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

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BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION

A Digest of Current Literature and a Forum of Communication

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Literature Selected and Abstracted

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PREFACE

Biological Effects of Electromagnetic Radiation is a publication researched and prepared by the Franklin Institute Research Laboratories, Science Information Services Department, under a grant from the U. S. Army Research Office. The grant is co-sponsored by the Bureau of Radiological Health, Food and Drug Administration; Office of Naval Research; U. S. Navy Bureau of Medicine and Surgery; U. S. Air Force School of Aerospace Medicine; and the Walter Reed Army Institute of Research. The U. S. Environmental Protection Agency is cooperating in this project.

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

Biological Effects of Electromagnetic Radiation is published quarterly. Volume I, 1974, consists of three issues, which cover the scientific literature published from July 1973 through December 1974. The first several issues also cover past work of importance. The quarterly issues of Volume II, and future volumes, will include materials received during the preceding three months. Each issue will include news items and announcements, a listing of meetings and conferences, abstracts of current literature, and a directory of current research. Articles carried over because of space limitations and materials for which full text is not available will be included as citations. When available, a special report section, technical note, book review, or topical retrospective literature survey will be included.

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ABBREVIATIONS AND ACRONYMS

- A -

A, amp - ampere
ac - alternating current
AF - Air Force
AMP - adenosine monophosphate
ANSI - American National Standards Institute
ARP - adenosine triphosphate

- B -

bpm - beats per minute
BRH - Bureau of Radiological Health
BSA - bovine serum albumin
BSI - British Standards Institute
BUN - blood urea nitrogen

- C -

c - cyclic
C - centigrade
CISPR - Comite International Special des Perturbations Radioelectrique (Special International Committee on Radio Interference)
CL - Current Literature
cm, cm^2 - centimeter, square centimeter
CNS - central nervous system
cps - cycles per second
CR - Current Research
CW - continuous wave

- D -

dB - decibel
dc - direct current
DOD - Department of Defense

- E -

E, $\hat{E}$ - electric field
ECG - electrocardiogram
EEG - electroencephalogram
EHF - extremely high frequency
ELF - extremely low frequency
EM - electromagnetic
EMC - electromagnetic compatibility
EMF - electromagnetic field
EMI - electromagnetic interference
EMP - electromagnetic pulse
EMR - electromagnetic radiation
EPA - Environmental Protection Agency
ES - electrostatic
ESF - electrostatic field

- F -

f - frequency
FDA - Food and Drug Administration
FM - frequency modulation

- G -

g - gram
G - Gauss
GH - growth hormone
GHz - gigahertz

- H -

H, $\hat{H}$ - magnetic field
Hb - hemoglobin
HEW, DHEW - Department of Health, Education and Welfare
HF - high frequency
hr - hour
Hz - hertz

- I -

IEEE - Institute of Electronic and Electrical Engineers
IMPI - International Microwave Power Institute
i.p. - intraperitoneal
IR - infrared
ISM - assigned industrial, scientific and medical frequencies
i.v. - intravenous

- J -

J - joule

- K -

kA - kiloampere
kg - kilogram
kHz - kilohertz
km - kilometer
kV - kilovolt
kW - kilowatt

- L -

l - liter
LDH - lactate dehydrogenase
LF - low frequency

- M -

m, m^2 - meter, square meter
mA - milliampere
mc - megacycle
MF - medium frequency
mg - milligram
mho - unit of measurement of conductivity
MHz - megahertz
min - minute
ml - milliliter
mm - millimeter
mmho - millimho
mon - month
mW - milliwatt
Mw - megawatt
MW - microwave
mV - millivolt

ABBREVIATIONS AND ACRONYMS

- N -

NADH - reduced nicotinamide adenine dinucleotide
NBS - National Bureau of Standards
NIH - National Institutes of Health
NIR - nonionizing radiation
nm - nanometer
NMR - nuclear magnetic resonance
nsec - nanosecond
NSF - National Science Foundation
NIOSH - National Institute for Occupational Health and Safety
NTIS - National Technical Information Service

- O -

ONR - Office of Naval Research
OSHA - Occupational Safety and Health Administration
OTP - U.S. Office of Telecommunications Policy

- P -

P - pulsed
PEMF - pulsed electromagnetic field
PFD - power flux density
PHS - Public Health Service
PMF - permanent magnetic field
pp - pulsed power
pps - pulse per second
PRR - pulse repetition rate
PW - pulsed waves

- R -

R - Roentgen
RBC - red blood cell
RC - resistance-capacitance
RF - radiofrequency
RMF - rotating magnetic field
RNA - ribonucleic acid
rpm - revolutions per minute

- S -

s.c. - subcutaneous
sec - second
SGOT - serum glutamic oxalacetic transaminase
SHF - super high frequency

- T -

TEM - transverse electromagnetic mode

- U -

U - unit, units
UHF - ultra high frequency
USAFSAM - U.S. Air Force School of Aviation Medicine
USDA - U.S. Department of Agriculture
UV - ultraviolet

- V -

V - volt
VA - Veterans Administration
VLF - very low frequency
vol - volume

- W -

W - watt
WBC - white blood cell
WG - waveguide
WHO - World Health Organization
wt - weight

- Y -

yr - year

SYMBOLS

ε - dielectric constant
λ - wavelength
μ - micro
σ - *specific conductance*
Ω - ohm
$\sim$ - approximate
γ - gamma

Biological Effects Electromagnetic Radiation II(2), June 1975

NEWS ITEMS

CONFERENCE ON BIOLOGIC EFFECTS OF NONIONIZING RADIATION, NEW YORK, 1974

Abstracts of the proceedings of the conference on Biologic Effects of Nonionizing Radiation, which was held by The New York Academy of Sciences on February 12-15, 1974, are included in the Current Literature section of this issue of *Biological Effects of Electromagnetic Radiation Digest* (CL 0480 through CL 0530). The proceedings were published in *Annals of the New York Academy of Sciences*, volume 247, 1975.

MICROWAVE TREATMENT OF BRONCHIAL ASTHMA

V. M. Inyushin, et al. have announced a way to treat bronchial asthma by EM irradiation using monochromatic coherent rays on acupuncture skin locations. This method, which lowers undesirable side effects of prolonged irradiation, is based on irradiation of the thorax localization for ten sec to two min at 0.1-20 mV for 10-20 days. *Soviet Inventions Illustrated*, W(11):1, 1975

UTAH BIOENGINEERING NEWSLETTER RESEARCH REPORTS

A research program is underway at the University of Utah to determine the feasibility of reflected and transmitted MW radiation to measure pulmonary parameters. This research is being performed by C. Durney and associates with assistance from Dr. Alan Toronto, Medical Director at Utah Biomedical Test Laboratory.

A research program to determine the therapeutic effects of combined hyperthermia and x-ray radiation treatment for abdominal cancer is being conducted using a special 915 MHz waveguide irradiation apparatus. A liquid crystal fiberoptic temperature probe is invaluable in monitoring and controlling body temperature. Cellular assays are being directed at determining possible thermal enhancements for differential cancer/normal cell destruction.

Utah Bioengineering Newsletter, May, 1975

EPA SEEKING DATA ON HIGH-VOLTAGE LINES

The EPA is collecting data to determine whether or not there is a need to provide radiation standards to protect the public from environmental effects associated with the operation of extremely high voltage (≥ 700 kV) power lines. It is estimated that 10,000 miles of lines at 765 kV or higher will be built in the next 15 yr and system voltages up to 2000 kV are considered feasible. *Mach. Des.* 47(13):18, 1975

ZEUGMATOGRAPHY

Paul C. Lauterbur, University Center at Stony Brook, New York, has invented a process to study tissues in living animals using zeugmatography, a technique in which images are revealed through the interaction of radiowaves and a magnetic field. When small animals are simultaneously exposed to LF radio waves and placed between the poles of a circular magnet, a small fraction of the RF energy is intercepted by the spinning nuclei of hydrogen atoms in the water of the animal tissue. These nuclei glow, and when the transmitter is turned off the glow fades quickly in some organs, slowly in others, and most slowly in malignant tissue. The radio glows can be resolved into images and, by use of a nonuniform magnetic field, may be tuned in and obtained, usually with the help of computer calculations. Equipment will be assembled to project these images on a TV screen with color coding to denote rates at which glows fade. Eventually equipment large enough to accommodate a whole human being and reveal images transparent to x-rays will be available. *Chemistry* 48(6):23-24, 1975

MICROWAVE WORKSHOP

Microwaves as an Adjunct to Cancer Treatment, a workshop arranged by the American Association for the Advancement of Science and the National Cancer Institute, Division of Cancer Treatment, was held at the National Institutes of Health, Bethesda, Maryland, on April 24, 1975. The workshop was chaired by Dr. E. R. Atkinson, with Dr. F. J. Adrian, Dr. J. B. Block, Dr. P. D. deIpolyi, Dr. J. W. Frazier, Dr. B. C. Giovanella, Dr. A. C. Hollinshead, Dr. A. W. Guy, Dr. E. Postow, Dr. H. P. Schwan, Dr. M. Stamm, and Dr. S. J. Webb participating.

ITEMS FROM THE COMMERCE BUSINESS DAILY

o RESEARCH ON THE EFFECTS OF RADIOFREQUENCY RADIATION.

The Office of Naval Research, Arlington, Virginia, has contracted with Wayne State University, Detroit, Michigan, for the above study. (April 2, 1975)

o EFFECTS OF MICROWAVE RADIATION ON THE NERVOUS SYSTEM.

The National Institute of Environmental Health Sciences is interested in receiving contract proposals for the above study. (April 25, 1975)

o AUDITORY NEURAL RESPONSE OF CATS TO LOW-POWER PULSED MICROWAVE IRRADIATION: A PILOT STUDY.

The Environmental Protection Agency proposes to contract with Research Triangle Institute, North Carolina, for the above study. (May 9, 1975)

o STUDY ON THE EFFECTS OF MICROWAVE RADIATION OF THE CENTRAL NERVOUS SYSTEM.

The Food and Drug Administration, Rockville, Maryland, has contracted with George Washington University, Washington, D. C., for the above study. (June 6, 1975)

o RESEARCH ON INVESTIGATION OF OCULAR EFFECTS OF CHRONIC EXPOSURE OF PRIMATES TO MICROWAVE RADIATION AT 2.45 GHz.

The U.S. Army Medical Research and Development Command, Washington, D.C., has contracted with Stanford Research Institute, Menlo Park, California, for the above study. (June 11, 1975)

GENETIC MUTATIONS FROM RADIO WAVES?

Sidney Mittler, of Northern Illinois University, has reported results of experiments on fruit flies exposed to radiofrequency radiation. The flies were exposed for 12 hours to radiation of 146 and 29 MHz, frequencies used by ham radio operators. The flies exhibited no genetic damage although they received 600 times the energy that one would be exposed to while standing at the base of a 300 foot antenna of a 50,000 W FM transmitter. *Science News* 107(21): 339, 1975.

THE OFFICE OF RADIATION MEASUREMENTS: A NEW NBS VENTURE

A new Office of Radiation Measurements is being established in the Institute for Basic Standards in NBS. This organization will serve as a means of increasing the contacts between the extensive radiation measurement activities within NBS and the user groups throughout the country. The goals of ORM are fourfold: to promote the effective transfer to federal, state and local regulatory bodies and to the medical community the capability for measurement of radiation at levels that may be biologically hazardous, to assist the technical divisions in monitoring the radiation measurement needs of these groups, to coordinate and assist the technical divisions in their activities undertaken to meet these needs, and to maintain liaison with other organizations with related environmental, energy, health or safety programs.

SOVIET MICROWAVES CAUSE ALARM

Jack Anderson and Les Whitten have reported that the USSR is aiming a microwave beam at the United States believed to keep a round-the-clock watch on U.S. missile sites in the Dakotas. The rays are so powerful that Russians in the area have been moved out and are monitoring the beam by computer from a distance. Just across the border, Finns have developed very high rates of cancer and heart disease. Ilomantsi, the town nearest the MW station, has the highest rate of any place its size in the world, according to the World Health Organization. Dr. Milton Zaret, who investigated the situation, blamed the installation for the diseases. *Washington Merry-Go-Round*, May 16, 1975

ORGANIZATION OF THE NATIONAL CONFERENCE ON RADIATION MEASUREMENTS

A new National Conference on Radiation Measurements is being formed to provide a forum for discussion, to assist member organizations in their planning, to sponsor technical meetings on radiation measurements, and to promote the development of uniform regulations and procedures. A planning meeting will be held June 11, 1975, and an organizing meeting will be held August 27, 1975 at NBS. Planned participants include the states, federal regulatory agencies, the medical community, industrial organizations, standards writing groups, representatives of the general public, and the National Bureau of Standards.

MEETINGS AND CONFERENCES

****** XXII INTERNATIONAL CONGRESS OF AVIATION AND SPACE MEDICINE**

Date: October 7-11, 1974
Place: Beirut, Lebanon
Sponsor: International Academy of Aviation and Space Medicine
Requests for Information: Dr. F. H. Zebouni, POB 206, MEA Medical Department, Beirut International Airport, Lebanon

Selected Bibliography of Papers to be Presented:

PROTECTION AGAINST MICROWAVE HAZARDS. K. D. Woolas (Minist. Def., United Kingdom).

****** ELECTROMAGNETIC COMPATIBILITY INTERNATIONAL SYMPOSIUM**

Date: July 13-16, 1975
Place: Washington, D.C.
Sponsor: Institute of Electrical and Electronics Engineers
Requests for Information: W. C. Green, 1625 Eye St., NW, Washington, D.C. 20006

****** EUROPEAN MICROWAVE CONFERENCE 1975**

Date: September 1-4, 1975
Place: Hamburg, Germany
Sponsor: VDE, in cooperation with the Convention of National Societies of Electrical Engineers of Western Europe, IEEE, International Microwave Power Institute, German National Committee of URSI, and Microwave Exhibitions and Publishers, Ltd.
Requests for Information: Dr. H. J. Schmitt, Conference Chairman, Philips Forschungslaboratorium, Vogt Koellnstrasse 30, D2 Hamburg 54, W. Germany

****** ELECTROMAGNETIC COMPATIBILITY SYMPOSIUM**

Date: October 7-9, 1975
Place: San Antonio, Texas
Sponsor: Institute of Electrical and Electronics Engineers
Requests for Information: W. E. Cory, Southwest Research Institute, Box 28510, San Antonio, Texas

****** USRI/USNC 1975 ANNUAL MEETING**

Date: October 20-23, 1975
Place: Boulder, Colorado
Sponsors: URSI, in cooperation with the Institute of Electrical and Electronics Engineers
Requests for Information: Prof. J. R. Wait, Rm. 242, RBl, CIRES, University of Colorado, Boulder, Colorado 80302

****** RADIOLOGICAL SOCIETY OF NORTH AMERICA**

Date: November 30-December 5, 1975
Place: Chicago, Illinois
Sponsor: Radiological Society of North America
Requests for Information: T. A. Tristan, MD, RSNA

****** INTERNATIONAL MICROWAVE SYMPOSIUM**

Date: June 14-16, 1976
Place: Cherry Hill, New Jersey
Sponsor: Institute of Electrical and Electronics Engineers
Requests for Information: IEEE (tentative)

****** MEASUREMENTS FOR THE SAFE USE OF RADIATION TECHNICAL CONFERENCE**

Date: March 1-4, 1976
Place: Gaithersburg laboratory of NBS
Sponsors: Conference of Radiation Control Program Directors, Health Physics Society, and American Association of Physicists in Medicine
Requests for Information: J. M. Wyckoff, Radiation Safety Coordinator, National Bureau of Standards, Washington, D.C. 20234 (301) 921-2029

****** RADIATION RESEARCH SOCIETY ANNUAL MEETING**

Date: May 11-15, 1975
Place: Miami Beach, Florida
Sponsor: Radiation Research Society
Requests for Information: W. C. Dewey, Dept. Rad. and Rad. Biol., Colorado State University, Fort Collins, Colorado 80521

Selected Bibliography of Papers to be Presented:

INTERACTION OF DAMAGE DUE TO IONIZING AND NONIONIZING RADIATION IN CHINESE HAMSTER CELLS. A. Han (Argonne Natl. Lab., Argonne, Ill.) and M. M. Elkind.

RADIATION INACTIVATION OF HUMAN LYMPHOCYTES. D. Kwan (Univ. California, Los Angeles) and A. Norman.

CELL MEMBRANE DAMAGE IN CULTURED MAMMALIAN CELLS EXPOSED TO ULTRASOUND. B. I. Martins (Lawrence Berkeley Lab., Berkeley, Calif.), M. R. Raju, T. L. Hayes, and C. A. Tobias.

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THE EFFECTS OF MICROWAVES ON THE TRANSPORT OF ASCORBIC ACID IN THE RABBIT LENS. J. R. Rabinowitz (Med. Cent., New York Univ., New York) and R. B. Olcerst.

****** MICROWAVE POWER SYMPOSIUM 1976**

Date: July 27-30, 1976
Place: Leuven, Belgium
Sponsor: International Microwave Power Institute
Requests for Information: Robert V. Decareau, P. O. Box 247, Amherst, New Hampshire 03037

CURRENT LITERATURE

0455 NEUROTRANSMITTER CONTENT OF MOUSE BRAIN AFTER INACTIVATION BY MICROWAVE HEATING. *(E.)* Merritt, J. H. (U.S. Air Force Sch. Aerosp. Med., Brooks Air Force Base, Tex.), M. A. Medina, and J. W. Frazer. *Res. Commun. Chem. Pathol. Pharmacol.* 10(4):751-754, 1975.

Norepinephrine, dopamine, serotonin, 5-hydroxyindoleacetic acid, and homovanillic acid were assayed in mouse brain after rapid MW inactivation of the brain enzymes. Male Swiss mice (20-25 g) were sacrificed in a MW inactivation system (300 msec at 6 kW). Brain temperatures immediately after inactivation were 75 C. Control mice were sacrificed by cervical dislocation. In both cases the brains were removed, homogenized in acidified butanol, and assayed for neurotransmitters and metabolites. The content of the assayed materials was significantly higher in the brain tissue of irradiated mice than in the brains of unirradiated controls: norepinephrine was 1153 ng/g brain tissue in irradiated mice, 436 ng/g in controls; dopamine 1702 ng/g in irradiated mice, 1068 in controls; similar results were obtained for other assayed materials. Thus, values obtained after conventional methods of sacrifice may not reflect *in vivo* concentrations. The increase may represent a neurotransmitter pool with a very rapid turnover rate. (6 references)

0456 HUMAN WHOLE-BODY EXPOSURE TO INFRASOUND. *(E.)* Slarve, R. N. (Aerosp. Med. Res. Lab., Wright-Patterson Air Force Base, Ohio), and D. L. Johnson. *Aviat., Space, Environ. Med.* 46(4): 428-431, 1975.

Recent reports have attributed serious psychophysiological effects to infrasound, low frequency sound in which pressure variations are below 20 Hz. Levels of infrasound which are of practical concern should be determined so that humans may be protected from unnecessary routine exposure. A dynamic pressure chamber (DPC) was constructed in which human whole-body exposure experiments were run. Four normal subjects were chosen for a series of 8 min runs at 120-144 dB and 1-30 Hz. Prior to the run, preexposure audiograms were performed and state of health was checked. Three electrodes were placed on the chest, respiration rate was measured and an ECG was obtained. Heart and respiration rate were continuously monitored, and visual and audio contact was maintained. The subject remained seated but performed simple tasks. Post-exposure otoscopic examinations and audiograms were performed. There were no significant changes in hearing threshold levels. Painless pressure buildup was consistently reported, as well as 34/55 observations of chest and/or abdomen vibrations, probably due to direct transmission from DPC surfaces. Voice modulation, which correlated with the vibratory phenomena of the chest, occurred frequently; however, there was no interference with speech understanding. A few episodes of decreased ability to concentrate, drowsiness and time contraction were reported although there was no objective evidence of the primacy of infrasound in this type of response. None of the effects consistently observed would indicate that infrasound exposures as high as 144 dB are harmful to healthy subjects. (4 references)

0457 EFFECT OF ELECTRIC FIELDS ON GROWTH RATE OF EMBRYONIC CHICK TIBIAE IN VITRO. *(E.)* Watson, J. (Dep. Electr. Eng., Univ. Col., Swansea, Univ. Wales, U.K.), W. G. deHaas, and S. S. Hauser. *Nature* 254(5498):331-332, 1975.

Embryonic chick tibiae grown *in vitro* were subjected to a static, non-varying electric field (1000 V/cm) and a pulsed, transverse electric field (100 V/cm at 1 pulse/sec); gross development was measured. The 8-9-day-old embryos were decapitated and the tibiae excised with one bone serving as experimental material and one as control. The bones were incubated for 9 days. In static field experiments, no significant differences were observed between test and control fractional increases. The pulsed field experiments resulted in clearly significant increases in the ratio of test to control bones (1.12:1). Macroscopic and microscopic studies revealed no differences in growth patterns between the two sets of bones. The conclusion is that the embryonic bone has a transducer mechanism which allows the electric field to interact directly and modify the growth rate of hydroxyapatite since the bones are in a pre-osseous phase. Because only pulsed fields have an effect, repeated cycles of charge separation are involved. (7 references)

0458 INTERACTION OF ELECTROMAGNETIC TRANSIENT RADIATION WITH BIOLOGICAL MATERIALS. *(E.)* Lin, J. C. (Dep. Rehabil. Med., Univ. Washington Sch. Med., Seattle). *IEEE Trans. Electromagn. Compat.* EMC-17(2):93-97, 1975.

The nature of EM pulse interaction with living systems was studied using frequency dependent complex dielectric properties. The problem is formulated in the frequency domain using a mathematical model for a Gaussian pulse impinging normally on a semi-infinite plane layer of muscle material. Results indicate that the incident pulse undergoes severe reflection upon striking the biological medium, and the transmitted pulse amplitude is quite small. For example, for an incident pulse of 50 kV/m, the transmitted pulse strength for a pulse width of 1 μsec is 221 V/m. The transmitted pulse is independent of location within the depths (≤ 30 cm) of interest, indicating that the medium exerts no appreciable effect on pulse width for sufficiently narrow pulses. Considerable broadening takes place for longer pulses. (15 references)

0459 EFFECTS OF MICROWAVE IRRADIATION ON EMBRYONIC BRAIN TISSUE. *(E.)* Rioch, D. M. (Inst. Behav. Res., Inc., Silver Spring, Md.). *U.S. Army Res. Off. Rep.*, Contract No. DAHC04 74 C 0004, 1974, 7p.

Experiments were conducted to replicate earlier observations which showed that radiation on the 13th day of gestation stimulated the growth process. Different strains of rats were irradiated in an anechoic chamber and in a MW oven for 20 min to 16 hrs at 5 - 30 mW/cm^2. Most rats were sacrificed on the 19th day of gestation. All except one group were exposed early in the diurnal cycle between 0700 and 1100 hrs and showed no significant differences between control and exposed fetuses. For the last group, exposed at 1700 hrs or overnight, the average fetus weight was significantly greater than that of the control group ($p \leq 0.005$), with the control group weighing approximately 10% less and brains approximately 10% smaller than experimental rats. Thus, there may be a critical period in the diurnal cycle (circadian rhythm) during which radiation is effective in increasing the growth rate. (4 references)

0460 FISH MUSCLE IN THE FROZEN STATE: TIME DEPENDENCE OF ITS MICROWAVE DIELECTRIC PROPERTIES. *(E.)* Kent, M. (no affil.). *J. Food Technol.* 10(1):91-102, 1975.

Experiments were performed to determine permittivity and loss in frozen fish muscle at -30 C and 915 MHz and intrinsic attenuation at 9.47 GHz. Measurements at 915 MHz showed that the loss factor changed considerably even with the samples held at a given temperature. At 9.47 GHz, MW attenuation properties of frozen fish muscle exhibited a time dependence, falling in value over periods of 1-3 wk. This reduction in attenuation is due to gradual accretion of ice in the frozen system at the expense of unfrozen water. At least two exponential components were observed in the overall change. Both are thermally activated and the activation energies for the characteristic time constants are in the range 32-49 kJ/mol. This is similar in value to activation energies for diffusion through dehydrated and frozen systems after recalculation of Jason's data for the latter. What is observed is either the diffusion of liquid water through clathrate type ice structures to a point on the surface where crystallization can take place, or diffusion through the surface states of the ice crystals themselves. (12 references)

0461 MICROWAVE DIELECTRIC LOSS OF *Bacillus Subtilis* SPORES IN AQUEOUS SUSPENSIONS. *(E.)* Ballario, C. (Ist. Fis. Univ., Rome, Italy), A. Bonicontro, and C. Cametti. *J. Colloid Interface Sci.* 51(1):191-195, 1975.

Adjacent to a solid interface, regardless of the nature of the solid substrate, structured elements of water may become stabilized in the sense of acquiring longer average lifetime. Temperature dependent dielectric loss of aqueous suspensions at MW frequencies may be explained by layers of water with different properties than those of bulk water around particles. If this dielectric loss represents an interface phenomenon, similar anomalies may occur in biological systems. The dielectric loss ε'' for aqueous suspensions of *Bacillus subtilis* spores has been measured at 10.0 GHz and 0 - 60 C. A remarkable anomaly in the temperature dependence of ε'' for the spore suspensions occurs around 40 - 45 C, essentially due to dipolar loss of the water component. The partial volume of modified water had a different growth rate at different temperatures before the transition region for spore suspensions at different concentrations, indicating that the characteristics observed in the spore suspension depended on geometric parameters rather than the physical or chemical nature of surfaces. Above the transition temperature "bound water" made no contribution to dielectric loss at sufficiently high frequencies. The presence of this structured water has an important role in the properties of biological systems as it may exert a profound influence on the immediate environment of macromolecules and may be responsible for many observed thermal anomalies in biological systems. (11 references)

0462 EFFECTS OF LOW INTENSITY MICROWAVE RADIATION ON MAMMALIAN SERUM PROTEINS. *(E.)* Cleary, S. F. (Dep. Biophys., Virginia Commonw. Univ., Richmond). *Dep. Army Res. Rep.*, Contract No. DADA 17-72-C-2144, 78p, 1974.

Low intensity, nonlethal, reversible effects of exposure to 1.7 GHz MW radiation were investigated and mechanisms for such effects were determined. Rabbits were exposed to 1.7 GHz MWs at a known intensity for a predetermined period of time. Immediately afterwards rectal temperature was determined. There was no significant difference with variation of radiation frequencies from 1.7 to 2.45 GHz. Lethal rectal temperature elevation for Dutch rabbits exposed to MW radiation was approximately 5 C. The presence of 2 rabbits in the field was found to cause perturbations resulting in a significant increase in energy absorption in the experimental animals. The effect of 1.7 GHz exposure on the duration of sodium pentobarbitol induced sleep resulted in a statistically significant decrease in sleeping time for power densities $\geq$ 10 mW/cm^2. Measurements of rectal temperatures implied that the MW induced decrease was a function of mean rectal temperature elevation and mean rate of rectal temperature elevation. The temperature increase probably induced redistribution of the anesthetic from the CNS due to an increase in blood flow. The effects of MW exposure and thermal denaturation were compared in *in vivo* and *in vitro* studies of serum proteins using acrylamide gel electrophoresis. It appeared that changes induced by MW radiation are not the same as those resulting from *in vitro* heating to 43, 45, or 50 C. Studies on effects of single exposures to 1.7 GHz radiation on blood chemistries showed that glucose, SGOT, LDH, BUN, uric acid, total protein, inorganic phosphate, total bilirubin, and cholesterol appeared to be affected; transient alterations were elicited by exposure at 25, 20, and 5 mW/cm^2, although few differences were statistically significant. (No references)

0463 SOME RECENT TRENDS IN EMC TESTS AND MEASUREMENTS. *(E.)* Lambdin, W. S. (Electrometrics, Div. Penril Corp., Amsterdam, N.Y.). *Microwave J.* (4):49-51, 1975.

A new product is tested for EMC to determine its suitability for entry into the EM environment. This testing is concerned with: (1) emissions from the product which must be controlled to restrict or eliminate interference with other equipment, and (2) susceptibility of the product to emissions levels expected from already operational equipment. There are 2 sets of standards set up, MIL-STD-461/2 and CISPR, which are not compatible and normally require quite different instrumentation. A calibrated sensor for emissions testing is connected to an interference analyzer for the simplest measurements; to this an X-Y plotter, a programmer, a CRT Spectrum Display Module and a digital computer may be added for more automation. Ultimately this handles 20 Hz to 1 GHz and 1 GHz to 12.4/18 GHz systems and may be used for the most advanced MIL-STD measurements. However, it cannot make CISPR measurements, which must be linear, unless it is modified. This is done by adding a Metering Module which automatically splits the radiation into channels required by CISPR. Thus, at the same time a CISPR reading is made, the peak level is registered by the Interference Analyzer for MIL-STD use. (No references)

0464 GENERAL BIOLOGICAL AND EMBRYOTROPIC EFFECTS OF PERMANENT MAGNETIC FIELD. *(Rus.)* Perepechin, E. A. (N.P. Ogarev Mordva University, Saransk, USSR), V. M. Dubova, L. N. Semenov and T. G. Knyazeva. *Gig. Sanit.* (9):23-26, 1974.

The effect of PMF on the generative function was studied in 60 180-240 g pregnant Wistar rats and 423 embryos exposed to 21.01 ± 0.94 kA/m and 2.40 ± 0.47 kA/m fields in the first series of experiments and 8.12 ± 0.29 kA/m fields in the second (fields most frequently present under industrial conditions). The rats were exposed for 2 hr daily through the entire pregnancy. To study the embryotropic action of PMF, measurements were made of fertility, pre-implantation destruction of ovicells, postimplantation embryonal mortality, the weight and length of the embryos and placentas, and organ and skeletal deformities. Exposure to 21.01 kA/m resulted in higher embryonal mortality, individual cases of deformity and greater incidence of tissue hemorrhage (32.55% in the controls and 58% in the experiment), pulmonary hemorrhage (13.95% and 38.7%, resp.), and hepatic hemorrhage (2.33% and 22.58%). In the second series, embryotropic effect of PMF involved higher postimplantation mortality and slower embryonal development. The general biological effect of PMF consisted of the changes in the composition of total proteins and protein fraction ratios in the serum. (3 references)

0465 AVOIDANCE BY RATS OF ILLUMINATION WITH LOW POWER NONIONIZING ELECTROMAGNETIC ENERGY. *(E.)* Frey, A. H. (Randomline, Inc., Huntingdon Valley, Pa.) and S. R. Feld. *J. Comp. Physiol. Psychol.* 89(2):183-188, 1975.

To determine the motivation properties of MWs at low average power densities, Sprague-Dawley rats were exposed to sham illumination or to pulsed 1.2 GHz energy (30 μsec pulses, 100 pulses/sec). Pulse-illuminated animals spent significantly less time (29%) in halves of shuttle boxes that were not shielded from the 1.2 GHz radiation than did sham-illuminated rats (57%). Over 7 days of testing, the respective proportions of time spent in the illuminated side within the first 15 min were 32% and 54% for experimental and control groups, resp. Boxes with unshielded halves illuminated by an average power density of 0.4 mW/cm^2 (133 mW/cm^2 peak power density) produced an aversion in experimental animals similar to that induced by boxes in which the average power density in the unshielded half was 0.9 mW/cm^2 (300 mW/cm^2 peak power density). In a second experiment, the energy was presented both continuously and in pulse-modulated form, i.e., 0.5 msec exponentially decaying pulses at 1000 pps. The average power density of the CW energy was 2.4 mW/cm^2 and the average power density of the pulse-modulated energy was 0.2 mW/cm^2; the peak power density of the modulated energy was 2.1 mW/cm^2. The rats avoided the pulsed energy but not the CW energy; the difference between the two groups was significant in the last two sessions of a four-session sequence. In these sessions, the pulse illuminated rats averaged 30% of their time in the unshielded halves of shuttle boxes compared with 64% for the CW-illuminated animals. These behavioral observations are in agreement with a physiological study showing that pulsed, but not CW, energy significantly affected fluorescent dye-complex penetrability of the brain barriers of the diencephalon. (12 references)

0466 RADIOFREQUENCY AND MICROWAVE RADIATION LEVELS RESULTING FROM MAN-MADE SOURCES IN THE WASHINGTON, D.C. AREA. *(E.)* Smith, S. W. (Div. Electronic Products, Bur. Radiol. Hlth., Rockville, Md.) and D. G. Brown. *DHEW Publ.* No. (FDA) 72-8105, BRH Pub. No. BRH/DEP 72-5, 56p., Nov. 1971.

During the summer of 1969, man-made radiation levels from 20 Hz to 10 GHz were made at 10 scattered sites from 20 Hz to 10 GHz were measured at 10 scattered sites within a 25 mile radius of Washington, D.C. The lyzed; a summation of power densities from narrow-band sources was made of four biologically relevant portions of the total spectrum measured: less than 400 MHz, 400-1000, 1000-3000, and 3000-10,000. The peak ambient radiation measured approached a maximum of 10^{-2} mW/cm^2 (10^{-3} mW/cm^2 excluding high-powered, low-duty-cycle, pulsed radar signals). The average background thus is at least two to three orders of magnitude less than any published U.S. recommendations for exposure to RF radiation. Almost all the power density measured could be attributed to commercial broadcasting and/or high-powered radar installations in close proximity to the monitoring site. On the basis of these results, it is recommended that no further broadband environmental surveys be carried out unless prior calculations indi-