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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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electric fields						
magnetic fields						
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BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION

A Digest of Current Literature and a Forum of Communication

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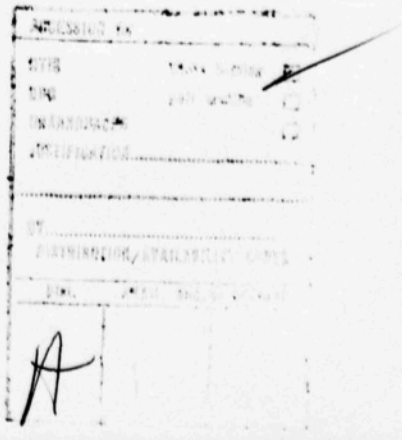
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Biological Effects Electromagnetic Radiation II(3), September 1975

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Literature Selected and Abstracted
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THE FRANKLIN INSTITUTE RESEARCH LABORATORIES
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Bruce H. Kleinstein, Ph.D., Technical Editor



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.

This digest serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and radiofrequency radiation) are compiled, condensed and disseminated on a regular basis. *Biological Effects of 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. The issues of Volume II, and future volumes, will include materials received during the preceding three months. Each issue will include news items and announcements, a listing of meetings and conferences, abstracts of current literature, and a directory of current research. Materials for which full text is not available will be included as 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
AECH - application of electric current to the head
AF - Air Force
AMP - adenosine monophosphate
ANSI - American National Standards Institute

- B -

BRH - Bureau of Radiological Health
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
CMF - constant magnetic field
CNS - central nervous system
CPK - creatine phosphokinase
cps - cycles per second
CR - Current Research
CW - continuous wave

- D -

dB - decibel
dc - direct current
DOD - Department of Defense
DRL, drl - differential reinforcement of low rates

- 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
FFA - free fatty acids
FI - fixed interval
FM - frequency modulation
FR - fixed ratio

- G -

g - gram
G - Gauss
GHz - gigahertz
GI - gastrointestinal

- H -

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

- I -

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

- J -

J - joule
JPRS - Joint Publications Research Service

- K -

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

- L -

l - liter
LD_{50} - 50% mortality
LDH - lactic dehydrogenase
LF - low frequency
LH - limited hold

- M -

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

- N -

N_2 - nitrogen
NBS - National Bureau of Standards
NIH - National Institutes of Health

ABBREVIATIONS AND ACRONYMS

NIR - nonionizing radiation
nm - nanometer
NSF - National Science Foundation
NIOSH - National Institute for Occupational Health and Safety
NTIS - National Technical Information Service

- O -

Oe - oersted
ONR - Office of Naval Research
OSHA - Occupational Safety and Health Administration
OT - Office of Telecommunications
OTP - 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 - pulses per second
PRF - pulse repetition frequency
PRR - pulse repetition rate
PW - pulsed waves

- R -

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

- S -

s.c. - subcutaneous
sec - second
SGOT - serum glutanic oxalacetic transaminase
SHF - super high frequency
SW - shortwave

- T -

TEM - transverse electromagnetic mode
TLC - thin layer chromatography
TSEE - thermal stimulated exo-electron emission
TSH - thyroid stimulating hormone

- U -

U - unit, units
UHF - ultra high frequency
US - ultrasound
USAFSAM - U. S. Air Force School of Aerospace 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
$\hat{\varepsilon}$ - complex permittivity
λ - wavelength
μ - micro
σ - specific conductance
Ω - ohm
γ - gamma

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NEWS ITEMS

DEVELOPMENT OF A MICROWAVE DIATHERMY STANDARD

The FDA has announced its intent to develop a radiation safety performance standard for MW diathermy equipment which is used in heat treatment for aching muscles and joints. The BRH believes recent technical developments for control of unnecessary radiation associated with these units makes a performance standard both feasible and desirable. Comments received after August 1, 1975, may be considered depending on the stage of development of the standard at the time they're received. Comments should be sent to The Hearing Clerk, Food and Drug Administration, Room 4-65, 5600 Fishers Lane, Rockville, Md. 20852. *FDA Consumer* 9(5):30, 1975

MICROWAVE OVEN RECALL

General Electric will recall 17,800 MW ovens that may leak as much as 10 times the amount of radiation allowed by federal regulations. GE's corrective program includes letters to dealers and oven owners. The owners are advised to discontinue use until they can be examined by the manufacturer. All of the ovens use a wire mesh seal around the door which prevents MW energy from escaping when pressed tightly around the door. The major reason for the reported leakage is warped frames which cause gaps around the doors. *FDA Consumer* 9(5):30, 1975 and *Electrical Times* (4334):2, 1975

CANADIAN STANDARDS FOR MICROWAVE OVENS

Radiation standards for MW ovens used in Canada have been amended as follows: where the generation of x-rays within a MW oven in excess of 2.5 mR/hr averaged over 10 cm^2 is possible while the oven is functioning in the prescribed manner, an x-irradiation warning sign that is clearly visible while the oven is being serviced must be permanently affixed to the MW power generating component. The leakage radiation at 5 cm from the oven, when fully assembled and operating at maximum output must not exceed: (1) 1.0 mW/cm^2 when the oven is loaded with the minimum operating load, and (2) 5.0 mW/cm^2 with no load for an oven with a total MW power generating capacity of less than 3 kW. The intensity of x-ray exposure 5 cm from the external surface must not exceed 0.5 mR/hr averaged over an area of 10 cm^2 when the oven is fully assembled and operating with its service and user controls adjusted to yield maximum output. *Int. Dig. Health Legis.* 26(1):59-60, 1975.

NO EMP EXPOSURE STANDARDS

In response to a 1972 request from the Boeing Company that safety standards for exposure to EMPs be set following guidelines set forth by the U.S. Air Force, a notice was placed in the *Federal Register*. This announcement requested information and advice on the need for regulations, merits of the AF requirements, alternate suggestions, cost, environmental impact, injury and illness information, and other related information. The prevailing response was that the need for a standard at this time was doubtful and that data is insufficient to determine an appropriate maximum permissible exposure limit. No evidence of illness or injuries associated with EMPs was demonstrated. Therefore it was decided not to issue an EMP exposure standard at this time. *Federal Register.* 40(111):24579-24580, 1975.

TREATMENT FOR BURN SHOCK

V. P. Lapshin, B. N. Tkachenko, V. I. Shpakov, *et al.* have developed a method of correcting bioelectric activity of the brain under burn shock by using an alternating magnetic field of sine-curce form at fixed frequency to act on the brain. The form of the magnetic field is gradually changed from sine-curve (3-13 Hz frequency) to sawtooth (14-30 Hz frequency). The process continues until the basic rhythms are restored. A sine-curve magnetic field is then applied until a stable clinical effect is obtained and normal bioelectric activity is stably dominant on the EEG. *Soviet Inventions Illustrated* W(22):8, 1975

ARTERIAL ANEURISM TREATMENT METHOD

An arterial aneurism magnetic treatment method which uses a constant magnetic field to form a partial thrombus has been developed by R. P. Kikut and D. K. Miller of the Riga Traumatology and Orthopaedics Research Institute. To prevent complete blockage of the treated artery during thrombus formation the affected part of the artery is placed in a CMF. The vessel is filled with blood which is passed through the catheter inside which is a simulated saccular aneurism. The blood flow-rate is adjusted to 12 cm/sec and the catheter is then placed in the CMF (2500 Oe) which produces an EMF of 125 μV perpendicular to the direction of flow for 0.5-1.5 hr. Thrombus formation is medically accelerated and clot formation is monitored. *Soviet Inventions Illustrated* W(20): 2-3, 1975

ITEMS FROM THE COMMERCE BUSINESS DAILY

o BEHAVIORAL AND ELECTROENCEPHALOGRAPHIC RESPONSES OF SQUIRREL MONKEYS EXPOSED IN UTERO TO 2450 MHz ELECTROMAGNETIC RADIATION.

The Environmental Protection Agency, Research Triangle Park, North Carolina, has contracted with Stanford Research Institute, Menlo Park, California, for the above study. (July 8, 1975)

o MAINTENANCE OF A DATA BASE ON AVAILABLE LITERATURE PERTAINING TO BIOLOGICAL EFFECTS OF NON-IONIZED ELECTROMAGNETIC RADIATION.

Biological Effects Electromagnetic Radiation II(3), September 1975

The Office of Telecommunications Policy, Washington, D.C., has contracted with Mead Technology Laboratories, Dayton, Ohio, for the above study. (July 11, 1975)

o CONTINUATION OF ONGOING WORK IN THE STUDY OF THE BEHAVIORAL EFFECTS OF ANIMALS EXPOSED TO MICROWAVE RADIATION.

The Department of Health, Education, and Welfare, Rockville, Maryland, has contracted with Randomline, Inc., Huntingdon Valley, Pennsylvania, for the above study. (July 21, 1975)

o A FURTHER RESEARCH ON MICROWAVE RADIATION.

The Office of Naval Research, Arlington, Virginia, proposes to contract with Battelle Memorial Institute, Richland, Washington, for the above study. (August 13, 1975)

o STUDY OF THE EFFECTS OF A HIGH LEVEL OF EXPOSURE TO MICROWAVE RADIATION ON THE OFFSPRING OF MILITARY PERSONNEL.

The Department of Health, Education, and Welfare, Rockville, Maryland, has contracted with the American Health Foundation, New York, N. Y., for the above study. (July 3, 1975)

MEETINGS AND CONFERENCES

****** AMERICAN SOCIETY FOR NEUROCHEMISTRY**

Date: March 9-14, 1975
Place: Mexico City, Mexico
Sponsor: American Society for Neurochemistry
Requests for Information: Dr. M. M. Rapport, N. Y. State Psychiatric Institute, Div. of Neuroscience, 722 W. 168 St., New York, N.Y. 10032

Selected Bibliography of Papers Presented:

LEVELS OF GAMMA-AMINO BUTYRIC ACID IN MOUSE BRAIN FOLLOWING TISSUE FIXATION BY MICROWAVE IRRADIATION. Knieriem (no affil.).

LABILE METABOLITE LEVELS IN RAT BRAIN AFTER RAPID TISSUE INACTIVATION WITH MICROWAVE IRRADIATION. Medina (no affil.).

APPLICATION OF 300 mSEC MICROWAVE IRRADIATION FOR INACTIVATION OF CHOLINERGIC ENZYMES IN MOUSE BRAIN TO STUDY OF REGIONAL ACETYLCHOLINE LEVELS AND ITS DIFFERENTIAL MODIFICATION BY PENTOBARBITAL. McCoy (no affil.).

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

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

****** IEEE INTERNATIONAL SYMPOSIUM ON ELECTROMAGNETIC COMPATIBILITY**

Date: October 7-9, 1975
Place: San Antonio, Texas
Sponsor: IEEE
Requests for Information: W. E. Cory, Southwest Research Institute, Box 28510, San Antonio, Texas 78284

Selected Bibliography of Papers Presented:

HAZARDS: THE EFFECTS OF OPTICAL RADIATION ON BIOLOGICAL ENVIRONMENTS AND MATERIALS. W. T. Ham, Jr. (Med. Coll. Virginia, Richmond).

CALIBRATION OF A MULTIMODE MICROWAVE EXPOSURE CHAMBER. E. L. Bronaugh (Southwest Res. Inst., San Antonio, Tex.) and D. R. Kerns.

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

Date: November 30 - December 5, 1975
Place: Chicago, Illinois
Sponsor: Radiological Society of North America and American Association of Physicists in Medicine
Requests for Information: T. A. Tristan, M.D., Radiological Society of North America

****** IAEA SYMPOSIUM ON BIOLOGICAL EFFECTS OF LOW-LEVEL RADIATION PERTINENT TO PROTECTION OF MAN AND HIS ENVIRONMENT**

Date: November 3-7, 1975
Place: Chicago, Illinois
Sponsor: International Atomic Energy Agency
Requests for Information: J. H. Kane, Office of Information Services, ERDA, Washington, D.C. 20545

BOOK NOTES

BIOLOGIC AND CLINICAL EFFECTS OF LOW-FREQUENCY MAGNETIC AND ELECTRIC FIELDS

by

J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti

This book is the result of a symposium and workshop held in Aspen, Colorado in 1973 to examine the current state of knowledge on the effects of static and slow-changing magnetic and electric fields on the communication processes in all forms of life. The forum was designed to bring about collaborative efforts by engineers and life scientists to produce significant advances in the area of quantitative information regarding the effects of man-made EM emanations upon living organisms. The workshops included criteria and recommendations for a comprehensive research plan in the areas discussed applicable for research, industry, and government use. Pertinent chapters will be abstracted in the next issue of *Biological Effects of Electromagnetic Radiation.*

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   - III. Critical Review of the Biological Effects of Electric and Magnetic Fields
   - IV. Electric and Magnetic Fields Produced by Commercial Power Systems
   - V. Psychological Effects of Magnetic and Electric Fields

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   - X. Extra Low Frequency (ELF) Electromagnetic Radiation as a Biocommunications Medium: A Protein Transreceiver System
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   - XXVII. Magnetics and Nuclear Magnetic Resonance

(Springfield: Charles C. Thomas, 1974), 345pp.

MAGNETISM AND ITS EFFECTS ON THE LIVING SYSTEM

by

A. R. Davis and W. C. Rawls, Jr.

Explanations of how magnetism affects the life of all living systems are found in this book, which deals with the two effects that are supplied by the two forms of energy transmitted from each pole of all magnets. The book is written without mathematical data to make it comprehensible to the layman as well as the student and scientist. A 34-item bibliography of general research references is included.

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    Biomagnetic Biological Electronics
    The Present and Future Research into Very High Gauss Magnetic Energies (VHG)
    Conclusion

(Hicksville: Exposition Press, 1974), 132pp.

CURRENT LITERATURE

0551 SEARCH FOR EFFECTS OF 45 Hz MAGNETIC FIELDS ON LIVER TRIGLYCERIDES IN MICE. *(E.)* Beischer, D. E. (Naval Aerosp. Med. Res. Lab., Pensacola, Fla.) and R. J. Brehl. *Res. Rep.* No. NAMRL-1197, 8p., 1975.

Eight-week-old female Charles River mice were exposed to an ELF electromagnetic field in a search for possible bioeffects of the field. One hundred forty mice were acclimated for 3 wk prior to exposure; seventy of these were randomly selected for exposure for 24 hr to a 45 Hz magnetic field with a field strength of 1 Oersted. Ten mice were decapitated immediately following exposure and 10 were randomly selected and sacrificed on each subsequent day. Livers were removed, prepared, and extracted with isopropanol for glycerides measurements. The 70 control mice were treated similarly. For all mice, body wt, liver wet wt and dry wt, and liver triglyceride content were measured. Water content of the liver and the ratio of liver to body wt were calculated. There were no significant differences between control and experimental animals for values determined during the time period studied. In this specific situation of short term exposure to low field strength EM energy, no effects of the field were observed. (1 reference)

0552 STIMULATION OF THE DEFENSES OF MICE WITH TRYPANOSOMIASIS BY EXPOSURE TO RADIATION ASSOCIATED WITH A MAGNETIC FIELD AND ELECTROMAGNETIC WAVES. *(Fr.)* Pautrizel, R. (Lab. Parasite Immunol. Biol., Univ. Bordeaux II, France), A. Prioré, P. Mattern, and A. N. Pautrizel. *C. R. Acad. Sci. (Paris)* [D] 280(16):1915-1918, 1975.

Swiss mice were inoculated i.p. with 20,000 *Trypanosoma equiperdum* and, 48 or 72 hr later, were exposed to radiation associated with a magnetic field and electromagnetic waves for 6 hr/day for 6 days (no further details). Mice were irradiated the day after they had been inoculated with 100 trypanosomes and diffusion chambers had been implanted. One group received cyclophosphamide (70 mg/kg i.p.) the day before and the day after inoculation, while another group received a single i.p. injection of antigen immediately after the first session of therapy. Newborn mice from noninfected mothers were given 1000 trypanosomes s.c. on the day of their birth. Infected mice exposed to radiation 48 hr after inoculation had the same number of parasites in the blood as controls until 72 hr after infection. The number of parasites then decreased rapidly until, after 96 hr, none of these mice had parasites in the blood. Mice exposed to radiation 72 hr after inoculation were also freed of infection and survived, while all untreated controls died within 6 days after inoculation. All mice which recovered had a strong immune response (hemagglutinating antibody titers of 1:2000 or more) 8 days after inoculation, and only 2 of 22 had recurrences 15 days after radiation exposure was discontinued; these parasites, however, had different antigens than the ones the mice were originally inoculated with. Mice given cyclophosphamide and then exposed to radiation had no signs of parasitic infestation after 5 days of treatment, but all had recurrences, starting on day 12. Antibody titers in cyclophosphamide-treated mice were not as high as those in untreated mice 8 days after inoculation. No matter whether they were treated or not, newborn mice developed large numbers of parasites in their blood and died on day 6. Radiation increased antibody production in mice immunized with parasite antigen; 10 days after immunization, the titer was 1:16 in comparison to 1:2 in untreated mice. Radiation had no effect on the multiplication of trypanosomes placed in diffusion chambers. (6 references)

0553 THE EFFECT OF SIMULATED SFERICS (WEATHER-DEPENDENT ELECTROMAGNETIC RADIATION) ON PLATELET ADHESIVENESS. *(Ger.)* Jacobi, E. (2nd Med. Clin., Univ. Dusseldorf, Germany) and G. Krüskemper. *Inn. Med.* 2(2):73-81, 1975.

In an insulated steel chamber with controlled temperature and humidity, 115 volunteers were subjected to simulated sferics at a pulse intensity of 0.4 V/m and a carrier frequency of 10 kHz; 30 volunteers subjected to an electric zero level served as controls. In most cases, exposure times were 3 hr. The simulated sferics had PRFs which ranged from 2 to 20 Hz. *In vitro* measurements of platelet adhesiveness were made before and after exposure. Platelet adhesiveness was increased at a PRF of 10 Hz, but was decreased at electric zero levels and at 2, 5, and 20 Hz. A PRF of 10 Hz reduced the decrease in platelet adhesiveness induced by the electric zero climate. No differences in platelet adhesiveness were found in subjects exposed to pulse intensities of 0.2 V/m and those exposed to 0.4 V/m. Double blind studies were performed on 40 additional volunteers to determine whether drugs which reduce platelet adhesiveness have any effect on sferic-induced increases. These 40 subjects were divided into 4 groups of 10 subjects each. These groups received orally: (1) a placebo; (2) 75 mg of dipyridamole; (3) 300 mg of acetylsalicylic acid; and (4) 75 mg of dipyridamole + 300 mg of acetylsalicylic acid. Sferic-induced increases in platelet adhesiveness were suppressed only by the combination of both drugs. Subjects with an increased tendency to exhibit psychasthenic insecurity, as determined by the Minnesota Multiphasic Personality Inventory, tended to show the greatest sferic-induced responses in platelet adhesiveness, while those with high scores on the lying scale showed no changes. Although these studies do not demonstrate a causal relationship between sferics and increased platelet adhesiveness resulting in thrombosis, such a relationship may exist, particularly if some other predisposing factors are present. (18 references)

0554 LOW ENERGY ELECTROMAGNETIC PERTURBATION OF AN ENZYME SUBSTRATE. *(E.)* Goodwin, B. C. (Sch. Biol. Sci., Univ. Sussex, Brighton, England) and S. Vieru. *Physiol. Chem. Phys.* 7(1):89-90, 1975.

Irradiation of enzyme substrates in crystalline form