0001 RADIOFREQUENCY RADIATION INTERFERENCE (RFI) OF MEDICAL PROSTHETIC DEVICES. Mitchell, J. C.; Hardy, K. A. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

This study is aimed at developing test data on the interaction of Air Force radiofrequency radiation emitters and medical prosthetic devices. The initial objective is to assess manufacturers' progress in developing cardiac pacemakers to operate properly pulsed radiofrequency fields of 200 V/m. The overall purpose of this research and development effort is to resolve the potential hazard to cardiac pacemaker users in the vicinity of radiofrequency radiation emitters. A state-of-the-art test sample of cardiac pacemakers including approximately 20 types made by 10 different manufacturers will be tested to a variety of radiofrequency radiation sources. Tests will be conducted in both "free-field" and "simulated-implant" configurations, in the laboratory, and at radar and communication sites remote from Brooks Air Force Base. Test plans include studies using the AWACS radar, AN/FPS-24 and 35 research radar, AN/MPS-T1 ECM threat simulators, AN/FRT-49 ground to air telemetry system, and a LORAN system. The AN/FPS-85 and and AN/TPS-44 may also be studied. (7/75-6/76)

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

0002 NONIONIZING ELECTROMAGNETIC RADIATION INTERACTION WITH CENTRAL NERVOUS SYSTEM CNS FUNCTION (ABBREV). Diachenko, J. A.; Glaser, Z. R. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

Nonionizing, electromagnetic radiation may interact with the central nervous system. However, the course, character, and extent of central nervous system interaction has not been clearly defined. Neuromuscular microtremor measured at the fingertip offers a sample of central nervous system function. The literature amply demonstrates that normal human tremor (typically measured with the finger pressed upon a transducer) exhibits a major peak neuromuscular frequency between 8-12 Hz, and where the central nervous system has been acted upon by toxic substances, the tremor typically shifts to a lower frequency below 8 Hz. Workers exposed to electromagnetic radiation will be studied via microtremor sampling to investigate changes in central nervous system function and to obtain a better definition of the onset and course of electromagnetic interaction. A tremor sensing device has been built and used to obtain samples from workers exposed to electromagnetic radiation and from control personnel. Testing does not involve intentional exposure of subjects to electromagnetic radiation. Samples are obtained from electromagnetic radiation-exposed workers before and after any exposure encountered in their normal work and consist of analog recordings from the fingertip as it presses a sensitively balanced transducer. The transducer forms one side of a balanced bridge circuit such that minute force changes on the transducer cause larger unbalanced voltages within the bridge, thus obtaining a direct translation of finger vibrations (tremor) into voltage shifts. These voltage changes are analyzed through a fourier spectrum analyzer, which yields power spectra for each 2 minute sample—literally a sorting of frequencies with attendant power. This power spectrum offers visual evidence of the normal tremor peak between 8-12 Hz. (7/75-6/76)

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

0003 CARDIOVASCULAR EFFECTS OF MULTIFREQUENCY MICROWAVE RADIATION. Reno, V. R.; Beischer, D. E. (U.S. Navy, Biomedical Division, Pensacola, FL 32512).

Laboratory experiments will be conducted to evaluate the effects of operational microwave exposure of naval personnel. This study is part of an approach that involves considerations of dosimetry, scaling and frequency specificity as related to the observed changes in the electrocardiogram (ECG). Subhuman primates will be exposed to microwave radiation in the range of 1-30 mW/cm^2 for extended periods. Vertically or horizontally polarized radiation will be used at selected frequencies between 1 and 12.4 GHz to characterize frequency and polarization specific effects. Changes in cardiac performance will be determined by computer analysis of the ECG and correlated with the various radiation parameters. The results from these experiments will be integrated with those from studies under the same conditions to provide more complete insight into the biological effects of microwave radiation. This new work unit continues previously performed research. (7/75-6/76)

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

0004 PROGRAM ON THE QUANTITATION OF THE EFFECTS OF ELECTROMAGNETIC ENERGY ON HUMAN TISSUE. Guy, A. W. (Univ. Washington, Medical Rehabilitation Research & Training Center, 15th Ave. N.E., Seattle, WA 98105).

The purpose of this investigation is to advance the existing knowledge on the human body and to provide realistic guidelines for safety standards of human exposure. The electromagnetic field patterns from external sources of energy, both in and exterior to the tissues of human subjects and test animals, will be established quantitatively. The test animals will be exposed to the various continuous wave and modulated electromagnetic sources at both thermal and nonthermal lower levels while monitoring the energy in the tissues. The physiological and behavioral characteristics of the animals will be observed before, during, and after exposure to electromagnetic radiation. The time and power density thresholds for cataract production will be determined in animals exposed to microwave radiation. Safe human exposure levels will be determined, taking into proper account the source, configuration, frequency, and location. The theoretical analysis involves the solution of Maxwell's equation for the absorbed power by biological systems for a host of different geometries. The experimental studies involve controlled exposure of test animals to select sources of electromagnetic energy with the aim of quantifying observable effects and changes on the biological systems. Thus far, the minimum catar-

actogenic threshold in the eye of a rabbit exposed to electromagnetic energy has been determined. The threshold for human auditory perception of incident microwave pulses was found to correspond to a specific pulse energy density regardless of average or peak power. Calculated peak pressures induced in mammalian tissues by the incident electric field energy were found to be above the bone-conduction threshold. The behavior of the spinal cord exposed to high level microwaves indicates that this central nervous system structure is subject to functional alteration by the impingement of radiation. These effects are not unique; they are the same as the effects of nonradiation heating. If the tissues are properly cooled during microwave illumination, the effects are ameliorated or even reversed. The effect of radiating the abnormally cold spinal cord with microwaves is to change the activity in the direction toward normalcy. (7/75-6/76)

Supporting Agency:HEW, Social & Rehabilitation Serv., Office of Res. Demons. & Trng., Res. & Trng. Centers Div.

0005 INTERACTION OF ELECTROMAGNETIC FIELD WITH HUMAN BODY. Chen, K. (Michigan State Univ., Sch. Engineering, Engineering Building, East Lansing, MI 48824).

This research program will concentrate on the interaction of an electromagnetic field with the human body. A theoretical study will be conducted to determine the internal electromagnetic field induced inside the body and the external electromagnetic wave scattered by the body when it is illuminated by an electromagnetic wave. The accuracy of the theoretical results will be verified by an experimental study that will be conducted to measure the electric fields induced inside of simple boxes containing saline solution and inside the phantom model, which closely approximates the actual human tissues and torso. The theoretical method involves the numerical solution of a tensor integral equation for the electric field induced inside an irregularly shaped body. Various models of the human torso or other biological systems will be considered. It is anticipated that after the accuracy of the theoretical method is established a user-oriented computer program for the field calculations will be developed. (8/75-7/76)

Supporting Agency:U.S. Natl. Sci. Found., Div. Eng.

0006 BIOLOGICAL EFFECTS OF LOCALIZED E- AND H-FIELDS IN THE STANDING MICROWAVE FIELD. Beischer, D. E.; Reno, V. R. (U.S. Navy, Biomedical Division, Pensacola, FL 32512).

Standing waves are found on board ship due to microwave reflections from metal walls and equipment. The effects of localized E- and H-fields on living objects will be investigated. Electric (E) and magnetic (H) fields will be generated at different microwave frequencies by reflection of a traveling wave from a metal plate in an anechoic chamber. Measurements based on previous experience will provide information on the degree of local separation of the E- and H-components of the field. Small organisms, such as, *tribolium pupae* will be introduced into known parts of the field and the bioeffects (wing deformation in the imagio) determined. This series of experiments should provide some of the first information available on specific bioeffects of E- and H-fields at microwave frequencies. (7/75-6/76)

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

0007 BEHAVIORAL CHARACTERISTICS OF MONKEYS AND RATS IRRADIATED WITH MICROWAVES. Delorge, J. O.; Beischer, D. E. (U.S. Navy, Biomedical Division, Pensacola, FL 32512).

The effects of low power density microwave radiation on monkeys and rats will be investigated by measuring their ongoing operant behavior. Rhesus monkeys, squirrel monkeys, and rats trained on various operant tasks will be exposed for prolonged durations to microwave radiation at power levels of 8-16 mW/cm^2, pulsed at selected frequencies. The animals, while working, will be exposed to vertically or horizontally polarized radiation at 1.7 and 6 GHz to demonstrate differential effects of polarization and frequency. The exposures will occur in essentially non-reflective restraint devices. In addition the animals, chosen for size differences, will perform similar tasks and provide information for comparative study of animal size and microwave parameters utilizing behavior as the dependent variable. This new work unit continues previously performed research. (7/75-6/76)

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

0008 COMPARISON OF THEORETICAL AND EXPERIMENTAL ABSORPTION OF RADIOFREQUENCY. Durney, C. H.; Johnson, C. C. (Univ. Utah, Sch. Engineering, 1400 East 2nd St., Salt Lake City, UT 84112).

Recent data indicate that the biological hazard of nonionizing electromagnetic radiation is frequency dependent, and body shape, size, and orientation are important variables affecting power deposition and subsequent hazard. The Air Force is advocating a frequency related safety standard approach with the objective of extending theoretical radiofrequency power absorption calculations and to perform experimental measurements necessary for assessing realistic personnel exposure criteria in the 10 kHz to 100 MHz frequency range. Assessment techniques will account for size and orientation effects, to extrapolate from animal to human radiofrequency exposure situations. A set of prolate spheroid models will be constructed to represent the rhesus primate and human. Theoretical calculations will be made to determine the amount of power absorbed for exposures between 10 kHz and 100 MHz. Power absorption measurements will be performed from 10-30 MHz and the results compared with theory. Rhesus primates will be exposed in the same geometry as the phantoms to evaluate anisotropic effects. The resulting data will be used to establish appropriate personnel exposure guidelines for a broader frequency range

than can be measured with available experimental apparatus. (7/75-6/76)

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

0009 IONIZING AND NON-IONIZING RADIATION BIOLOGY. Appleby, A. (Rutgers State Univ., Agricultural Experiment Station, Old Queens Building, New Brunswick, NJ 08903).

The investigators will evaluate the effect of chronic low level microwave exposures on the mammalian anterior lens as they relate to cataract formation at various age levels. Fundamental data will be obtained relevant to the understanding of the chemical and biological processes involved in the interaction of radiation with organisms. The results will be used to develop practical means to inhibit, neutralize, or reverse the biological damage caused by radiation. The mitotic index of chosen mammalian species of different age groups will be measured after various exposure periods, using a tritiated thymidine-autoradiographic technique, followed by observing cataract producing doses. The relative radiation sensitivity of experimental animals (e.g., rats) with or without treatment by radiated gas will be determined by standard procedures. (7/75-6/76)

Supporting Agency:New Jersey State Govt.

0010 IMPACT OF RF BIOEFFECTS ON AF OPERATIONS. Mitchell, J. C.; Hardy, K. A. (U.S. Air Force, Sch. Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Specific Air Force systems radiofrequency emission and bioeffects studies will be conducted, and a state-of-technology data base will be maintained to support environmental impact positions and operational radiofrequency safety criteria for future and ongoing systems such as AN/FPS-85, AWACS, 487L, 414L, PAVE-PAWS, and SEEK-SAIL. Radiofrequency radiation effects data applicable to Air Force radiofrequency safety criteria and systems' operations will be compiled as background information. Systems' studies will be undertaken in accordance with mission direction. The radiofrequency biomedical data base generated under this effort will be used to support the Air Force petition for a change in OSHA standards, Title 29, CFR 1910.97 and in the revision of AFM 161-7. Initial state-of-the-art data will be obtained through a multi-agency contract with the Franklin Institute to provide a quarterly *Digest of Biological Effects of Microwave and Radiofrequency Radiation*. (7/75-6/76)

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

0011 NAVY ENVIRONMENT: EFFECTS ON BIOLOGICAL SYSTEMS DUE TO MICROWAVE IRRADIATION. Durney, C. H.; Lords, J. L. (Univ. Utah, Sch. Engineering, 1400 East 2nd St., Salt Lake City, UT 84112).

Recent increases in the use of microwave emitting devices have caused growing concern about the health hazards resulting from exposure of personnel to microwave radiation. Though there is general agreement on the hazards resulting from tissue heating by high-level microwave irradiation, little is known about possible damage produced by exposure to low-power microwave radiation. This research is investigating the response of isolated turtle hearts to pulsed irradiation and to different frequencies. Hearts from freshly killed turtles are placed in Ringers solution and a record of physical and electrical activity is taken until stabilization occurs. Microwave power is then delivered to the heart, and the activities of the heart recorded. Chemical stimulants and depressants are added to determine which of the two parts of the autonomic nervous system is most affected by the microwave field. The microwave field parameters are varied and mammalian (rat) hearts also are being studied. (7/75-6/76)

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

0012 BIOLOGICAL EFFECTS OF MICROWAVES. Baranski, S. (Coord. Comm. Polish American Collab., Warsaw, Poland).

The objective of this monograph is to reduce the effects of microwave irradiation and improve current treatment methods by disseminating new knowledge and technological capability. The monograph, intended for international use in research or medical practice, will review the biological effects of microwave irradiation. The use of microwave generators in industry, radio-navigation, radio-communication, radio-location, and in research will be reviewed, and the possible hazards for personnel employed within the compass of irradiation will be identified. The physical characteristics of microwaves, the biological effects of microwave exposure, and methods aimed at preventing the health hazards arising from continued exposure to microwave irradiation will be identified. The monograph will consist of approximately 350 pages including supporting tabulations and photographs. (7/75-6/76)

Supporting Agency:HEW, PHS, NIH, Fogarty Intl Ctr.

0013 NAVY ENVIRONMENT: INVESTIGATION OF THE BIOLOGICAL EFFECTS OF PULSED ELECTROMAGNETIC FIELDS GENERATED BY NAVAL OPERATIONS. Cleary, S. F. (Virginia Commonwealth Univ., Sch. Medicine, 901 W. Franklin St., Richmon, VA 23219).

High frequency, high intensity electromagnetic pulse (EMP) fields can be produced by certain naval operations. Evidence tends to point toward reversible effects in some biological systems. This research is an attempt to determine whether the instantaneous field strengths and pulse characteristics of EMP are capable of producing biological alterations of interest to man. This will be a two-part study. The first will be a study of the effects of EMP fields on serum proteins, blood chemistry, and drug-induced (pentobarbital) sleeping time in the dutch rabbit. Comparisons will be made to recent related study

findings. The second phase of this work will examine the EMP fields on an artificial biomembrane of known resistance, membrane potential, and dielectric breakdown potential. These membrane properties will then be investigated as a function of the amplitude and pulse repetition rate of an applied EMP field. All exposures will be made using the EMP simulator at the naval weapons laboratory, Dahlgren, Virginia. (7/75-6/76)

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

0014 NAVY ENVIRONMENT: MUTAGENIC EFFECTS DUE TO MICROWAVE RADIATION GENERATED BY NAVAL OPERATIONS. Varma, M. M.; Joshi, S. R. (Howard Univ., Sch. Engineering, 2400 6th St. N.W., Washington, DC 20001).

The use of microwave generators in communications, navigations, industry and the military has increased tremendously in recent years. The possibility exists that naval personnel may be exposed to these radiations. This research will evaluate the mutagenicity as a function of frequency, exposure time, and power level of microwaves when used to expose testes of mice. Mice testes will be exposed to microwaves at the Walter Reed Army Medical Center. After each exposure the males will be mated to three unexposed virgen females for five days. The females will be replaced weekly for eight consecutive weeks. Mated females, as evidenced by the presence of a vaginal plug, will be dissected on day 13 of the pregnancy and the total number of implants, viable implants, and early and late fetal deaths will be recorded. The results will be compared with concurrent control groups. Adverse genetic effects will be studied by observation of the F1, F2 and F3 progeny of exposed male mice. The experiments have proceeded in an orderly fashion since they were begun. There is some indication that the percentage of early deaths resulting from matings is related to the time of mating following exposure of the mouse testes. Results are still inconclusive pending further tests now in progress. (7/75-6/76)

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

0015 NAVY ENVIRONMENT: QUANTITATION OF MICROWAVE RADIATION EFFECTS ON THE HEAD AND EYES OF RABBITS, PRIMATES AND MAN. Kramer, P. O.; Emery, A. (Univ. Washington, Sch. Medicine, C304 Health Sciences Building, Seattle, WA 98105).

Exposure to microwave radiation can cause the production of opacity and damage in the eye. The exact conditions under which the effect occurs are yet to be established. Consequently, there is a great deal of controversy concerning the safe level of human exposure to microwave radiation. The increased use of high power microwave equipment by the Navy and other armed services, as well as by the general population, demands well-planned and expertly executed theoretical and experimental investigations. Using well established and quantified exposures, the cataractogenic threshold for the eyes of the rhesus monkey will be established for 2450 MHz. A computer model of the power absorption in the eye of the monkey, together with the model of the rabbit eye should allow for some extrapolation to humans. Rabbit lenses will be exposed to threshold and sub-threshold levels of microwaves and sections will then be examined by electronmicroscopy for ultrastructural changes. A number of rabbits will be exposed to chronic, sub-threshold levels. Studies of the disturbances in blood coagulation mechanism will be monitored together with the eye examinations. (7/75-6/76)

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

0016 NAVY ENVIRONMENT: NEUROPHYSIOLOGICAL AND BEHAVIORAL EFFECTS DUE TO MICROWAVE IRRADIATION. Guy, A. W.; Lovely, R. H. (Univ. Washington, Sch. Medicine, C304 Health Sciences Building, Seattle, WA 98105).

An outstanding problem in the interaction of microwave energy with biological systems is one of determining at what level the interaction constitutes a hazard. In order to provide a better understanding of the hazards associated with microwave irradiation and a scientific basis for safety standards, it is proposed in this study to quantify the biological effects of continuous wave and pulsed microwaves, as well as their frequency and intensity dependence through controlled exposure of test animals. Current emphasis in this research on the effects of acute and chronic exposure to microwave radiation in laboratory animals is placed on the quantification of behavioral change effects and on physiological mechanisms, such as, the endocrine stress response. Behavioral studies are carried out by using operant and classical conditioning techniques. Monitoring of pituitary-adrenal axis activity will determine the influence of microwave radiation on normally functioning hormonal systems. Additional work is concerned with a theoretical investigation of energy distribution inside the animal bodies. (7/75-6/76)

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

0017 BIOLOGICAL EFFECTS OF AF RF TRANSMITTER FIELDS. Frazer, J. W.; Merritt, J. H. (U.S. Air Force, Sch Aerospace Medicine, Brooks Air Force Base, San Antonio, TX 78235).

Firm foundations for electromagnetic safety standards for Defense Department personnel and the general population affected by Department of Defense radiators, depend on: (1) precise knowledge of the magnitude of the radiofrequency insult, as in any environmental consideration, (2) the relationship between insults and responses of experimental animals to those of man, (3) the bases on which the insult, in this case internal distribution of electromagnetic fields, acts, and (4) the magnitude of insult levels no longer producing a measurable response. This effort will investigate the biological consequences of Air Force aircrew exposures to unique radiofrequency radiation environments and to extrapolate the empirical findings to adjust personnel exposure criteria. Responses of experimental animals to field modulations reportedly

at frequencies of brain theta rhythms have been reported. The present hypothesis of high field Kerr effects and low field thermal distribution as major factors in inducing responses to electromagnetic radiation fields are at variance with assumed processes producing such effects. Field modulation effects, including pulsed fields, on a variety of central nervous system ionic and chemical distributions will be examined. Lymphocyte responses will be examined as a function of field amplitude in intact animals, while culture responses are examined in another study. (7/75-6/76)

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

0018 BIOPSYCHOLOGICAL STUDIES OF MICROWAVE IRRADIATION. Justesen, D. R.; Sheridan, C. L.; Levinson, D. M. (U.S. Veterans Admin. Hosp., 4801 Linwood Blvd., Kansas City, MO 64128).

Three years after fetal irradiation by 2450 MHz microwave energy, the last survivors among a group of CWF mice have now died. The rats were irradiated once daily on the 11th-14th days of gestation with a 36 J/g energy dose administered at the rate of 30 mW/g for 1200 seconds. The rats were exposed in a multi-mode cavity at 20°C and with a high turnover of air (approximately 3 M^3/min), at 40-60 percent relative humidity. Complex modulation was used: 60 Hz sinusoid half-waves superimposed upon 12 Hz pulses induced by mode-stirring. Sham-irradiated control mice reached the 50 percent mortality level near the 22nd month, post-partum; radiated mice, near the 31st month. In the same study, mice that had been innoculated with an homogenate of reticular cell sarcoma developed tumors at a slower rate in radiated than in sham-irradiated groups. The finding of enhanced longevity of mice (p much less than .01) following intense fetal microwave irradiation confirms that found (but apparently not recognized) earlier by Prausnitz & Susskind (IRE Trans. on Biomed. Elec., BME-9, 104-108). In another study, teratology, survival, and maze learning by mice of the C3H/HeJ strain were observed after a single, fetally administered dose (approximately 23 J/g) of energy in the same cavity. Dosing of dams on the 11th, 12th, 13th, or 14th day of gestation had no reliable effects as a function of radiation per se. However, high rates of fetal mortality resulting from treatment of dams with a single, 5 mg dose of cortisone as an acetate were reliably reduced by the 23 J/g dose of radiation. (7/75-6/76)

Supporting Agency:U.S. Veterans Adm.

0019 PERSONNEL TECHNOLOGY: THE EFFECTS OF IONIZING AIR AND RADIO ENERGY UPON THE PERFORMANCE OF NAVAL PERSONNEL. Frey, A. H. (Randomline Inc., Old York & Moreland Rd., Willow Grove, PA 19090).

Navy personnel are exposed, in many relatively closed spaces, to varying levels of electromagnetic radiation and/or ionized air which could affect individual performance. This work unit is concerened with the effects of exposure to radiofrequency energy and ionized air on neural activity and behavior. The effects of prolonged exposure to low power, modulated VHF energy on the physiology and behavior of mammals are being studied. The experiments employ a fluorescent dye technique as an indicator of brain barrier permeability and a behavioral measure which gives quantifiable data to relate to the physiological data. A comparison of the effects of natural light spectrum exposure and cool white spectrum exposure on physiology and emotionality also is underway. The work will determine whether such exposures affect physical performance and neuro-endocrine function. (7/75-6/76)

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

0020 NAVY ENVIRONMENT: X-RAY AND MICROWAVE RADIATION INTERACTION WITH MUSCLE CELLS; APPLICATION TO PROTECTION AND TREATMENT. Portela, A.; Perez, J. C. (Consejo Nac. de Inv. Cien. Tec, Junin 956, Buenos Aires, Argentina).

This research seeks to identify and characterize in cellular and subcellular structures the critical membrane systems, organelles, and biochemical mechanisms that are affected by the absorption of ionizing (X-rays) and nonionizing (microwaves) radiation likely to exist in the environment of naval personnel. Efforts will be made to develop specific agents to prevent or counteract side-effects of these radiations. This research will concentrate primarily on microwave irradiation. The area and nature of damage due to microwave fields at the cellular and subcellular level is being investigated *in vivo* and *in vitro*, using skeletal muscles of frogs and rats. Several parameters of cells and cell membranes such as water content, ion transport, conductance, protein-phospholipid structure and resistance and capacitance, will be analyzed for microwave induced changes. Electromagnetic emission from active nerve and muscle fibers will be spectrally analyzed to determine if this technique is able to detect changes due to nonionizing and ionizing radiation. (7/75-7/76)

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

0021 MECHANISMS OF NEUROENDOCRINE RESPONSE TO ELECTROMAGNETIC RADIANT ENERGY. Michaelson, S. M. (Univ. Rochester, Sch. Medicine & Dentistry, 601 Elmwood Ave., Rochester, NY 14642).

Neuroendocrine function provides a sensitive indicator of the body response to environmental insults. As representative of the neuroendocrine systems, the hypothalamic-hypophysial-end organ axis (HHEO) has been chosen for study. Because of the importance of this hierarchical system to the body's economy, perturbation at any link in the chain could have profound pathophysiologic consequences. Studies are being performed in the rat and dog to relate the sequential changes in hypothalamic and pituitary function to alterations in body metabolism or homeokinetic perturbations as a result of exposure to various regimens of X-rays, microwaves, or combinations of these two electromagnetic energies. Various periods in the lifespan of the rat from neonates to old age are being studied. Radioim-

munoassay techniques are utilized to measure fluctuations in pituitary hormones; to study homeostasis, impairment of physiologic capacity, and structural and functional integrity of the neuroendocrine system; to assess alteration in circadian rhythms, maturation, and pathophysiologic sequelae as a consequence of exposure to electromagnetic radiant energies. The influence of microwaves alone and together with X-rays in the therapy of cancer is also under investigation. Studies on head and neck X-irradiation of rats indicate that the processes leading to the appearance of pituitary and thyroid neoplasms are hormone dependent. In the head X-irradiated dog, thyrometabolic consequences are compatable with secondary hypothyroidism due to hypopituitarism and/or a hypothalamic lesion. Assay of adrenalcortical function in rats exposed to microwaves reveals a definite correlation between corticosterone and colonic temperature. This suggests nonspecific stress at certain power density/time relationships for microwave irradiation. (7/75-6/76)

Supporting Agency: ERDA

0022 VARIABLE FREQUENCY MICROWAVE EXPOSURE SYSTEM. McRee, D. I.; Walsh, P. J.; Mathews, P. (U.S. Dept. Health, Education & Welfare, Public Health Service, Natl. Inst. Health, Durham, NC 27709).

The purpose of this study is to develop a microwave exposure system that can provide a plane-wave type field and a variable frequency capability of 1-10 GHz. The system has been assembled and calibrated. The system generates a 90% uniform field over a 10 cm diameter circle with a power density capability range of 0-20 mW/cm^2. Small biological specimens can be exposed to variable frequencies in either a continuous wave or modulated wave mode. (7/75-7/76)

Supporting Agency:HEW, PHS, NIH.

0023 REGIONAL CNS UPTAKE OF AMINO ACIDS. Perez, V. J. (Texas Technological Univ., Sch. of Arts & Sciences, P.O. Box 4340, Lubbock, TX 79409).

The major objectives of this research are (1) to measure in infant and adult mice the smallest amount of glutamate (Glu) that accumulates in the arcuate nucleus of the hypothalamus (ARH) to produce neuronal necrosis, (2) to determine if there is a time in gestation when the brains of fetal mice are unaffected by Glu, (3) to ascertain why GABA, glutamine and alanine are not toxic in the central nervous system, (4) to determine if other toxic amino acids accumulate in the ARH as does Glu, and (5) to compare the effects on consummatory behavior of radiofrequency lesions and those produced by excitatory amino acids. Results will contribute to the understanding of placental barriers to amino acids and will provide a better understanding of central nervous system regional blood-brain-barriers to specific amino acids and how these change with age. Comparisons of rates of central nervous system uptake and maximal levels reached and time course of return to control levels will be made between Glu and Asp, both of which are neurotoxins. Data will be obtained to determine if nontoxic amino acids are accumulated in the ARH as is neurotoxic Glu. Results obtained from these studies of experimentally induced lesions will enable the evaluation of the importance of an intact neuronal and/or neuroglial system in maintaining function "regulated by" lesioned areas. Results from these experiments go beyond those in which tissue slices or whole brain are used because quantitative histochemical measurements will be made in histologically homogeneous brain areas. Long term goals of this research are to measure the metabolism of neurotoxic amino acids in the ARH and liver, to investigate how patterns of metabolism vary with age, and to study behavioral abnormalities, which may be produced by neurotoxic amino acids and localizing subcortical neuronal destruction. (9/75-8/76)

Supporting Agency:HEW, PHS, NIH.

0024 VESTIBULO-COCHLEAR EFFECTS OF UHF-MICROWAVE RADIATION. Lebovitz, R. M.; Seaman, R. (Univ. Texas, Sch. Medicine, 5323 Harry Hines Blvd., Dallas, TX 75230).

This research concerns the experimental examination of the neural activity in the vestibular system of animals subjected to acute, cranial microwave radiation. This work will proceed initially on mongrel cats and progress to monkeys as techniques are refined. With the animal immobilized in a stereotaxic frame, we apply microwave radiation to the cranium at an incident frequency of 918 MHz, using power densities in the range of 5-80 mW/cm^2. The relevant data include gross field and single cell electrical activity in the vestibular nerve and associated nuclei. Interspike intervals are analyzed by computer for average rate and interval statistics, and correlated with the microwave radiation. As a control, known but weak cranial acceleration is applied before and during microwave radiation exposure to classify the unit and field response pattern. Other controls include vestibular nerve section, intracranial temperature monitoring, and histological verification of electrode sites. Particular attention is paid to the suppression of microwave radiation induced field artifacts in electrodes and to the calibration of absorbed energy. A secondary aim of this work will be to examine similarly the effects of microwave radiation on unit activity in the auditory pathway. (5/76-4/77)

Supporting Agency:HEW, PHS, FDA.

0025 ULTRASTRUCTURAL STUDIES OF MICROWAVE CATARACTOGENESIS. Simon, D. R.; McKee, A. E. (U.S. Navy, Experimental Pathology Dept., Bethesda, MD 20014).

Microwave radiation (electromagnetic radiation, EMR) has been shown to be cataractogenic. Although some reports suggest that microwave cataracts are a consequence of elevated intraocular temperature associated with microwave radiation, the mechanism(s) of microwave cataractogenesis, earliest structural changes in the lens, and exposure thresholds remain controversial. Exposure of both military and civilian personnel to

microwave radiation (radar, microwave ovens, etc.) may, indeed, constitute a genuine health hazard. The objective of this research is to investigate the earliest ultrastructural changes in mammalian lenses following exposure to electromagnetic radiation, with special emphasis on defining the thermal effects. Microwave cataractogenesis will be studied using scanning and transmission electron microscopy and light microscopy. New Zealand red rabbits and owl monkeys will be used as experimental animals. (7/75-6/76)

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

0026 GENETIC AND CELLULAR EFFECT OF MICROWAVE RADIATION. Dutta, S. K.; Nelson, W. H.; Blackman, C.; Brusick, D. (Howard Univ., Sch. Liberal Arts, 2400 6th St. N.W., Washington, DC 20001).

The proposed research will utilize a fast and highly sensitive series of genetic tests and simple tests to study cell morphological changes in order to evaluate the effects of low intensity microwave radiation. Since the nonthermal (< 1 mW/cm^2) effects of microwaves are difficult to distinguish from the thermal effects in large whole animal systems, the distinction will be studied using repair-deficient his-mutants of *Salmonella typhimurium* and D-4 strain of *Saccharomyces cerevisiae*. Two component heterokaryons and excision repair-deficient mutants of *Neurospora crassa* will be used to investigate chronic and delayed effects of continuous and pulsed microwaves in the environment. Work will then be extended to study alteration, if any, of repair process by microwave radiations using human fibroblast cultures. (7/75-6/76)

Supporting Agency:EPA

0027 EFFECTS OF CHRONIC EXPOSURE TO HIGH PEAK POWER PULSED ELECTROMAGNETIC RADIATION ON ANIMALS. Ogrady, T. C.; Hosszu, J. (U.S. Navy, Surface Weapons Center, Dahlgren, VA 22448).

The objective of this study is to evaluate the long term effects of exposure to high peak power (HPP) pulsed electromagnetic radiation to develop information useful in safety factor analysis. It is intended to find some areas of interaction between the HPP radiation and the functioning biological systems in animals and to investigate these areas in further detail. The experimental approach involves the chronic (up to 10 months) exposure of laboratory animals, usually rodents, to HPP electromagnetic radiation. Three groups of approximately 100 animals each will be used as follows. Two groups of 100 animals each (70 experimental, 30 controls) will be exposed from day of birth to full maturity. At two months of age, 7 experimental and 3 controls will be sacrificed at 20 day intervals and analyzed. The third group of 100 (70 experimental, 30 controls) will be exposed from birth and then sacrificed from 1 day after birth to 2 months at 2 day intervals for the first 10 days and twice weekly intervals for the remaining time. After sacrifice, a variety of parameters will be investigated in each case including: clinical hematologies (hematocrit, platelet count, WBC, differential count), serum proteins, gross anatomy and activity of a series of glycolytic and gluconeogenic enzymes (phosphoglycerate kinase, phosphofructokinase, pyruvate kinase, and hexokinase) from liver, skeletal muscle and heart. This approach should identify specific areas for further, more detailed studies of *in vivo* and *in vitro* systems. (7/75-6/76)

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

0028 LABORATORY AND FIELD EVALUATIONS OF HEAT ENERGY TO CONTROL STORED-PRODUCT INSECTS. Kirkpatrick, R. L. (U.S. Dept. Agriculture, Stored Products Insects Research & Development Lab., 3401 Edwin Ave., Savannah, GA 31405).

The objective of this project is to develop rapid, simple, and practical techniques in the laboratory and adapt these methods for field evaluations using temperature, including infrared and microwave radiation, to control stored-product insects infesting grain or other stored commodities. Research data obtained from these laboratory and field tests will be used to develop a practical and inexpensive commercial unit to control stored-product insects. The laboratory tests will determine the repellancy, attractancy, effect on life history, behavioral responses, and dosage-mortality relationship of stored-product insects exposed to infrared, microwave radiation and other types of heat energy. (7/75-6/76)

Supporting Agency:U.S. Dep. Agric., Agric. Res. Serv., Georgia/South Carolina Area.

0029 THE EFFECTS OF MICROWAVE RADIATION ON THE CENTRAL NERVOUS SYSTEM. Albert, E. N. (George Washington Univ., Sch. Medicine, 1331 H St. N.W., Washington, DC 20037).

This research will investigate the existance of morphological alterations in animals exposed to microwave irradiation. Chinese hamsters will be irradiated with microwaves at 12.5 cm and power levels of 10, 25, and 50 mW/cm^2. Brain nuclei will be examined for radiation-induced changes using both light and electron microscopy. Special emphasis will be placed on the mitochondria, nucleolus, rough endoplasmic reticulum, golgi apparatus, and lysosomes. (7/75-6/76)

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

0030 INVESTIGATION OF BIOMOLECULAR FUNCTIONS BY MICROWAVE RADIATION. Eisenbud, M., Rabinowitz, J. R. (New York Univ., Sch. Medicine, 550 First Ave., New York, NY 10016).

The objective of this research is to describe the mechanisms by which the absorption of microwave energy can interfere with the function of the absorbing biological molecule. An attempt will be made to demonstrate these mechanisms in biological systems and identify the specific biomolecules involved.

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