor cooling. During heating in the gel, the temperature was monitored immediately adjacent to but not inside the tumor. Target temperatures were 42, 43, 43.5, and 44 C, together with an ambient temperature control. During heating in the liquid bolus, tumor temperatures were monitored for one of six animals per data point. Target temperatures were 42, 43, and 44 C; thermal controls were MW-heated to 37.5 C. The liquid bolus was kept at [illegible] C below target temperature for the tumors and sufficient MW power used to elevate tumor temperature to a level equal to or in exces of the target temperature. Data from tumors treated in the gel bolus yielded lower regrowth slopes and higher intercepts (greater regrowth times) than those of the control and the water bath-heated tumors. This may be due to nonuniform heating by MW energy with some small fraction of the tumor vol about 1 C below the target temperature. Regrowth curves that were consistent with homogeneous heating were obtained for tumors heated in liquid bolus. Slopes were steeper than for the semisolid bolus and there was little or no indication of the biphasic nature of the response curves seen after heating in the gel. A plot of thermal sensitivity vs. temperature suggested that all parts of the tumor were at or slightly above (0.4 C) target temperature. Thus, any difference in the effect of MW and water bath heating on the regrowth time of the tumors studied in this experiment was very small. Regrowth time of tumors with thermal probes left in place during the treatment was significantly greater than that of tumors in which no probe was present during MW irradiation.

0727 TREATMENT OF NON-UNION OF FRACTURES BY PULSING ELECTRO-MAGNETIC FIELDS. (Eng.)

Hutchings, J. (Royal Hospital, Chesterfield, England). Radiography 48(566):25-32; 1982 (5 refs).

Results of treament of non-uniting fractures with the ElectroBiology International Bi-Osteogen System 204 unit are reported. The unit consists of a 250 V time-operated, quasi-square wave generator powering an O-shaped treatment coil and a plastic positioning block which is centered over the fracture site and attached to the external surface of a plaster of Paris cast moulded to the contours of the limb. The procedure for prescribing the system is outlined. Of 52 patients treated during the period 1976-1980, 38 fractures were proved to be radiographically and clinically united, representing a success rate of 73.07%. The 14 failures were [illegible] difficulty in immobilization with a minimum gap of 5 mm or more, and a case with a fixation screw within the gap, possibly causing and alteration [illegible] induced field or the cell population in that area.

0728 MODEL FOR THE GROWTH OF BACTERIA UNDER ELECTROMAGNETIC RADIATION. (Eng.)

Akyel, C. (Sect. d'Electromagnetisme & d'Hyperfrequences, Dept. Genie Electrique, Ecole Polytechnique, P. O. Box 6079, station "A", Montreal, Quebec, H3C 3A7, Canada); Bosisio, R. G. Speculations Sci Technol [illegible]:15-22; 1982 (10 refs).

A multi-resonant interaction (MRI) model is proposed for the growth of cells in the presence of electromagnetic (EM) radiation. The cell growth cycle of Escherichia coli predicted by the MRI model is in good agreement with experimental data obtained since 1969 on the growth of E. coli subjected to EM radiation of variable frequency in the millimeter wave lengths. The MRI phenomenon is probably due to a difference in the dielectric properties of the cell colony and the adjacent medium. The hypothesis conceives that the retardation or stimulation of cellular growth is directly linked to the applied frequency of low power EM waves. An electro-mechanical resonance phenomenon may be the interacting agent which defines a given length of cellular colony at a given stage of development. According to the model, it should be possible to stimulate or retard cell growth by suitably programming the EM radiation periods regardless of the chosen operating frequency point.

0729 EFFECT OF MICROWAVE HEATING ON THE RADIATION RESPONSE OF RHABDOMYOSARCOMA. (Eng.)

Zywietz, F. (Inst. Biophysics & Radiobiology, Univ. Hamburg, D-2000 Hamburg, W. Germany). Strahlentherapie 158(4):255-257; 1982 (12 refs).

The response of rat rhabdomyosarcoma R1H to single doses of X-rays (15 and 30 Gray) applied alone or in combination with hyperthermia (43 C) induced by 2450 MHz microwave (MW) radiation was investigated. Heat was delivered to the 2.3 cm^3 tumors by a [illegible] contact applicator 4.0 cm in diameter. MW heating of the tumors was performed 20 min after X-irradiation in 3 steps: (1) the tumors were heated [illegible] min with the Radarmed 12T202 generator's maximum output power of 25 W, which led to a fast temperature rise; (2) the power was reduced to [illegible] W [illegible] min; and (3) by applying 7 to 9 W, a constant tumor temperature of 43.0 ± 0.3 C was maintained [illegible] temperature of the rat did not exceed [illegible] treatment. Heating the tumors at 43 [illegible] growth delay that increased linearly with treatment time, up to 120 min. However, the animals [illegible] always tolerate 2-hr treatments. RIH tumors showed enhanced volume regression and tumor growth delay after combined treatment as compared to irradiation alone. After a single dose of 15 Gray, postirradiation hyperthermia treatments for 30 and 60 min led to thermal enhancement ratio (TER) values of 1.3 and 1.6, respectively. After a dose of 30 Gray combined with 30 or 60 min of hyperthermia, TER values were 1.5 and 1.7.

0730 MODELLING OF THE PERTURBATION INDUCED BY LOW-FREQUENCY ELECTROMAGNETIC FIELDS ON THE MEMBRANE RECEPTORS OF STIMULATED HUMAN LYMPHOCYTES (MEETING PAPER). (Eng.) Chiabrera, A. (Electrical Engineering Dept., Univ. Genoa, Viale Causa 13, I-161 45 Genoa, Italy); Grattarola, M.; Viviani, R.; Braccini, C. Studia Biophysica 90:77-78; 1982 (1 ref).

Lectins are known to induce the in vitro reactivation of human lymphocytes by acting as ligands of membrane receptors. Since most of the molecules involved are electrically charged, an effect on the parameters of the process due to electromagnetic (EM) perturbation can be anticipated. Two differential non-linear equations are proposed as a model of the interactions between receptors and lectins which give the time evolutions of the concentrations *of couples of receptors (encounters)* and complexes, respectively. Computer simulations of the time evolutions of receptors and complexes do not agree with experimental results and do not take into account the time spent by receptors together. Therefore, a gain function is introduced which is the ratio between the fraction of couples that, in the presence of lectins, remain together longer than a given time and the same expression in the absence of lectins. In principle, sinusoidal perturbations will always inhibit the process by lowering the value of the gain factor. This concept is in qualitative agreement with available experimental data.

0731 MOLECULAR BIOLOGICAL IMPLICATIONS OF ELECTRIC-FIELD EFFECTS (MEETING PAPER). (Eng.) Berg, H. (Central Inst. Microbiology and Experimental Therapy, Dept. Biophysical Chemistry, Acad. Sciences GDR, Beutenbergstrasse 11, DDR-6900 Jena, E. Germany) Studia Biophysica 90:169-176; 1982 (34 refs).

The interactions between biopolymers and biological membranes and electric fields produced by high single pulses with different electrodes or pulsed electromagnetic fields are reviewed. Single pulses can orient biopolymers and their complexes in solution, increase the permeability of membranes and disrupt cell walls, and fuse animal cells and protoplasts. In contrast to the single pulse technique, low pulsating fields re[illegible] over a longer peri[illegible] logical and metabolic effe[illegible] other investigators and [illegible] ticle. Normally, bursts [illegible] gular pulses (10 [illegible] 15 msec are used in biomedi[illegible]

0732 ELECTRIC-FIELD-INDU[illegible] (MEETING PAPER). [illegible] (Arbeitsgruppe Membran[illegible] Kernforsch[illegible] D-5170 Julich 1, W. Germa[illegible] G. Studia Biophysica [illegible]

The use of electri[illegible] fields [illegible] cells is described. Membrane [illegible] is achieved by dielectrophoresis [illegible] ac field resulting in the formati[illegible] pearl-chains. Suitable field strength [illegible] of pearl-chains are in the range [illegible] To initiate cell fusion, closer membrane [illegible] has to be established by increasing the field strength for a very short time [illegible] the breakdown pulse. The frequency range [illegible] dielectrophoretic collection should be between [illegible] kHz and 1 MHz. Reversible electrical breakdown in the zone of membrane contact is the primary process responsible for the initiation of fusion. Electrical breakdown is achieved by the application of a field pulse of short duration and of sufficient strength (0.5 to 7 kV/cm). Breakdown causes a few pores to be generated in the cell membrane so that [illegible] is formed between the two cells, through which mass transport can take place. Fusion is generally observed between cells within a pearl chain when a field pulse of 2 to 50 usec is applied and when the field strength is 1.5- [illegible] higher than the critical field strength normally required for breakdown in the membrane sites. [illegible] can be used for the form[illegible]

0733 MODELLING OF THE [illegible] BY LOW-FREQUENCY ELECTROMAGNETI[illegible] N THE MEMBRANE RECEPTORS OF STIMULAT[illegible] HUMAN LYMPHO-CYTES. I. INFLUENCE OF THE FIELDS ON THE [illegible] FREE ENERGY. (Eng.) Grattarola, M. [illegible] trotecnica, Univ. Genoa, Viale Causa [illegible] Genoa, Italy); Viviani, R.; [illegible] Biophysica 91(2):117-12[illegible]

An attempt is made to model the [illegible] onstrated inhibitory effect of [illegible] electromagnetic (EM) [illegible] reactivation of human lympho[illegible] reactivate human lymphocytes [illegible] complexes with membrane recept[illegible] or more glycoproteins [illegible]

[illegible] encounter distance is shorter than a critical distance R_c. Several possible field effects on the interaction kinetics between membrane receptors and lectins are postulated. Three EM signals are considered: 2Hz sinusoidal, 4 kHz sinusoidal, and a repetition of a burst of rectangular positive and negative pulses of about 250 usec followed by a zero signal period, the signal time average being zero, and the period [illegible] msec. The low field EM exposures considered in this paper have a small influence on the values of the numbers of encounters and complexes per unit surface area so that the small-signal linear approximation holds. The model does not predict any inhibition induced by the EM field.

[illegible] MODELLING OF THE PERTURBATION INDUCED BY LOW-FREQUENCY ELECTROMAGNETIC FIELDS OF THE MEMBRANE RECEPTORS OF STIMULATED HUMAN LYMPHOCYTES. II. INFLUENCE OF THE FIELDS ON THE MEAN LIFETIMES OF THE AGGREGATION PROCESS. *(Eng.)* Chiabrera, A. (Inst. Elettrotecnica, Univ. Genoa, Viale Causa 13, [illegible] Genoa, Italy); Grattarola, M.; Viviani, R.; Braccini, C. Studia Biophysica 91(2): [illegible]-131; 1982 (2 refs).

In order to model the interaction of electromagnetic (EM) exposure and lectin-induced reactivation of human lymphocytes in vitro, a reactivation gain function G is introduced which is the ratio between the fraction of receptors that remain together longer than a given time in the presence of lectins (encounters and aggregates), and the same expression in the absence of lectins (encounters alone). Such a mitotic gain takes into the account the clustering life-times of lymphocyte surface receptors and allows a more appropriate measure of reactivation effectiveness. The introduction of an electrical perturbation decreases the value of G, thus inhibiting the reactivation process, in agreement with the experimentally observed effects of weak low-frequency EM fields on lectin-stimulated lymphocytes.

[illegible] RECESSION OF CHANGES IN DIELECTRIC PARAMETERS OF SELECTED RAT TISSUES CAUSED BY SINGLE EXPOSURE TO PULSE MICROWAVE RADIATION. I. EXPERIMENTAL RESULTS. (Eng.) Staniszewska, M. [illegible] (Dept. Physical Hazards, Inst. Occupational Medicine, Teresy Str. 8, 90-950 Lodz, Poland); Terlecki, [illegible] Studia Biophysica 91(2):155-161; 1982 (no refs).

To investigate the effects of exposure to microwave (MW) radiation on the dielectric properties of rat [illegible], adult male Wistar rats were exposed to [illegible] pulsed MW energy (pulse width, 1.5 usec, [illegible] pulses per sec) at a specific absorption rate (SAR) [illegible] W/kg for 30 min. The rats were decapitated [illegible], 2, 6, 17, [illegible] and 48 hr after MW exposure. After decapitation, temperature in the abdominal cavity was [illegible] submaxillary salivary [illegible] tained. [illegible] tissue samples was [illegible] tance method [illegible] tivity and loss [illegible] function [illegible] MW radiation. [illegible] damped harmonic [illegible] priate physical [illegible] the respective [illegible] weight-defined water [illegible] glands and femoral [illegible] function of time [illegible]

[illegible] RECESSION OF CHANGES IN DIELECTRIC PARAMETERS OF SELECTED RAT [illegible] SINGLE EXPOSURE TO PULSE MICROWAVE [illegible] THEORETICAL [illegible] (Dept. Physical Hazards, [illegible] cine, Teresy [illegible] Biophysica [illegible]

A mathematical model [illegible] changes in the dielectric parameters [illegible] submaxillary salivary gland [illegible] single exposures to pulsed [illegible] (2880 MHz, 1.5 usec pulse width, [illegible] for 30 min). The complex dielectric [illegible] tissue samples was measured [illegible] a frequency of 3 GHz. [illegible] data on the real and imaginary parts [illegible] permittivity as a function of time [illegible] MW exposure, the appropriate [illegible] recessional process of [illegible] meters is some kind of damped [illegible] ter content in the tissue and the [illegible] the abdominal cavity also [illegible]

[illegible] EFFECTS OF [illegible] ON THE DEVELOPMENT [illegible] EBELLUM. (Eng.) [illegible] Biophysics, NIEHS, [illegible] Park, NC 277[illegible]); [illegible] tal [illegible]

The morphologic [illegible] the devel[illegible] quail after [illegible] wave [illegible]

[illegible] were examined histologically. To [illegible] effect of MW irradiation [illegible] the cerebellum. [illegible] hatch and were [illegible] cerebella from 22 exposed [illegible], and the extent [illegible] the stem of the [illegible] the perikaryon of [illegible] ex impregnated [illegible]. A slight developmental retardation was [illegible] the cerebellar cortices of the irradiated [illegible]. The growth and subsequent decline of the external granular layer, the growth of the molecular layer, the [illegible] differentiation and the alignment of Purkinje cells, and the accumulation of [illegible] cells beneath the Purkinje cell layer were [illegible] in the MW-exposed embryos. The mean body [illegible] brain wt were also reduced in the exposed embryos. However, these effects were temporary with the [illegible] and the cytoarchitecture appearing normal at 8 wk of age. In the 8-wk-old quail, no significant differences were noted between irradiated and control cerebella in the morphological measurements of Purkinje cells. These findings suggest that the developmental retardation in the embryonic stage following MW irradiation had no effect [illegible] the later development of the cerebellum.

0738 TERATOGENIC EFFECTS OF 27.12-MHz RADIOFREQUENCY RADIATION IN RATS. (Eng.)
Lary, J. M. (Physical Agents Effects Branch, NIOSH, Cincinnati, Ohio 45226); Conover, D. L.; Foley, E. D.; Hanser, P. L. Teratology 26(3):299-309; 1982 ([illegible] refs).

Pregnant Sprague-Dawley rats were exposed to hyperthermic levels of 27.12 MHz radiofrequency (RF) radiation to study the teratogenic and embryolethal effects of exposure to relatively high levels of RF radiation. Awake rats were irradiated separately in a RF near-field synthesizer operating in the dominant magnetic field mode under continuous wave conditions at an ambient temperature of 23 ± 2 C. Eight groups, each consisting of 16 to 28 pregnant rats, were exposed to a magnetic field strength of 55 A/m and an electric field strength of 300 V/m on gestation days 1, 3, 5, 7, 9, 11, 13, or 15. The rats were irradiated to a colonic temperature of 43 C rather than for a constant time period; the average irradiation period was 26-32 min. The specific absorption rate for the RF-irradiated animals averaged from 11.1 to 12.5 mW/g. Eight matching control groups were sham irradiated for 30 min (their colonic temperature rose an average of 0.5 C during the exposure period from an initial 38.6 C), and an untreated group of 29 pregnant rats was left in the animal quarters throughout their gestation. RF exposure caused a significant incidence of fetal malformations throughout the postimplantation period (days 9-15). It also caused a low but significant incidence of preimplantation malformations. Fetal wt and crown-rump length were reduced in the postimplantation exposure groups but [illegible] by preimplantation exposure. The [illegible] or resorbed fetuses was significantly [illegible] rats exposed on days 7 or 9. The [illegible] appeared to be caused by RF induced [illegible] the treated dams. A number of industrial, [illegible]fic, and medical devices operating at or near [illegible] MHz can cause hyperthermia in humans, [illegible] results suggest that women of childbearing [illegible] avoid exposure to RF-radiation levels [illegible] current US occupational standards. It is [illegible] that maximum permissible exposure levels [illegible] pregnant workers in Czechoslovakia and West Germany [illegible] from 2 to 50 V/m, much below the ANSI [illegible] 200 V/m.

0739 LOCAL MICROWAVE HYPERTHERMIA IN [illegible] THERAPY. PRELIMINARY REPORT. [illegible]
Valdagni, R. (Centro Oncologico, Inst. [illegible], 38100 Trento, Italy); Amichetti, M.; [illegible] G. Tumori 68(3):247-251; 1982 (23 refs).

Microwave (MW) hyperthermia was used in [illegible] with radiotherapy (15 patients) or [illegible] patient) to treat 19 histologically [illegible] superficially seated malignancies ([illegible] noma, 4 melanoma, 1 adenocarcinoma, and [illegible] refractory to other therapeutic measures. [illegible] patients (5 females and 11 males; [illegible] average age, 65 yr) 15 had a Karnofsky [illegible] Local MW hyperthermia to a preselected [illegible] temperature (42.5, 43, 43.5, and 44 C) was applied [illegible] for 20-55 min by a BSD-1000 computer-controlled [illegible] hyperthermia unit operating at frequencies [illegible] MHz. Thermometry was performed by [illegible] probes placed on the skin and intratumorally [illegible] inserted catheters. After radiotherapy [illegible] hyperthermia (< 20 min), a complete response [illegible] observed in 9/18 treatment fields in [illegible] partial response > 50% in 5 and [illegible] patient was not evaluable. Tumor regression [illegible] ally began about 2 wk after the first treatment. No tumor progression was observed during [illegible] therapy or in mo 1 of follow-up. The [illegible] effects directly attributable to hyperthermia were [illegible] skin burns in 147 treatment sessions. The [illegible] patient receiving chemotherapy 3 hr before [illegible] after hyperthermia exhibited no response.

0740 STUDY OF THE EFFECT OF PULSED [illegible] NETIC WAVES ON THE BLOOD [illegible] LIMB. (Eng.)
Mollan, R. A. B. ([illegible] Surgery, Queen's Univ., Belfast, N[illegible]); Allen, J. D.; Orr, J. F.; McCrain, S. [illegible] 51(1):67-70; 1982 (13 refs).

Pulsed electromagnetic (EM) energy was [illegible] the calf of eight healthy 21-29-yr [illegible]

[illegible] to investigate the effect of electrical stimulation on blood flow. An electronic device was constructed to deliver a train of pulses 200 usec wide in bursts every 5 msec with a repetition frequency of 10-15 Hz. Three separate signal generators were used to produce a composite signal which was magnified and fed into a set of coils wired in series. The induced field between the coils was 1.5-4.5 mV/cm. In four experiments, the coils were applied to the left thigh and right and left calf blood flow was measured by venous occlusion plethysmography. In a second series of four experiments, the coils were incorporated in a water-filled plethysmograph made of polycarbonate and the EM filed was applied to the calf at the level at which bood flow was being measured. In all eight experiments, calf blood flow was recorded for a 3-min control period before the coils were switched on, then for 3-min periods when the coils had been on for 10, 20, and 27 min, and finally for 3 min after they were switched off. No significant difference was detected between right and left calf blood flow in either series of experiments. These findings suggest that the reported osteogenic effect of electrical stimulation on bone is not produced by variations in blood flow to the stimulated limb.

0741 ELECTROMAGNETIC AND ACOUSTIC PROPERTIES OF TISSUES. (Eng.) Burdette, E. C. (Biomedical Res. Div., Engineering Experiment Station, Georgia Inst. Technology, Atlanta, GA 30332). In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8:105-150; 1982 (87 refs).

In beneficial applications of electromagnetic (EM) and ultrasonic energy, an accurate knowledge of tissue dielectric and acoustic properties is essential. A brief discussion of the basic principles underlying EM and ultrasonic absorption and dispersion in tissues is presented, tissue property measurement techniques are reviewed, and results of dielectric and acoustic tissue property investigations are described. A brief description of in situ tissue property measurement techniques is given and in situ properties of living normal and tumor tissues are presented. Substantial differences have been found between the dielectric properties of tumors and normal host tissues. Accurate dielectric or acoustic property information that reflects in vivo characteristics is necessary for successful application of EM or ultrasonic diagnostic and treatment techniques in medicine and for accurately determining absorption in tissues. The capability for accurate in situ measurements of tissue dielectric and acoustic properties could be used in dosimetry determinations and in treatment planning for cancer patients using EM or ultrasonic-induced hyperthermia.

0742 PHYSICAL ASPECTS AND METHODS OF HYPERTHERMIA PRODUCTION BY RF CURRENTS AND MICROWAVES. (Eng.) Iskander, M. F. (Univ. Utah, Salt Lake City, UT 84112). In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8:[illegible]; 1982 (22 refs).

The noninvasive production of hyperthermia for cancer therapy by electromagnetic (EM) techniques is described. The basic aspects of EM absorption in tissue are reviewed, with emphasis on the laws that decribe the propagation of EM waves and the mechanisms involved in their interaction with materials such as tissue. The interaction of EM fields with tissue produces two basic types of effects which are reflected in the dielectric behavior, one related to the drift and oscillation of free charges and the other the polarization both through the alignment of the already existing electric dipoles or the production of new ones. The fundamental differences between heating mechanisms in short-wave (conduction current type) and microwave (radiation type) diathermy are discussed. Examples of specific practical systems are used to illustrate the advantages and limitations of both procedures. Factors affecting the optimum frequency range for microwave diathermy are discussed. EM and ultrasound applications in hyperthermia are compared.

0743 POWER DEPOSITION WITH MICROWAVES. (Eng.) Paglione, R. W. (RCA Labs., Princeton, NJ 08540). In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8:192-[illegible]; 19[illegible] (10 refs).

A short review of the dielectric and thermal properties of tissues is presented. The success of hyperthermic treatment for cancer appears to be related to the ability to deliver uniform heat to specific volumes of tissues and to maintain the optimum temperature for the required period of time. The depth to which radiofrequency waves can penetrate into tissues and produce heating is primarily a function of the dielelectric properties of the tissues and of the frequency. The designs and uses of waveguide, printed-circuit antenna, and coaxial applicators at microwave and radio frequencies are described and illustrated.

0744 CLINICAL HYPERTHERMIA WITH RF CURRENTS. (Eng.) Oleson, J. R. (Div. Radiation Oncology, Arizona Health Sciences Center, Tucson, Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8:280-306; 1982 (35 refs).

Mechanisms of interaction between radiofrequency (RF) radiation and biological tissue are reviewed briefly. RF fields are coupled to biological matter either in a capacitive mode in which RF current passes from one electrode to another through through tissue interposed between electrodes, or in an inductive mode in which current flow results in tissue placed within an alternating RF magnetic field. Examples are presented illustrating each of these modes of RF heating as used for clinical hyperthermia. Phantoms are used to illustrate power deposition patterns in heterogenous materials. Temperature distributions observed in clinical situations are qualitatively compared to these power density distributions. Work is in progress in the laboratory and clinical evaluation of newer techniques using magnetic induction. These include the following: 1) A coaxial pair of coils (Helmholtz pair) for heating by magnetic induction. Careful positioning of the coils is necessary to result in a maximum eddy current density passing through the tumor; 2) Ferromagnetic implants used in conjunction with the magnetic induction technique to preferentially absorb energy from an applied RF field. The tissue in the vicinity of the implant is heated by thermal conduction from the hot seed rather than by direct absorption of energy from the magnetic field; and 3) Curie point seed heating. These newer techniques may extend the usefulness of RF heating in clinical applcations.

0745 CLINICAL APPLICATIONS OF HIGH FREQUENCY METHODS FOR LOCAL TUMOR HYPERTHERMIA. (Eng.) Corry, P. M. (Dept. Physics & Developmental Therapeutics, Univ. Texas System Cancer Center, Houston, TX 77030); Barlogie, B. In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8: 307-328; 1982 (10 refs).

Methods operating at frequencies in the high frequency (HF) spectrum (3-100 MHz) to induce local or regional temperature elevation in human tumors are reviewed. Criteria for an ideal system are presented and compared with methods that have been or can be used, including capacitive dielectric heating, magnetic induction heating, HF currents from implanted electrodes, ferromagnetic induction and hysteresis, as well as the use of phased annular arrays of radiators and folded dipole antennae driven at 433 MHz. Although there is no single method available which is ideal or which will facilitate hyperthermia induction in a wide range of tumor sizes, histologies, and anatomic locations, the work to date has provided guidelines for systems of the future. The ability t[illegible] at least 45 C is essential, [illegible] Toxicity information indicat[illegible] attention must be focused [illegible] interface to make the system [illegible] observation of deep seated cal[illegible] visceral lesions suggests that th[illegible] localized to the vicinity of th[illegible]

0746 CLINICAL HYPERTHERMIA [illegible] (Eng.) Sandhu, T. S. [illegible] Lake City, UT 84132). In: [illegible] perthermia. Nussbaum, G. H., [illegible] of Physics: New York); American A[illegible] in Medicine, Medical Physics M[illegible] 1982 (61 refs).

Instrumentation required to treat [illegible] crowave (MW) induced hyperthermia [illegible] MW hyperthermia equipment includes a MW [illegible] circulator or isolator, power [illegible], stub tuners, and MW applicators. [illegible] cators include the external wave[illegible] slot, and intracavitary antenna [illegible] Invasive methods include the use [illegible] coaxial antenna applicators and [illegible] cators. Static tissue equivalent phant[illegible] heating studies allow the selection of the type of applicator, the aperture size, and the MW frequency to be used to treat a prescribed target tissue volume. A dynamic phantom is described which can be used to study the effects of blood [illegible] the thermal field size produced by an applicator. The system is designed for use with noninvasive heat transducers and consists of a chamber di[illegible] partments, with liquid (e.g., saline [illegible] the top and bottom ones, and foam [illegible]. The flow in this system is simulated [illegible] direction, but the data obtained can be [illegible] to account for counter current blood flow.

0747 MICROWAVE TECHNIQUES FOR CLINICAL HYPERTHERMIA. (Eng.) Cheung, A. Y. (Dept. Radiation Therapy, Univ. Maryland [illegible], Baltimore, MD 21201). In: Physical [illegible] thermia. Nussbaum, G. H., ed. (American [illegible] Physics: New York); American Assoc. [illegible] in Medicine, Medical Physics Monograph [illegible], 1982 (15 refs).

The rationale behind a systems [illegible] to microwave (MW) hyperthermia for cancer [illegible] and innovative engineering appli[illegible] ing to the implementation of clinical [illegible] MW hyperthermia systems are described. A MW [illegible] for the induction of localized hyperthermia [illegible] divided into six subunits: induction [illegible], temperature measurement; power and temp[illegible]

[illegible], data acquisition and storage; operator interface; and failure/error-checking. The induction subsystem consists of the power source, power monitoring and impedance matching network, and the applicators. At MW frequencies, the two types of applicator commonly used are direct contact external applicators and implantable internal radiators. The clinical system developed at the University of Maryland Hospital is described as an example of an integrated, safe and reliable unit for MW-induced hyperthermia for cancer treatment.

7248 UNITED STATES RADIATION SAFETY AND REGULATORY CONSIDERATIONS AND PROCEDURES FOR RADIOFREQUENCY HYPERTHERMIA SYSTEMS. (Eng.) Bassen, H. I. (Bureau Radiological Health, FDA, Rockville, MD 20857); Coakley, R. F., Jr. In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8:372-392; 1982 (15 refs).

Radiofrequency (RF) radiation may be effectively utilized to produce therapeutic heating in human tissues, but stray radiation emissions from devices using this modality may expose clinical personnel and the patient's non-prescribed tissue to relatively high field strengths. Studies of RF emissions from shortwave and microwave (MW) diathermy devices by the Bureau of Radiological Health (BRH) have lead to a proposed standard for MW diathermy devices operating above 900 MHz. The provisions of the proposed standard involve four basic concepts: leakage of MW radiation beyond the intended treatment area is limited to 10 mW/cm^2 at a distance of 5 cm from the diathermy unit, except in the treatment beam; required controls, indicators, RF power stabilizers and controls, and safety interlocks; heating effectiveness is required to be quantified through tests using standard phantoms; and a requirement to provide the operator with sufficient information to treat a patient with maximum efficiency and minimum leakage. Present U.S. radiation safety standards allow much higher unintentional human exposures than do those in several East European countries, but a trend to lower permissible exposures is underway.

7249 THE PHILOSOPHY AND USE OF TISSUE-EQUIVALENT ELECTROMAGNETIC PHANTOMS. (Eng.) Cetas, T. C. (Div. Radiation Oncology, Univ. Arizona Health Sciences Center, Tucson, AZ 85724). In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8:441-461; 1982 (44 refs).

The use of tissue equivalent phantoms for studies of [illegible] used t[illegible] contents and [illegible] the idea of [illegible] is the use of [illegible] field in tissues [illegible] sition pattern. [illegible] in order [illegible] upon the [illegible] result in [illegible] systems are dis[illegible] at certain as[illegible]

7250 ELECTROMA[illegible] AND PHANTOM MEASUREMENTS [illegible] (Univ. Utah, Salt Lake [illegible] cal Aspects of [illegible] (American Inst. of [illegible] Assoc. of Physicists [illegible] Monograph 8:[illegible]

because of the problem [illegible] urement of electromagnetic [illegible] scale phantoms, [illegible] The mathematical [illegible] sented. Mathematical [illegible] tive procedure [illegible] hence the [illegible] models exposed to extern[illegible] internal fields and the power [illegible] in a two-dimensional [illegible] human subjects can be cal[illegible] procedure. This [illegible] larly useful for hyperthermia [illegible] takes into account the [illegible] different tissues in the [illegible] field characteristics [illegible]

7251 ANALYSIS OF [illegible] DOSIMETRIC EFFECTS [illegible] HEAT, RADIATION AND HEAT [illegible] OF A PHASE III RANDOMIZED [illegible] ANIMALS. (Eng.) Dewhirst, M. [illegible] Oncology, Univ. Arizona [illegible] Tucson, AZ 85724); M[illegible] Physical Aspects of Hyperthermia. [illegible] (American Inst. of Phys[illegible] New [illegible] Assoc. of Physicists in Medicine, [illegible] Monograph 8:[illegible]

The results of a randomized Phase III trial to compare the relative efficacies of heat alone, radiation alone, and radiation plus heat to treat tumors in pets are reported. A total of 77 dogs and cats with a variety of spontaneous malignancies were stratified by tumor type and randomized to receive therapy. The heat prescription was 44 ± 2 C for 30 min 1/wk, while the radiation dose was 460 rad/fraction 2/wk for 8 fractions. When the treatments were combined, heat preceeded one radiation treatment each week by no more than 10 min. All but 3 of the heated patients were treated with 500-kHz radiofrequency current using parallel plates, needles, or a plate plus needles; 3 patients with superficial tumors received 2450 MHz microwaves. A comparison of overall response rates showed that the fraction of patients with no response was significantly higher for heat alone than with either of the other two treatment arms. The complete response rates for heat alone and radiation alone were significantly lower than that for heat plus radiation. Analysis of potential therapeutic gain factors based on moist desquamination as a normal tissue endpoint indicates that larger values are possible for large tumors (> 10 cm^3) than for small ones. In the heat plus radiation group, response rates and durations were dependent on minimum temperature monitored in the tumor. Temperature measurements should be made during each treatment, since predictable heating patterns were not seen except in a few cases. In patients treated with heat alone, there was no correlation between minimum heat dose and prognosis.

0752 BIOELECTROCHEMISTRY - ELECTROPHYSIOLOGY - ELECTROBIOLOGY. (Eng.) Findl, E. (Bio Research, Inc., 315 Smith St., Farmingdale, NY 11735). In: Modern Aspects of Electrochemistry, Bockris, J. O., Conway, B.E., White, R.E. eds. (Plenum Publishing Co:New York) Vol 14:509-555; 1982 (127 refs).

A review is presented of interactions between electric fields and biological matter, with emphasis on transmembrane potentials, bioelectrokinetic phenomena, and surface charges of biomaterials. *Topics* discussed include electric fields and ion transport, cellular transmembrane potentials, potentials that are generated in vivo by motion between biofluids and cellular materials in the cardiovascular system, and potentials generated in bone and cartilage. The author presents results from in vivo and in vitro experiments to support the hypothesis that electrocardiogram waveforms are largely due to electrokinetic potentials. Medical and biological applications include the use of electric fields to stimulate bone growth and limb regeneration, and electric currents to induce electroanesthesia and to relieve chronic pain and eliminate pain during surgical procedures (e.g., in dentistry, gynecology, surgery, neurology, and psychiatry). The surface charge and *surface energy* of a material have been shown to affect the ability of the material to absorb blood components and to be critical to the [illegible] Electric currents or electric fields [illegible] to facilitate passage of substances [illegible] blood-brain barrier, to influence [illegible] and cellular differentiation, [illegible] brane breakdown, and to promote [illegible]

0753 RISK/BENEFIT ANALYSIS [illegible] CASE. (Eng.) Steneck, [illegible] Francisco Press: San Francisco, [illegible]

A conference sponsored and [illegible] Michigan Collegiate Inst. [illegible] and the National Science Foundation [illegible] ues in Science and Technology [illegible] 1981 was the basis of this [illegible] the problem of setting safety standards [illegible] to radiofrequency (RF) and microwave [illegible] through risk/benefit analysis [illegible] papers in the volume cover the [illegible] origins and present state of the MW [illegible] fication of critical cost/benefit [illegible] cations of RF and MW energy, [illegible] ty practices in the USSR and [illegible] tions; results of an inquiry by the [illegible] nications Commission on potential [illegible] radiation; the costs of perceived [illegible] of MW radiation; a suggested use [illegible] analysis in the MW debate; cost, risk, [illegible] the military; the importance of the [illegible] environment; cost/benefit analysis, [illegible] analysis in the formulation of [illegible] nonionizing electromagnetic standards and [illegible] plementation; the effect of extra[illegible] on MW research; science, objectivity [illegible] While individually, the papers in this [illegible] vide no simple, correct resolution [illegible] debate, as a group, they cover the major [illegible] view that must be considered seriously [illegible] making, if consensus is to be achieved. [illegible] agreement and disagreement among the [illegible] ticipants are summarized in an appendix.

0754 MICROWAVE AND RADIOFREQUENCY [illegible] (Eng.) Michaelson, S. M. (Dept. [illegible] Biology and Biophysics, Sch. Medicine & Dentistry [illegible] Univ. Rochester, Rochester, NY). [illegible] Radiation Protection. Suess, M. J., ed. (WHO, Regional Office for Europe, Copenhagen, Denmark, [illegible] Regional Publications, European Series [illegible] 174; 1982 (375 refs).

The frequency ranges considered are [illegible] MHz for radio frequency radiant energy [illegible] 300 MHz-300 GHz for microwaves (MW). A [illegible] has been made to delineate areas of [illegible] respect to biological effects and gaps in the [illegible] of knowledge. The review covers [illegible]

[illegible]sical principles; biological effects and health aspects; instrumentation and measurement; MW/RF sources and devices; protection measures and techniques; protection guides and standards; and health monitoring. It is recommended that the development of new and additional sources of MW/RF exposure be carefully followed and monitored. Consistent efforts should be made to minimize the impact of these sources on man and the environment. Continued attention should be given to the development of instrumentation and to the standardization of measurement techniques; greater attention should be given to the investigation of fundamental interactions of MW/RF energy with biological systems.

0755 ELECTRIC AND MAGNETIC FIELDS AT POWER FREQUENCIES, WITH PARTICULAR REFERENCE TO [illegible] AND 60 Hz. (Eng.) Hauf, R. (Res. Inst. Electropathology, Freiburg, W. Germany). In: Nonionizing Radiation Protection. Suess, M. J., ed. (WHO, Regional Office for Europe, Copenhagen, Denmark); WHO Regional Publications, European Series No. 10: [illegible]; 1982 (68 refs).

Electric (E) and magnetic (H) fields are generated by power transmission systems and wherever electric energy is used, whether in domestic activities, in transportation, or in industry. Future power transmission network voltages are expected to exceed the present level of 800 kV, and a transmission voltage of [illegible] kV is projected for the near future. In the interest of health protection, the effects that the E and H fields may have on man are reviewed. It is concluded that many observed phenomena, particularly changes in behavior, attributed to the effects of E and H fields can easily be explained by secondary effects which are not field-specific. Experimental studies show that E fields of intensity up to 20 kV/m and H fields of intensity up to 240 A/m, whether individually or in combination, do not constitute a danger to health. Epidemiological studies of exposure to E fields in workers in high-voltage substations and on power lines have failed to show any adverse health effects. No mechanism of action is known whereby power frequency fields can produce direct effects on living organisms, and no specific symptoms have been detected in humans as a consequence of exposure to these fields. E and H fields caused by transmission systems up to 420 kV are not considered to constitute a danger to human health; it can be assumed that this is also true for 800 kV systems.

0756 MEDICAL APPLICATIONS OF RADIOFREQUENCY-RADIATION HYPERTHERMIA (FINAL REPORT Jan-[illegible]). (Eng.) Kiel, J. L. (USAF/SAM, Brooks AFB, TX). Report No. SAM-TR-82-38, Oct 82. Contract No. [illegible]; [illegible]. [available through NTIS, Springfield, VA 22161, Document No. [illegible]] 1982.

This report provides an [illegible] applications of radiofrequency [illegible] thermia. RFR has limitations [illegible] tration but can heat tissue [illegible] sis of water content and [illegible]. Nonionizing electromagnetic [illegible] through several mechanisms, which [illegible] the amount of energy deposited [illegible] type of tissue irradiated. These [illegible] great versatility in the [illegible] RFR. Furthermore, the synergism [illegible] with ionizing radiation and [illegible] treatment increases their effective[illegible] lower doses. Lowered toxicity is a [illegible] a lower effective dose in the presence of RFR. With improved therapeutic instrumentation [illegible] metry and a better understanding of [illegible] anisms, the number of medical applications [illegible] effectiveness of RFR should [illegible].

0757 EFFECTS OF 200, [illegible] AND [illegible] MHz MICROWAVES ON CEREBRAL ENERGY METABOLISM. (Eng.) Sanders, A. P. (Duke Univ. Medical Center, Durham, NC); Joines, W. T. Sponsored by Health Effects Research Lab., Research Triangle Park, NC. Report No. EPA-600/182-014, Oct 82. Prepared in cooperation with Duke Univ., Durham, NC Dept. of Electrical Engineering. Contract No. [illegible]. [available through NTIS, Springfield, VA, Document No. PB83-116913]:72 p.; 1982.

Previous work has shown that levels of key biochemicals in the energy production system of rat brain are affected by exposure to 591 MHz microwave radiation at 13.8 mW/cm^2. The objectives of this study were to determine whether there are direct microwave effects on the biological system or whether they are secondary to the hyperthermia produced in the tissue, to establish dose-response relationships for the effects, and to investigate different frequencies of exposure and modulation of the carrier signal. The fluorescence of reduced nicotinamide adenine dinucleotide (NADH) in the rat brain was measured in vivo during exposure to the microwave radiation, and adenosine triphosphate (ATP) and creatine phosphate (CP) levels were measured chemically after exposure.

0758 MICROWAVE TESTING ON MICE YIELDS [illegible]TIVE EFFECTS (NTIS TECH NOTE). (Eng.) Dept. of the Navy (Washington, DC). Write NTIS for information about Tech Notes subscriptions and back-issue packages available. [available through NTIS, Springfield, VA 22161, Document No. [illegible]] [illegible] p.; 1982.

This citation summarizes a one-page announcement of technology available for utilization. A single, 15-min exposure to 2450-MHz microwave radiation is sufficient to reach a threshold that stimulates a significant increase in mouse splenic B lymphocytes bearing cell surface receptors for the third component of complement, according to recent tests. They also showed that the effect of absorption of multiple subthreshold quantities of energy was cumulative, provided the exposures occurred within 1 hr of each other. For additional information, contact: Navy Technology Transfer Fact Sheet. Code E411, Naval Surface Weapons Center, Dahlgren, VA 22448; refer to No. 70504/TN.

0759 HYPERTHERMIA IN RHESUS MONKEYS EXPOSED TO A FREQUENCY (225 MHz) NEAR WHOLE-BODY RESONANCE. (Eng.) Lotz, W. G. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). Report No. NAMRL-1284, 1 Jun 82. Contract No. F58524; MF5852-4020. [available through NTIS, Springfield, VA 22161, Document No. AD-A118 364]:13 p.; 1982.

Exposure of Rhesus monkeys to 225 MHz radiation caused severe hyperthermia at power densities > 5 mW/cm^2 (2.3 W/kg). A comparison of body temperature responses to exposure at two frequencies, 225 and 1290 MHz, indicated that the resonant frequency (225 MHz) is at least 2-x more effective in causing hyperthermia than the higher frequency, even after considerations of specific absorption rate (SAR) are included in the analysis. It was concluded therefore, that the effects on Rhesus monkeys of exposure to a resonant frequency (225 MHz) were substantially greater than what could be predicted based upon straightforward comparisons of dosimetric information (SAR) and the effects of exposures to a much higher frequency (1290 MHz).

0760 BIOLOGICAL EFFECTS OF STATIC MAGNETIC FIELDS: A SELECTIVE REVIEW WITH EMPHASIS ON RISK ASSESSMENT. (Eng.) Easterly, C. E. (Oak Ridge Natl. Lab., TN). Contract No. W-7405-ENG-26. [available through NTIS, Springfield, VA 22161, Document No. DE82-013350]:78 p.; 1982.

Rather than focusing on literature per se, the current study determines the status of magnetic field information that is applicable to risk assessment. Hence, an attempt is made to identify both the literature that is useful to the goal of risk assessment and a framework within which risk assessment methodologies can be derived. From this selected review, it is concluded that three areas exist for which adequate information can be found to begin modelling: disease induction, reproduction and development, and cardiovascular response. The first two are supported by a combination of positive and negative findings and the last [illegible] technique which utilizes the [illegible] principle of flow retardation [illegible] fluid moving through a magnetic field.

0761 MECHANISM OF ELECTROMAGNETIC [illegible] EFFECTS OF THE NERVOUS SYSTEM. (EXPERIMENTAL SYSTEM AND PRELIMINARY RESULTS). (Eng.) Campbell, N. L. (Naval Ocean Systems Center, San Diego, CA 92152); Brandt, C. L. Report No. NOSC-TR-[illegible], [illegible] July 82. Contract No. ZR00001; 01. [available through NTIS, Springfield, VA 22161, Document No. AD-A117 527]:68 p.; 1982.

Effects of high-level electromagnetic (EM) energy on living nerve tissue were assessed by subjecting individual nerve cells of the marine gastropod Aplysia californica to microwave radiation levels of 10-300 mW/cm^2. Of the 84 exposed cells, [illegible] showed inhibitory responses and 1 showed excitatory response that required 6-82 min to develop. In each case, the cell returned to normal activity within 70 min of removing the EM field. It [illegible] from the data collected that interaction of EM energy with the electrical activity of nerve cells does exist, and that this interaction is not heat-related. Understanding the mechanism of this interaction will provide a valuable tool in determining the hazards of nonionizing EM energy and [illegible] safety limits of exposure.

0762 ANNUAL REPORT, DIVISION OF [illegible] EFFECTS, BUREAU OF RADIOLOGICAL HEALTH (FISCAL YEAR 1980). (Eng.) Bureau of Radiological Health (FDA, Rockville, MD). Report No. [illegible], HHS-PUB, Mar 82. [available through NTIS, Springfield, VA 22161, Document No. [illegible]]:[illegible] 1982.

The Division of Biological Effects, Bureau of Radiological Health, plans, conducts, [illegible] epidemiological and experimental studies [illegible] effects of both ionizing and nonionizing [illegible], including x-rays, radiopharmaceuticals, [illegible] ultraviolet light and ultrasound. [illegible] al and extramural epidemiological [illegible] tory investigations and [illegible] literature, the division evaluates [illegible] assess the health effects [illegible] radiation. This report [illegible] completed and in progress for the period [illegible] 1979 through 30 September 1980 [illegible] related radiation research and evaluation [illegible] larly as it concerns the biological [illegible] sure to electronic products.

0763 INTERACTIONS OF RADIOFREQUENCY RADIATION WITH NITELLA: ELECTRICAL EXCITATION AND PERTURBATION OF THE CONTROL OF CYTOPLASMIC STREAMING (MASTER'S THESIS). (Eng.) Wong, L. S. (Air Force Inst. Technology, Wright-Patterson AFB, OH). Report No. AFIT-NR, Mar 82. [available through NTIS, Springfield, VA 22161, Document No. AD-A116 713]:94 p.; 1982.

Radiofrequency radiation (RFR) of 0.5 Hz - 2.5 GHz at field strengths on the order of 10 V/cm has been shown to interact with isolated Nitella internodal cells in two separate and frequency dependent manners. At frequencies up to approximately 10 KHz, RFR acts to directly excite the cell membrane, eliciting an action potential and halting cytoplasmic streaming. There is no reason to believe the RF induced action potentials and accompanying streaming cessations occur through a mechanism different from that which results from conventionally applied excitatory stimuli. Microscopic observations of the streaming in cells exposed to RFR gave no evidence of direct action by RFR upon the mechanism which generates the motive force. Streaming alterations, however, did indirectly indicate the existence of a field induced disruption of the calcium ion release which normally occurs upon membrane excitation. On the basis of these observations and previously reported theoretical models of RF interactions with biological systems, a molecular mechanism for the electrically mediated release of calcium ion is presented.

0764 OPEN-ENDED COAXIAL EXPOSURE DEVICES (PATENT APPLICATION). (Eng.) Burdette, E. C. (Dept. of the Air Force, Washington, DC). Report No. PAT-APPL-6-357 442; filed Mar 82. [available through NTIS, Springfield, VA 22161, Document No. AD-D009 487];24 p.; 1982.

A device for, and a method of, delivering a known amount (i.e., a dose) of electromagnetic energy radiation in the radiofrequency/microwave frequency range to a specimen of organic material (e.g., a cell and/or a tissue culture), and thereby exposing the specimen to the delivered energy. The device comprises a source of the desired electromagnetic energy to which is electrically connected a coaxial cable having an open end which terminates in a centrally located aperture of a circular brass ground plane plate to which, in turn, is electrically and mechanically connected to a metallic ring which is positioned such that it is equidistant from the aperture in which the energy-radiating open end of the coaxial cable is located. A circular culture dish which is positioned over the aperture, within the metallic ring, and on the ground plane plate holds the specimen of organic material which is exposed to the energy radiated from the open end of the coaxial

0765 REVIEW OF HEALTH AND SAFETY [illegible] VIDEO DISPLAY TERMINALS. [illegible] niet, W. C. (Communications Res. Centre, [illegible] Ont., Canada). Sponsored by NASA, Washington, [illegible] Report No. CRC-TN-712-E, Feb 82. [available through NTIS, Springfield, VA [illegible], Document No. [illegible] 19816]:39 p.; 1982.

The factors that contribute to worker [illegible] when video display terminals (VDT) are [illegible] into the workplace are investigated. [illegible] from field experiments indicate that [illegible] ergonomic factors and job characteristics [illegible] tribute to reports of discomfort from VDT [illegible]. Specifically, reports of visual discomfort [illegible] lated to improper ambient lighting (which [illegible] bothersome reflections and contrast [illegible] display quality, and ophthalmological def[illegible]. Reports of muscle pain and fatigue are [illegible] poor work-station design such as improper [illegible] of chair, keyboard, and display screen, [illegible] of source document holder, and no support [illegible] forearms and wrists. It is noted that the frequency of such complaints is influenced by the [illegible] attitude regarding the job. A negative att[illegible] arising from performing a meaningless, [illegible] task, or from having no opportunities for [illegible] advancement, will result in more complaints [illegible] ergonomic shortcomings. The issue of electromagnetic emissions from television displays is [illegible] considered.

0766 MECHANISMS OF MICROWAVE NEURAL INTERACTION (FINAL REPORT). (Eng.) [illegible] L. (Dept. Biology, Utah Univ., Salt Lake City, [illegible] 84112); Durney, C. H. Contract No. N[illegible] C932. [available through NTIS, Springfield, [illegible] 22161, Document No. AD-A111 [illegible]]:21 p.; 1982.

Examination of the binding characteristics [illegible] acetylcholine receptor (AchR) and either [illegible] labeled acetylcholine (^{3}H-Ach) or calcium [illegible] via a modified Hill plot revealed a [illegible] synergistic binding for both acetylcholine [illegible] and calcium (Ca++) in low concentrations. [illegible] crease was observed at a specific absorption rate (SAR) of 1.5 - 2.[illegible] mW/g [illegible] W [illegible] continuous wave at [illegible] Hz [illegible] used in both cases). Cooperative [illegible] was not changed at physiological concentrat[illegible] [illegible]). Experiments performed at [illegible] distinguished from those at [illegible].

[illegible]67 MICROWAVE INDUCED [illegible] IN THE [illegible] [illegible]OR). A DECADE OF [illegible] [illegible]lsen, R. G. (Naval Aerospace Medical [illegible]
[illegible]

81. Contract No. MR04108; MR0410801. [available through NTIS, Springfield, VA 22161, Document No. AD-A118 821]:15 p.; 1982.

Microwave-induced developmental effects in insects have been studied at several laboratories during the past decade. Results of the initial experiments were interpreted to show a so-called nonthermal microwave effect, but as more studies were conducted by various investigators, a predominantly thermal effect appeared to be the best explanation. This report presents the results of a comprehensive series of insect irradiation experiments including a rigorous statistical analysis of the data. Statistical analysis shows no microwave-induced effects for exposure of up to 4 hr at dose rates of 63 W//kg. Irradiation at higher intensities (102-126 W kg) did produce statistically significant effects when applied over a 2-4 hr period.

0768 THE EFFECT OF PULSED MICROWAVES ON THE BREATHING OF MICE. (Swe.) Criborn, C. O. (Foersvarets Forskningsanstalt, Stockholm, Sweden); Henriksson, C. I.; Clemedson, C. J. Sponsored by NASA, Washington, DC. Report No. FOA-C-54032-H2 H3, Apr 81. [available through NTIS, Springfield, VA 22161, Document No. N82-22873]:20 p.; 1981.

With the use of a specially constructed microwave generator, mice were exposed to microwaves synchronized to the different stages of respiration. Frequencies other than the respiratory rate affect the volume and rate of respiration in shorter intervals of exposure. Even though the animals were not heated at the low average effect, approximately 1mW/cm^2 during exposure, a change in body wt was measurable. These results indicate that the thermal energy balance in mice is somehow affected.

0769 DOSIMETRIC AND BEHAVIORAL ANALYSIS OF MICROWAVE-DRUG SYNERGISTIC EFFECTS ON OPERANT BEHAVIOR IN THE RAT. (FINAL REPT. Sep 79-Dec 81). (Eng.) Lovely, R. H. (Battelle Memorial Inst., Pacific Northwest Lab., Richland, WA); Lundstrom, D. L.; Phillips, R. D. Contract No. N00014-79-C-0819. [available through NTIS, Springfield, VA 22161, Document No. AD-A115 115]:26 p.; 1981.

Five male Long-Evans rats maintained at 80% of their free-feeding wt, were trained to bar press for food reward on a 1-min fixed-interval (FI1) schedule of reinforcement. Once stable FI1 baseline response rates were established dose-response functions were generated for Chlordiazepoxide HCl (CDZ). Subsequent treatments with CDZ were followed by 30 min pulsed microwave radiation (MWR) and FI1 behavioral assessment. Pulsed MWR exposure [illegible] zone of an anechoic chamber at an averaged [illegible] power density of 1 mW/cm^2 (PRF=3[illegible]/sec, [illegible] width). After 2 replications of the combined treatments another CDZ dose-response function was generated. This was followed by 3 more CDZ [illegible] replications the first of which was carried [illegible] averaged incident power density of 1 mW/cm^2 [illegible] creased rates of response for the CDZ and [illegible] MWR treatment were demonstrated relative to initial CDZ dose-response functions in 4 of [illegible] rats tested. However, the dose-response functions for CDZ a[illegible] that were generated following this apparent synergy showed the same shift in response rate. Further 8 mW/cm^2 pulsed MWR combined with CDZ also produced data similar to the 1 mW/cm^2 post-MWR exposure [illegible] dose-response functions for the animals te[illegible] Thus, an earlier demonstration of synergy between CDZ and MWR could not be replicated.

0770 SUBTLE CONSEQUENCES OF EXPOSURE TO WEAK MICROWAVE FIELDS: ARE THERE NON-THERMAL EFFECTS. (Eng.) Lovely, R. H. (Bioelectromagnetics Res. Lab., Univ. Hosp., Seattle, WA [illegible]); Mizumori, S. J. Y.; Johnson, R. B.; Guy, A. W. Prepared in cooperation with Battelle Pacific Northwest Labs., Richland, WA, Biology Dept., and California Univ., Berkeley, Dept. of Psychology. Contract No. N00014-75-C-0464. [available through NTIS, Springfield, VA 22161, Report No. AD-A1[illegible] 169/3]:53 p.; 1983.

When we speak of subtle consequences of exposure we mean only that the effects were observed in the absence of changes in core temperature due to microwave exposure. When we measure the difference in core temperature consequent to microwave exposure we are witnessing a breakdown of thermoregulatory mechanisms. Short of this event, the exposed subject makes a number of thermoregulatory and metabolic accommodations to maintain a constant body temperature and to deal effectively with the energy being deposited in its tissues. These latter changes should interest us for they are the subtle consequences of exposure to weak microwave fields. The long-term accommodations, which [illegible] chronic exposure, can lead to a number of [illegible] ing effects some of which are described below. [illegible] fundamentally different types of experimental protocol were employed. In Experiment IA, independent groups of male rats were either exposed [illegible] posed to 915 MHz microwaves for 10 hr [illegible] to 4 mo. In Experiment IB, independent [illegible] rats were similarly exposed, or sham-exposed, [illegible] 2450-MHz microwaves for 10 hr/night for [illegible] mo. In Experiment II, using a different [illegible] pregnant female rats were exposed [illegible] 19 days of gestation. Control groups were [illegible] sham-exposed or served as caged controls. The main focus of the study attended to assessment of [illegible] functions and the developmental status of the [illegible] rats' progeny.

[illegible] THE CURRENT STAT[illegible] KNOWLEDGE [illegible] RADIOWAVES AN[illegible] WAVES. [illegible] New York [illegible] Contract No. [illegible] (available [illegible] NTI[illegible] Document No. [illegible]

[illegible] radiowaves [illegible] microwaves. [illegible] safety limits [illegible] various [illegible]

[illegible] AND HUMAN [illegible] Medicine [illegible] Aerospace Medicine, Brooks [illegible] (available through [illegible]

[illegible] exposure [illegible] function of [illegible] resulting from exposure to micr[illegible] absorption rate [illegible] to the results of [illegible] the results were highly [illegible] provided no evidence [illegible] current [illegible] inappropriate [illegible]

[illegible] Administration, [illegible] DC. [illegible] available [illegible] Document No. [illegible]

[illegible] thermal [illegible]

[illegible] being determined from [illegible] evation values of water in a plasti[illegible] rats the body temper[illegible] higher [illegible] heat or microwave radiation. [illegible] rise in the brain, compared with the [illegible] ture, was observed. Anesthetized [illegible] animals showed an acceler[illegible] tory rate as the body temperature [illegible] microwave intensities over 3[illegible] mw [illegible] temperature rose.

[illegible] ANNUAL REPORT OF THE [illegible] CAL EFFECTS, BUREAU [illegible] HEALTH, FISCAL YEAR 198[illegible], October [illegible], 19[illegible] [illegible], 1981. (Eng.) National Center [illegible] health (Rockville, Md.) [illegible] FDA [illegible] FDA/NCDRH-[illegible] through NTIS, Springfield, VA [illegible]; see also [illegible]

The Division of Biological Effects [illegible] Risk Assessment [illegible] epidemiologic and experimental [illegible] effects of exposure [illegible] radiation, magnetic fields, an[illegible] report [illegible] Fiscal Year [illegible] mural and extramural epidemiological studies, [illegible] investigations, and critical review [illegible] erature, the Division studies [illegible] health effects resulting from exposure [illegible] and studies and develops techniques [illegible] ment of energy distribution in biological tissue in order to provide quantitative dose-effect [illegible] mation. The responsibility for risk assessment [illegible] the development of scientifically-based [illegible] criteria in support of exposure standards, perf[illegible] ance standards, and voluntary guidelines [illegible] radiation emission and radiation [illegible] marily within the Division.

[illegible] POTENTIAL HUMAN [illegible] NON-IONIZING RADIO[illegible] FR[illegible] EFFECTS. (Eng.) [illegible] Inc., McLean, VA [illegible] by Health Effects Research [illegible] angle Park, NC. Report No. [illegible] Contract No. EPA-[illegible] through NTIS, Springfield, [illegible] PB8[illegible] p., 198[illegible].

[illegible]

ous occupations and applications of radio frequency radiation (RFR) were identified and evaluated for their suitability for further study. Many populations were eliminated early because their potential exposure to RFR was too limited or data necessary for epidemiological research were unavailable. Eight populations were evaluated in detail and appear to satisfy many of the criteria for epidemiological research and could be useful study groups in an investigation of the health effects of nonionizing radiation. The eight potential study populations are: RF heat sealer operators, high frequency tube welder operators, medical diathermy operators in Veterans Administration hospitals, medical diathermy operators in rehabilitation facilities, school children located near broadcasting towers, state policemen, security guards, and radar technicians.

0776 EFFECTS OF ELECTROMAGNETIC RADIATION ON CALCIUM IN THE BRAIN (TECHNICAL REPORT). (Eng.) Greengard, P. (Southeastern Center for Electrical Engineering Education, Inc., St. Cloud, FL); Douglas, W. W.; Nairn, A. C.; Nestler, E. J.; Ritchie, J. M. Prepared in cooperation with Yale Univ. New Haven, CT, Dept. of Pharmacology. Report No. SAM-REVIEW-2-82, Jul 82. Contract No. F33615-78-D-0617; 7757; 01. [available through NTIS, Springfield, VA 22161, Document No. AD-B066 872/3]:117 p.; 1982.

Electromagnetic radiation has been reported to alter several aspects of nervous system function. Authors have claimed effects of radiation on calcium efflux from nervous tissue, on thermoregulation, on the blood-brain barrier, and on several other aspects of brain function, including behavioral, electrophysiological, and neurochemical processes. In most cases, either the results of these studies cannot be confirmed by other investigators or the biological significance of the results is unclear. Most (but not all) investigators accept that radiation alters the efflux of calcium from nervous tissue. But even accepting the validity of these findings, one is left with little indication as to what the results mean for the functioning of the central nervous system. Despite the plethora of studies that demonstrate radiation effects on the blood-brain barrier, the available evidence, together, indicates that permeability of the barrier remains intact except when the exposure involves very high power densities which cause thermal damage.

0777 PRELIMINARY STUDY OF [illegible] BEHAVIORAL AND BIOLOGICAL EFFECTS OF HIGH INTENSITY 60 Hz ELECTRIC FIELDS (INTERIM TECHNICAL [illegible] REPORT No. [illegible]). (Eng.) [illegible], [illegible] (Southwest Research Inst., San Antonio, TX); [illegible]; Smith, [illegible]; [illegible]. Sponsored by Dept. Energy, Washington, [illegible]. Contract No. AC[illegible]. [available through NTIS, Springfield, VA 22161, Document No. [illegible]]:[illegible] p.; 198[illegible].

Increasingly higher voltages for overhead power transmission lines are currently anticipated. The increased efficiency of such lines, coupled with increases in the cost of energy, will make the use of ultra-high voltage lines a necessity. The serious question arises of what effects these high intensity electric fields will have on living organisms. The objective of the preliminary study (Phase I) is to develop and thoroughly test the apparatus and experimental protocols which are planned for a long-term study (Phase II) which will begin when the preparatory study is complete. The experiments in Phase I were not intended to produce scientifically valid results. The results should be considered as anecdotal but potentially useful in designing Phase II. In Phase I a group of six individual subjects and a group of four social subjects were placed in the exposure facility. An initial pre-exposure period allowed data to be gathered for [illegible] before any electric fields were turned on. A similar (post-exposure) period followed the exposure period. For the first experimental group, the exposure period was a 6-wk period during which data were gathered on [illegible] days. The exposures [illegible] in the preliminary study were to 30 kV/m [illegible] fields.

0778 EFFECTS OF MAGNETIC FIELD EXPOSURE ON FERTILIZATION SUCCESS OF RAINBOW TROUT, SALMO GAIRDNERI (CONFERENCE PROCEEDINGS). (Eng.) Strand, J. A. (Battelle Pacific Northwest Labs., Richland, WA); Abernethy, C. S.; Skalski, J. R.; Genoway, R. G. Sponsored by Dept. Energy, Washington, DC. Report No. PNL-SA-[illegible]; CONF-[illegible], Jul 81. Contract No. AC06-76RL0[illegible]. [available through NTIS, Springfield, VA 22161, Document No. DE81-[illegible]]:[illegible] p.; 1982.

Initial studies conducted at this laboratory (Strand et al., 198[illegible]) suggested that fertility of trout eggs could be affected by magnetic fields of 1 Tesla. Additional studies were performed to confirm these results and to examine the relative susceptibility of eggs and sperm to magnetic fields. Preliminary results and their interpretation are presented. For additional information see [illegible], Volume 11, Number 1, Abstract No. [illegible].

0779 BIOLOGICAL EFFECTS OF HIGH DC MAGNETIC FIELDS. (Eng.) Tenforde, T. S. (Lawrence Berkeley Lab., Univ. California, Berkeley, CA); [illegible]. Sponsored by Dept. Energy, Washington, [illegible]

1978.

Research conducted during the contracting period has involved a continuation of an investigation of the in vivo effects of exposure of Dutch rabbits to electromagnetic pulsed (EMP) fields and an in vitro study of the effects of transient electrical and electromagnetic fields on biomembranes. Phenomenological studies of the effects of EMP exposure of Dutch rabbits have been undertaken in an attempt to characterize the nature of the alterations induced by such fields, whereas the biomembrane studies have been directed toward a mechanistic understanding of field-induced alterations in biological model systems.

0783 INVESTIGATION OF THE BIOLOGICAL EFFECTS OF PULSED ELECTRICAL FIELDS (ANNUAL PROGRESS REPT. NO. 2, 1 Feb 76 - 30 Jan 77). (Eng.) Cleary, S. F. (Dept. Biophysics, Virginia Commonwealth Univ., Richmond, VA 23298); Hoffman, R.; Liu, L. Contract No. N00014-75-C-0334. *[available through NTIS, Springfield, VA 22161, Document No. AD-A091 813/6]*:74p.; 1977.

The investigation of the effects of pulsed electrical fields on mammalian erythrocytes indicates that such fields produce *transient pores or channels* in the cell membrane as evidenced by the release of intercellular potassium ions and hemoglobin (and perhaps other intracellular protein molecules). The release has been found to be strongly dependent upon the duration of the electric field pulse as well as the amplitude of the electric field. Significant intracellular potassium release occurs under exposure *conditions* that do not result in release of protein molecules, suggesting that the size of the induced pore is dependent upon the induced field strength and the duration of the field. The mechanism of dielectric breakdown of cell membranes does not adequately account for these results. The results of studies of the relationship of field strength and pulse duration for the rupture of an artificial bilayer lipid membrane (oxidized cholesterol) indicate a dependency on the pulse duration that is consistent with the effects upon cell membrane permeability. The in vivo studies have involved the exposure to Dutch rabbits to repetitively pulsed electromagnetic fields in an EMP simulator. Such exposure has not been found to result in significant alterations in a number of physiological response variables including the duration of drug induced sleeping time and serum chemistry changes, although there is some suggestion (nonstatistically significant) of a post-exposure increase in certain serum enzymes.

0784 THE EFFECTS OF C[illegible]RDIAMINE AN[illegible] M[illegible] THE ECG DURING AC[illegible]TE MICROWAV[illegible]TION. (Rus.) Koldaev, V. M. (Medical [illegible] [illegible]divostok, USSR). Farm Toksikol [illegible] (12 refs).

The protective effects of analeptic and [illegible]ic drugs during acute microwave (MW: [illegible] length) irradiation were studied in random-[illegible] bino mice. The animals were subjected [illegible] MW exposure at 37.2 J/cm² (for 10 min), [illegible] (for 12 min), or 75 J/cm² (for 20 min). [illegible] after irradiation, the animals received [illegible] injection of cordiamine (25, 50, 100, [illegible] or mesatone (5, 10, 25, 50 or 100 mg/kg). [illegible] mals were follwed up for 3 wk. The optim[illegible] of cordiamine and mesatone that provided a [illegible] increase in the survival of MW-irradiated [illegible] 100 and 10 mg/kg, respectively. MW irradiat[illegible] duced a transient dose-dependent increase [illegible] temperature and decrease in pulse rate of [illegible] ECG examination showed marked elongation of [illegible] and PQ segments in mice *irradiated at* 55.8 and [illegible] J/cm². Administration of the drugs enhanced [illegible] ization of the ECG changes induced by MW radia[illegible]

0785 *WEATHER RADARS AS A SOURCE OF* [illegible] FREQUENCY ELECTROMAGNETIC FIELDS AN[illegible] PROBLEMS OF ENVIRONMENTAL HYGIENE. (Rus.) [illegible]skii, Iu. D. (A. N. Marzeev Res. Inst. [illegible] Community Hygiene, A. I. Voeikov Chief Ge[illegible] Observatory, Central Aerological Observator[illegible] USSR); Nikitina, N. G.; Tomashevskaia, I. A.; [illegible]iavko, F. R.; Zhupakhin, K. S.; Iurman[illegible] Gig Sanit (2):7-11; 1982 (7 refs).

To evaluate the potential environmental and [illegible] hazards of weather radar generating superhig[illegible]quency (SHF) electromagnetic fields (wave [illegible] of 0.8, 3, 10 and 17 cm, power flux dens[illegible] 1-4,000uW/cm²), random-bred albino rats were [illegible]jected to chronic 4-mo exposure to SHF fields [illegible] 115, 60, 40, 25, 10, and 5 uW/cm². Biologica[illegible]fects were estimated by behavior reactions, [illegible]cal endurance, biochemical and immunologica[illegible]meters. Exposure to SHF fields at 115 [illegible] uW/cm² resulted in a 1.5- to 1.3-fold increas[illegible] the threshold of galvanic skin response and [illegible] decrease in physical endurance. At power [illegible]sities of 40 and 25 uW/cm², the animals [illegible] changes in the reflex latency. Exposure [illegible] fields at 115 and 60 uW/cm² caused inhib[illegible] cholinesterase activity, increase in ser[illegible] plasmin activity, a significant increase [illegible] urea and nitrogen levels, and a decrease [illegible] glycogen levels. SHF fields at 40 and [illegible] resulted in the increase in adrenaline lev[illegible] the brain and in the adrenal glands.

0786 HYGIENIC EVALUATION OF 8-mm ELECTROMAGNETIC FIELDS. (Rus.) Dumanskii, Iu. D. A. N. Marzeev Res. Inst. General and Community Hygiene, Kiev, USSR); Tomashevskaia, L. A. Gig Sanit [illegible]; 1982 (4 refs).

The potential health hazards of 8-mm electromagnetic fields generated by weather radars were studied in albino rats. Daily exposures to EM fields were carried out at power densities (PD) of 140, 100 and 60 uW/cm^2 (12 hr/day for 4 mo). The biochemical effects of exposure were estimated by blood urea and residual nitrogen concentration, liver glycogen levels, blood cholinesterase activity, serum cerulloplasmin and transferin concentrations, and succinate dehydrogenase and cytochrome oxidase activity in liver and brain mitochondria. Exposure to PDs of 140 and 100 uW/cm^2 caused an increase in blood urea levels, inhibition of succinate dehydrogenase and cytochrome oxidase in liver mitochondria, and inhibition of blood cholinesterase. Exposure to a PD of 140 uW/cm^2 increased the residual blood nitrogen level, decreased the liver glycogen level, and increased cerulloplasmin activity. The most marked changes in biochemical parameters were observed after exposure to 140 and 100 uW/cm^2 fields for 3 and 4 mo. Exposure to the 60 uW/cm^2 field failed to induce any changes in rat metabolism.

0787 HYGIENIC EVALUTAION OF THE BIOLOGICAL EFFECTS OF NONIONIZING MICROWAVE RADIATION. (Rus.) Belokrinitskii, V. S. (A. N. Marzeev Res. Inst. General and Community Hygiene, Kiev, USSR). Gig Sanit (6):32-34; 1982 (7 refs).

The results of studies on the biological effects of centimeter-band electromagnetic (EM) radiation are summarized. A Luch-58 generator (wavelength, 12.6 cm) was used to irradiate experimental animals in an anechoic shielded chamber, at power densities ranging from 1-5 uW/cm^2 to 500 mW/cm^2. Rats exposed to low power density EM radiation (1-50 uW/cm^2) exhibited a mild increase in succinate dehydrogenase and glucose-6-phosphate dehydrogenase activity. Chronic exposure to EM radiation at 10, 25, and 50 uW/cm^2 (3 hr/day for 2 mo) resulted in dose-dependent changes in the ultrastructure of brain cells. Single exposure to EM radiation at 500 uW/cm^2 caused damage of mitochondria, endoplasmic reticulum, cell nuclei and nucleoli; the structural damage was associated with an increase in enzyme activity and enhanced synthesis of glycogen, DNA, and RNA. Single exposure of cats and dogs to EM radiation at 10 or 400-500 mW/cm^2 resulted in marked dilatation of blood arterioles, enlargement of intercellular space, marked decrease in collagen level, demyelination and vacuolization of nerve fibers, and changes in the size and shape of various cells. These findings indicate that histochemical and ultrastructural parameters are highly sensitive to EM radiation and that changes in these parameters can be used in hygienic estimation of maximum permissible [illegible] of exposure to microwave radiation.

0788 INCIDENCE OF DIGESTIVE SYSTEM DISEASES WORKERS EXPOSED TO LEAD IN COMBINA WITH SHF ELECTROMAGNETIC FIELD. (Rus.) Tiinus, S. (Res. Inst. Industrial Hygiene & Occupatio Diseases, Ukranian SSR Ministry Public Health, Ki USSR). Gig Sanit (9):93-94; 1982 (4 refs).

The health hazards of combined exposure to lead superhigh frequency (SHF) electromagnetic fie were studied in workers in the electronics ind try. Analysis of the incidence of digestive sys disorders in workers exposed to lead vapors al or in combination with SHF fields (dosages wit or slightly greater than maximum permissible ex sure levels) showed frequent food intolerance, l of appetite, and epigastric pain. The incidence chronic gastritis, chronic cholecystitis, st ulcer, and duodenal ulcer in workers exposed lead vapors alone was significantly greater t that in workers exposed to SHF fields alone or combination with lead vapors. The characteris feature of exposure to SHF fields alone was hy acid gastric secretion, compared with hyperaci after exposure to lead vapors alone.

0789 GENETIC HAZARDS OF MICROWAVES OF THERMAL INTENSITY AND THEIR HYGIENIC PECTS. (Rus.) Shandala, M. G. (A. N. Marzeev Inst. General and Community Hygiene, Kiev, US Antipenko, E. N.; Koveshnikova, I. V.; Timche O. I. Gig Sanit (10):38-41; 1982 (17 refs).

To evaluate potential genetic hazards of micro (MW) radiation of nonthermal intensities, random-bred albino rats were irradiated with generated by a Luch-58 apparatus (2,375 MHz) power flux densities (PFD) of 10 uW/cm^2 (7 hr for 45 days), 50 uW/cm^2 (7 hr/day for 45 days), 500 uW/cm^2 (single 7 hr exposure). One day a termination of exposures at 10 uW/cm^2, the ani were subjected to x-irradiation (12.9 mCi/kg). day 7 after MW and x-irradiations, the rats un went partial hepatectomy, and the liver specim were subjected to cytogenetic analysis. A si exposure to MW at PFD of 500 uW/cm^2 did not crease the number of cells with chromosome abe tions (16.[illegible]%, compared with 17.[illegible]% in contro The incidence of chromosome aberrations in subjected to chronic MW irradiation at 10 uW was 2x lower than that in the controls (7.1[illegible] 1[illegible]%, respectively). Preliminary exposure t at 10 uW/cm^2 reduced the incidence of chrom aberrations induced by x-rays. The rats subje to chronic exposure at a PFD of 50 uW/cm^2 sh a bimodal distribution of chromosome aberrati

[illegible]

[illegible] HEAT DISTRIBUTION [illegible] AFTER EXPOSURE [illegible] Med [illegible] refs).

[illegible] the therapeutic effi[illegible] ultrahigh frequency [illegible] field (EMF), heat distribution [illegible] was studied in dogs. [illegible] and 4 mm in diameter were [illegible] anterior and posterior surfaces [illegible] UHF EMF was generated by an apparatus with [illegible] W. The temperature [illegible] under the electrode was [illegible] made within the tissue [illegible] distances from the [illegible] were plotted. The results [illegible] of temperature [illegible] plotted.

[illegible] BIOCHEMICAL INDICES OF TUMOR TISSUE AFTER [illegible] HYPERTHERMIA AND IRRADIATION. [illegible] R. Med Radiol [illegible] refs).

[illegible] radiosensitizing effect of [illegible] hyperthermia was studied in random bred rats with transplanted sarcoma. The animals [illegible] x-irradiation alone [illegible] exposure with UHF [illegible] apparatus [illegible] MHz [illegible] temperature of the tumor tissue was [illegible] biological effects of exposure were estimated [illegible] dehydrogenase (LDH) and [illegible] tumor tissue. Combined [illegible] led to a marked increase in the [illegible] compared with a decrease in [illegible] x-irradiation [illegible]

[illegible]

radiation is characterized by deep absorption in tissues at depths of [illegible] 9 cm; the method is used in patients with chronic inflammation and disorders of peripheral circulation.

0794 EXPERIMENTAL EVALUATION OF THE USE OF LOW FREQUENCY PULSED ELECTRIC CURRENT FOR STIMULATION OF BONE REGENERATION. (Rus.) Landa, V. A. (N. N. Priorov Central Inst. Traumatology and Orthopaedics, Moscow, USSR). Ortop Travmatol Protez (2):52-57; 1982 (21 refs).

The potential use of weak electric currents to stimulate bone regeneration was studied in rabbits. An 0.5-cm segment of the radius was resected and platinum wire electrodes inserted between the bone fragments. Electric stimulation (8-10 uA, 1-sec pulses with intervals of 3 to 8 sec between the pulses) enhanced formation of the bone callus. *Mineralization* of the bone callus reached levels comparable to intact bone 75 days after the fracture compared with 3 mo in control animals. Radionuclide studies indicated that electric stimulation increased accumulation of [illegible] in the region of bone wound. Electron microscope examination of the callus tissue indicated enhanced cell proliferation and predominance of osteoblasts. Blood flow determinations showed enhanced blood flow velocity due to revascularization of the bone wound region. Improved blood supply was associated with increased ATP concentration, pyruvic acid levels, and redox potential.

0795 EFFECT OF WIDE-BAND MODULATED ELECTROMAGNETIC FIELDS ON WORKERS OF HIGH-FREQUENCY TELEPHONE EXCHANGES. (Bul.) Dimitrova, M. (no affiliation given); Dobrev, B.; Kiriakov, K.; Kirkov, V.; Panova, Z.; Nakova, L.; Izrael, M.; Khadzieva, [illegible]; [illegible], L.; Kostova, M. Probl Khig (7):21-29; 1982 (13 refs).

Health hazards of radio-frequency electromagnetic fields (RF EMF) were studied in 82 workers (60.25% women, average age 35.1 yr) at an international telephone exchange. The workers were exposed to amplitude modulated or pulsed EMF with frequencies of 4 KHz to 12 MHz; the average intensities of the electric and magnetic components at the workplace were [illegible]-7.7 V/m and 0.5 A/m, respectively. The maximum intensities were 29.6 V/m for the electric component and 5 A/m for the magnetic component. The workers who had an occupational exposure to RF EMF showed elevated blood pressure, headache, fatigue, irritability, hyperesthesia, neurasthenia, menstruation disorders, inhibition of neutrophil phagocytosis, a decrease in the erythrocyte count, and a decrease in serum albumin concentrations.

0796 [illegible] IN ANIMALS [illegible] EXPOSURE [illegible] LOW-FREQUENCY [illegible] FIELDS. (Rus.) [illegible], A. M. [illegible] refs).

[illegible] effects of short-term [illegible] frequency low intensity [illegible] (EMF) were studied in adult and [illegible] male rabbits The animals were irradiated with sine-modulated E generated by the NGPK-3m apparatus at a field in tensity of [illegible], 2.5-5.0 V/m, [illegible] pulses, and total durations of exposure of 15-12 min. T effects of EMF were estimated by the changes electrical activity of the cerebral cortex and changes in heart rate. Electroencephalograp (EEG) showed that adult rabbits assumed the 5-[illegible] modulation rhythm of EMF; the effect was less pr nounced for a 1-2-Hz modulation. In contrast wi adult rabbits, the EEG biopotentials in old anima did not assume the EMF modulation rhythm. Electr cardiographic (ECG) analysis showed that 1-hr ex sure to 5-8-Hz EMF at intensities of 2.5-[illegible] resulted in a mild decrease in the heart rate. Ex posure of old rabbits to 8-Hz EMF at 2.5-[illegible] induced extrasystoles.

0797 ANALYSIS OF FREQUENCY RELATIONS OF BI LOGICAL EFFECTIVENESS OF A MAGNETIC FIE IN A RANGE OF MICROPULSATION OF A GEOMAGNETIC FIE (0.01-100 Hz). (Rus.) Makeev, V. B. (no affilia tion given); Temur'iants, N. A. Probl Kosm Bi 43:116-128; 1982 (42 refs).

To evaluate biological activity of short-period os cillations of a geomagnetic field, random-bred ma rats were exposed to an alternating magnetic fie (AMF) generated by a NGPK-3m apparatus (intensit of 5,100, 50 and 5.0 gamma, rectangular or sine-mod ulated pulsed with duty factor of 0.5). Biologic effects of AMF were estimated by blood cell cou and the functional characteristics of periphera blood neutrophils. The biological activity of A depended upon its frequency and type of modulati Exposure to AMF at 0.02 Hz resulted a marked i crease in peroxidase, alkaline phosphatase, a cationic protein concentrations, an increase in t phagocytic index, and an increase in serum gamm globulin levels indicative of enhanced nonspecif resistance. Exposure to AMF at 8 Hz was associat with a decrease in all histochemical indices, a de crease in the phagocyte index, and a decrease blood complement and lysozyme levels. Exposure AMF at 0.5 Hz resulted in an increase in peroxidas activity in peripheral blood neutrophils and a co comitant decrease in cationic proteins and alkali phosphatase levels. Opposite effects on the indi of nonspecific resistance were also observed aft exposure to AMF at 9-10 Hz. The biological activit of rectangularly-modulated AMF was more pronounc than that of sine-modulated AMF.

[illegible] BIOLOGICAL EFFECTIVENESS OF WEAK INFRA-LOW-FREQUENCY ELECTROMAGNETIC FIELDS. (Rus.) Temur'iants, N. A. (*no affiliation given*). Probl Kosm Biol 43:128-139; 1982 (20 refs).

Biological effects of infralow-frequency weak electromagnetic fields (EMF) were studied in young (3-4 mo old) and adult rabbits, in 3-wk-old puppies, and in adult dogs. The animals were exposed to 8 Hz EMF with intensities of 7, 0.7, and [illegible] V/m for a single 3-hr exposure, or for 7x for 3 hr/day, every 3 days. Intensities of EMF corresponded to the intensity of the geomagnetic field during the period of high solar activity. The biological activity of EMF was estimated by changes in the functional state of peripheral blood neutrophils. Single exposures to EMF resulted in an increase in neutrophil size, a marked decrease in the activities of oxidases and alkaline phosphatase, and a mild decrease in glycogen levels. Analysis of the effects of chronic exposure showed two-phase changes in the cytochemical indices: a marked decrease in enzyme activities and glycogen levels after the first 3 irradiations, followed by progressive normalization of the cytochemical indices during the last 4 exposures. Puppies and young rabbits were more sensitive to EMF exposure than adult dogs and rabbits. The decrease in enzyme activity and glycogen level was more pronounced in rabbits than in dogs.

0799 PATHOLOGICAL CHARACTERISTICS OF EXPERIMENTAL MYOCARDIAL INFARCTION AFTER EXPOSURE TO LOW-FREQUENCY LOW-INTENSITY ELECTROMAGNETIC FIELDS. (Rus.) Artishchenko, V. A. (no affiliation given); Vinogradov, S. A.; Volynskii, A. M.; Perederii, V. G. Probl Kosm Biol 43:139-147; 1982 (14 refs).

The effects of low-frequency low-intensity electromagnetic fields (EMF) on pathogenesis, clinical manifestations, and healing of myocardial infarctions were studied in rabbits and guinea pigs. Myocardial infarction was induced by ligation of the left coronary artery. The animals were subjected to whole-body continuous irradiation with EMF (8 Hz, 0.8 V/m) generated by the NGPK-3m apparatus. Within 2-10 days after exposure, the animals were sacrificed, and myocardium specimens were examined histologically and histochemically. Exposure of animals with myocardial infarction to EMF resulted in more pronounced hyperemia of the perivascular and interstitial connective tissue, development of dystrophic processes in the myocardium tissue adjacent to the infarction zone, and development of

0800 REACTIONS OF A BIOLOGICAL SYSTEM TO ADEQUATE WEAK LOW-FREQUENCY ELECTROMAGNETIC FIELDS. (Rus.) Kislovskii, L. D. (no affiliation given). Probl Kosm Biol 43:[illegible]; 1982 ([illegible] refs).

The mechanisms of response of a biological system to weak low-frequency electromagnetic fields (EMF) are discussed. A characteristic feature of any complex biological system is a nonlinear or phase response to a stimulus. Specific effects of weak magnetic and electric fields are associated with changes in the optical orientation of atoms and a decrease in orientation entropy of water in chemical reactions. Weak magnetic fields have a specific effect on an excited unstable system if their intensity does not exceed a certain critical value. Cooperative effects provide for significant elongation of the duration of the excited state. Weak stimuli affect cluster structures of water, and the formation of metastable structures. These structural changes create the conditions conducive for kinetic isolation of a calcium ion with several water molecules for a time sufficient for the rearrangement of electron orbits.

0801 EFFECT OF MAGNETIC FIELDS ON RADIOSENSITIVITY OF MICE. I. EFFECT OF INFRALOW-FREQUENCY LOW INTENSITY MAGNETIC FIELDS ON SURVIVAL OF ANIMALS SUBJECTED TO WHOLE BODY X-IRRADIATION. (Rus.) Kopylov, A. N. (Life Science Faculty, M. V. Frunze State Univ., Simferopol, USSR); Troitskii, M. A. Radiobiologiia 22(5):[illegible]; 1982 ([illegible] refs).

The modifying effect of low-frequency magnetic fields was studied in random-bred male mice subjected to whole-body x-irradiation (56 rad/min, total dose of 750 rad). Before or after irradiation, the animals were exposed to an alternating magnetic field (AMF) at frequencies of [illegible] and 8 Hz, and intensities of 4.06 and [illegible] A/m for 3 hr. A 30-day survival rate in the animals subjected to x-ray irradiation alone was 24.8%. Exposure to AMF had a significant effect on the survival of irradiated mice. Preirradiation exposure to [illegible] Hz AMF had a radioprotective effect at both intensities (57.3% and 69.4% respectively), while 8 Hz AMF had a radioprotective effect only at 4.06 A/m ([illegible]%), compared with 36.0% at [illegible] A/m). Postirradiation exposure to AMF failed to provide a [illegible] effect.

0802 USE OF MATHEMATICAL MODELS FOR ANALYSIS OF ADAPTATION PROCESSES IN PERIPHERAL BLOOD. (Rus.) Antomonov, M. Iu. (A. N. Marzeev Res. Inst. General and Community Hygiene, Kiev, [illegible]

[illegible] separated exposures [illegible] peripheral blood [illegible] after exposures [illegible] after [illegible] exposures indicated that the response of peripheral blood to EMF irradiation consisted of cumulative and adaptation components. The adaptation component could be described by a differential equation of the first order.

[illegible] STANDARDIZATION OF PHYSICAL CONDITIONS IN ANALYSIS OF BIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS. (Rus.) Pfützner, H. (Inst. [illegible] of Electrical Engineering, Technical Univ., [illegible], Austria). Soobsh Akad Nauk Gruz SSR [illegible]; 1982 (5 refs).

To improve the reproducibility of the results of experiments on biological effects of electromagnetic fields (EMF), a system of standardization of physical properties of EMF is described. Significant variability of the values of threshold intensity of an electric field (E) can be explained by [illegible] E as the intensity of the field of the capacitor. Placing the biological material with significant conductivity and dielectric permeability in the field results in a significant decrease in the intensity of the field inside the material and a concomitant increase of the intensity of the field on its surface. For comparison of the results of different experiments, it is recommended that the following data should be included: the potential on the electrodes instead of E; the distance between the electrodes, and the size and geometrical localization of the material (for estimation of the edge effect). In the case of magnetic fields, the intensity can be assumed to be equal to that in a vacuum. The data on the magnetic fields should include their gradients, effective parameters (for sine-modulated fields), and Fourier series spectra (for nonsine-modulated fields).

[illegible] MAGNETOTHERAPY IN VARIOUS DISEASES AND INJURIES IN SPORTSMEN. (Rus.) Shepeleva, I. [illegible] (N. N. Priorov Central Res. Inst. Traumatology and Orthopedics, USSR); Kamenev, Iu. F.; Demetskaia, N. A.; Bogdanov, Iu. V.; Sliusarenko, V. G.; [illegible], V. Sh. Teor Prakt Fiz Kul't [illegible]:56-58; 198[illegible] ([illegible] refs).

[illegible] restoration of the [illegible]. [illegible] of elastic magnets resulted in normalization of the leukocyte count and erythrocyte sedimentation rate [illegible] days [illegible] after the onset of the treatment.

0865 IRRADIATION OF THE THYROID GLAND WITH DECIMETER-BAND ELECTROMAGNETIC WAVES IN THE TREATMENT OF PATIENTS WITH STOMACH AND DUODENAL ULCER. (Rus.) [illegible], V. M. (Central Inst. Balneology and Physical Therapy, Moscow, USSR); [illegible], V. M.; Frenkel', I. D.; [illegible]; Ponomarev, Iu. T.; [illegible]. Ter Arkh [illegible]; 1982 ([illegible] refs).

The therapeutic efficacy of irradiation of the thyroid gland with decimeter-band waves (DBW) was studied in [illegible] patients ([illegible]) with stomach or duodenal ulcers. DBW were generated by [illegible]mashka" apparatus (460 MHz, wave length [illegible], power flux density of 120 mW/cm², [illegible] min/day, for a total of 15-20 irradiations per course). Complete healing of the ulcer was observed in [illegible] of the patients, compared with [illegible] after [illegible] therapy. Remissions of [illegible] and 1.5 yr were observed in 71.5% and 40% of the patients, respectively. DBW irradiations stimulated secretion of thyrotropin and thyroid hormones, reduced gastric [illegible] secretion, reduced gastric acidity, increased blood lysozyme and complement levels, decreased titers of circulating antibodies against stomach and duodenal tissues, and improved gastric motility. These findings indicated that the therapeutic effect of DBW in patients with stomach and duodenal ulcers is associated with stimulation of the [illegible]

0866 [illegible]ORGANISMS AND MAGNETIC FIELDS. (Rus.) Kholodov, Iu. A. (Inst. Higher Nervous Activity and Neurophysiology, USSR Acad. Medical Sciences, Moscow, USSR). Usp Fiziol Nauk [illegible]; 1982 ([illegible] refs).

Current literature data on the biological effects of magnetic fields (MF) and on methods [illegible] biomagnetic fields are reviewed. [illegible] parameters of MF depend upon its [illegible] pulse type, vector, gradient, localization, and duration of exposure. The sensitivity of an organism to MF is associated with its age, sex, and individual characteristics. Response to MF is characterized by a prolonged latent period; changes in the biological parameters of MF produce insignificant changes in response latency. Both slow and fast systems of initial sensory response were observed after exposure to superhigh frequency electromagnetic fields. The initial response to MF is followed by an overall rearrangement reaction and an adaptation reaction. An adaptation response which involved the endocrine system was observed after daily exposures of > 20 min in duration. MF-induced adaptation reactions were associated with changes in erythropoiesis, redox potentials, and cell membrane permeability. Therapeutic applications of MF are associated with increased resistance to infection, temperature exposure, and ionizing radiation. Prolonged exposure to MF induced various pathological changes. The biophysical mechanisms of MF activity can be described by changes in sodium-potassium gradient, orientation of RNA and DNA macromolecules, and polarization of the side-chains of protein molecules.

0807 AUTOALLERGIC EFFECTS OF EXPOSURE OF RATS TO SUPERHIGH FREQUENCY ELECTROMAGNETIC FIELDS AND THEIR ACTION ON THE FETUS AND OFFSPRING. (Rus.) Shandala, M. G. (A. N. Marzeev Res. Inst. General & Community Hygiene, Kiev, USSR); Vinogradov, G. I. Vestn Akad Med Nauk SSSR (10):13-16; 1982 (11 refs).

The role of immunological factors in the mechanism of hazardous effects of superhigh frequency (SHF) electromagnetic fields (EMF) was studied in pregnant Wistar rats. The animals were exposed to SHF EMF generated by a Luch-2 apparatus (500 uW/cm^2) for 7 hr/day during the entire 20-day gestation period. To evaluate the effect of autoantibodies on embryogenesis, pregnant intact rats were immunized with serum from irradiated or intact donor rats. Donor rats were irradiated at 500 uW/cm^2 for 7 hr/day for 30 days. Exposure to SHF EMF resulted in marked stimulation of autoimmune reactions; the average number of plaque-forming cells at the end of the gestation period was 7.3% compared with 1.1% in intact controls. Irradiation of pregnant females caused inhibition of immunogenesis estimated by phytohemagglutinin-induced lymphocyte blast transformation (24.6% compared with 41.7% in controls). Immunization with serum from intact rats did not affect the course of pregnancy, while immunization with serum from irradiated rats resulted in increased embryolethality and decreased viability of the offspring.

0808 CLINICAL ASPECTS OF THE EFFECT OF ALTERNATING MAGNETIC FIELDS ON POSTOPERATIVE COMPLICATIONS. (Rus.) Verzin, A. A. (Dept. E
Diseases, Eye Microsurgery Res. Lab., N. I. Piro
Second Medical Inst., Moscow, USSR); Kolesnikova,
N. Vestn Oftalmol (3):56-57; 1982 (2 refs).

The therapeutic efficacy of alternating magnet
fields (AMF) was studied in 33 patients with post
operative complications following eye surgery. T
patients were divided into three groups: 18 patien
with hypema follwing intracapsular cataract extra
tion (Group 1); 11 with partial postoperative hemo
thalmos(Group 2); 4 with postopererative inhibit
of the cornea with blood (Group 3). Patients fr
Group 1 were exposed to AMF (50-80 Oe) for 4 mi
session for 10 sessions while patients from Grou
2 and 3 were exposed to AMF (80-100 Oe) for 5-8 mi
session. After 2 to 3 AMF applications, ≥ 75%
the patients in Group 1 exhibited resorption of hy
phema compared with 50% of the control group. A
Group 2 patients showed complete restoration of co
neal transparency. In Group 3, half of the patient
showed resorption of the hemorrahage after 10 A
applications versus 36.3% of the controls. AMF a
plications enhanced the normalization of visual ac
ity in patients in all 3 groups.

0809 MICROWAVE THERAPY. (Rus.) Kuleshova,
S. (Dept. Physical Therapy, Central Inst
Advanced Training Physicians, Moscow, USSR). Vo
Kurortol Fizioter Lech Fiz Kult 2:63-67; 1982 (
refs).

Indications for therapy with microwave (MW) radi
tion are outlined. Centimeter-band MW (2375 MH
12.6 cm) is generated by Luch-2 (20 W output powe
and Luch-58-1 (150 W output power) units. Decimet
band MW (65 cm, 460 MHz) is generated by Romash
(20 W) and Volna-2 units. The duration of a sing
irradiation ranges from 5-10 min for Luch-2 a
Romashka units to 10-20 min for Luch-58 and Volna
units. Patients are subjected to daily irradi
tions; the total number of applications per cour
ranges from 5 to 20. The therapeutic effect of M
radiation is associated with thermal and nontherm
actions. MW therapy is indicated for parodontosi
arthritis of the maxillo-temporal joint, inflamm
tion of the paranasal sinuses, furunculosis, tonsil
itis, chronic dermatoses, prostatitis, endocervic
tis, chronic and recurrent nonspecific bronchopu
monary diseases in children, pyelonephtitis in chi
dren, arthritis of the shoulder joint, osteoarthr
tis of the ankle joint, coxarthrosis, osteochondr
sis, rheumatoid arthritis, bronchial asthma, chro
ic pneumonia, peptic ulcer, chronic gastritis wi
hyposecretion, chronic colitis, chronic adnexitis
lactation mastitis, hypertension, renovascular hy
pertension, vibration disease, chronic pyelonephr
tis, and atherosclerosis of cerebral vessels.
therapy is contraindicated in patients with cance
active tuberculosis, fever, hemorrhages, thyrotox
cosis, and cardiovascular insufficiency.

[illegible] CONSTANT MAGNETIC FIELD [illegible] CONSTRICTION OF THE CAROTID AR[illegible] ANOXIA (EXPERIMENTAL STUDY). (Rus.) [illegible] Central Res. Inst. Balneology and [illegible] Moscow, USSR). Vopr Kurortol [illegible] Fiz Kult (3):15-18; 1982 (no refs).

[illegible] effects of constant magnetic fields (CMF) on re[illegible] asphyxia and brain anoxia were studied [illegible] rats. The head of a rat was placed [illegible] poles of heterogenous CMF; induction at the [illegible] surface was 12 mTesla. In the first series of [illegible] experiment, animals were subjected to CMF exposure for 120 min/day for 4 days, followed by constriction of the carotid arteries. Brain function and its recovery were estimated by development of conditioned reflex (avoidance learning). In the second series, the animals were exposed to CMF for 4 and 10 days; the rats were placed in air-tight chambers on days 4 and 10 after exposure, and resistance [illegible] asphyxia was estimated by duration of survival. [illegible] CMF improved the reproducibility of con[illegible] reflex in rats with cerebral anoxia. CMF [illegible] resistance to oxygen deficiency; du[illegible] survival in an air-tight chamber increased [illegible], respectively, after 4- and 10-day ex[illegible].

[illegible] BAND MAGNETIC FIELDS IN [illegible] DISEASES. (Rus.) Kakulia, A. G. [illegible] Koniashvili Res. Inst. Balneology & Physical Therapy, Tbilisi, USSR); Abuladze, L. A.; Glonti, L. [illegible] Melikishvili, M. N.; Urpanishvili, L. S. Vopr Kurortol Fizioter Lech Fiz Kult (3):18-21; 1982 (no refs).

[illegible] therapeutic efficacy of low-frequency alternat[illegible] fields (AMF) was studied in 60 pa[illegible] with arteriosclerosis obliterans and in 3[illegible] with osteoarthrosis deformans. A 10 kHz, [illegible] AMF was generated by a therapeutic apparatus. [illegible] consisted of daily irradiations of the [illegible] min for 15 days. The treatment was [illegible] of the patients with arterioscler[illegible] obliterans. The patients showed the following [illegible] elevation of skin temperature by 0.8-1.6 [illegible] increase in the rheographic index; normaliza[illegible] blood concentrations of total lipids, [illegible] and beta-lipoprotein cholesterol; [illegible] in the bicycle ergometry test. Ex[illegible] AMF resulted in clinical improvement in [illegible] patients with osteoarthrosis deformans. [illegible], increased movement [illegible] of chondroitin sul[illegible] AMF treatment was ineffective [illegible] with [illegible] of the hip joint.

0812 CURRENT THERAPEUTIC [illegible] FIELDS. (Rus.) [illegible] Res. Inst. [illegible] USSR). Vopr Kurort [illegible] 62-67; 1982 (26 refs).

Various therapeutic apparatuses [illegible] magnetic field sources are [illegible] field parameters in the body [illegible] netic field frequency, the type [illegible] size and shape. A magnetic field is characterized by the vector of magnetic induction, [illegible] geneity of magnetic fields is characterized [illegible] gradient of magnetic induction. The magnetic [illegible] source (inductor or magnet) is the [illegible] all devices for magnetotherapy. [illegible] trial apparatus for low-frequency [illegible] the Polius-1, consists of 1-2 inductors operated [illegible] sine-modulated or pulsed 50-Hz current. The [illegible] ian apparatus, the Magnetodiaflux, consists of [illegible] solenoids operated by pulsed 50-Hz and [illegible] rents. The Soviet portable apparatus, the Polius-101, consists of two solenoids generating [illegible] ulated [illegible] Hz magnetic fields; magnetic [illegible] at a distance of [illegible] from the center [illegible] noid is at least 1 mTesla. [illegible] of permanent magnetic [illegible] magnets) include the treatment of [illegible] various proctological and gynecological [illegible]. The maximum magnetic induction at the [illegible] applicator is 35 mTesla.

0813 A DEVICE FOR EXPOSURE [illegible] MATERIALS TO CONSTANT MA[illegible] (Rus.) Golinskaia, M. S. (Experimental Dept., [illegible]tral Inst. Balneology & Physical Therapy, Mos[illegible] USSR); Kozlov, G. D. Vopr Kurortol Fizioter [illegible] Fiz Kult (3):65-66; 1982 (no refs).

A special apparatus was developed to provide [illegible] exact localization of constant magnetic fields [illegible] given body areas of small [illegible]. The device consists of 2 ferrite magnets [illegible] concentrators for the magnetic flux. The [illegible] of the magnetic field between the [illegible] changed by insertion of paper liners. [illegible] was in the shape of a [illegible] plate. The magnets were placed in plexiglas [illegible] attached to vertical stands. The area of the plate of the concentrator was [illegible] the magnet. Changes in the concentrator [illegible] by 180 degrees affected the magnetic field [illegible] tion between the concentrators.

0814 RECOMMENDATION [illegible] PHYSICAL THERAPY [illegible] USSR ACADEMY OF M[illegible] FIELD OF MECHANISM OF ACTION AND [illegible]

TIONS OF MAGNETIC FIELDS. (Rus.) Balneology & Physical Therapy Res. Council (USSR Acad. Medical Sciences). Vopr Kurortol Fizioter Lech Fiz Kult (3):68-69; 1982 (no refs).

Methodological guidelines for experimental and clinical studies have been developed to coordinate research on the biological effects of magnetic fields (MF). Reports should include the following: type of apparatus, type of MF (constant or alternating), pulse duration and frequency, applicator type and size, inductivity in mTesla, location of the applicator, duration of exposures and total number of exposures. The effects of MF should be recorded after the 1st, 5th, and 10th exposures, and following completion of the treatment. Recommendations include the use of MF with inductivity of 3-30 mTesla, a distance of 0-5 cm between the constant magnet or the inductor and the body surface, exposure duration of 10-30 min, and a total of 10-30 exposures. The biological effects studied should include hemodynamic indices, blood coagulation, hematocrit, erythrocyte sedimentation rate, cell membrane permeability for inorganic ions, free radical oxidation, membrane potential, electron paramagnetic resonance, and water structure. Therapeutic efficacy of MF should be tested in patients with acute and chronic aseptic and infectious inflammations of the locomotor apparatus, peripheral nerve diseases, vascular diseases and dystrophic skin diseases.

0815 ALL-UNION SYMPOSIUM ON PHYSICO-CHEMICAL MECHANISMS OF THE BIOLOGICAL ACTIVITY OF STATIC AND LOW-FREQUENCY ELECTROMAGNETIC FIELDS. (Rus.) Kuznetsov, A. N. (Moscow, USSR); Shtemler, V. M. Vopr Kurortol Fizioter Lech Fiz Kult (3):70; 1982 (no refs).

The agenda of the First All-Union Symposium on Physico-Chemical Mechanisms of the Biological Activity of Static and Low-Frequency Electromagnetic Fields is outlined. The symposium was held 19-20 October 1981 in Pushchino, USSR. Six reports and 18 communications were presented. The reports summarized the results of studies of the effects of electromagnetic fields on free radical biochemical reactions, liquid crystal structure of cell membranes, and ferromagnetic inclusions in biological materials. The symposium emphasized the need for further evaluation of maximum permissible levels of exposure to electromagnetic radiation.

0816 EFFICACY OF DECIMETER-BAND WAVES AND MAGNETOPHORE THERAPY IN PATIENTS WITH HYPERTENSION. (Rus.) Orzheshkovskii, V. V. (Dept. of Physical Therapy, Inst. Advanced Training for Physicians, Kiev, USSR); Chopchik, D. I.; Fastykovskii,

A. N. [illegible]

Comparative therapeutic efficacy [illegible] magnetophore therapy [illegible] decimeter-band waves [illegible] resulted [illegible] patients [illegible] improvement [illegible] Magnetophore therapy [illegible] produced [illegible] of the patients [illegible] It was concluded that [illegible] effective in the treatment [illegible] magnetophore applications.

0817 THE EFFECT OF AN ELECTRIC FIELD OF INDUSTRIAL FREQUENCY ON THE INDICES OF NATURAL IMMUNITY. (Rus.) Liubchenko, S. A. (A. N. Marzeev Res. Inst. General & Community Hygiene, Kiev, USSR). Vrach Delo (8):[illegible]; 1982 [illegible] refs.

The results of comprehensive studies of the effects of electromagnetic (EM) fields of industrial frequency (50 Hz) on natural immunity are reported. Chronic exposure of rabbits ([illegible] kV/m, 2 hr/day for 2 mo) resulted in a transient decrease in blood bactericidal activity and beta-lysine levels. Exposure of male albino rats for 2 hr/day to 50 Hz EM fields with intensities of 1, 2, 4, 7, and 15 kV/m caused a transient increase in blood complement activity in animals exposed to 7 and 15 kV/m, while blood bactericidal activity in rats exposed to 50 Hz EM fields did not differ from that in controls. Exposure of human volunteers at 5 kV/m for 2 hr/day for 1 mo did not change complement and lysozyme titers. Exposures to EM fields with intensities of 1, and 15 kV/m (30 min 2/day with 1 hr intervals between the exposures for 10 days) resulted in slight and transient elevation of the complement titer; complement titer and blood bactericidal activity did not differ from those in controls. These findings can be used for the establishment of maximum permissible levels of exposure to 50 Hz EM fields for residential areas.

0818 MORPHOLOGICAL CHANGES IN CENTRAL NERVOUS SYSTEM NEURONS AFTER EXPERIMENTAL EXPOSURE TO CENTIMETER BAND ELECTROMAGNETIC WAVES. (Rus.) Belokrinitskii, V. S. (A. N. Marzeev Res. Inst. General & Community Hygiene, Kiev, USSR)

Vrach Delo (8):105-109; 1982 (13 refs).

The effects of centimeter band (CB) electromagnetic fields (EMF) on the morphology of central nervous system neurons were studied in dogs and cats. CBEMF were generated by a Luch-58 apparatus. The animals were exposed to CBEMF of thermal intensities (400-500 mW/cm²); dogs were irradiated for 4 hr and cats for 1 hr. Morphological changes in the central nervous system included swelling of the neurons, displacement of the nucleus, irregular contours of cell and nuclear mambranes, redistribution of chromatin, and the appearance of vacuoles. The most pronounced changes were observed in neurons from the hypothalamus, limbic area, and temporal lobe. The neurons from the sensorimotor cortex, reticular formation, brain stem, and cerebellum were least affected by CBEMF. Exposure to CBEMF caused morphological changes in the neurons from all regions of the spinal cord.

[illegible] [illegible] LIVER CIRCULATION AFTER COMBINED EXPOSURE TO LEAD AND ELECTROMAGNETIC FIELDS. (Rus.) [illegible], M. M. (Lab. Functional Diagnosis, Res. Inst. Industrial Hygiene and Occupational Diseases, Dept. Medical Radiology, Inst. for Advanced Training of Physicians, Kiev, USSR); Oderii, F. A.; Vrach Delo (8):[illegible]9-111; 1982 (6 refs).

The state of liver circulation was studied in 218 workers who had an occupational exposure to lead vapors and/or super-high frequency electromagnetic (EM) fields. The lead levels and EM field exposures were within the maximum permissible exposure limits. The workers exposed to the EM fields alone showed a significant decrease in liver clearance, inhibition of liver excretory function, and a decrease in the accumulation capacity of liver cells. The changes in liver circulation after combined exposure to lead and EM fields were similar to those after exposure to EM alone.

0820 BRAIN AND LIVER METABOLISM AFTER EXPERIMENTAL EXPOSURE TO SHF-FIELDS OF NONTHERMAL INTENSITIES. (Rus.) *Belokrinitskii*, V. S. (A. N. Marzeev Res. Inst. General & Community Hygiene, Kiev, USSR); Tomashevskaia, L. A. Vrach Delo (10): [illegible]; 1982 (no refs).

The effects of superhigh frequency (SHF) electromagnetic fields on brain and liver metabolism were studied in albino rats. The SHF fields were generated by a Luch-58 apparatus (12.6 cm wavelength). The animals were irradiated at 50 uW/cm² (6 hr/day for 10 days). On day 30 after the last exposure, the rats were subjected to a single irradiation at 500 uW/cm². The metabolic activity of the brain and liver was estimated by [illegible] DNA, RNA, [illegible] concentrations and by activities of succinate dehydrogenase (SDH), malate dehydrogenase (MDH), [illegible] tate dehydrogenase [illegible], [illegible] dehydrogenase [illegible]. [illegible] SHF fields (50 uW/cm²) resulted [illegible] vation of SDH, MDH, [illegible] and hepatocytes, marked inhibition of the oxidati phosphorylation in brain and liver mitochondria, a a mild increase in DNA and RNA levels. Normaliz tion of the histochemical and biochemical [illegible] was observed 1-2 mo after termination of irradi tion. Preliminary exposures to low intensity S fields increased resistance of animals to irradi tion at 500 uW/cm².

0821 EFFECT OF LOW-INTENSITY SHF-ENERGY RESPIRATION AND OXIDATIVE PHOSPHORYLATI IN MITOCHONDRIA AND ACTIVITIES OF VARIOUS BLOOD E ZYMES. (Rus.) Rudnev, M. I. (A. N. Marzeev Re Inst. General and Community Hygiene, Kiev, USS Tarasiuk, N. F.; Kulikova, A. D. Vrach Delo (93-95, 1982 (7 refs).

The effect of a superhigh-frequency (SHF) electr magnetic field (EMF) on energy metabolism was stu ied in random-bred albino rats. The animals we exposed to SHF EMF generated by a Luch-58 apparat (wavelength of 12.6 cm) at a power flux densi (PFD) of 50 uW/cm² (7 hr/day, for 5, 10, 20, or days) or of 500 uW/cm² (single 7-hr exposure). T metabolic changes were estimated by respiration a oxidative phosphorylation in liver and brain mit chondria and by activities of serum transaminas and alkaline phosphatase. Repeated irradiations 50 uW/cm² resulted in temporary inhibition of r spiration, an increase in serum aspartate amin transferase and marked inhibition of alanine amin transferase and alkaline transferase activitie The significant decrease in blood glucose levels days 1 and 5 after exposure to 50 uW/cm² was ind cative of enhanced glycolysis. Single irradiati at 500 uW/cm² failed to induce significant chang in liver and brain mitochondria.

0822 THE EFFECT OF A CONSTANT MAGNETIC FI ON EPILEPTOGENIC FOCI IN RABBIT HIPPOCA PUS. (Rus.) Tyvin, I. I. (Medical Pediatric Ins Leningrad, USSR). Zh Vyssh Nerv Deiat 32 [illegible] [illegible]; 1982 (19 refs).

The effects of heterogeneous magnetic fields M on the functional activity of the hippocampus we studied in rabbits. The animals were subjected administration of [illegible] ml of penicillin soluti into the left or right hippocampus. Penicill injection produced marked changes in electroen phalogram activity and development of epileptoge discharges. Immediately after development of the epileptogenic foci, the elastic magnets were placed above the right and/or left hippocampus. The maximum induction of MF at the magnet surface was 18 or 28 mTesla, the gradient was 30 or 45 mTesla/cm, and the average induction in the area of the epileptogenic focus was 0.3 or 0.5 mTesla. Exposure to a weak heterogeneous MF produced marked stimulation of epileptogenic activity. MF enhanced the epileptogenic activity of the left hippocampus. The mechanisms of the stimulating effects of MF were associated with MF-induced hyperplasia of the glial calls, hypoxic state of brain structures, changes in glycogen metabolism, and changes in neuronal membrane permeability.

0823 ELECTRICAL AND ELECTROMAGNETIC EFFECTS ON OSTEOGENESIS AND BONE GROWTH (EDITORIAL). (Ger.) Ungethum, M. (Aeskulapwerk, Postfach 40, D-7200 Tuttlingen). Munch Med Wschr 124(26):621-622; 1982 (6 refs).

Methods of therapeutic electric osteostimulation and their evaluation are discussed. Current commercial electrical osteostimulation methods are so different in principle and design that it is impossible to evaluate them relative to one another. Electric osteostimulation seems to be indicated in the case of fractures in which repeated surgical interventions were unsuccessful. Ultrasound absorption measurement, x-raying after venography, transcutaneous measurement of the fracture potential, and double-blind methods are available for evaluating the effectiveness of electrical osteostimulation. The problem of quantitative evaluation of therapeutic effects is illustrated by the treatment of loosened total endoprostheses with purely magnetic fields, in which no radiological changes are apparent, even though subjective results suggest the effectiveness of this method. Surgery combined with electrodynamic field therapy was successful in more than 93% of 351 patients with mostly atrophic pseudarthroses of low reactivity after several unsuccessful operations. Electrical osteostimulation improves the retention of autologous spongiosa transplants.

0824 APPLICATION OF PHARMACOLOGICAL METHODS TO *THE STUDY OF BIOLOGICAL EFFECTS OF* MICROWAVE RADIATION DURING LOW-LEVEL IRRADIATION. (Fre.) Klein, M. J. (Div. neurophysiologie appliquee, Centre d'etudes et de recherches de medicine aerospatiale, 26, blvd. Victor, 75996 Paris Armees); Stern, I.; Milhaud, C. L.; Rosolen, S. G. Radioprotection 17(4):225-241; 1982 (34 refs).

Synergistic effects between microwave (MW) radiation and psychopharmacologic agents were investigated in 813 mice and 120 rats. Charles River mice and Wistar rats were exposed to MW power (2.45 GHz, continuous wave, 12.25 cm wave length) provided by an industrial generator (Thomson CHF 12.1, 1.2 kW output power) for 30 min at power densities of 2 and 5 mW/cm². No significant difference was observed in motor activity between irradiated and control mice injected with various dosages of d-l amphetamine sulfate or l-amphetamine sulfate immediately before exposure. MW irradiation had no effect on the incidence or severity of stereotypic events in rats receiving d-l-amphetamine sulfate or apomorphine chlorhydrate before exposure. MW irradiation either *before or after administration* of the convulsant agents bicuculline and cardiazol to mice had no effect on the chronology of convulsions or their average duration; thus exposure to MW did not interfere with the metabolism of the convulsants in mice. There was no evidence of blood brain barrier permeability in mice receiving oxotremorine plus methylatropine before MW irradiation. In motor activty tests in mice, irradiation at 2 mW/cm² significantly potentiated the sedating effects of a 5 mg/kg dose of chlordiazepoxide; the effect was not statistically significant at other dose levels. Although the rectal temperature of control mice was not affected by irradiation at either power level, mice with hypotnermia induced by injection of oxotremorine and apomorphine had significantly higher rectal temperatures after irradiation than nonirradiated mice.

0825 IMPACT OF LOCALIZED MICROWAVE HYPERTHERMIA ON THE PH-DISTRIBUTION IN MALIGNANT TUMORS. (Ger.) Vaupel, P. (Physiologisches Inst., Univ. Mainz, Saarstrasse 21, D-6500 Mainz, W. Germany). Strahlentherapie 158(3): 168-173; 1982 ([illegible] refs).

The effect of localized microwave (MW) hyperthermia (2.45 GHz, 43 C for 1 hr) on pH distribution in mammary adenocarcinoma was studied in 12 female C3H SED-BH mice 10-20 days after sc tumor implantation into the lateral femoral region. Treatment was performed with a special MW applicator connected to a Raytheon magnetron (model CMD-10). Glass pH microelectrodes were used to measure pH values. The mean pH value measured in small tumors weighing [illegible] without appreciable necrosis was 6.75 (6.[illegible]) immediately before hyperthermia. Immediately after tissue temperature returned to the initial value after hyperthermia, the mean pH was 6.21 (5.[illegible]). The reduction in pH value was statistically highly significant (2p < 0.005). The mean pH was 7.[illegible] in large tumors (1.1-1.5 g) in which more than [illegible] of the tumor mass was necrotic. The pH values were significantly higher than in small, nonnecrotic tumors, but showed inhomogeneous distribution. Hyperthermia caused no significant changes in pH in the large tumors. The findings indicate that MW hyperthermia markedly intensifies preexisting tissue acidosis, but causes no significant changes in the pH value in the case of more alkaline values.

0826 COMBINATION OF HYPERTHERMIA AND RADIATION IN CANCER THERAPY. PART I. CLINICAL FINDINGS WITH MICROWAVE-INDUCED HYPERTHERMIA. (Germ.) Abe, M. (Dept. Radiology, Faculty Medicine, Kyoto Univ., Kyoto, Japan), Hiraoka, M., Takahashi, M. Strahlentherapie 158(5):[illegible]; 1982 (11 refs).

Radiotherapy followed by 2,450 MHz microwave (MW) hyperthermia was used to treat 26 patients with malignant tumors refractory to radiotherapy (squamous epithelial carcinomas, adenocarcinomas, malignant melanomas, and myoblastomas). External hyperthermia using tunnel-shaped applicators was used for 22 of these: 8 had recurrent tumors after radiotherapy with total doses exceeding 5,000 rad. The radiation dose administered during the combination therapy was 2,100-4,000 rad. Each MW treatment was 20-30 min, and the total number of fractions was 3-14 (2-5/wk). The temperature reached in the target area was 42.5-43 C. Complete remissions (CR) were achieved in 5/8 patients, partial remissions (PR) in 2/8 and no response occurred in 1/8. Total radiation doses of 1,200-7,000 rad along with 3-26 MW treatment sessions of 20-30 min each (1-5 sessions/wk) were given to 14/22 patients who were not pretreated. The temperature in the target area was [illegible] C. CR was achieved in 7/14 patients, PR in [illegible], and 3 showed no response. Four of the 26 patients underwent radiotherapy (total dose 1,200-[illegible] rad) with MW hyperthermia generated by interstitial applicators. The number of MW therapy sessions was 3-12 (1-2/wk), at 30 min/session. The temperature reached in the target area was 43-46 C. CR was achieved in 1 patient and PR in 3 others.

0827 NONSURGICAL TREATMENT OF UNUNITED FRACTURES BY SPECIFIC PULSED ELECTROMAGNETIC FIELDS. (Germ.) Bassett, C. A. L. (Orthopaedic Res. Lab., Columbia Presbyterian Medical Center, Columbia Univ., New York, NY). Z Orthop 120(4):439-496; 1982 ([illegible] refs).

Clinical and experimental results obtained by specific pulsed electromagnetic (EM) field treatment of fracture non-unions with the EBI Bi-Osteogen System are reviewed. A current of 1-1.5 mV/cm is induced in fluids and cells by the specific pulsed EM field generated by the coils placed on the cast. The coils are applied by the patient every day for [illegible] hr. Infections and the presence of metals do not influence the results. A success rate of 77% was achieved by this treatment in 1,007 patients with fracture nonunions, including 322 with an average duration of disability of 4.7 yr. The same success rate was achieved in 126 patients with fracture nonunions after internal fixation. A success rate of [illegible]% was recorded in a group of [illegible] patients with unsuccessful arthrodeses after removal of knee prostheses, including 18 with infections. A high success rate was also achieved in patients with congenital pseudarthroses, and the results [illegible] rosis are also [illegible] results [illegible] possible [illegible] fracture site and [illegible] months. Clinical studies [illegible] healing of large fractures [illegible] treatment. The treatment had [illegible] effect [illegible] osteotomies in dogs compared to untreated [illegible]. Female beagles with osteotomies after radiation therapy were treated with specific pulsed EM fields. [illegible] radiologically manifest consolidation, alkaline phosphatase activity in the region of the fracture [illegible], mineralization of the fibrous bony tissues and [illegible] vascularization were observed after [illegible] days.

0828 ON THE PROBLEM OF THE HAZARDS OF NONIONIZING RADIATION - MICROWAVES, LASERS, [illegible]. Florian, H. J. (Inn. Medizin & Arbeitsmedizin, Betriebsarzt Siemens AG, [illegible] München [illegible], W. [illegible]). [illegible] Arbeitsmed [illegible] Arbeitsch Prophyl [illegible].

The health hazards of microwave (MW) radiation and related safety standards are reviewed. The depth of penetration and absorption rate of MW are frequency-dependent. The absorption rate is nearly 100% in the 1-3 GHz range in which most radar equipment operates. The safety standard established on the basis of the thermal effect of MW radiation is 10 mW/cm², which corresponds to an increase [illegible] in body temperature during [illegible] irradiation of a body surface of [illegible] with [illegible] W. Exposure of the crystalline lens and of the testicles are most relevant medically in connection with partial body irradiation. Transient infertility was observed after exposure of testicular tissue to MW energy at densities above [illegible] mW/cm². Development of cataract was observed in persons exposed occupationally to MW periodically for several mos at levels exceeding [illegible] mW/cm². However, extensive [illegible] studies on exposed military and civilian personnel failed to show any increase in the incidence of cataracts when age and such as synergistic effects (metabolic disorders, [illegible] drugs) were taken into account. [illegible] > [illegible] mW/cm² at an exposure [illegible] can be considered to be the threshold [illegible] cataract formation in the frequency range [illegible] GHz, as determined in rabbits. The critical temperature of the media of the eye can be considered to be > 45 C. The nonthermal effects of MW include psychovegetative effects (changes in blood pressure and blood picture, and decrease in performance). However, there is no justification for lowering the safety standard in view of such long-term, low-level effects, even though further studies are necessary. The energy flux density [illegible] should not exceed [illegible], averaged over [illegible].

0829 TECHNICAL ASPECTS OF HEAT DELIVERY (MEETING ABSTRACT). (Eng.) Hand, J. W. (MRC Cyclotron Unit, Hammersmith Hosp., London W12, England). Br J Radiol 55(660):941; 1982.

The use of non-ionizing electromagnetic waves (microwaves and radiofrequency) and ultrasound to induce hyperthermia in patients was briefly reviewed. The advantages and disadvantages of a number of techniques were explained through reference to simple physical considerations. The techniques discussed included aperture microwave (MW) sources, interstitial and intracavitary MW sources, localized current fields, interstitial ferromagnetic seeds, capacitive coupling of radiofrequency (RF), inductive coupling of RF and focused ultrasound. The problems associated with heating deep tissues were also addressed, with an emphasis on those techniques commercially available. The availability of non-perturbing thermometers was discussed. Until the advent of suitable non-invasive thermometry, information concerning temperature distributions achieved during therapy will be acquired through a necessarily small number of invasive thermometers. The implications of this limitation in thermal dosimetry for the effectiveness of hyperthermal treatments were outlined.

0830 MICROWAVE RADIATION EXPOSURE INDUCES TRANSLOCATIONS AND UNIVALENTS DURING *SPERMATOGENESIS IN MICE (MEETING ABSTRACT).* (Eng.) Manikowska-Czerski, E. (Bureau Radiological Health, FDA, HHS, 5600 Fishers Lane, Rockville, MD). *J Cell Biol* 95(2):A301; 1982 (0 ref).

In attempts to clarify inconsistent and contradictory results from dominant lethal testing of microwave exposed rodents, cells were examined from testes of mice. For examination, cells were prepared with a modified Meredith technique. Irradiations were at frequencies of 0.915, 2.45, and 9.4 GHz, continuous wave, and 9.4 GHz pulsed, with whole body average absorbed dose rates of 0.05, 0.5, 1, 5, 10, and 20 mW/g. Spermatogonial and spermatocyte I and II metaphases were counted and examined for chromosomal abnormalities. Metaphase numbers decreased below control values at low dose rates, and increased at high dose rates. A dose rate dependent increase in translocations was observed. The incidence of univalency increased at 10 and 20 mW/g. The findings are interpreted to indicate interference with normal spermatogenesis during late spermatogonial and spermatocyte prophase I stages. Further, inheritance of the chromosomal changes seems a possibility.

0831 PULSING ELECTROMAGNETIC FIELDS AFFECT [illegible] CELLULAR REGULATORY PROCESSES (MEETING ABSTRACT). (Eng.) Goodman, R. (Coll. Physicians & Surgeons, Columbia Univ., New York, NY); Bassett, C. A. L.; Henderson, A. S. J Cell Biol 95(2):A474; 1982.

The functional and temporal pattern of general cellular metabolism can be altered by changes in the electrical environment. It was hypothesized that exogenously administered pulsed electromagnetic fields (PEMFs) can be used to trigger prescribed cellular responses. This has been tested in a study of pattern alterations in specific cellular events in the polytene salivary gland chromosomes of the dipteran Sciara coprophila. The experimental design uses both cytological and biochemical methods to follow alterations in the pattern of genetic activity resulting from the use of PEMFs alone or in combination with hormonal induction of puffs, heat shock and variation in the ionic environment. Alterations in transcription and translation were monitored by sucrose gradient centrifugation, gel electrophoresis, cytological nick-translation and transcription autoradiogram. Specifically, both repetitive single pulse (RSP) and repetitive pulse burst (RPB) induced alterations in transcriptional events up to 60 min. The effect of RPB is an increase in RNA synthesis in all size classes following 45 min of pulse. RSP, however, induced a 10-fold increase in the specific activity of mRNA at 15 and 45 min of pulse. This is reflected in the protein synthetic pattern. The results suggest that the two signals evoke distinctly different cellular responses. Induction is influenced by the type of pulse as well as the cellular environment. The recognition of mediating factors in the use of PEMFs should allow us to define more specifically the role of electrical fields in the normal function of the cell.

0832 RADIOFREQUENCY HAZARDS IN THE VLF TO MF BAND (MEETING ABSTRACT). (Eng.) Gandhi, O. P. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112); Chatterjee, I. J Microwave Power 17(4):323; 1982.

The paper gives the currents that can flow through a human body for conditions of conductive contact with ungrounded metallic objects such as cars, trucks, fences, etc. These are then compared to the threshold currents for perception and let go, for frequencies in the 10 kHz - 30 MHz range, deriving thereby the incident electric field intensities for these phenomena to occur. It is shown that the ANSI proposed guideline of 100 mW/cm² (approximately 615 V/m) in the frequency band 300 kHz - 3 MHz may result in a potential for radiofrequency burns for conditions of conductive contact with these commonly encountered metallic objects.

[illegible] IN MEDICAL [illegible] (MEETING ABSTRACT). [illegible] Electrical Engineering, Univ. [illegible] J Microwave Power [illegible]

[illegible] magnetic (EM) techniques have recently [illegible] useful for medical diagnosis, [illegible] are underway to develop them for clinical use. These include impedance plethysmography, [illegible] (MW) methods for lung water measurements, [illegible] techniques, and EM flow meters. Other methods such as the use of MW Doppler radar to monitor arterial wall movements, and EM imaging are in preliminary research stages and still need to be developed. In this paper, we describe the principles underlying the operation of each method and present important results illustrating the advantages and limitations of each method. In most cases it will be noted that, while the EM diagnostic are attractive and promising, much more work still needs to be done before these method become suitable for [illegible] clinical use.

[illegible] SOME COMMENTS ON THE SAFE LIMITS OF EXPOSURE TO 60-Hz ELECTRIC FIELDS (MEETING ABSTRACT). (Eng.) Bridges, J. E. (IIT Res. Inst., [illegible] West 35th St., Chicago, IL [illegible]). J Microwave Power 17(4):[illegible]-324; 1982.

The thrust of programs to determine the safe limits of exposure to electric fields, principally 60-Hz fields, is examined. The major difficulty has been that the effects of 60-Hz electric field exposure are weak and very likely to be overshadowed by other competing factors which are reviewed. Elimination of these factors can lead to long and costly experiments. Since definitive answers to many biological effects may be some time off, some useful interim conclusions can be drawn by comparing human exposures to fields which are routinely experienced in the home and in industrial settings. This approach could be strengthened by making extensive measurements of the household and industrial electric field environments and resulting body currents. Computer aided studies, followed by laboratory verification in animal models, to develop the spatial distribution of body current could also be used to determine comparative exposure levels arising from power-line or household environments.

[illegible] PULSATING ELECTROMAGNETICALLY INDUCED CURRENTS HAVE ANTI-TUMOR ACTIVITY IN VIVO (MEETING ABSTRACT). (Eng.) Norton, L. (Mount Sinai Sch. Medicine, New York, NY 10029); Tausman, L. S.; Pevelson, W.; Geller, S.; Pilla, A. A. J Electrochem Soc 129(3):132C; 1982.

We [illegible] magnetic [illegible] (PEMIC) [illegible] cell membrane [illegible] chemotherapy. [illegible] of PEMIC with [illegible] PYRAN. Mice were treated [illegible] with [illegible] PYRAN [illegible] tween [illegible] Helmholtz coils. The results show that the median survival time [illegible] was [illegible] increased by PEMIC or PYRAN alone [illegible] controls. However, a synergistic response, increasing survival time to [illegible] wk, was observed in [illegible] mice treated with PEMIC and PYRAN. These results provide evidence for an effective and nontoxic anticancer modality. Histology showed enhanced necrosis for PEMIC exposed tumors, suggesting a mechanism of synergy with the macrophage and NK-cell stimulating PYRAN.

0836 EFFECTS OF MODULATED RADIOFREQUENCY ELECTROMAGNETIC RADIATION ON THE EFFLUX OF CALCIUM IONS WITH BRAIN TISSUE IN VITRO (MEETING ABSTRACT). (Eng.) Blackman, C. F. (Experimental Biology Div. (MD-72), Health Effects Res. Lab., EPA, Research Triangle Park, NC [illegible]). J Electrochem Soc [illegible]; 1982.

Radiofrequency radiation [illegible] MHz [illegible] modulated at brain wave frequencies [illegible] causes changes in the rate of efflux [illegible] ed calcium ions from [illegible]. However, only specific [illegible] radiation are effective. [illegible] lated 50-MHz radiation produce similar [illegible] identical findings. The results at different carrier frequencies can be reconciled if the fundamental variable is taken to be the intensity of the electric field within the tissue rather than the intensity of the electric field in free space.

0837 AN ELECTROMAGNETIC FIELDS ANALYSIS OF THE HELMHOLTZ COIL DELIVERY FOR BIOLOGICAL STUDIES (MEETING ABSTRACT). (Eng.) McLeod, B. R. (Dept. Electrical Engineering & Computer Science, Montana State Univ., Bozeman, MT [illegible]); Samson, M.; Pilla, A. A. J Electrochemical Soc [illegible] 132C; 1982.

Helmholtz coils that are being used to induce currents in biological systems are examined. The well known but complex fields equations are presented in graphical form for easy reference. An analysis is also done on an in vitro system in the uniform field region of the coils. Analytical and experimental data are presented and compared. [illegible] attention [illegible] directed at [illegible] perturbation given to a living cell by the Helmholtz coils.

0838 EFFECTS OF ELECTROMAGNETIC FIELDS ON THE CELL SURFACE (MEETING ABSTRACT). (Eng.) Marron, M. T. (Biomedical Res. Inst., Univ. Wisconsin-Parkside, Kenosha, WI 53141); Goodman, E. M.; Greenebaum, B.; Luzander, S. J Electrochem Soc 129(3):133C; 1982.

Effects on the cell surface of Physarum polycephalum amoebae grown in 60 Hz sinusoidal field of 1.0 V/m and 1.0 G can be detected using aqueous two-phase partition chromatography. We report the first direct observation of cell surface effects due to weak, low frequency electromagnetic fields.

0839 THE EFFECT OF PULSING ELECTROMAGNETIC FIELDS (PEMFs) ON RNA TRANSCRIPTION IN POLYTENE CHROMOSOMES (MEETING ABSTRACT). (Eng.) Goodman, R. (Dept. Pathology, Columbia Univ., New York, NY 10032); Henderson, A. S.; Bassett, C. A. L. J Electrochem Soc 129(3):133C; 1982.

Using tritiated uridine incorporation to monitor transcription, RNA was extracted from control and PEMF-treated (single pulse and pulse train) salivary gland cells at 15 min intervals up to 2 hr. Cytologically transcription was monitored by transcription autoradiographically. Biochemically PEMFs induced a marked increase in the specific activity of RNA: (i) the single pulse induces increased specific activity of presumptive messenger RNA (6S-17S) at 15 and 45 min; (ii) the pulse train induces one peak of activity at 45 min in the 18S region; (iii) following peaks in RNA activity induced by PEMFs, fall-off in transcription is sharp and after 60 min, and more prolonged PEMF treatment, specific activities fall below control levels; (iv) the effect of sudden elevated temperature (heat shock) and PEMF together produce a synergistic effect; and (v) by taking the cells in and out of the field, it is apparent that the reduced rate of transcription resulting from long time periods in PEMFs can be reversed. Studies on this rebound effect are discussed.

0840 THE EFFECT OF PULSATING ELECTROMAGNETIC FIELDS (PEMF) ON OSTEOBLAST-LIKE CELLS IN CULTURE (MEETING ABSTRACT). (Eng.) Rodan, G. A. (Dept. Oral Biology, Univ. Connecticut Sch. Dental Medicine, Farmington, CT 06032); Johnson, D. E. J Electrochem Soc 129(3):133C; 1982.

The object of this investigation was to study the mechanism through which PEMF promotes fracture healing. In this study we report the establishment of an experimental system in which PEMF elicits reproducible effects on osteoblast-like cells in culture. Under growth restrictive conditions (in early cultures and at confluence), PEMF stimulates proliferation. This effect is associated with a postponement of phenotypic maturation, as measured by alkaline phosphatase levels. The PEMF effects were proportional to the repetition rate of PEMF in the range of 5-25 Hz. The time course and the pleiotypic nature of PEMF effects are similar to hormone effects in this system.

0841 EFFECTS OF INDUCED ELECTROMAGNETIC FIELDS ON THE HORMONAL RESPONSES OF BONE AND BONE CELLS IN VITRO (MEETING ABSTRACT). (Eng.) Luben, R. A. (Div. Biomedical Sciences, Univ. California, Riverside, CA 92521); Cain, C. D. J Electrochem Soc 129(3):133C; 1982.

The effects of pulsed electromagnetic fields on bone healing are well known. However, the molecular and cellular actions of these fields remain obscure. The current study examined the effects of clinically useful fields on bone and bone cells in tissue culture. Exposure of cells to Bi-Osteogen™ fields produced significant inhibition of several biochemical responses to parathyroid hormone (PTH), suggestion that some or all of the in vivo actions of the fields may be mediated by blocking the osteolytic effects of PTH in localized areas. Studies were also performed to examine the role of the fields in stimulating differentiation of precursor cells into osteoblasts. Further results are discussed.

0842 PULSED ELECTROMAGNETIC FIELD EFFECTS CHONDROBLAST CULTURE (MEETING ABSTRACT). (Eng.) Norton, L. A. (Univ. Connecticut Health Center, Sch. Dental Medicine, Farmington, CT 06032). J Electrochem Soc 129(3):133C; 1982.

Changes in products of differentiation were measured in cultured chondroblasts exposed to a pulsed electromagnetic field (PEMF) for 48 hr. Relative to control groups, PEMF cultures had a decreased glycosaminoglycan, and increased DNA and an enhanced hydroxyproline content per dish. The lysozyme activity increased 2x, the hyaluronic acid in the medium increased, while the total protein of the cultures decreased. Chitotriose, a specific lysozyme inhibitor, abolished the PEMF effects. Addition of exogenous lysozyme augmented the effects. Increase in lysozyme activity in the presence of PEMF was seen when cycloheximide was added to the culture. Thus, lysozyme appears to [illegible]

[illegible]

[illegible] INDUCTION [illegible] VIA ELECTROCHEMICAL [illegible] Pilla, A. A. [illegible] Medical Engineering [illegible] New York, [illegible] 1982.

[illegible] designed to couple to electr[illegible] at the cell surface have been [illegible] biological effect in a [illegible] in vivo cell systems, in[illegible] application to heal recal[illegible] fractures. This study extends the [illegible] information transfer approach to [illegible] active ion transport. It is [illegible] existing correla[illegible] induced current waveform parameters [illegible] processes as active ion [illegible] regeneration, and radial [illegible] in the rat, strongly suggests that [illegible] current induction operates via [illegible] pathways very fundamental to cell [illegible]

[illegible] CURRENTS IN [illegible] NEURONS [illegible] M. [illegible] (Dept. [illegible]

[illegible]

[illegible] Paris, France [illegible]

[illegible] the first effective [illegible] (presented [illegible] strong correlation between [illegible] observed cell surface [illegible] effective stimuli [illegible]

[illegible] EFFECTS OF [illegible] MAGNETIC FIELDS [illegible] THYMIDINE UPTAKE IN MICE [illegible] ABSTRACT), (Proc.) [illegible] Dept. Radiation [illegible] Lexington, KY [illegible] 1982.

Adult BALB/c mice were divided [illegible] mice each. Five of the groups were [illegible] 2 x 20 cm square [illegible] continuously [illegible] (PEMF). The sixth group [illegible] brains, with [illegible] were [illegible] injected with [illegible] removed after [illegible] at 2, 5, [illegible], and 15 Hz, and depressed at 1 Hz with respect to the controls.

0848 ALTERED BIOLOGICAL RESPONSES IN PARAMECIUM INDUCED BY WEAK PULSATING CURRENT (MEETING ABSTRACT). (Eng.) Smith-Sonneborn, J. (Dept. Zool. & Physiol., Univ. Wyoming, Laramie, WY 82071); Pilla, A. A. J Electrochem Soc 129(3):132C; 1982.

The biological response of the single-celled organism Paramecium to specific pulsating current was monitored with respect to longevity and length of cell cycle. Paramecium are eukaryotic protozoan cells which can be viewed as excitable cells capable of generating receptor and action potentials in response to proper electrical, mechanical, or chemical stimuli. Clonal aging in Paramecium provides a model system of cellular senescence which exhibits a species-specific number of cell divisions since the previous fertilization. Cells cultivated continuously in pulsating currents showed significantly (P < 0.05) increased survival relative to controls in response to current signals. The induced voltage was obtained using air-gap coils driven by a programmable power supply (Electro-biology Corp., Fairfield, NJ). The length of the cell cycle was found to be modulated in response to specific pulsating current and was a function of current density.

0849 A CELL ELECTRICAL SIMULATION ACCOUNTING FOR IONS TRANSPORT AND ABSORPTION PROCESSES (MEETING ABSTRACT). (Eng.) Drago, G. P. (Istituto Circuiti Elettronici-C.N.R. 16145 Genoa, Italy); Marchesi, M.; Ridella, S. J Electrochem Soc 129(3):132C; 1982.

A multilayer spherical structure, simulating a cell, is studied under the influence of an alternate electric field. Refining previous works, the cell membrane and the cell nucleus are simulated accounting for ion fluxes and binding processes under linear hypothesis. The parameters of the model are obtained from data of experimental origin. The main quantities of physical and biological interest and their transfer functions, with respect to the external electric field, are computed within each layer. Many of these quantities present multimodal behaviors against the frequency, sometimes with strong maxim a of particular interest (e.g. ion concentrations and fluxes).

0850 ELECTRIC FIELD MEDIATED ION TRANSPORT (MEETING ABSTRACT). (Eng.) Seto, Y. J. (Electron Device & Biophysics Res. Lab., Dept. Electrical Engineering, Tulane Univ., New Orleans, LA [illegible]); [illegible], S. T. J Electrochem Soc [illegible]; 1982.

The effect of electric field perturbation on the diffusional transport of ions has been analyzed. The analysis reveals that periodic time varying electric field may enhance or retard the ion transport depending on the intrinsic system parameters such as the diffusion resistance and ion turnover rate. The theoretical results also present some potential applications of electric fields in the kinetics of pharmacokinetic and localized enzyme systems.

0851 ON-LINE SYSTEM IDENTIFICATION AND EQUIVALENT CIRCUIT MODELING OF BIOELECTROCHEMICAL KINETIC PARAMETERS (MEETING ABSTRACT). (Eng.) Cerf, G. (Dept. Physiology, Coll. Physicians and Surgeons, Columbia Univ., New York, NY 10032); Pilla, A. A. J Electrochem Soc 129(3):132C; 1982.

The identification and estimation of the functional parameters in biological cell response to applied electrochemical stimuli has figured significantly in optimizing electromagnetically induced pulsed signals for clinical use. As it has been demonstrated that biological systems respond to stimuli of specific frequencies and amplitude, it is critical to accurately determine the time constants of cellular transient response. An on-line measurement and analysis technique has therefore been developed to resolve impedance data from 0-10 MHz. The existing frequency domain technique based on the Laplace transform has been replaced by a nonlinear optimization algorithm and results have been obtained for amphibian epithelium and the human red blood cell.

0852 OCULAR CHANGES INDUCED BY MICROWAVE DIATHERMY IN THE RABBIT (MEETING ABSTRACT). (Eng.) Miki, H. (Dept. Ophthalmology, Kansai Medical Univ., Japan); Doi, H.; Miki, K.; Okada, H. Jpn J Ophthalmol 26(1):135; 1982.

An apparatus for microwave (MW) coagulation was developed that emits pulse radiation with 2450 ± 50 MHz and 0-200 W. The rabbit eye was irradiated under various conditions and the ocular changes were studied clinically and histologically. After irradiation with 30 W for 5-30 min, no particular change was noted. After irradiation with 50 W for 6-10 min, a slight cataract developed, and about 1 mo later the cataract was absorbed; subsequently the eye became shrunken. Destructive effects were mainly on the iris, ciliary body and lens, and the [illegible] tumors. [illegible] HT, the [illegible] was [illegible], the [illegible] the whole cellular tissue [illegible]. The MW hyperthermia method may be useful for [illegible] disease [illegible] appropriate energy [illegible] rate [illegible] used.

[illegible] IMMUNITY OF JUVENILE AND ADULT JAPANESE QUAIL EXPOSED TO MICROWAVE RADIATION DURING EMBRYOGENY (MEETING ABSTRACT).

(Eng.) Thaxton, J. P. (Dept. Poultry Science, North Carolina State Univ., Raleigh, NC [illegible]); Galvin, M. J.; McRee, D. I. Poult Sci [illegible]; 1982.

Fertile Japanese quail eggs were exposed to 2.45 GHz [illegible] microwave radiation for the first [illegible] days of embryogenation. Exposed and nonexposed [illegible] of both sexes were reared to either [illegible], [illegible], or [illegible] weeks of age. At these times quail were evaluated for humoral immune responsiveness to sheep red blood cells, delayed hypersensitivity to phytohemagglutinin, and total and absolute circulating levels of leukocytes. All parameters were equivalent in exposed and non-exposed quail at [illegible] weeks of age. However, [illegible] delayed hypersensitivity was reduced in exposed quail, and total and absolute leukocyte numbers were increased in exposed females. Possible sex hormone and age dependent influences on immune responsiveness are feasible explanations of these results.

[illegible] EFFECTS OF MICROWAVE HYPERTHERMIA ON THE UPTAKE OF MISONIDAZOLE BY TUMOR TISSUE IN VIVO (MEETING ABSTRACT).

(Eng.) Neubert, S. (New York Univ., New York, NY [illegible]); Goldfeder, A. Proc Annu Meet Am Assoc Cancer Res 23:[illegible]; 1982 (1 ref.).

A previous report from this lab [illegible] demonstrated that the greatest potentiation [illegible] tumor regression and cure by the radiosensitizer misonidazole (MIS) was achieved when the tumors were [illegible] simultaneously treated with [illegible] and [illegible] MW hyperthermia (HT). The present studies were undertaken to assay the uptake of MIS [illegible] tumor tissue under both ambient and HT conditions. Three transplantable tumor lines were used, all carried in [illegible] mouse hosts: mammary carcinomas designated [illegible]MAH and M12 and a spindle-cell [illegible] designated TLC. Tumor tissue was transplanted s.c. by trocar, and the tumors were studied when they reached a volume of [illegible] ± [illegible]. MIS was injected i.p. at [illegible] body weight. For HT, mice were placed in lead shields with only the tumor exposed, and MW ([illegible] MHz) were directed at the tumor with the intratumor temperature regulated at 42.5 ± 0.5. The tissue was removed and extracted with methanol and water and extracts were analyzed by reversed-phase [illegible]. [illegible] MIS [illegible]. There was [illegible] significant difference [illegible] concentration of MIS at [illegible] temperature [illegible] tissue. When HT was given [illegible] MIS there was a significant reduction in [illegible] uptake in all 3 tumor types: TLC [illegible]%, M12 [illegible]%, [illegible] 29%. When HT was given after MIS, there was [illegible] significant effect on MIS uptake in TLC or M12, while in MAH there was a slight decrease. The results indicate that the potentiating effect of [illegible] HT is probably not due to increased permeability of tissue to the drugs, and the HT is preferably given after drug injection.

[illegible] RADIOFREQUENCY HYPERTHERMIA IN MALIGNANCY: A PHASE I-II STUDY (MEETING ABSTRACT).

(Eng.) [illegible], [illegible]; [illegible]; [illegible], F.; [illegible], R.; [illegible]. Proc Annu Meet Am Assoc Cancer Res [illegible]; 1982 (1 ref.).

Hyperthermia (HT) either alone or in combination with radiation (RTX) and/or chemotherapy (CT) induces tumor (T) regression. Local HT can be delivered with a variety of techniques. Magnetic [illegible] radiofrequency (RF) [illegible] unit, [illegible] through magnetic loop [illegible] coils. In Jan. [illegible] we initiated a phase I-II trial with magnetrode given as [illegible] course [illegible] either [illegible] treatments, given over a [illegible] period. [illegible] either immediately preceding, or following [illegible]. In selected cases, CT was given [illegible] RT. In each patient [illegible] temperature [illegible]. In selected cases intratumoral temperature were measured with thermistor [illegible] with [illegible] system. Sixty [illegible] patients unlikely to benefit from conventional [illegible] entered the trial [illegible] [illegible] ceeds 43 C.

0856 SYNERGY OF PYRAN CO-POLYMER (PYRAN) AND PULSATILE ELECTROMAGNETICALLY INDUCED CURRENTS (PEMIC) AGAINST B16 MELANOMA (M) IN VIVO. (MEETING ABSTRACT). (Eng.) Norton, L. (Mount Sinai School of Medicine, New York, NY 10029); Tansman, I. S.; Regelson, W.; Geller, S.; Pilla, A. A. Proc Annu Meet Am Asoc Cancer Res 23:193; 1982 (1 ref.)

The antineoplastic activity of the immunomodulating polyanion PYRAN, in clinical trial as MVE-2, is enhanced by simultaneous exposure of tumor-bearing mice to PEMIC, a nontoxic, low power, nonthermal, nonionizing current designed to influence membrane-enzyme electrochemistry. This extends the anticancer activity of PEMIC, which has already demonstrated a synergy with cytotoxic combination chemotherapy in the M system. One hundred female BDF_1 or BCF_1 mice were given no drug or PYRAN 75 mg/kg ip 1 or 7 days after sc implantation of 1 mm^3 M. Mice randomized to receive PEMIC were placed 4/cage between air-gap coils (Electro-biology, Fairfield, NJ) inducing 2 Hz currents of 50 msec bursts of 250 usec main polarity, 4 usec opposite polarity, peak density 0.1-1 uA/cm^2, for 12 hr/day from day 2 continuously. Dummy cages were used for nonPEMIC mice. Species or day of thereapy did not influence survival. At a median survival of 7 wk, 24 mice with PEMIC alone were not *different from 28 mice* with PYRAN alone or untreated controls, although 20% of PYRAN-only mice has a slight survival improvement. However, 20 mice with both PYRAN and PEMIC had a median survival in excess of 10 wk ($x^2 = 6.63$, $p < 0.05$). This was due to an inhibition of the initial pseudo-exponential portion of the Gompertzian growth curve, resulting in an overall displacement of the survival curve for 100% of mice. Histology suggested enhanced necrosis of PEMIC-exposed tumors, which suggests the mechanism of synergy with the macrophage and NK-cell stimulating PYRAN.

0857 SELECTIVE RESPONSE OF TUMORS TO MICROWAVE HYPERTHERMIA (MEETING ABSTRACT). (Eng.) Goldfeder, A. (Cancer & Radiobiological Res. Lab., New York Univ., New York, NY 10003); Perrino, P. Proc Annu Meet Am Assoc Cancer Res 23:220; 1982 (1 ref).

Previous studies in this laboratory used microwave (MW) hyperthermia as an adjunct to x-irradiation and misonidazole. The present study is concerned with effects induced by MW hyperthermia alone. Two mouse mammary carcinomas (MT2, DBAH) and a spindle cell sarcoma (TEC) of standard size growing in isogenic hosts have been exposed to 4250 MHz induced MW hyperthermia at 42-43 C for a predetermined time of 60 min for 5 days. Measurements of treated and control tumors were made daily. At 12-24 hr posttreatment the tumors increased slightly, presumably due to edema. Shrinkage of tumors started at about 48 hr later. Of the three types of tumors treated, the DBAH proved most thermosensitive, regressing completely within 2-3 wk after treatment. The MT2 carcinoma similarly treated formed a dark crust in the center while new growth appeared at the edge of the treated tumor. Of the TEC tumors treated daily for 60 min, 75% totally regressed, the remainder continued to grow at a slower rate. The results indicate a difference in thermoresponse among the three tumor types and emphasize the significance of studying each tumor type individually. The mechanism(s) of MW effects on cellular components is being studied by high pressure liquid chromatography and will be presented.

0858 CLINICAL PILOT TRIAL OF RADIOFREQUENCY (RF)-INDUCED REGIONAL HYPERTHERMIA OF SUPERFICIAL (SF) AND DEEP-SEATED (DS) TUMOR LESIONS (MEETING ABSTRACT). (Eng.) Choksi, J. (M. D. Anderson Hosp. and Tumor Inst. Houston, TX 77030); Corry, P.; Headley, D.; Bernadino, B.; Barlogie, M. D. Proc Annu Meet Am Soc Clin Oncol 1:21; 1982.

A clinical pilot trial was conducted to evaluate anti-tumor effects and toxicities of RF-induced regional hyperthermia for the treatment of recurrent SF (27 patients) and DS (6 patients) tumor lesions unresponsive to conventional therapy. Histologic diagnosis included 16 sarcomas, 11 breast cancer and 6 miscellaneous tumors. Treatment for 1 hr at a desired starting temperature of 43 C was administered daily for 5 days/wk for 2 wk followed by a 2 wk treatment-free interval. Subsequent heating was performed using gradual increments in temperature to a maximum of 52 C. A RF apparatus operating at 13.56 MHz served as a heating source. The maximum tumor temperature was independent of histopathology, size of treated lesions and prior exposure to ionizing radiation. The overall objective response rate for 25 evaluable patients receiving at least 5 consecutive treatments was 44% including 2 complete and 9 partial remissions. Three additional patients had a minor response. RF-induced anti-tumor effects were temperature-dependent, i.e. lack of tumor regression below 42 C including 8 SF and 3 DS tumor lesions; while 55% of 11 patients treated at 42 to 48 C responded, and heating to > 48 C induced responses in all 6 patients treated. Tumors treated at ≥ 46 C showed longer remission duration than those treated at < 46 C. Pain was the treatment-limiting toxicity in 15 patients. Blisters were noted in 4 patients, and 1 patient each developed bleeding and infection. Thus, externally applied RF-induced regional hyperthermia is a safe and effective antitumor treatment modality with minimal biological effect at temperatures ≤ 42 C, whereas higher temperatures produce tumor regression in half of the treated patients.

0859 PRODUCTION OF WHOLE BODY HYPERTHERMIA BY MICROWAVE ENERGY (MEETING ABSTRACT). (Eng.) Hornback, N. B. (Indiana Univ. Sch. Medicine, Indianapolis, IN 46223); Shupe, R. E.; Morphis, J. G.; Marshall, C. Proc Annu Meet Am Soc Clin Oncol 1:52; 1982.

Hyperthermia in cancer therapy has been viewed with increasing interest; however, an effective, reproducible method has been needed for local and whole body hyperthermia. A variety of techniques and equipent has been developed to produce localized hyperthermia with a fairly consistent degree of reproducibility. Whole body hyperthermia has been produced by either extremely expensive or mostly unsatisfactory methods including: 1) injection of bacterial toxins, 2) heated steam cabinets, 3) inhalation of heated gases with hot wax baths, 4) circulating heated water body suits, and 5) heated blood perfusion techniques. Over the past 18 mo, 29 patients with advanced cancer have undergone a total of 141 body hyperthermia treatments utilizing microwave generators. Core body temperatures of between 40.5 and 41.5 C were maintained for 60 to 120 min in these patients. The procedure and equipment used to produce the desired levels of temperature for varying periods of time provides a safe, reliable and inexpensive method for whole body hyperthermia. This simplified technique will be described in detail and preliminary results of therapy will be presented.

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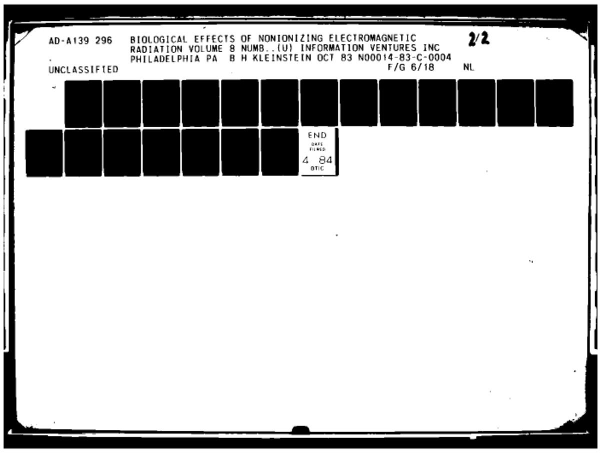

AD-A139 296 BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION VOLUME 8 NUMB..(U) INFORMATION VENTURES INC PHILADELPHIA PA B H KLEINSTEIN OCT 83 N00014-83-C-0004 2/2

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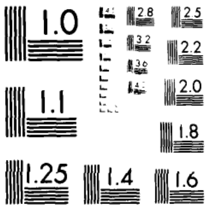

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NATIONAL BUREAU OF STANDARDS 1963-A

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