Tranquilized rabbits will be irradiated at 2450 MHz to determine the cause of the decrease in ascorbic acid concentration of the lens. Irradiated and control lenses will be cultured in a medium containing C^{14} ascorbic acid; C^{14} activity of the lenses will then be determined after removal from the medium. If it is transport that is affected, and the element changed is in the transport system of the lens, then an attempt will be made to determine whether ascorbic acid transport is stereo-specific in the lens. In addition, the research is aimed at determining whether microwave irradiation increases the concentration of acetylcholamine when an animal is irradiated at 2450 MHz using a power density of 40 mW/cm^2, and whether the hydrolysis of acetylcholamine by acetylcholine esterase is affected by irradiation. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0031 NAVY ENVIRONMENT: EFFECTS OF MICROWAVE RADIATION AS FROM NAVY RADAR ON EMBRYONIC BRAIN TISSUE. Rioch, D. (Inst. Behavioral Research, 2426 Linden Lane, Silver Spring, MD 20910).

The objective of this research is to determine whether there is a critical period(s) in the circadian rhythm of the rat fetus during which microwave fields are effective in increasing the fetal growth, particularly the growth of the cerebral hemispheres. Pregnant Holtzman (albino) rats will be exposed to 1700 MHz, 10 mW/cm^2 microwaves from 1700-1800 hours on the 6th-9th and 12th-16th days of gestation. Additional rats will be similarly exposed overnight for 12-14 hours at 5 mW/cm^2. On the 20th day of gestation, the rats will be sacrificed, fetuses weighed and brains removed and fixed in Bouin's solution. The gross form and size of the brains will be studied under a dissection microscope. The brains will then be dehydrated and imbedded in paraffin for histological evaluation. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0032 EFFECTS OF HIGH POWER PULSED AND LOW LEVEL MICROWAVE RADIATION ON OPERANT BEHAVIOR IN RATS. Diachenko, J. A.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

This study will evaluate the effects of nonionizing electromagnetic radiation on animal behavior. Analogous animal behavior (rats and rabbits) will be studied over a range of electromagnetic combinations of frequency, low level power and exposure durations. Results will contribute to: (1) better definition of electromagnetic radiation exposure safety margins, (2) understanding perception of electromagnetic energy, (3) differentiation between chronic and acute effects relative to time frame of behavioral change onset, course, and recovery. Standard operant conditioning techniques will be used wherein quantified response rates such as bar pressing are rewarded with food to establish a predictable baseline performance in lower animals. Subjects will then be systematically exposed for long durations (i.e., 2 hours daily for 2 months or more) to combinations of high power pulsed fields, pulse modulated and continuous wave fields over a wide range of frequencies, and power levels. Also, as a collaborative effort, subjects studied for specific neurophysiological change by other researchers will be behaviorally tested to see how neurological changes might be reflected in behavioral correlates. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0033 ALTERATIONS IN THE SLEEP PROCESS OF THE RABBIT AS A FUNCTION OF CHRONIC LOW INTENSITY ELECTROMAGNETIC RADIATION EXPOSURE. Manthei, R. C.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

Data have shown brain electrical activity associated with sleep states to be biologically constant for any given species. Furthermore, nonionizing radiation exposure has been shown to alter brain electrical activity. The sleep process is characterized by cyclic fluctuations between alertness (W), slow wave (SW), and paradoxical (REM) stages. Rapid eye movement (REM) is a very active state metabolically. REM is functionally defined as that period of sleep in which cortical activity paradoxically reveals low voltage, fast activity characteristic of the awake phase, concurrent with rapid eye movement, and atonus of neck muscle. This study is designed to test the hypothesis that prolonged exposure of an organism to electromagnetic radiation will decrease the frequency and duration of REM stage sleep. These data, if tenable, will guide the author toward synergistic bodies of biochemical, anatomical, and behavioral data relative to the sleep process. Sleep is viewed as a potential index of central nervous system adaptation to prolonged electromagnetic radiation exposure while being associated with broad theoretical, yet practical implication. Brain electrical activities of rabbits surgically implanted with plastic guide tubes will be continuously monitored for a period of up to sixty days following daily exposures of microwave and pulsed high energy (HEP) electromagnetic radiation. The scope of this project depends on the inexpensive test of the REM sleep hypothesis. Data should be available within three months from the onset of the irradiation and should be considered conclusive evidence for, or against, sleep modification. Positive results will require consideration of biochemical, anatomical and behavioral correlates to the sleep process as related to electromagnetic radiation insult. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0034 BIOPHYSICS OF ELECTROMAGNETIC FIELD INTERACTIONS. Frazer, J. W.; Sexauer, S. W. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Present electromagnetic radiation safety standards based on total power absorption and resulting thermal load are being challenged on the basis that pulsed fields may be more harmful to man than equivalent

continuous wave fields. The objective of this effort is to investigate the relative effect of pulsed and continuous wave fields on a large variety of tissue components. Several sizes of experimental animals will be examined for different field distributions radiometrically. Several types of tissue, both within animals and as slices in a special spectrometer cell, will be examined for polarization and fluorescence changes of compounds whose Kerr constants have been determined in free solution. Polarization, dual and triple wavelength spectrometry and special fluorescence polarization measurements are to be utilized. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0035 EFFECTS OF HIGH PEAK POWER PULSED ELECTROMAGNETIC RADIATION ON CELLULAR KINETICS. Ogrady, T. C.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

The objective of this study is to evaluate the long term exposure effects of high peak power (HPP) electromagnetic radiation on cellular systems to develop information useful to be used in safety factor analysis. The main value in studying such simple systems as bacteria and root meristematic tissue lied in the use of these systems as models of more complex systems. Thus, the growth of bacteria and the division cycle of root tip cells reflect processes occurring in higher organisms. Furthermore, the rapidity of these processes allow many experimental replicates with a variety of experimental parameters being investigated (e.g., power levels, frequencies). The experimental approach in these experiments is divided into two areas—bacterial growth kinetics and root tip cell cycle timing studies. The bacterial studies involve exposing populations of common bacteria (*Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Serratia marcescens*) during their entire growth cycle to fields of approximately 100 kV/m, 25 MHz frequency. At various time intervals, aliquots are withdrawn and counted in a coulter counter. Comparison can then be made between control and experimental groups' growth kinetics. The root tips (of *Vicia fava*) are exposed for 12 hours (100 kV/m, 25 MHz) prior to a 1 hour pulse label with ^{3}H-thymidine. The labeled root tips are transferred to non-radioactive media and then harvested at hourly intervals, stained with acid shiff (feulgen) stain to reveal chromosomes, and autoradiographed. After exposure and development, the slides are observed microscopically to determine the presence of labeled chromosomes. The numbers of labeled chromosomes versus time after pulse labeling allows cell cycle timing to be determined. This parameter can then be compared between control and experimental groups. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0036 NAVY ENVIRONMENT: WORK SESSION—THE ROLE IN BRAIN FUNCTION OF EXTERNAL ELECTROMAGNETIC FIELDS AND ELECTROTONIC INTERACTIONS BETWEEN NEURONS. Worden, F. W. (Massachusetts Inst. Technology, Graduate Sch., Cambridge, MA 02139).

It is generally acknowledged that the central nervous system is critically sensitive to electromagnetic fields. In order to better understand the interactions which occur, this work session will attempt to increase the knowledge of the basic electrophysiological processes within the human brain. The neurosciences research program will plan a work session, with suitable input from ONR, which will assemble approximately 25-30 of the world's leading scientists in neurophysiology, neuroanatomy, biophysics and bioengineering. Following the 2-day work session, the proceedings will be published in a special issue of the NRP bulletin. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0037 THE EFFECTS OF EXTREMELY LOW FREQUENCY (ELF) RADIATION ON MAN. Deischer, D. E.; Grissett, J. D. (U.S. Navy, Aerospace Medical Res. Lab., Pensacola, FL 32512).

Navy operational interest in electromagnetic radiation effects on man includes the possible effects of the extremely low frequency region of the spectrum. A series of carefully selected physiological and psychological tests is being used to determine the effects of low intensity fields below 100 Hz. Well-controlled laboratory exposure of animals and human volunteers should furnish needed data. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0038 ALTERED CSF CONSTITUENTS AS A FUNCTION OF CHRONIC LOW INTENSITY ELECTROMAGNETIC RADIATION EXPOSURE IN RABBITS. Manthei, R. C.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

The nerve membrane surface contains macromolecules whose functional group, sialic acid (NANA), allows for rapid conformational change and reversible binding of calcium ion. Two such classes of macromolecules, gangliosides and glycoproteins, can be judged as to complexity and binding capability by means of sialic acid content. It is hypothesized that electromagnetic radiation exposure could alter both sialic acid and calcium content in whole brain extracts and cerebrospinal fluid. Since cerebrospinal fluid is intimately associated with extracellular fluid surrounding neuron populations, it is reasonable to suggest that membrane-bound substances, including calcium ion, might appear in cerebrospinal fluid following electromagnetic radiation exposure. The author suggests that such membrane alterations as a function of electromagnetic radiation insult could affect the quantal presynaptic release of neurotransmitter substances. This mechanism is viewed as vital to central nervous system function. Techniques required for analysis of sialic acid and calcium will be perfected using whole brain extracts of adult male mice. Such techniques will then be applied to rabbit brain tissue, cerebrospinal fluid, and serum samples. Rabbits will be surgically implanted with cannulae suitable for cerebrospinal fluid and blood extraction. The implant will be designed such that no metal elements are associated with the animal during exposure. Values obtained

from cerebrospinal fluid and blood will be obtained on a daily basis following daily exposure to chronic low intensity microwave and high energy pulsed electromagnetic radiation. Following a period of time specified by irradiation protocol, the animals will be sacrificed, and whole brain analysis will be performed. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0039 MICROWAVE THAWING OF FROZEN TISSUE. Lehr, H. B.; Holst, H. I.; Ketterer, F. (Univ. Pennsylvania, Sch. Medicine, 36th & Hamilton Walk, Philadelphia, PA 19104).

The use of microwaves to thaw solid organs, viably preserved in the frozen state is intriguing and promising. The objectives of these experiments are threefold: (1) to measure the unknown electrical properties of frozen tissue, (2) to calculate the heating potential distributions of solid organs and to develop equipment to apply microwaves evenly to these organs, and (3) to prove that properly prepared frozen solid organs are viable in mammalians. These objectives are to be accomplished by direct measurements of the electrical properties of ice, physiological saline with cryoprotectants, gelatin molds, and frozen mince mammalian tissue. The thawing equipment will be a meld of commercially available microwave ovens in different frequency ranges with rabbit and canine kidneys comprising the mammalian test organs. (4/76-3/77)

Supporting Agency:HEW, PHS, NIH

0040 MEDICAL SURVEILLANCE OF PERSONNEL OCCUPATIONALLY EXPOSED TO ELECTROMAGNETIC RADIATION. Benedum, J. L.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

This task is to evaluate the effects of exposure to nonionizing electromagnetic radiation (EMR) on occupationally exposed personnel. The aim is to develop health and safety information for use with personnel exposed to various EMR systems. Particular emphasis is placed on advanced systems such as high power pulse (HPP) generators. An additional objective is to provide input into hardware development at an early state of design to produce better intrinsic safety features. A group of approximately 100 NSWC/DL personnel is examined on an annual basis. The group includes: microwave and radiofrequency exposed personnel, personnel exposed to high peak power pulse (HPP) transmitters, and a control population with no occupational exposure to EMR. The examination includes a hematocrit, white blood count, differential count, a urinalysis, a modified SMA-12 serum chemistry analysis, an electrocardiogram, and a screening electroencephalogram. Records of ophthalmologic examinations, performed on contract by a private ophthalmologist, are reviewed. The merger of NOL and NWL to form NSWC has brought an additional occupational group into the study-personnel exposed to the empress electromagnetic pulse (EMP) simulator. These examinations are performed at NSWC/WOL with results forwarded to this laboratory for analysis. Data obtained are statistically analyzed on the CDC-6600 computer both between groups and longitudinally within groups. Close contact is maintained with the subject populations throughout the year so that situational examinations may be done as indicated. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0041 VISUAL SYSTEM DISEASES IN AIRCREWMEN. Tredici, T. J.; Shacklett, D. E. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

This study attempts to determine the incidence and significance of diseases of the visual system in aircrewmen from the standpoint of retention without compromising flying safety. Investigators are trying to develop the means to prevent or correct such disorders and develop techniques for early diagnosis or prediction of development of such disorders. Aircrewmen with ophthalmologic problems receive a comprehensive aeromedical evaluation and a battery of function testing, including manifest and cycloplegic refractions, motility tests, tonometry, tonography, fundus photography. Response to aerospace environmental factors (e.g., acceleration, altitude and electromagnetic radiation) is studied in special cases. Longitudinal basic studies will assess the significance of disease in relation to flying operations and the validity of current aeromedical standards. Fluorescein fundus photography, electro-retinography, electro-oculography, static perimetry, and biomicroscopy will be utilized to study the effect of disease and stress on aircrewmen. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0042 CARDIAC OUTPUT MEASUREMENT BY MEANS OF RF ATTENUATION MEASUREMENT. Frazer, J. W. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Cardiac output determinations are necessary to acquire physiological data on which to base safe exposure criteria for Air Force operational environments. Present cardiac output measurements in high acceleration or radiation environments depend on vascular intervention with subsequent laboratory analysis of blood or respiratory gases, or alternatively exposure of subjects to appreciable doses of ionizing radiation for chest fluoroscopy with subsequent film development and analysis. The objective of this effort is to develop a microwave attenuation measurement capable of detecting changes in cardiac output in adverse Air Force environments without disturbing the subject. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0043 ELECTRICAL & ACOUSTIC PROPERTIES OF BIOLOGICAL MATERIAL. Schwan, H. P.; Takashima, S.; Fischler, H.; Schwartz, G. (Univ. Pennsylvania, Sch. Engineering & Applied Science, 4001 Spruce St., Philadelphia, PA 19104).

This research will investigate the electrical and acoustic properties of biological materials and related problem areas such as electrode polarization and forces induced by alternating electrical fields acting on biological particles. Present and future emphasis will be on: (1) The behavior of electrodes used for impedance measurements and excitation purposes in physiology and cardiology (pacemaker) in frequency and time domain with particular emphasis on their nonlinear characteristics. (2) Electrical characteristics of macromolecules and water bound to their surface. (3) Electrical characteristics of biological and artificial cells and membranes as related to their structure and function. (4) Acoustic properties of tissues and biological macromolecules and the reasons why their specific absorption varies so considerably from one type to another. (5) Field induced force effects; particularly alternating field induced forces acting on biological cells and of significance either from a hazard point of view or with a potential for new biological research techniques. (10/75-9/76)

Supporting Agency:HEW, PHS, NIH

0044 COMBINED STRESS STUDIES IN HF BAND FIELDS. Cupello, J. M. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Exposure of Air Force personnel to radiofrequency radiation environments can produce an added stress to the thermal regulatory system. Existing exposure standards are based on the extent to which this stress can be tolerated. This effort will evaluate biologic responses under combined temperature and radiofrequency radiation stress. Plexiglass environmental chambers for holding experimental animals during radiofrequency radiation exposure are being designed and constructed. These chambers will allow control of the temperature and relative humidity of the air surrounding the animals. The effects of heat stressing the animal during exposure to radiofrequency radiation, thereby overburdening his heat dissipation mechanism, will indicate the effect of combined stress in radiofrequency fields. Monitoring the chambers' input and output temperature with relative humidity will allow quantitation of the amount of heat generated in the rate due to radiofrequency exposure. Larger chambers will be constructed at a later date to perform this same study on rhesus monkeys. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0045 THE EFFECTS OF LOW POWER DENSITY ELECTROMAGNETIC ENERGY ON BIOLOGICAL SYSTEMS. Flanigan, W. F.; Ridgway, S. H. (U.S. Navy, Biosystems Research Dept., San Diego, CA 92132).

The objective of this project is to study the electrophysiology (i.e., brain wave activity, heart rate) and behavior of reptiles (turtles) exposed to low power density ($\leq$ 10 mW/cm^2) electromagnetic radiation at a number of frequencies within a range of 0.1-10 GHz. Nonmetalic electrodes will be developed to enable both EEGs and ECGs to be recorded from the brain and heart, respectively, of acute and chronically implanted animals. All field exposure experiments will be conducted in air. Acutely implanted turtles will be anesthetized and restrained. EEGs and ECGs will be simultaneously recorded. Chronically implanted animals will be prepared using a standardized procedure. Each animal will serve as its own control. Baseline recordings prior to any field exposure will be compared with those obtained when an animal is exposed to electromagnetic radiation. Cumulative effects of recurring field exposure will be investigated by comparing baseline recordings to recovery recordings made between periods of irradiation as well as by comparing subsequent field exposure recordings with prior field exposure recordings. Baseline field exposure recovery recordings will range from a fraction of a second to hours for acute preparations and minutes to days for chronically implanted animals. Electrophysiological techniques will be employed including spectral analyses of EEGs and averaged cortical evoked potentials using a computer of averaged transients to determine sensitivity to electromagnetic radiation. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0046 COMPARISON OF RF FIELD DELIVERY TECHNIQUES AND MEASURABLE RESULTS IN CELL CULTURE AND WHOLE ANIMALS. Guy, A. W. (Univ. Washington, Sch. Medicine, C304 Health Sciences Building, Seattle, WA 98105).

High level national concern over the adequacy of existing radiofrequency safety standards has highlighted the need to define experimental exposure fields accurately, insure intercomparability of power deposition and mechanism of injury studies and validate theoretical predictions with measured distributions in experimental animals. This effort will investigate ground plane and position effects on power absorption in several man models at the University of Washington and at USAFSAM/RA. Investigators will intercompare field measurement techniques used at the University of Washington and those used at USAFSAM, and compare the theoretical and measured distributions in experimental animals exposed in both facilities. In addition, an exposure system will be designed and constructed for cell or tissue cultures when fields within culture can be exactly specified. Investigators hope to demonstrate the utility of the culture system by exposing freshly isolated primate lymphocytes with and without simulating antigens. University of Washington personnel are to bring thermographic equipment and field measurement devices to USAFSAM to compare their measurements with those at USAFSAM. Killed animal models and physical models are to be examined after exposure to a variety of frequencies generated by the HF band coax, near field synthesizer and the University of Washington resonant cavity at USAFSAM and at the University of Washington. Fields generated by the multiple frequency exposure apparatus will also be provisionally examined at SAM. An exposure cell is to be constructed from readily available materials, and its utility

demonstrated by exposure of freshly isolated lymphocytes to fields calculated for an equivalent field in man models exposed to a variety of field geometries. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0047 NAVY ENVIRONMENT: EVALUATION OF THE SAFETY EXPOSURE LIMITS OF RADAR USED BY NAVAL PERSONNEL. Hunt, E. L.; Phillips, R. D. (Battelle Memorial Inst., P.O. Box 999, Richland, WA 99352).

Naval personnel exposed to the powerful electromagnetic radiation of radar on shipboard may suffer possible nervous side-effects as a result of long-term exposure, which are not immediately apparent. This research is designed to test for possible ill effects of chronic low-level microwave exposure. Studies will be limited to behavioral and neurophysiological investigations for the detection and characterization of effects that might be produced by short term exposure to pulsed microwaves at low power levels (10 mW/cm^2 or less average power), or following chronic exposures to pulsed microwaves at low average levels. Discrimination performances will be tested using operant conditioning procedures. One test will look for a disturbance in the level of performance following exposure. Another will look for disturbances in the learning of a simple discrimination task. Research will continue attempts to verify the avoidance by rats of the pulsed microwave field. In addition, susceptibility to sound-induced seizures will be studied in sensitive and insensitive mice following exposure to pulsed microwaves in a series of daily 3-hour exposures. (7/75-6/76)

Supporting Agnecy:U.S. Dep. Def., Navy.

0048 TO DESIGN AND STUDY THE EFFECTS OF BIOMEDICAL SYSTEMS ON ANIMALS. Dracy, A E.; Sander, D. E.; Busch, L. F. (South Dakota State Univ., Agricultural Experiment Station, Brookings, SD 57006).

The threefold objectives of this study are: (1) to design and test the validity of a volume conduction system for measuring body temperature continuously, (2) to study the effects of microwaves for partial and complete sterilization of farm animals, and (3) to design and test a unit, which will have an exciting effect on rats and mice. The latter will also be used for rodent control. The stated approach is to use the circuitry built during the school year and improve on the water stability problems as they affect the operation of the circuit; implant and monitor temperatures of the internal organs of the animal; build a microwave cavity and obtain equipment to irradiate safely the testicles of a sheep; and irradiate the subject and test the amount of sterility as a function of radiation power and time of exposure. In addition, investigators will design and build a power supply from existing sources and test the effectiveness of the sound source on the eradication of rats and mice. To date, a low-power, three channel telemetry system has been designed, built, and laboratory tested. This telemetry system transmits temperature, respiration, and electrocardiogram data simultaneously to an FM receiver-cassette tape recorder combination. The data are then transferred to the laboratory to be demodulated and analyzed. The circuitry utilizes low power amplifying multiplexing and modulation circuits as well as a low power transmitter. The entire transmitter package is housed in butal cement and nontoxic silicone rubber for implanting. Electrodes for the ECG, a thermistor probe for temperature, and a strain gage mounted on a three-inch metal fulcrum for respiration are attached to the transmitter via connecting wires. The life-time of the present system is about 60 days with the batteries used. The entire system was designed to gather data to determine excitability and state of emotional excitement in animals when exposed to different noises and sounds. It is known that heart rate, temperature, and to a lesser degree, respiration rate is affected by excitement stimuli. (7/75-6/76)

Supporting Agency:South Dakota State Govt.

0049 ELECTROMAGNETIC RADIATION AND BIOLOGICAL SYSTEMS. Bawin, S. M.; Adey, W. R.; Medici, R. J.; Walter, D. O. (Univ. California, Sch. Medicine, 405 Hilgard Ave., Los Angeles, CA 90024).

The study of the effects of electromagnetic radiations (450 MHz, amplitude modulation 0-90%, 0.1-10 mW/cm^2) on behavioral performances and brain neurochemistry of laboratory animals, (monkeys, cats, and chickens) will be continued, using the field exposure techniques developed and tested in this laboratory during the 1974-75 research period. Internal dosimetry studies and development of recording electrodes will be pursued in chronically and acutely exposed preparations. Theoretical models of brain tissues will be developed to provide a basis for interpretation of the experimental results and possible new designs of brain tissue simulation. (12/75-11/76)

Supporting Agency:HEW, PHS, FDA, Bur. Radiol. Health.

0050 NAVY ENVIRONMENT: EFFECTS OF MICROWAVES ON MATURATION IN THE RAT. Michaelson, S. (Univ. Rochester, Sch. Medicine & Dentistry, 601 Elmwood Ave., Rochester, NY 14642).

Research to date has shown that microwaves affect the growth and development of the rat fetus when the exposure is properly placed during the gestational period. Brain growth appears to be most affected. This research will attempt to study how subsequent neo-natal development and maturation of temperature regulation, which involes neural, hormonal and mutational facets, are modified by the *in utero* exposures. The development of the brain and ontogeny of temperature will be studied by exposing individual rats (previously exposed *in utero*) of specific ages to a mild cold stress (25-30° C) and measuring metabolism (O_2 consumption) and peripheral venous vasoconstriction. If a deficit appears, substrate, hormonal or neural factors which may be responsible will be examined. Some animals will be decapitated for gross and microscopic examination of the brain. During the second

year, power density/time relationships will be developed on the basis of body surface. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0051 CLINICAL ASPECTS OF MICROWAVE EXPOSURE. Michaelson, S. M. (Univ. Rochester, Sch. Medicine & Dentistry, 601 Elmwood Ave., Rochester, NY 14642).

Evaluation of alterations in the functional status of the neuroendocrine system after exposure to microwaves and elucidation of threshold levels, cumulative effects, interaction with other stresses and environmental factor is the objective of this study. Mature rats will be exposed to microwave irradiation in three different regimens: 100 mW/cm^2, 10 mW/cm^2, and 1 mW/cm^2 for eight weeks. Periodically throughout the exposure, body weight and temperature will be taken, and blood drawn. Gross behavioral observations will also be made. Thyroid function will be evaluated using T3 and T4 resin sponge absorption studies. Pituitary function will be determined by a bioassay of TSH. Mature dogs also will be exposed to microwave irradiation. Evaluation of changes in body weight, temperature, behavior, thyroid and pituitary function will be carried out as with the rats. In addition, hematology, clinical chemistries, free T4TSH, and growth hormones will be studied by radioimmunoassay and serum electrophoresis. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0052 AN INVESTIGATION OF THE EFFECT OF MICROWAVES ON ISOLATED NEURONS. Wachtel, H.; Joines, W. (Duke Univ., Sch. Arts & Sciences, Durham, NC 27706).

The effect of microwave irradiation on the neurons of the marine mollusc *aplysia* will be investigated. Special emphasis will be given to the pacemaker cells which exhibit regular firing patterns in the absence of external stimulation. A neuron from the abdominal ganglion of *aplysia* is pined out in a small chamber that is inserted into a microwave strip line. The neuronal activity is monitored with intracellular microelectrodes. Both incident and reflected power are recorded. Theoretical, as well as experimental, determinations of the absorbed power are made. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0053 EFFECTS OF NON-IONIZING ELECTROMAGNETIC RADIATION ON SUBCELLULAR PREPARATIONS. Straub, K. D. (Univ. Arkansas, Sch. Medicine, 4301 W. Markham St., Little Rock, AR 72201).

The effect of extremely low frequency and microwave radiations on the subcellular preparations responsible for active transport and oxidative phosphorylation will be explored. Microsomal (cell membrane) (Na^+ and K^+) ATPase from several sources (ox brain, rat brain, gar olfactory nerves, and invertebrate peripheral neurons) will be exposed to both ELF-VLF (10 Hz-30 kHz), VHF-UHF (30-300 MHz) and microwave radiation (1-12 G"z) in specially constructed cells. Various parameters of this membrane preparation including K_m and V_{max} for Na^+, K^+, and Mg^{++} and ATP, ubain sensitivity and lipase activation will be measured. Fluorescent probes of membrane structures will be used to assess the extent of change in membrane conformation. Simultaneously, rat liver and rat brain mitochondria will be exposed to these frequencies using the same exposure cells. The O_2 consumption, ADP/O ratios, state 3-4 transition, control ratios, swelling and shrinking, and state of electron carriers will be measured. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0054 EFFECTS OF NON-IONIZING RADIATION ON BIOMEMBRANES AND BIOLOGICAL MACROMOLECULES. Sheridan, J. P.; Weiss, J. A. (U.S. Navy, Research Lab., Washington, DC 20390).

This Navy program will investigate the possible effects of non-ionizing radiation of living organisms. The objective of this research is to determine the effects of pulsed and continuous wave non-ionizing electromagnetic radiation on biomembranes and biological macromolecules. By obtaining data on these interactions at the molecular level it should be possible either to substantiate or refute the possible implications of low level effects and aid in establishment of a safety level with sound and comprehensive scientific backing. The structural properties of various model membrane systems under the influence of low to moderate power non-ionizing electromagnetic radiation will be studied using raman spectroscopy, fluorescence spectroscopy, and microcalorimetry. The frequency dependence of any observed effects will be investigated over the 100 MHz-20 GHz spectral region using both pulsed and continuous wave sources. These studies will serve as the basis for the investigation of real biological membranes and other biologically active and accessible membrane structures. Concurrent with these studies, the effects of electromagnetic radiation on biological macromolecules including polypeptides, proteins and polynucleotides will be examined. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0055 BIOCHEMICAL EFFECTS OF MULTIFREQUENCY MICROWAVE RADIATION. Reno, V. R.; Beischer, D. E. (U.S. Navy, Biomedical Division, Pensacola, FL 32512).

Biochemical studies will be conducted in primates as an index of effects of microwave radiation on naval personnel. Subhuman primates will be exposed to pulsed and continuous wave microwave radiation in the range of 1-30 mW/cm^2 for extended periods. Radiation frequencies of 1-12.4 GHz will be used and the polarization varied to identify frequency and polarization specific effects. Serial blood sampling procedures will provide material for biochemical and hematological analysis. Results will be statistically

correlated with the radiation parameters and other significant physical factors, such as, the ratio of the animal size to the wavelength of the radiation. The observed biochemical and hematological changes will be considered in relation to other studies conducted under the same conditions. This new work unit continues previously performed research. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0056 RADIOFREQUENCY RADIATION EFFECTS ON BIOCHEMICAL SYSTEMS IN THE CENTRAL NERVOUS SYSTEM. Merritt, J. H.; Frazer, J. W. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

The Air Force has an on-going research and development effort to evaluate the biological effects of radiofrequency radiation associated with planned or operational radar systems. This effort will evaluate "near field" exposures representative of those associated with the 414L OTH radar system. Data will be applied to Air Force safety criteria for this and other systems. The study will evaluate the effects of radiofrequency radiation on those biochemical events subserving and associated with neural impulse transmissions in the central nervous system. Simultaneous estimations of 5-hydroxyindoleacetic acid, homovanillic acid, norepinephrine, dopamine, and 5-hydroxytryptamine will be made in discrete brain areas of rats exposed to radiofrequency fields. Preliminary studies of the effect of a defined electrical stimulus and hyperthermia on the levels of these transmitters will be made. After preliminary data have been obtained, the effect of "far field" conditions (19 MHz) at both continuous wave and pulsed modes on the neurotransmitters will be determined. The same studies will be done using animals exposed on the SAM "near field" simulator. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Air Force.

0057 REFLECTION AND DIFFRACTION ASPECTS OF BIOLOGICAL MICROWAVE DOSIMETRY. Reno, V. R.; Beischer, D. E. (U.S. Navy, Biomedical Division, Pensacola, FL 32512).

Procedures will be developed to provide new insight into the energy absorbed from microwave fields by living systems to estimate validly the effects of microwave energy on naval personnel. Reflection and diffraction studies will be performed, with the ultimate objective of estimating absorption of microwave energy from information contained in the spatial and amplitude distribution of energy in proximity to illuminated objects. Holographic procedures are among those that will be applied to data from field scans taken near animals and objects of different shape and composition. This is conceptually a new approach that may provide an improved, noninvasive method for estimating the absorption of microwave energy by living organisms. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0058 MICROWAVES. Anonymous. (Natl. Scientific Res. Center, 15 Quai Anatole, Paris, France 75700).

Microwaves have significant effects on materials and biological substances. This study will investigate the effects of microwaves and thermal treatments on industrial materials in addition to the effects of microwaves on insects and microorganisms. (7/75-6/76)

Supporting Agency:Natl. Sci. Res. Ctr., France.

0059 NAVY ENVIRONMENT: BIOMEDICAL EFFECTS OF RADIO FREQUENCY RADIATION. Lin, J. C.; Kraus, G. E. (Wayne State Univ., Sch. Engineering, 5950 Cass Ave., Detroit, MI 48202).

As a major user of electromagnetic radiation, especially in the area of communication in the UHF to VHF portion of the spectrum and having many potential human exposure situations, the Navy is attempting to establish a sound basis for exposure standards. This research will be a part of the effort to determine the potential for hazard in the frequency range of 50-300 MHz. This study will investigate the effect of radiofrequency radiation on the growth, reproduction, and pathology of mice. The mice will be exposed, both acutely and chronically, in a parallel strip transmission chamber where plane wave fields with variable E/H ratios can be produced. Temperature distribution and patterns will be used to establish correlations. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0060 OCULAR EFFECTS OF MICROWAVE RADIATION. Carpenter, R. L. (U.S. Dept. Health, Education & Welfare, Public Health Service, Food & Drug Admin., Winchester, MA 01890).

The objective of this project is to determine the threshold conditions for the production of microwave induced cataracts and to uniquely characterize these cataracts. The effect of frequency, dose regimen and pulsing on the threshold for cataract formation in rabbits will be investigated. Biochemical and histopathological examinations of microwave irradiated lenses will be made to determine if microwave induced cataracts differ in any characterizable manner from cataracts of other etiologies. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0061 PROSPECTIVE EPIDEMIOLOGICAL STUDY TO EVALUATE NAVAL PERSONNEL OCCUPATIONALLY EXPOSED TO NON-IONIZING ELECTROMAGNETIC RADIATION. Blais, B. M.; Kelly, R. (U.S. Navy, Ophthalmology Dept., 17th & Pattison Ave., Philadelphia, PA 19145).

No descriptive information is available. (7/75-6/76)

Supporting Agency:U.S. Dep. Def., Navy.

0062 MICROWAVE HEATING (MAMMALS). Guy, A. W. (Univ. Washington, Sch. Engineering, 206 Guggenheim Hall, Seattle, WA 98105).

See CR 0063 for description of this research. (10/75-9/76)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Gen. Med. Sci.

0063 MICROWAVE NERVE AND MUSCLE STIMULATION BY IMPLANTED DIODES (MAMMALS). Daniels, P. (Univ. Washington, Sch. Engineering, 206 Guggenheim Hall, Seattle, WA 98105).

This project is part of a broader program (GM 16436-08) conducted by the Center for Bioengineering, which represents a multidisciplinary research program involving faculty and students from all the departments of engineering engaged in collaborative research with health scientists from many medical and dental disciplines. Teams of investigators have been mobilized and organized to attack more than seventy projects of mutual interest ranging from the most basic "bioengineering science" problems to instrumentation and clinical engineering applied directly to patients. In accordance with carefully conceived plans, these individual collaborative research efforts have now been organized into eight groups, with common research objectives, facilities, requirements, budgets, and a responsible investigator. This major effort has been built upon a small central management including accounting, purchasing, central shop, and inventory control. The success of this effort is attributable in part to a few basic policies: (1) the Center supports existing department programs and does not dilute or compete with them, (2) the participants must have clear professional benefits from the program, (3) the engineers and life scientists must work as equal partners, (4) the future of biomedical research resides at the interface between disciplines. The Center for Bioengineering also serves as an interface between the University and the community, nurturing interaction with extramural medical research laboratories, not-for-profit research and development laboratories, local industry, medical centers and the community at large. By these means a comprehensive effort is directed toward transferring the fruits of biomedical engineering research and development to the health care delivery system. (10/75-9/76)

Supporting Agency:HEW, PHS, NIH, Natl. Inst. Gen. Med. Sci.

4500 EFFECTS OF MICROWAVES ON THE TWENTY-FOUR HOUR RHYTHM AND TWENTY-FOUR HOUR URINARY EXCRETION OF SEVENTEEN HYDROXYCORTICOIDS AND SEVENTEEN KETOSTEROIDS (SYMPOSIUM SUMMARY). (Eng.) Szady, J. (Postgraduate Medical Center, Military Medical Acad., ul Szsaserow 128, Warszawa 60, Poland); Siekierzynski, M.; Dziuk, E.; Jedrzejczak, W. W.; Czarnecki, C. *J. Microwave Power* 11(2): 139-140; 1976.

The urinary excretion of 17-hydroxycorticoids (OHCS) and 17-ketosteroids (KS) was determined in subjects exposed to microwave radiation. Investigations were carried out in two groups. Group I comprised 12 male subjects aged 20-22 years, working under exposure to microwave radiation pulse-modulated at different frequencies, used in radiolocation and at a mean energy beam density of 2-60 W/m^2. Group II (control) contained 15 males of the same age not exposed to microwave radiation. In all subjects the urinary excretion of 17-OHCS (Porter-Silber method) and 17-KS (Norymberski-Zimmerman method) was determined, and changes in the 24-hour rhythm of excretion of these hormones were analyzed. The determinations were performed at four-period time intervals during 48 hours, i.e., on a workday and the following day. The results failed to demonstrate differences in 17-OHCS and 17-KS excretion between these groups, and the 24-hour rhythm of excretion of these hormones corresponded to the normal physiologic rhythm. (No refs.)

4501 COMPARATIVE STUDY OF THE ACTION OF THREE TYPES OF MICROWAVE FIELDS UPON THE BEHAVIOR OF THE WHITE RAT (SYMPOSIUM SUMMARY). (Eng.) Servantie, B. (Ecole d'Application du Service de Sante pour la Marine--Centre d'Etudes et de Recherches Biophysiologiques appliquees a la Marine, 83800 Toulon Naval, France); Gillard, J.; Servantie, A. M.; Obrenovitch, J.; Bertharion, G.; Perrin, J. C.; Creton, B. *J. Microwave Power* 11(2): 145-146; 1976.

Behavioral perturbations induced in the white rat were studied after two weeks exposure to 2.45 GHz continuous wave field, 9.4 GHz, 0.15 µsec, 2000 Hz and 9.4 GHz, 0.5 µsec, and 1000 Hz microwave fields. Rats were first exposed to a 9.4 GHz field modulated with 2000 Hz, 0.15 µsec pulses, with a low average power density (0.7 mW/cm^2). Their behavior was modified: in control animals, locomotor activity, emotivity, and watchfulness decreased during the test, while exploratory activity increased; in irradiated animals, locomotor activity remained uniform, watchfulness at first increased then decreased, and exploratory activity increased more slowly. The same test was used to compare the action of three different fields: a 2.45 GHz continuous wave field with a power density of 5 mW/cm^2; a 9.4 GHz pulsed field with 0.15 µsec pulses, 2000 Hz pulse repetition frequency, and an average power density of 0.7 mW/cm^2; a 9.4 GHz pulsed field with 0.5 µsec pulses, 1000 Hz pulse repetition frequency and an average power density of 0.7 mW/cm^2. After 15 days of exposure to a field the rats were subjected to the test. The 2.45 GHz continuous wave field and the 9.4 GHz 0.15 0.5 µsec pulsed field produced only weak alterations. behavioral alterations; on the contrary, the 9.4 GHz µsec pulsed field produced only weak alterations. The theoretical values of the fields into the rat head were computed using data from the literature. It is postulated that the action of microwave fields on the behavior of rats is linked to the peak power density and not to the average power density. Moreover, this action seems to be independent of the modulation of the field. (No refs.)

4502 BIOLOGICAL MEASUREMENTS IN RODENTS EXPOSED CONTINUOUSLY THROUGHOUT THEIR ADULT LIFE TO PULSED ELECTROMAGNETIC RADIATION. (Eng.) Baum, S. J. (Armed Forces Radiobiology Res. Inst. Defense Nuclear Agency, Bethesda, MD 20014); Ekstrom, M. E.; Skidmore, W. D.; Wyant, D. E.; Atkinson, J. L. *Health Phys.* 30: 161-166; 1976.

Possible late effects in Sprague-Dawley rats continuously exposed to a total of 2.5 x 10^8 pulses of electromagnetic pulse (EMP) for 94 weeks of their adult life were investigated. The EMP generator produced 5 pulses/sec for 2.5 x 10^8 pulses and a maximum electric field strength of 447 kV/m. Blood chemistry, chromosomal damage, red blood cell production, fertility and reproductive capabilities, blood and bone marrow cellular concentration, and appearances of tumors or other defects were monitored. Exposed rats and controls showed no differences in nucleated bone marrow. The final combined mean number of nucleated cells/mm^3 of bone marrow was 8.1 x 10^5 ± 10^5. Early in the study exposed rats showed an increase in the number of reticulocytes, but this difference disappeared in the last 25 weeks of the study. The incidence of tumors was similar for both groups. Rat pairs exposed to 3.4 x 10^7 EMP showed no loss of fertility and no anatomic abnormalities were recorded for progeny. In effect, EMP was believed to pose no biologic hazard to the rodents, although it is difficult to prove that minute somatic changes had not occurred that could be of future deleterious consequences. (9 refs.)

4503 EFFECTS OF EXTREMELY LOW FREQUENCY ELECTROMAGNETIC FIELDS ON *PHYSARUM POLYCEPHALUM*. (Eng.) Goodman, E. M. (Univ. Wisconsin-Parkside, Kenosha, WI 53140); Greenebaum, B.; Marron, M. T. *Radiat. Res.* 66(3): 531-540; 1976.

Effect of extremely low frequency (ELF) electromagnetic fields (EMF) was studied on microplasmodia of the slime mold *Physarum polycephalum*. Experiments included observations of vegetative growth, sporulation or encystment, sexual life cycle, and protoplasmic streaming. Ten experimental plates (versus 10 controls) were continually subjected to a particular EMF, then the mitotic cycle ascertained by ethanol fixed smears. The ability of plasmodia to form spherules or to encyst was determined by pigment extraction. The ability of plasmodia to sporulate and germinate, and then fuse to form plasmodia was studied in experiments on the sexual cycle. Protoplasmic streaming was determined by the oscil-

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latory period of four streaming channels and choice of 4-10 channels per culture. ELF EMF exposures of 75, 60, and 45 Hz, 2.0G, 0.7 V/m caused lengthening of the mitotic cycle and slowing of shuttle streaming at 14, 90, and 120 days of exposure, respectively. These results may indicate that mitotic delay is frequency dependent. Delay in cycle may be due to interference with the mitotic cycle. Threshold intensities for affect are between 0.4 and 2.0 G, and 0.15 and 0.7 V/m. Mitotic delay is reversible. EMF had no significant effect on ability to form spherules or encyst, but delay in nuclear division was noted. (17 refs.)

4504 USE OF 300-MSEC MICROWAVE IRRADIATION FOR ENZYME INACTIVATION: A STUDY OF EFFECTS OF SODIUM PENTOBARBITAL ON ACETYLCHOLINE CONCENTRATION IN MOUSE BRAIN REGIONS. (Eng.) Modak, A. T. (Univ. Texas Health Science Center at San Antonio, San Antonio, TX): Weintraub, S. T.; McCoy, T. H.; Stavinoha, W. B. *J. Pharmacol. Exp. Ther.* 197(2): 245-252; 1976.

Microwave irradiation (300 msec) was used to inactivate cholinesterase and choline acetyltransferase to study the effects of sodium pentobarbital on acetylcholine concentrations in the brain of male Sprague-Dawley rats. Microwave irradiation of 6 kw at 2450 MHz for 300 msec was used to sacrifice mice and rats treated intraperitoneally with sodium pentobarbital (50, 80, 100 mg/kg). This technique rapidly causes irreversible inactivation of the brain enzymes. Not only did the enzyme levels remain close to *in vitro* levels, but the tissue was fixed, thus simplifying microdissection of the brain. The highest levels of acetylcholine were found in the striatum (81 nmol/g), while the cerebellum had the least (17 nmol/g). Increases of acetylcholine in the brain after treatment with sodium pentobarbital was found not to be due to hypothermia or anoxia. The drug caused an increase of acetylcholine in all areas of the brain studied, except the cerebellum, where there was a decrease. Central nervous system depression was correlated with high acetylcholine levels. When neuronal activity returned to normal, acetylcholine levels decreased. (31 refs.)

4505 SOME ASPECTS OF ETIOLOGICAL DIAGNOSIS IN OCCUPATIONAL DISEASES DUE TO THE ACTION OF MICROWAVE RADIATION. (Rus.) Gus'kova, A. K. (Inst. of Industrial Hygiene and Occupational Diseases of the U.S.S.R. Academy of Medical Sciences, Moscow, U.S.S.R.); Kochanova, E. M. *Gig. Tr. Prof. Zabol.* (3): 14-18; 1976.

Predisposing risk factors for cardiovascular diseases were analyzed in 21 men, aged 35-54 year, who had been occupationally exposed to intense super high frequency radiation for a prolonged time, and in whom radiowave sickness was diagnosed. The duration of the occupational exposure was over 10 years in 19 patients. Clinical examinations revealed hypertonic neurocirculatory dystonia in 7 patients, hypertension in 10 patients, ischemic heart disease in 2 patients, and hypothalamic insufficiency in another 2. A reexamination 2-3 years after the cessation of the occupational exposure showed no marked improvement. Among the risk factors predisposing to cardiovascular diseases were nervous-emotional stress, which was found in 14 cases, overload factors due to combination of work and study in 4 cases, night shifts in 17 cases, regular smoking in 7 cases, moderate alcohol consumption in 7 cases, moderate alcohol consumption in 7 cases, hereditary load in 5 cases, cranial trauma in the anamnesis in 3 cases, overweight in 5 cases, hypercholesterolemia in 12 cases, and arterial hypertension in 10 cases. Combination of 3-6 of the above risk factors was found in 10 patients. The findings indicate that microwave radiation may be one of the risk factors of cardiovascular pathology rather than a sole factor of the disease. (16 refs.)

4506 THE RELATION OF SEX, AGE, AND WEIGHT OF MICE TO MICROWAVE RADIATION SENSITIVITY. (Eng.) Rugh, R. (U.S. Dept. of Health, Education and Welfare Public Health Service, Food and Drug Administration, Bureau Radiological Health, 5600 Fishers Lane, HFX-120 Rockville, MD 20852). *J. Microwave Power* 11(2): 127-132; 1976.

Male and female CF_1 strain mice were irradiated to death to determine whether sex, age, or weight affected their sensitivity to microwave radiation. Weanling (one month old), sexually mature (two months old) and aged mice (fourteen months) were exposed to 2450 MHz radiation at 7.5 watts forward power. A total of 114 mice were used with a minimum of 14 per group. Results show that under the same radiation condition both sexes displayed an increase in time of death with increased age and weight. Time to death increased from 4.10-7.66 minutes for males and from 3.80-5.56 minutes for females. Absorbed dose in J/g at death rose slightly, but not significantly, with age for males (43.9-47.80) but declined slightly with age for females (42.90-39.30). The slight depression in absorbed dose at death for females is believed to be sex related and due to the physiological stress of bearing approximately 100 offspring. In the same sex group, the mean absorbed lethal dose was essentially the same for all ages and weights but differed considerably between the sexes. All males absorbed more microwave energy in J/g at death than comparable females, and therefore, are more radioresistive. Normal male mouse temperature was 37.9°C and 38.4°C for females. Lethal rectal temperature was >43°C. There was no evidence of change in radioresistance with age. (11 refs.)

4507 MODIFICATION OF THE REPAIR OF RADIATION DAMAGE OF HAEMATOPOIESIS IN MICE BY MICROWAVES (SYMPOSIUM SUMMARY). (Eng.) Rotkovska, D. (Inst. Biophysics, Czechoslovak Acad. Sciences, Brno, Czechoslovakia); Vacek, A. *J. Microwave Power* 11(2): 141-143; 1976.

Microwaves (2450 MHz, 100 mW/cm^2) were used to modify postirradiation repair of hematopoiesis in the mouse in an early period until 24 hours after whole-