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-

body sublethal exposures to X-ray irradiation. Experiments were performed with C57Bl/10 strain mice subjected to whole-body irradiation with a sublethal dose of 600 to 750 R. The animals were irradiated with microwaves (100 mW/cm^2, 2450 MHz, 5 min) at different times until 24 hours after X-ray irradiation. A control group was exposed solely to X-ray irradiation. In contrast to the control group, the number of hematopoietic stem cell colonies in the spleen increased after combined irradiation, and the difference between the control and experimental groups became statistically significant ($p<0.01$) for the intervals of 30 minutes, 6 hours, and 12 hours. Increased repair of the radiation damage of hematopoiesis was also demonstrated by a higher percentage of ^{59}Fe incorporation in the spleen and a more rapid improvement of the peripheral indicators of hematopoiesis as compared with that of X-ray controls. On day 8 and day 20 after combined irradiation, the number of leukocytes in peripheral blood was twice that of controls. In addition, the microwave irradiation resulted in a prolonged mean survival period of the experimental groups as compared with controls. The results demonstrate that microwave irradiation can modify the course of repair processes in the hematopoietic stem cells in an early period following the exposure to X-rays. (No refs.)

4508 HUMAN AUDITORY SYSTEM RESPONSE TO LOWER POWER DENSITY PULSE MODULATED ELECTROMAGNETIC ENERGY: A SEARCH FOR MECHANISMS (SYMPOSIUM SUMMARY). (Eng.) Eichert, E. S. (Randomline, Inc., County Line and Mann Roads, Huntingdon Valley, PA 19006); Frey, A. H. *J. Microwave Power* 11(2): 141; 1976.

The human auditory system response to lower power density, pulse modulated, electromagnetic energy may provide a new tool to investigate the human auditory system and new insight into nervous system and behavioral effects. Several mechanisms, which have been suggested, were studied including thermally launched acoustic waves, direct neural stimulation, and direct interaction with portions of the auditory system. These proposals were considered in conjunction with the entire body of radio frequency-sound data. New data, particularly human responses to pulse pair and pulse train modulation, interferometric studies with animals, and reports of cochlear microphonics during ultra high frequency exposure were included in the analysis. Most of the suggested mechanisms were either difficult to test or inconsistent with available data. The models' success and failure as explanatory mechanisms are discussed, and additional lines of investigation are suggested. (No refs.)

4509 CYTOTOXIC EFFECTS OF ELECTROMAGNETIC RADIATION ON CHINESE HAMSTER CELLS IN CULTURE (SYMPOSIUM SUMMARY). (Eng.) Chen, K. C. (Dept. Biology, Wayne State Univ., Detroit, MI 48202); Lin, C. J. *J. Microwave Power* 11(2): 140-141; 1976.

The cytotoxicity of Chinese hamster cells produced after irradiation was demonstrated in terms of growth rate, morphological transformation, and colonizing capacity. By employing an improved fluid-filled wave guide exposure chamber originally designed by Lin and Chen (1975), the nonthermal effect of 2450 MHz microwave radiation on Chinese hamster cells in culture was demonstrated. The differential effects of microwave radiation on Chinese hamster cells were examined as a function of the position of the cell within its generation cycle. The cytotoxicity of the cells produced after irradiation was compared over a 12-day incubation period. Although a clearcut cyclic response of mammalian cells to microwave radiation could not be established, the results with Chinese hamster cells indicate that the growth rate of irradiated cells showed a decrease of 10-60%, depending on the level of the microwave exposure. Consistent with previous observations, a great number of the "giant-ruffle cell" transformations were seen when a high level of incident power density of microwave was applied. Such microwave-induced morphological transformations in the Chinese hamster cell appeared to be irreversible. (No refs.)

4510 INFLUENCE OF PULSED MICROWAVES ON HAEMATOPOIESIS OF ADOLESCENT RATS (SYMPOSIUM SUMMARY). (Eng.) Pazderova-Vejlupkova, J. (Clinic of Occupational Diseases, Charles Univ., Prague, Czechoslovakia); Frank, Z. *J. Microwave Power* 11(2): 139; 1976.

Pulsed electromagnetic fields caused a transient decrease of weight increment, hematocrit, and alkaline phosphatase activity in the course of intermittent irradiation of growing rats. Twenty male rats (initial average weight 65.53 g) were irradiated for seven weeks (5 days/week, 4 hours/day) by pulsed electromagnetic fields with the following parameters: working frequency 2736.5 MHz, repetition frequency 395 Hz, pulse width 2.6 μsec, polarization vertical, mean power density 24.4 mW/cm^2 (accuracy of measurement ± 6). The rectal temperature of the irradiated animals increased an average of 0.3°C after 3 hours of irradiation. The weight, hematocrit, leucocyte count, differential count, leucocyte alkaline phosphatase activity, and nucleoli of lymphocytes of the irradiated rats were compared with findings in 20 controls. After the first week of irradiation the weight increment was significantly lower, persisting for one week after the irradiation. The hematocrit was lower in the middle of the irradiation period and during the first month after exposure. After the beginning of the fourth week of irradiation the average leucocyte count was lower due to the decrease of the absolute number of lymphocytes. Recovery took place 2 months after irradiation. The alkaline phosphatase activity was lower at the end of irradiation only. All the differences presented were in the 1% level of significance. (No refs.)

4511 HUMAN THERMAL LOADING BY EXPOSURE TO EMISSIONS FROM A MICROWAVE OVEN (SYMPOSIUM SUMMARY). (Eng.) Prucha, R. V. (Range Component Engineering, General Electric Company, Building 2, Room 248, Louisville, KY 40225). *J. Microwave Power* 11(2): 160; 1976.

Thermographic measurements in full scale human phantoms exposed to emissions from a microwave oven were used to calculate temperature rise in a thermal model of the human body. Full scale phantom models of a two-year-old child and a woman were exposed to emissions from a forced leak in a microwave oven. The operating frequency was 915 MHz. Thermographic analysis using the technique developed at the University of Washington and reported in a companion paper by A. W. Guy provided data on specific absorption rate (SAR) and identification of the heating pattern. These data, which relate to the defined leakage source intensity, were used as the basis for heat input and temperature rise calculations in thermal models of humans. Both worst case and typical case calculations based on movement patterns were made and the results were compared with those produced by other heating means, such as, changes in metabolic rate (deep heating) and exposure to normal sunlight (surface heating). Results also were compared with medical diathermy practice. These results show the very conservative nature of the current microwave oven emission standards. (No refs.)

4512 EFFECT OF MICROWAVES ON VIRUS MULTIPLICATION IN MAMMALIAN CELLS *IN VIVO* AND *IN VITRO* (SYMPOSIUM SUMMARY). (Eng.) Luczak, M. (Center of Radiobiology, Radioprotection, 00-909 Warsaw, Poland); Szmigielski, S.; Janiak, M.; Kobus, M.; de Clerq, E. *J. Microwave Power* 11(2): 173-174; 1976.

It has been suggested that microwaves at subthermal field power densities may influence multiplication of virus particles *in vitro*. Experiments on virus multiplication *in vitro* were performed using WISH cells (continuous line of human embryonic cells) and myxovirus para-influenza 3. The cell cultures were irradiated with 3 GHz microwaves at far field conditions in anechoic chambers (30 minutes) at field power densities 5 or 20 mW/cm^2. Inoculation with viruses (0.01 $TCID_{50}$/cell) was performed 2 hours before, simultaneously, 2, or 24 hours after irradiation with microwaves. Irradiation of cells at a field power density of 5 mW/cm^2 resulted in an increase of virus multiplication in cultures inoculated 2 hours before, simultaneously, or 2 hours after inoculation. This suggests that the increased multiplication is due to stimulation of cell metabolism (protein and nucleic acid synthesis). Irradiation of WISH cells at 20 mW/cm^2 resulted in lowered multiplication of viruses in cells irradiated at 2 hours before or after inoculation. In cultures irradiated 24 hours after inoculation normal multiplication of viruses was found. *In vivo* experiments were performed on young CFW mice infected intravenously with vaccina or Herpes viruses. The animals were irradiated for 7 days postinfection (3 GHz microwaves, anechoic chamber, far field conditions, field power density 40 mW/cm^2, 2 hours daily). Several of the infected and irradiated animals were additionally injected with Cytosar or cytosine arabinoside (ARA-C). The results indicate that irradiation with microwaves influenced the course of viral infections in mice, the effect being dependent on the schedule of irradiation. Exposure to microwaves after infection resulted in lowered multiplication of Herpes viruses (as measured by number of lesions on tails) and enhanced the inhibiting effect of Cytosar and ARA-C. (No refs.)

4513 MICROWAVE THERAPY AND MUSCLE BLOOD FLOW IN MAN (SYMPOSIUM SUMMARY). (Eng.) McNiven, D. R. (Physiotherapy Dept., Inst. Neurological Sciences, Southern General Hosp., Govan Road, U.K.); Wyper, D. J. *J. Microwave Power* 11(2): 168-170; 1976.

The effect of microwave therapy on muscle blood flow in man was studied. Five healthy subjects (3 male and 2 female), in the age range 20 to 40, were investigated. Muscle blood flow was measured using the xenon-133 clearance technique. Xenon-133 (200 μCi) dissolved in 0.1 ml of sterile isotonic saline was injected into the muscle (vastis lateralis). A scintillation counter was used to monitor the count rate. A single injection of xenon-133 was used to measure muscle blood flow at rest, during application of the microwave therapy, and during static exercise. Once a steady value was obtained for the resting flow, the microwave apparatus (2450 MHz) was switched on, with the power output adjusted to produce the maximum comfortable heating. After about 8 minutes, the slope of the clearance curve was observed to increase, indicating an increase in muscle blood flow. On obtaining a new steady value, the apparatus was switched off. Flow was maintained at the higher level for about 5 minutes before gradually decreasing. The investigation was concluded by the subject performing static quadricep contractions. A highly significant increase in muscle blood flow was produced in all subjects; the mean values being 2.9 ml/100g/min at rest and 11.4 ml/100g/min at the end of microwave application. No significant correlation was found between athletic fitness and blood flow or between resting blood flow and the time delay between the start of microwave application and the blood flow increase; this varied from 5 to 12 minutes. (No refs.)

4514 ACUTE MICROWAVE IRRADIATION AND CATARACT FORMATION IN RABBITS AND MONKEYS (SYMPOSIUM SUMMARY). (Eng.) Kramer, P. (U.S. Public Health Service Hosp., Seattle, WA); Guy, A. W.; Emery, A. F.; Harris, C. *J. Microwave Power* 11(2): 135-136; 1976.

The special characteristics of the leakage field from an imperfect microwave oven were investigated. Effective power density (EPD)/time levels were chosen as single, acute exposures in adult New Zealand rabbits to determine the cataractogenic threshold, using the near field of the 2450 MHz slot applicator. In all cases the right eye was irradiated, while the left eye served as the control. The lowest cataractogenic level was found with an EPD level of 180 mW/cm^2 applied for 140 minutes with a peak specific absorption rate (SAR) level of 99.4 W/kg. Within one to two days following radiation, typical posterior cortical banding was found with the biomicroscope. SAR patterns in two young-adult rhesus monkeys were determined by placing the hori-

zontally oriented dipole with its center 5 cm from the bridge of the nose. Although peak SAR in the eye was again found in the lens (2.9 W/kg/W), less power was abosrbed in the monkey than in the rabbit (5.4 W/kg/W). An additional SAR pattern was determined in one monkey with the slot centered over one eye. Peak SAR in the eye was found in the lens, with relatively symmetrical surface heating of the periocular tissues. This SAR pattern may be used as a basis for determining the cataractogenic threshold in the monkey. (No refs.)

4515 EFFECT OF MICROWAVES COMBINED WITH INTERFERON AND/OR INTERFERON INDUCERS (POLY I-POLY C) ON DEVELOPMENT OF SARCOMA 180 IN MICE (SYMPOSIUM SUMMARY). (Eng.) Szmigielski, S. (Center for Radiobiology, Radioprotection, 00-909 Warsaw, Poland); Luczak, M.; Bielec, M.; Janiak, M.; Kobus, M.; Stewart, W. E., II.; de Clerq, E. *J. Microwave Power* 11(2): 174-175; 1976.

Neoplastic cells are highly sensitive to elevated temperatures. The use of microwave radiation for cancer treatment by hyperthermia (choice of wave frequency, control of temperature, perspectives, and problems) is reviewed, and the experiments on tumor-bearing mice irradiated with 3 GHz microwaves in combination with cytostatics (Endoxan), high doses of vitamin A, stroptolysin S, or staphylococcal toxins are discussed. Mice with transplanted Sarcoma 180 were irradiated with 3 GHz microwaves (anechoic chamber, far field conditions, 40 mW/cm^2, 2 hr daily) during the whole period of tumor growth. Part of control (tumor-bearing) and irradiated animals were injected with interferon (highly concentrated mouse interferon 100 IU/g daily) or Poly I-Poly C (2 mcg/g, daily). Size and weight of tumors, as well as incorporation of tritiated precursors of nucleic acids and proteins and intracellular level of cyclic AMP, were checked 14 days after tumor transplantation. Irradiation with microwaves (general hyperthermia) inhibited tumor growth in about 25-30% of mice, while combination of microwaves with interferon and Poly I-Poly C led to inhibition of tumor growth in about 75% of animals. Mechanisms leading to tumor inhibition *in vitro* and *in vivo* by general and local hyperthermia were discussed, as well as perspectives in the use of microwaves for cancer treatment by intensive local hyperthermia (42-44°C). (No refs.)

4516 INFLUENCE OF MICROWAVES ON GENETICAL PROCESSES OF *ASPERGILLUS NIDULANS* (SYMPOSIUM SUMMARY). (Eng.) Baranski, S. (Military Inst. Aviation Medicine, 01-755 Warszawa, krasinskiego, 54 Poland); Debiec, H.; Kwarecki, K.; Mezykowski, T. *J. Microwave Power* 11(2): 146-147; 1976.

The influence of microwave radiation on the genetic processes of *Aspergillus nidulans* was investigated to determine whether microwave radiation at nonthermal power densities is mutagenic. *A. nidulans* was chosen for investigation, since it is a haploid under experimental conditions. As induced mutations are usually recessive, they are phenotypically noticeable in first generations only in the case of haploids. In addition, chromosomal mutations appear phenotypically as morphological changes in mycelium, which enables quick and easy detection of mutants. In this experiment, irradiation was performed in plastic containers at 2450 MHz, at power densities $\leq$10 mW/cm^2, for 10-240 minutes. The results do not show any mutagenic effects of microwaves. Currently, results of other experiments are being evaluated, in particular experiments in which different inhibitors of DNA repairing systems (e.g., caffeine) were used. (No refs.)

4517 EFFECT OF CONSTANT MAGNETIC FIELDS ON MACROMOLECULES. (Rus.) Miroshnichenko, F. D.; Stadnick, A. D. (Zaporozhe State Pedagogical Institute, Zaporozhe, U.S.S.R.). *Biofizika* 21(1): 178-179; 1976.

The exposure of discs of polymethylmetharcylate measuring 2 mm in thickness and 20 mm in diameter, previously heated to 100° in an electromagnetic field for 60 min led to a particular electretic state with a superficial charge density of about 10^{-10} Coulombs/sq cm, depending on the magnetic field potential. The appearance of charges was due to the orientation of the magnetically anisotropic macromolecules and their segments. The magnetic susceptibility, decreasing with time, increased with increasing field potential in a range of 0.0032-0.123 A/m. The decrease of the diamagnetic susceptibility is apparently due to the orientation process being accompanied by an increase in polarization paramagnetism. The changes in magnetic susceptibility explain some peculiarities of the mechanism of the effect of magnetic fields on biological objects. (3 refs.)

4518 MICROWAVE HEARING IN MAMMALS. (Eng.) Rissmann, W. J. (Dept. Electrical Engineering, Bioacoustics Res. Laboratory, Univ. Illinois, Urbana, IL 61801); Cain, C. A. *Natl. Electron. Conf. Proc.* 30: 239-244; 1975.

Threshold levels for the acoustic perception of microwaves were determined for the cat, dog, chinchilla, and several human subjects. Beckman type scalp electrodes (3 ohm impedance at 1000 Hz) were used to monitor auditory responses of nonhuman species. A speaker, and microwave generator were used as the stimulators. The restrained animal was exposed to speaker clicks and irradiated with 10 msec wide 3 GHz microwave pulses, both applied at a repetition rate of 0.5 Hz. The evoked responses appeared similar, except for a delay factor in the air conducted acoustic stimuli. No response was recorded when microwaves were replaced with a 50 ohm dummy load. The average energy density threshold for small mammals was 8.8 μJ/cm^2. Five of eight human subjects heard a click, which appeared to originate from in-

side the head when irradiated with a 15 msec pulse of 3 GHz microwave energy. The average threshold energy density level for humans was 10.5 $\mu J/cm^2$. Threshold levels seemed to be directly dependent upon the energy density per pulse rather than the peak power density per pulse. It is suggested that the differences in the human ability to detect microwaves was due to a hearing loss in a high frequency range that could not be tested. (15 refs.)

4519 NEUROENDOCRINE RESPONSE TO MICROWAVE IRRADIATION. (Eng.) Vetter, R. J. (Bionucleonics Dept., Sch. Pharmacy and Pharmacal Sciences, Purdue Univ., West Lafayette, IN 47907). *Natl. Electron. Conf. Proc.* 30: 237-238; 1975.

The effect of low level exposures to microwaves on the function of the neuroendocrine system was investigated. Pregnant rats were exposed for 15 days (days 6-21 of gestation) for 10 or 20 minutes to 0, 5, or 25 mW/cm^2 of 2450 MHz continuous wave microwave radiation. The rats were kept in an anechoic chamber with a -40 dB quiet zone. Blood samples were tested by radioimmunoassay for thyro-binding capacity. The results show that the thyro-binding ability of the blood serum increased with microwave exposure; thus thyroid hormone levels decreased. Results were inconclusive. First studies indicated a slight decrease in hormone levels and variance was high. Serum also was tested for protein transferrin by measuring serum iron and iron binding capacity. Protein levels increased with increasing energy exposure, indicating that protein synthesis was affected. Results show an attempt by the body to adjust to moderate temperature increases induced by microwaves (i.e., acclimatization). Further study is needed to determine whether the effects of long-term low level radiation (microwaves) are the results of adaptation or are subtle and dangerous effects. (6 refs.)

4520 EFFECTS OF MICROWAVES ON NORMAL AND TUMOR CELLS AS SEEN BY LASER-RAMAN SPECTROSCOPY (SYMPOSIUM SUMMARY). (Eng.) Webb, S. J. (Dept. of Physics, Univ. South Florida, Tampa, FL 33620). *J. Microwave Power* 11(2): 138; 1976.

The microwave absorption spectrum, between 50 and 200 GHz for tumor cells, differs from that of their homologous normal ones. The observed differences in the spectra of cells appear due to differences in the frequency constant that separates the absorbed frequencies in one or more of the series of frequencies absorbed by different cell types. Some *in vivo* energy states have been displayed as laser-Raman spectral lines from synchronized populations of cells. Many of these Raman lines are transient. Thus given that *in vivo* energy states are present, *in vivo*, only during specific stages of the cell cycle, this timed sequence of particular energy states seems to reflect the specific metabolic time clock of a given cell type. A study of the effect of exposure to various microwave frequencies on the time of appearance of given raman-shift lines has revealed that absorbed frequencies of 2-4 GHz increase the rate of the entire cell cycle. The exposure of cells to absorbed frequencies >50 GHz, however, does not increase the overall rate of the cell's metabolic time clock. All microwave effects seem to be frequency, or frequency series, specific and by far the most prevalent of them is the absence, in the raman spectrum of irradiated cells, of specific raman-shift lines. Thus, since tumor cells absorb frequencies that are not absorbed by normal cells, the metabolism of tumor cells may be selectively altered by their exposure to frequencies harmless to normal cells. (No refs.)

4521 EFFECT OF ELECTROMAGNETIC ENERGY ON THE FORMATION OF TRIGLYCERIDES: FREQUENCY INFLUENCE (SYMPOSIUM SUMMARY). (Eng.) Deficis, A. (Centre d'Etudes Recherches de Toulouse, Toulouse, France); Dumas, J. C.; Laurens, S.; Plurien, G. *J. Microwave Power* 11(2): 137-138; 1976.

A study was carried out on the effect of microwave frequency and power on the rate of formation of triglycerides in male Swiss mice. The authors tried to determine whether results, obtained at 2.4 GHz, would be duplicated at other frequencies between 2 and 10 GHz. Groups of 12 animals were placed in multimode cylindrical cavities of a 600 cm^2 cross section. Irradiations took place during 9 days (15 hours/day). The frequency between 2.4 and 9.4 GHz at 1.5 and 3.3 mW/cm^2 powers was investigated. Serum triglycerides were determined in 200 µl of serum by standard technique. Controls received infrared radiation. At 1.5 mW/cm^2 no difference was found between the triglycerides rate of the control animals and that of the animals exposed to microwaves, at any frequency. At 3.3 mW/cm^2 the triglyceride rate was the same in the control mice and mice exposed to microwaves at 2.9, 5.4, 9.4 GHz but significantly higher at 2.4 GHz. A study made at several power levels indicates that microwaves cause an increase in the rate of serum-triglycerides formation in mice at 2.4 GHz frequency. (No refs.)

4522 PULSED RADIOWAVE (27.12 MHz) EFFECTS ON *IN VIVO* AND *IN VITRO* TUMOR GROWTH (SYMPOSIUM SUMMARY). (Eng.) West, B. L. (Div. Medical Oncology, Box 273, Medical Coll. Virginia, Virginia Commonwealth Univ., Richmond, VA 23298); Regelson, W. *J. Microwave Power* 11(2): 176-177; 1976.

Inhibition of subcutaneous Lewis lung tumor was determined in BDF_1 mice after 23 daily 20-minute periods of exposure to a pulsed 27.12 MHz field. Mice were inoculated subcutaneously with 1×10^6 syngeneic Lewis lung carcinoma cells. Groups of eight mice were simultaneously irradiated at one of three different average power levels prior to tumor inoculation. Six groups received similar power levels of radiation immediately after inoculation. All groups were subsequently irradiated daily, twenty minutes per day, for 23 days. Significant reduction in tumor mass was observed in all postinoculated, irradiated groups. Measurement on postinoculation day 16 and 20 revealed a 60-90% inhibition of tumor mass when compared to controls. Pre-tumor inoculation radia-

tion demonstrated no change from control or an increase in tumor size. For both pre- and post-treated animals, no significant effects on survival were seen. An *in vitro* study was conducted to evaluate the response of tumor and normal cells to the same pulsed radiowave field. Each cell suspension, containing 1 ml (1×10^6 cells) was irradiated for twenty minutes. Post-radiation vital staining yielded a marked reduction of viability in 50-67% of all Lewis lung cells. In contrast, lethality for normal mouse embryo cells was 40%. In the case of Lewis lung tumor cells, the greatest lethality was observed in the cell suspensions experiencing the highest peak and average power outputs. L1210 leukemia cells obtained from DBA_2 mice were similarly processed and irradiated with a 60-90% lethality occurring, with toxicity directly related to the average power output. (No refs.)

4523 PHYSIOLOGICAL RESPONSES TO MICROWAVE EXPOSURE. (Eng.) Kinnen, E. (Dept. Electrical Engineering, Univ. Rochester, Rochester, NY 14627); Bogardus, R.; Lu, S.; Michaelson, S. *Natl. Electron. Conf. Proc.* 30: 233-236; 1975.

Five anesthetized dogs were exposed for 60 minutes to 60 mW/cm^2 incident power density at 2450 MHz continuous wave microwaves to determine the effect on temperature regulation. Exposure began 60 minutes after anesthetizing to allow for temperature stabilization. The tympanic, rectal, inguinal, axillary, back, hind toe and fore toe regions were monitored. Mean slopes of temperature curves for sham exposures (anesthetized, but not irradiated) did not become less negative by more than 0.36°C/hr. The change in mean slope for exposed animals appeared to be determined by size. Reduction of cooling rate was 1.5°C/hr for an 8.8 kg dog, 0.54°C/hr for a 12.6 kg dog and 0.62°C/hr for the remaining dogs weighing 23.5±0.9 kg. Rectal temperature was highest of recorded body temperatures 90 minutes after anesthesia in eight of nine experiments. Fore and hind toes showed a sudden increase in rate of cooling not apparent in other temperature curves during 6 of 9 experiments. Except for back, hind and fore toes, temperature differed in other locations on the same animal from between 0.5-2.9°C. Results show that animals remained homeothermic. Body heat regulation occurred through cooling of the extremities, aided by altered blood flow and was not dependent on microwave exposure. High rectal temperatures imply conduction and convection of heat from body core to skin or head. Convection to head is slowed or reversed during exposure. This study indicates significant changes in temperature gradients occur in anesthetized animals with or without head exposure to microwaves. (5 refs.)

4524 POTENTIAL MICROWAVE INJURIES IN CLINICAL MEDICINE. (Eng.) McRee, D. I. (National Inst. Environmental Health Sciences, Research Triangle Park, NC 27709). *Annu. Rev. Med.* 27: 109-115; 1976.

The use of microwaves in clinical medicine may be harmful, and their use requires precaution and an understanding of the potential danger. Microwaves have the valuable capability of penetrating biological materials to produce deep heating. The eyes and testes, however, are highly susceptible to damage by microwave exposure, since they have a limited blood flow for removal of heat. Exposure has been shown to cause cataracts in rabbits at 2450 MHz with a threshold at 150 mW/cm^2 for 100 minutes or for 10 minutes at 500 mW/cm^2. The eyes, therefore, should be shielded from exposure during diathermic treatment in the head region. The temperature sensitivity of testes has been demonstrated in one experiment in which Sprague-Dawley rats suffered testicular degeneration after 10 minutes of microwave exposure at 35°C and 2450 MHz. Effects on the central nervous system include headaches, increased fatiguability and irritability, sweating, difficulties in concentration and memory, and emotional instability. Other hazards include incorrect use of microwave blood-warmers, which may result in hemolysis, and possible electromagnetic interference with medical electronics, especially cardiac pacemakers. Proper administration techniques, therefore, should be used by trained personnel, with care taken to expose only the portion of the body being treated with adequate protection of the operator and those in surrounding areas. (27 refs.)

4525 THE PRACTICE OF MICROWAVE RADIATION SAFETY (SYMPOSIUM SUMMARY). (Eng.) Rexford-Welch, S. C. (RAF Consultant in Radiobiology, AWRE Aldermaston, Near Reading, Berkshire, U.K.); Lindsay, I. R. *J. Microwave Power* 11(2): 160-162; 1976.

The safety regimen adopted by major users of microwave radiation generally includes safety officer appointments, the production of safety instructions, area control, and classification and medical surveillance of workers, and incident investigation. Appointment of a safety officer for non-ionizing radiation requires no certified level of competency. This reflects the need for training stated by the World Health Organization. Safety orders are produced by major users without the spur of legislation and the guidance of codes of practice. The need for exposure standards for frequencies outside the microwave range, particularly 1-30 MHz, has to be recognised. Restricted areas are based on the microwave radiation personnel exposure standard (MPE) with only authorized entry during operation and hazard areas with no entry during operation. Also, it is imperative to reassess areas after equipment modification, new installation, and following an incident. Health surveillance should prevent the employment of persons who could be adversely affected by microwave radiation exposure. The classification of microwave radiation workers, based on the MPE of 10 mW/cm^2 and with required medical surveillance, is proposed, and the voluntary participation of associated workers in epidemiologic studies of exposures below this MPE is urged. Any untoward occurrance in a controlled area should be investigated as soon as possible, and preferably by a specialized team. This will include early technical assessment of the operating conditions and medical examination of exposed workers. Finally, the definition of a permissible exposure

level is paramount to any protection program, since it is not easy for the practitioner of microwave radiation safety to work with the divergence in recommended standards. (No refs.)

4526 THERMOSTABILITY OF THE ERYTHROCYTES OF MICE EXPOSED TO THE ACTION OF A MAGNETIC FIELD. (Eng.) Sebestik, V. (Inst. Hematology, Blood Transfusion, 128 20 Prague 2, U nemocnice 1, Czechoslovakia); Petz, R. *Physiol. Bohemoslov.* 25(3): 241-244; 1976.

The effect of a magnetic field, formed by the poles of a rotating permanent magnet of 200 gauss induction, on the thermostability of mouse erythrocytes was discussed. Fifteen CBA-strain female mice, 23-25 weeks of age, were exposed for an average of 17 weeks to the magnetic field; 15 additional mice served as a control group. These groups were compared to six animals exposed to the magnetic field during gestation. Erythrocyte thermostability was determined for this group three months postpartum. Results indicated that the rate of heat hemolysis of erythrocytes was significantly higher in the test groups exposed to the magnetic field, especially at 5 and 10 minutes of heating ($p<0.01$). After five minutes of heating, hemolysis in the exposed group had a mean value of 8.11 ± 4.36, while the mean of the group exposed *in utero* was 14.33 ± 6.24. The control group had a mean value of 3.76 ± 1.67. At 45 minutes, the differences between all groups were not significant. These results indicate that the effect of the magnetic field on the embryonic organism persists long after (three months) removal of the field. The decrease in the thermostability of the erythrocytes was associated with a decrease in their osmotic resistance, which was probably a direct result of the magnetic field on the erythrocyte cell membrane. (9 refs.)

4527 SCATTERING OF MICROWAVES BY DIELECTRIC MATERIALS USED IN LABORATORY ANIMAL RESTRAINERS. (Eng.) Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI 48202); Wu, C-L. *IEEE Trans. Microwave Theory Techniques* 24(4): 219-223; 1976.

In most experimental investigations of the biological effects of microwave radiation, it is necessary to use low-loss dielectric materials for restraining animals under irradiation. Because of the complexity of the analysis of the animal-restrainer combination, an analysis was made of the scattering of microwave fields by a simplified model of the restrainer with no animal present. The model chosen was that of a plane wave incident at an arbitrary angle upon a rectangular slab of finite width and thickness. Numerical results indicated that the scattered fields within a square region of one wavelength in distance from the slab surfaces are greatly enhanced and highly nonuniform. In particular, the maxima for parallel incidence exceeded those for normal incidence by almost a factor of 2. The results suggested that for minimal perturbation the broad face of an animal holder should be oriented toward the direction of propagation. Further, the individual members of the restraining device should be as thin as practicable, and the dielectric materials should correspond to the characteristics of free space. (5 refs.)

4528 EFFECTS OF MICROWAVE-INDUCED LOCAL HYPERTHERMIA ON MAMMARY ADENOCARCINOMA IN C3H MICE. (Eng.) Mendecki, J. (Dept. Radiotherapy, Montefiore Hosp. and Medical Center, 111 East 210th St., Bronx, NY 10467); Friedenthal, E.; Botstein, C. *Cancer Res.* 36(6): 2113-2114; 1976.

Microwave-induced hyperthermia, produced by a 10 W microwave generator at a radiation frequency of 2450 MHz, was focused locally upon mammary adenocarcinoma implanted in C3H mice when the tumor reached 6 mm in diameter. In 54 treated mice, all tumors diminished in size after the first exposure (43°, 45 minutes) and disappeared completely following the second treatment. No other effects from heat application were apparent. All the mice in the microwave-treated group survived the whole period of observation (4 months) without any evidence of tumor, while 18 nontreated controls died within 4 weeks after inoculation. (9 refs.)

4529 NON-PERTURBING MICROPROBES FOR MEASUREMENT IN ELECTROMAGNETIC FIELDS (SYMPOSIUM SUMMARY). (Eng.) Deficis, A. (O.N.E.R.A.-C.E.R.T., Laboratoire du D.E.R.M.O., 2 Avenue Edouard Belin, B.P. 40-25, 31055 Toulousse Cedex France); Priou, A. *J. Microwave Power* 11(2): 148-149; 1976.

The possibility of obtaining a dielectric microprobe that would not interfere with electromagnetic waves has been studied. Two types of probes were defined: one operating in the temperature range of 10°C to 40°C, another within the range -40°C to +20°C. Both probes included a head (different according to the temperature range or density to be measured) but comprising a thermosensitive dielectric material, dielectric light conductors (optical fibers), and associated electronics. The first probe, (a "cholesteric crystal and optical fibers dielectric probe"), had a head composed of an optical transducer, a thermal sensor made of micro-encapsulated cholesteric liquid crystals, and coating absorbing waves formed by a thin film of colloidal graphite. In this system only two optical fibers were used: one bringing in the light, the other collecting the reflected light containing information on the temperature or power density variations. The second probe was a dielectric thermometer operating within a range of -30°C to +10°C. The principle of the probe was based on the reflection of a light beam on a thermodilatable liquid, contained in a capillary glass pipe of small dimension. The electronics was similar for both probes. A white light source powered the optical fiber(s). The reflected light was collected by a photomultiplier driven by a power supply. The analysis of the reflected light was then made either by recording on a plotter or by any other process. (No refs.)

4530 FAILURE OF 2- AND 10-METER RADIO WAVES TO INDUCE GENETIC DAMAGE IN *DROSOPHILA MELANOGASTER*. (Eng.) Mittler, S. (Dept. Biological Sciences, Northern Illinois Univ., DeKalb, IL 60115). *Environ. Res.* 11(3): 326-330; 1976.

Adult male *Drosophila melanogaster*, exposed to nonthermal radio waves, were studied to assess whether radio waves used for transmissional purposes pose a mutational hazard. *Drosophila*, in vials, were attached to two antenna and exposed for 12 hours to the frequencies of 136.34 and 29.00 MHz, respectively. The progeny of the exposed *Drosophila* were tested for sex-linked recessive lethals, loss of X or Y chromosomes, and non-disjunction. There was no significant difference between offspring of the control and exposed flies with respect to the genetic mutations. Spermatogenesis also was unaffected. It is concluded that the average portable transmitter does not pose a threat to the genetic integrity of its operator, since the frequencies tested are in the radio wave band regions used by police, emergency vehicles, radio amateurs, and civilian radio operators. (13 refs.)

4531 DETERMINATION OF POWER ABSORPTION IN MAN EXPOSED TO HIGH FREQUENCY ELECTROMAGNETIC FIELDS BY THERMOGRAPHIC MEASUREMENTS ON SCALE MODELS. (Eng.) Guy, A. W. (Bioelectromagnetics Research Lab., Sch. Medicine, Univ. Washington, Seattle, WA 98195); Webb, M. D.; Sorensen, C. C. *IEEE Trans. Biomed. Eng.* 23(5): 361-371; 1976.

A technique is described in which thermographically determined power absorption measurements in scale phantom models of man exposed to very high frequency fields are used to obtain power absorption characteristics in full scale man exposed to high frequency fields. When the body of man, small compared to a wavelength, is exposed to high frequency electromagnetic fields, the absorbed power density patterns and total absorbed power may be approximated by the simple super-position of the internal electric fields obtained from the quasistatic coupling characteristics of the electric and magnetic field components determined independently. A VHF resonant cavity was used to provide the necessary field strengths for producing measurable power absorption patterns under simulated HF exposure conditions. Results indicated that peak power absorption densities as high as 5.63 W/kg could be produced in man exposed to 10 mW/cm^2, 31 MHz radiation fields. The results show that the absorption decreased as the square of the frequency, as predicated by theory for frequencies below 31 MHz. (8 refs.)

4532 ELECTROMAGNETIC FORCES AND CIRCADIAN RHYTHMS (LETTER TO EDITOR). (Eng.) Hopewood, P. S. (Univ. Vermont, Coll. Medicine, Burlington, VT). *N. Engl. J. Med.* 294(9): 501-502; 1976.

It is questioned whether a procedure, electromagnetic bougienage, (Hendron and Hale, *New England Journal Medicine* 293:428, 1975), will interfere with a newborn's ability to perceive geophysical stimuli, thus changing diurnal rhythms, necessary hormonal responses, and subsequent growth development. This concern is based on the belief that man's circadian rhythm is cued by a geophysical sensor, which interprets information from magnetic fields, cosmic radiation, and gravity. Evidence indicates that planaria and mud snails will change direction with a change in magnetic field. In addition, electric fields have been used to shorten man's diurnal rhythm. If geophysical phenomena can be registered, then perhaps this information can be used by the central nervous system to alter bioelectric activity and diurnal rhythms. (7 refs.)

4533 ELECTROMAGNETIC PULSE INTERACTION WITH MAMMALIAN CRANIAL STRUCTURES. (Eng.) Lin, J. C. (Dept. Electrical Engineering, Wayne State Univ., Detroit, MI 48202). *IEEE Trans. Biomed. Eng.* 23(1): 61-65; 1976.

The transmitted field strengths in homogeneous spherical models of human and animal heads were determined to be a function of time and position, using frequency analytic techniques for an impinging pulse of Gaussian character. A Debye relaxation model and constant conductivity model were considered for the electrical behavior of brain matter. The constant conductivity model was used to predict continued decreases in pulse amplitude as it advanced in the head starting from the leading surface; however, the relaxation model predicted reduction only from the surface to the center. Moreover, it appears that the transmitted pulse in a spherical model of the head was always related to the time derivative of the incident radiation. Numerical results indicate that the transmitted pulse amplitude is quite small and can be estimated using the constant conductivity model. (13 refs.)

4534 PAIN SENSATIONS ASSOCIATED WITH ELECTROCUTANEOUS STIMULATION. (Eng.) Mason, J. L. (Dept. Electrical Engineering, University of Canterbury, Christchurch, New Zealand); Mackay, N. A. M. *IEEE Trans. Biomed. Eng.* 23(5): 405-409; 1976.

The results of experiments to determine the feasibility of using electrocutaneous stimulation in sensory substitution systems are discussed. The system may provide some facility for sound localization to the totally deaf by directing auditory information to an alternate sense. One of the main drawbacks to the development of this system has been the sharp, pricking pain often associated with electrocutaneous stimulation. This has been found to be a result of thermal damage to the corneal layer of the skin. The high-energy densities required to create this damage often occur, even at moderate stimulation currents, because of the highly nonhomogeneous nature of the skin-electrode interface. However, this pain can be controlled without resorting to electrode pastes by adopting a simple procedure for applying the electrode. The dynamic range and the stability of the sensation magnitude have been measured under paste-free conditions, and

the conclusion was reached that electrocutaneous stimulation would be a viable alternative to mechanical stimulation in certain sensory substitution applications. (9 refs.)

4535 ELF COUPLING TO SPHERICAL MODELS OF MAN AND ANIMALS. (Eng.) Spiegel, R. J. (IIT Res. Inst., Washington, DC 20006). *IEEE Trans. Biomed. Eng.* 23(5): 387-391; 1976.

The induced fields, currents, and power absorbed by spherical models of humans or animals when exposed to extremely low frequency (ELF) electromagnetic fields were calculated. Spherical models can be expected to provide values of the right order of magnitude. The induced fields were a sum of the quasistatic solutions for a sphere irradiated by a uniform electric and magnetic field. Calculations were provided for ELF fields emanating from the proposed Navy's Sanguine antenna and extra high voltage (EHV)/ultra high voltage (UHV) transmission lines proposed by the utility industry. Converting the predicted absorbed power into the average heat produced in a 70-kg man by the ELF field was found too be approximately 10^{-5} cal/gs. This induced heat production is considered too low to interfere with normal biologic function; however, this should be verified. (16 refs.)

4536 ARE MOUSE FETUSES WHICH SURVIVE MICROWAVE RADIATION PERMANENTLY AFFECTED THEREBY? (Eng.) Rugh, R. (U.S. Dept. Health, Education and Welfare, Public Health Service, Food and Drug Admin., Bureau of Radiological Health, 5600 Fishers Lane, Rockville, MD 20852). *Health Phys.* 31(1): 33-39; 1976.

Time-mated CFI white mice (118) were exposed when their fetuses were at 9, 12, or 16 days gestation to 7.4 W forward power of 2450 MHz microwave radiation for 4 minutes--a sub-lethal exposure. Mean absorptions of energy ranged from 22.4 to 27.1 J/g and were inversely proportional to weight and gestation age. After a normal delivery, these fetally irradiated mice were again exposed to the same irradiation as previously, from two months of age until death. Death was electronically monitored on a polygraph. A parallel group of 25 two-month-old controls were similarly irradiated, and the absorbed dose in J/g and the time in min to kill were taken as the measure of radiation tolerance or radiosensitivity of the originally irradiated fetuses. Males initially exposed to microwave energies at 12 and 16 days gestation, and females irradiated at 16 days gestation showed a slight but statistically significant reduction in the mean time to kill. Only the 12 day males showed a significant reduction in the mean absorbed dose at death. None showed mean absorbed doses greater than did the controls; hence, there was no evidence of any acquired resistance to radiation effects. All males initially exposed *in utero* had mean body weights significantly lower than did the control males at two months of age. Females initially irradiated at 16 days gestation were, at two months, statistically lighter in mean body weight than any of the other irradiated or control females. There was no significant difference between the sexes in J/g absorbed dose to kill at two months of age, but there was a significant lowering of the time to death for those males previously irradiated at 12 and 16 days gestation age and females at 16 gestation days compared with their respective controls. (13 refs.)

4537 INFLUENCE OF 2450 MHz CW MICROWAVES ON RATS EXPOSED *IN UTERO* (SYMPOSIUM SUMMARY). (Eng.) Michaelson, S. M. (Dept. Radiation Biology and Biophysics, Univ. Rochester, Sch. Medicine and Dentistry, Rochester, NY 14642); Guillet, R.; Catallo, M. A.; Small, J.; Inamine, G.; Heggeness, F. W. *J. Microwave Power* 11(2): 165-166; 1976.

Rats exposed *in utero* to 2450 MHz continuous wave microwaves were examined for indices of maturational deficits. Long-Evans rats at 9 and 16 days of gestation were exposed to 2450 MHz continuous wave microwave radiation at 10 mW/cm^2 or 40 mW/cm^2 for 1 hour. These exposures did not seem to adversely affect the rat or her offspring; parturition was normal with no change in gestation duration, and there was no difference in litter size (10-16 pups) from exposed and sham-irradiated dams. Oxygen consumption in cold stressed neonates from the 40 mW/cm^2 exposed dams was increased (about 75 ml O_2/min/kg) relative to controls and 10 mW/cm^2 exposures (about 50 ml O_2/min/kg and 43 ml O_2/min/kg respectively). Preliminary results suggest that corticosterone and thyroxine levels were comparable in all neonates examined. Corticosterone levels in the first 24 hours of life ranged from 10-25 µg% then dropped and remained at <2µg% through the 14th day. Plasma thyroxine (T4) levels in the neonatal rat were low (<3µg%) for the first 10 days of life in pups from both exposed and non-exposed dams. At days 11-12 a rise in plasma T4 levels to 4-8 µg% (normal adult levels) was seen in both groups. (No refs.)

4538 TEMPERATURE CHANGES GENERATED BY MICROWAVE THERAPY IN THE THIGHS OF HUMAN SUBJECTS (SYMPOSIUM SUMMARY). (Eng.) Stevens, A. (Dept. Physical Medicine and Electromyography, Univ. Leuven, Faculty of Medicine, B-3000 Leuven, Belgium); Peluso, F. *J. Microwave Power* 11(2): 170-171; 1976.

Deep tissue temperature elevations generated after exposures to microwave therapy were studied in human subjects. The right antero-lateral thigh of 20 male subjects of around 25 years of age were exposed to microwave radiation at 2450 MHz. A power output of 50 W was applied at a 10 cm distance from the skin surface for 10 minutes. Tissue temperatures were measured immediately after exposure, and 5, 10, and 15 minutes thereafter at six depths, i.e., at the skin surface, 2, 6, 11, 16 and 21 mm beneath it. Temperature elevation decreased with depth. Immediately after exposure very modest temperature elevations in the various tissue layers were found, i.e., from 2.5°C ± 0.6 on the surface to 1.0°C ± 0.3 at 21 mm underneath. The temperature changes in

muscle were smaller, i.e., from 1.9°C at 11 mm depth to 1.0°C at 21 mm. Fifteen minutes after the end of the radiation, the temperature elevations in the muscle and at the fat-muscle interface were still significant. This after-exposure heating effect suggests that only small changes in blood flow occur and that other mechanisms may have to be invoked to explain the therapeutic success obtained with this type of therapy. (No refs.)

4539 MICROWAVE RADIATION AND OTHER HARMFUL FACTORS OF WORKING ENVIRONMENT IN RADIOLOCATION: METHOD OF DETERMINATION OF MICROWAVE EFFECTS (SYMPOSIUM SUMMARY). (Eng.) Siekierzynski, M. (Postgraduate Medical Center, Military Medical Acad., ul. Szaserow 128, Warszawa, 60, Poland); Czarnecki, C.; Dziuk, E.; Jedrzejczak, W. W.; Szady, J. *J. Microwave Power* 11(2): 144-145; 1976.

This analysis included 841 males with occupational exposure to pulse-modulated microwave radiation. The subjects were divided into two groups: Group I consisted of 507 subjects exposed to energy beam densities exceeding 2 W/m^2 (sometimes exceeding 60 W/m^2), and Group II consisted of 334 subjects exposed to energy beam densities never exceeding 2 W/m^2. The incidence of functional disturbances, gastric and duodenal ulcer, the functional state of the thyroid, lens transparency, causes of disability to work, consequences of excessive accidental radiation exposure, and changes in the abnormalities after cessation of exposure to radiation were determined. No differences were observed in the health state between groups differing only in the degrees of exposure to microwave radiation. It was found that the incidence of many abnormalities was influenced by increasing age of the subjects and not by the duration of work connected with exposure. This observation does not support the hypothesis of cumulative effects of microwave exposure with increasing length of work under conditions of exposure. The presence of various functional disturbances in nearly 60% of the subjects in both compared groups indicated a highly neurotizing influence of the whole complex of environmental factors other than microwave radiation. (No refs.)

4540 AN UPPER BOUND ON COEFFICIENT OF TRANSMISSION OF MICROWAVE LEAKAGE INTO BIOLOGICAL TISSUES (SYMPOSIUM SUMMARY). (Eng.) Kamal, A. A. (Dept. Electronics and Communications, Faculty of Engineering, Cairo University, Giza, Cairo, Egypt); Al-Badwaihy, K.; Hashish, E. *J. Microwave Power* 11(2): 159-160; 1976.

An attempt to find an upper bound on the transmission coefficient U for various near zone fields was undertaken. A planar model consisting of a half space of homogenous biological tissues with known electromagnetic properties (permittivity, conductivity and permeability) was used in the study. The source was an elementary electric or magnetic dipole located in the free space region above the biological half space. The incident field was decomposed into a continuous spectrum of cylindrical waves. For each component wave the transmitted field was found, and an integration gave the value of total transmitted field into the biological material. It is concluded that as the height of the dipole decreases, the maximum of the transmission coefficient U shifts towards the dipole projection. Also, its value increases, and for low values of the dipole heights, the maximum value of transmission exceeds that based on a plane wave assumption. (No refs.)

4541 VARIATION OF SERUM TRIGLYCERIDES RATE UNDER THE ACTION OF ELECTROMAGNETIC WAVES: POWER LEVEL INFLUENCE (SYMPOSIUM SUMMARY). (Eng.) Deficis, A. (Centre d'Etudes et de Recherches de Toulouse, Toulouse, France); Dumas, J. C.; Laurens, S.; Plurien, G. *J. Microwave Power* 11(2): 136-137; 1976.

The effect of electromagnetic field exposures on the liquid metabolism of mice was investigated. Groups of 12 mice (Swiss origin, male) were exposed for nine days (15 hours/day) to electromagnetic fields of 2.4 GHz at power densities ranging from 1-3.3 mW/cm^2. Three microwave power levels were applied to the animals. In the lowest case (1 mW/cm^2), the triglyceride rate was the same in every animal. However, at both other power levels (1.5 and 3.3 mW/cm^2), a significant increase in the triglyceride rate was observed in the exposed animals. In a second experiment, the triglyceride rate for animals exposed to electromagnetic radiation was compared to that of animals exposed to infrared radiation. At 1.5 mW/cm^2, the triglyceride rate was the same for every animal. However, this rate was significantly higher in animals that were exposed for nine days to microwaves at 3.3 mW/cm^2 than in animals that were exposed for the same period and at the same power level to infrared radiation. The results suggested the possibility that microwaves act on the lipid metabolism through an internal mechanism, which is noticeable only over a certain exposure level. (No refs.)

4542 RETINAL SENSITIVITY TO SHORT WAVELENGTH LIGHT (LETTER TO EDITOR). (Eng.) Marshall, J. (Inst. Ophthalmology, Judd St., London WC1H 9QS, U.K.); Weale, R. A. *Nature* 262: 629; 1976.

Conclusions in a recent article in *Nature* on potential hazards due to exposure of the primate retina to visible radiation of short wavelengths are questioned. The lesions were thought to be mediated by a photochemical mechanism; however, the reciprocity law was not obeyed in the data of the article, although both human rods and cones obey the law in the author's timespan. Thermal effects were minimized, even though the action spectrum resembled the absorption spectrum of melanin. The role of the crystalline lens as protection for the retina was emphasized, although the vitreous may be at risk in aphakic eyes. The morphology of the lesion was ignored. The authors also implied that viewing the sun under their experimental conditions, below the threshold for lesions of 100/sec, is safe. It should