4820 EFFECTS OF ELECTRIC FIELDS ON LARGE ANIMALS: A FEASIBILITY STUDY. (Eng.) Phillips, R. D.; Richardson, R. L.; Kaune, W. T.; Hjeresen, D. L.; Beamer, J. L.; Gillis, M. F. (Batelle Memorial Inst., Pacific Northwest Lab., Richland, WA 99352). 84 pp. [available through National Technical Information Services, Washington, DC. Document No. PB 251-632].

Experiments to determine the feasibility of and experimental conditions required for the long-term exposure of Hanford Miniature Swine to 60 Hz high-strength electric fields were conducted. The behavior of swine appeared normal at field strengths up to 50 kV/m. At 55 kV/m ear flicking was commonly observed, and one swine exhibited head shaking. No corona occurred on or near the swine at field strengths up to 55 kV/m. Minishocks were avoided at field strengths as high as 55 kV/m by maintaining the swine in a stall with nonconducting walls, by providing a metal ground plate for the animal to stand on, and by keeping the drinking water system at or close to ground potential. The threshold field strength for piloerection and hair oscillation was about 50 kV/m. The swine appeared to perceive electric fields at 30-35 kV/m without visible hair movement. Electric field measurements made with and without the swine in the electric field indicated that the field was markedly altered in the vicinity of the swine's body, emphasizing the need for more complete and detailed dosimetry if results from studies with experimental animals are to be used for establishing human exposure limits. Data for the design of a full-scale prototype configuration for investigating the possible biologic effects of exposure to high strength electric fields were obtained. (4 refs.)

4821 EMC DESIGN EFFECTIVENESS IN ELECTRONIC MEDICAL PROSTHETIC DEVICES. (Eng.) Mitchell, J. C.; Hurt, W. D.; Steiner, T. O. *In: Fundamental and Applied Aspects of Nonionizing Radiation.* Michaelson, S. M.; Miller, M. W.; Magin, R.; Carstensen, E. L., eds. (New York: Plenum Press): pp. 351-363; 1974.

Cardiac pacemakers were tested to assess the extent of radiofrequency electromagnetic radiation interference (EMI) possible from a variety of radiofrequency (RF) sources. Seventy pacemakers with 21 different designs and from 10 manufacturers were tested. Radiation sources included laboratory generators operating at pulsed frequencies of 450 and 3100 MHz, various household electric devices, and the RF emission from an automobile ignition. The pacemakers were tested in free-field and simulated-implant configurations for each of the radiation sources. Relative interference thresholds were vastly different, with the most sensitive pacemaker adversely affected at electric (E) field levels as low as 10 V/m and the least sensitive pacemaker relatively free of interference at levels as high as several hundred V/m. In many cases the real time E-field level around RF radiation emitters manifested itself as a pulsed or pseudo-pulsed (changing E-field level) signal, which could adversely affect cardiac pacemakers and was potentially hazardous for other types of medical prosthetic devices. It is concluded that pacemaker manufacturers will eventually resolve most of the potential pacemaker EMI problems. The authors recommend that manufacturers of other medical instrumentation and electronic prostheses incorporate good EMI rejection techniques in all new devices. (12 refs.)

4822 GROWTH AND DEVELOPMENT OF NEONATAL MICE EXPOSED TO HIGH-FREQUENCY ELECTROMAGNETIC FIELDS. (Eng.) Stavinoha, W. B.; Modak, A.; Medina, M. A.; Gass, A. E. (Univ. Texas Health Science Center at San Antonio, 7703 Floyd Curl Drive, San Antonio, TX 78284); 8 pp., 1975. [available through National Technical Information Services, Washington, DC, Document No. SAM-TR-75-51].

The effects of radiofrequency (RF) radiation on the growth and development of neonatal rodents were investigated in two studies. In the first experiment, 4-day-old Swiss Webster mice, in plastic containers, were exposed to 10.5, 19.27, and 26.6 MHz RF radiation for 20 min. The measured electric field was approximately 5800 V/m. Controls were kept in similar containers outside the exposure chambers. The animals were weighed daily to the nearest milligram for the following 21 days. In the second study, 4-day-old Swiss Webster mice were divided into three groups: (1) control mice, kept in individual cages; (2) thermal control mice, exposed to an environment of 37°C for 40 min for 5 consecutive days; and (3) irradiated mice, exposed to RF radiation at 19 MHz for 40 min for 5 consecutive days. Following exposure, the mice were weighed for 16 wk. No significant differences in growth and development were observed among the irradiated and nonirradiated mice in both studies. It is concluded that nonionizing radiation at the frequencies used had no effect on neonatal mouse growth. The authors point out, however, that since the size of the mice was much smaller than the wavelengths used, their bodies probably absorbed only a relatively small amount of energy. (9 refs.)

4823 COMPARISON OF IONIZING AND MICROWAVE RADIATIONS WITH RESPECT TO THEIR EFFECTS ON THE RODENT EMBRYO AND FETUS (ABSTRACT). (Eng.) Rugh, R. (U.S. Dept. Health, Education, Welfare, Public Health Service, Food and Drug Admin., Bureau Radiological Health, 5600 Fishers Lane, Rockville, MD); McManaway, M. *Teratology* 14(2): 251; 1976.

Rodent fetuses and embryos, exposed to nonionizing electromagnetic radiation from conception to organogenesis, were studied for the development of congenital anomalies. A radiation frequency of 2450 MHz was employed within a waveguide at a forward power of 7.5 W, at an average absorbed dose rate of 78.8-136.2 mW/g and a mean value of 107.4 mW/g. The incidence of congenital anomalies among rodent fetuses exposed for 4 min was highest at 8 and 10 days gestation. Teratogenesis followed both ionizing and

electromagnetic radiation exposures at comparable gestation stages, indicating the inherent radiosensitivity of embryos and fetuses. There was essentially no thermal stress with ionizing radiation and no ionizations with microwave heat energies. For humans, hypersensitivity stages correspond to gestation days 9 and 20. (No refs.)

4824 AN APPROACH TO BIOLOGICAL RESPONSE TO MICROWAVES: A PRELIMINARY THERMAL VERSUS NON-THERMAL EXPERIMENT. (Eng.) Wayland, J. R.; Brannen, J. P.; Morris, M. E. (Sandia Lab., Albuquerque, NM 87115). 18 pp; 1975. [available through Sandia Laboratories, Albuquerque, NM, Document No. SAND75-0494].

The separation of thermal and non-thermal effects in response to microwave radiation was studied using spore inactivation rate of *Bacillus subtilis* var *niger* as the measurable response. Dry spore stock in a quartz tube was exposed to microwave radiation at a frequency of 2450 MHz over power levels ranging from 9-30 kW. Thermal effects on inactivation were measured during dry heat inactivation, and the temperature during exposure to microwave energy was monitored by infrared microscopy. A comparison of the reaction rate constants versus power for heat alone and for exposure to microwaves revealed a non-thermal effect that was evidenced by a difference in the spore inactivation rate constants. (9 refs.)

4825 THE INSENSITIVITY OF FROG HEART RATE TO PULSE MODULATED MICROWAVE ENERGY. (Eng.) Liu, L. M. (Dept. of Biophysics, Medical Coll. of Virginia, Richmond, VA 23298); Rosenbaum, F. J.; Pickard, W. F. *J. Microwave Power* 11(3): 225-232; 1976.

The effect of pulse modulated microwave irradiation on the heart rate of the frog (*Rana pipiens*) was investigated. Two types of experiments were conducted. In one, frog hearts were irradiated *in situ* with 100 μsec bursts at a carrier frequency of either 10.0 GHz or 1.42 GHz at an average power delivered to the vicinity of the heart of either 16 μW or 12 μW, respectively. In a second experiment, isolated frog hearts were irradiated with 100 μsec bursts at a carrier frequency of 1.42 GHz and an average power (delivered to the vicinity of the heart) of 7 μW. No significant changes in heart rate were observed during either experiment. A comparison of the above negative results with similar experiments, which led to the production of tachycardia in isolated frog hearts, and performed by other investigators is made. It is concluded that the rate of energy absorption, though virtually unmeasurable with either a horn or a microprobe, may be of crucial importance and that, if an optimal dosage for the production of arrhythmias does exist, then it points toward the presence of a putatively athermal effect that is different from that implicated in the teratogenic action of microwaves. (12 refs.)

4826 A REPLY TO THE CONCEPT OF CANCER TREATMENT BY NMR (LETTER TO EDITOR). (Eng.) Reisse, J. (Chimie Organique E. P., Universite Libre de Bruxelles, 50, avenue F.D. Roosevelt, B 1050 Bruxelles, Belgium); Piccinni-Leopardi, C. *Physiol. Chem. Phys.* 8(2): 175-176; 1976.

The authors claim that a proposal advanced by Zaner and Damadian [*Physiol. Chem. Phys.*, 7, 437 (1975)] to irradiate tumors at "cancer specific frequencies" to selectively kill cancer cells is totally unrealistic. The proposal contended that a large scale radiofrequency (RF) source ("cavity resonator") could be constructed to provide a homogeneous field [with a homogeneity of a few parts per million (ppm) since the frequency differences between normal and cancer absorptions are of this magnitude] to irradiate the subject at "cancer specific frequencies" and selectively kill only neoplastic tissue and leave normal tissue unharmed. It is argued, however, that it is impossible to effect a selective increase in the temperature of cancer cells by subjecting a patient to RF irradiation. It is pointed out that Zaner and Damadian overlooked the fact that cancer specific absorption frequencies only existed because their test sample had been exposed to a very homogeneous magnetic field. With no magnetic field, specific absorptions would not exist either for cancer cells or for normal cells; only a non-specific absorption of RF radiation would be present. This non-specific absorption can be described as the result of dielectric loss. The patient would consequently be exposed not only to a "cavity resonator" but to a strong magnetic field. Moreover, this magnetic field would be extremely homogeneous since the difference between the absorption frequencies of normal and cancer tissues is a few ppm. The homogeneity of the field must therefore be superior to 1 ppm to maintain a distinction between normal and "cancer absorptions." It is concluded that, given the extreme difficulty which is encountered in obtaining such magnetic characteristics in a volume of 2 or 3 milliliters between the poles of an electromagnet (the poles having been set a few centimeters apart), it is apparent that the concept of an electromagnet, which could contain a man, even partially, is totally unrealistic. (1 ref.)

4827 A REPLY TO THE CONCEPT OF CANCER TREATMENT BY NMR (AUTHOR'S REBUTTAL) (LETTER TO EDITOR). (Eng.) Zaner, K. S. (No affiliation given); Damadian, R. *Physiol. Chem. Phys.* 8(2): 176; 1976.

The authors state that critics of their proposal to irradiate tumors at cancer specific frequencies failed to consider the possibility that the 2-milliliter spot of high uniformity, which they cite, could be moved through the patient. Therefore, the entire field need not satisfy a stringent high-resolution requirement. This is the basis of the FONAR (field focusing NMR) method for nuclear resonance imaging. (1 ref.)

4828 DIELECTRIC PROPERTIES OF BIOLOGICAL MATERIALS AND INTERACTION OF MICROWAVE FIELDS AT THE CELLULAR AND MOLECULAR LEVEL. (Eng.) Schwan, H. P. *In: Fundamental and Applied Aspects of Nonionizing Radiation.* Michaelson, S. M.; Miller, M. W.; Magin, R.; Carstensen, E. L., eds. (New York: Plenum Press): pp. 3-19; 1974.

Dielectric properties of biologic materials are reviewed and discussed in terms of the interaction of microwave fields at the cellular and molecular level. Forces that are caused by alternating fields are not likely to be significant at the molecular and microscopic cellular level unless huge field strength values are assumed--values so large that accompanying thermal effects may be significant. However, on a macroscopic level, these effects may well be significant. The phenomenon of hearing pulsed microwave fields may be explained by the forces rhythmically applied to the middle ear structures as the field is turned on and off. Therefore, forces which can be generated by the application of alternating fields (field evoked forces, dielectrophoresis, electromechanical effects) deserve consideration and may be responsible for the phenomenon of hearing pulsed field and also for some of the behavioral effects reported in the 1-10 mW/cm^2 range. range. There appears to be no basis for anticipating thermal effects below about 1 mW/cm^2, and any effects evoked by fluxes below this power level appear to be of the nonthermal type. (20 refs.)

4829 MICROWAVE AUDITORY EFFECT--A COMPARISON OF SOME POSSIBLE TRANSDUCTION MECHANISMS. (Eng.) Lin, J. C. (Dept. Electrical and Computer Engineering, Wayne State Univ., Detroit, MI 48202). *J. Microwave Power* 11(1): 77-81; 1976.

First order calculations were used to compare three possible physical mechanisms that may be involved in the auditory effects of pulse-modulated microwave radiation. The forces due to radiation pressure, strictive forces, and rapid thermal expansion were compared using a simple one-dimensional model that assumed uniform power absorption at and near the surface of the lossy dielectric body. A comparison of the magnitude of the acoustic energy generated by the radiation pressure, strictive force, and thermal expansion revealed that thermally induced forces exceeded radiation pressure by a large margin. While the strictive forces were high in comparison with radiation pressure, they were much smaller than thermal expansion in both water and muscle material. If a 6% coupling efficiency and a peak absorbed power density of 2400 W/m^2 (the minimally effective value for 2450 MHz microwave radiation to produce audible signals in an adult with normal hearing) are assumed, the computed maximum stress is approximately 0.02 Newtons-m^2 for both muscle and brain. This value is above the previously established threshold of hearing for bone conduction. The results indicate that while all three forces are capable of producing auditory effects, the stress resulting from thermal expansion may be so great that it completely masks the effects of radiation pressure and strictive force. The authors conclude that the amplitude of the stress-generated acoustic signal is of such magnitude that it represents a probable explanation of the microwave pulse-induced auditory phenomenon in man. (19 refs.)

4830 MEMBRANE-BOUND ATP SYNTHESIS GENERATED BY AN EXTERNAL ELECTRICAL FIELD. (Eng.) Witt, H. T. (Max-Volmer-Institut fuer Physikalische Chemie und Molekularbiologie, Technische Universitaet Berlin, 1000 Berlin 12, Strasse des 17, Juni 135, Germany); Schlodder, E., Graeber, P. *FEBS Lett.* 69(1): 272-276; 1976.

An external electrical field was used to generate membrane-bound adenosine triphosphate in isolated spinach chloroplasts. The chloroplasts were suspended in a cuvette between 2 platinum electrodes. Voltage pulses (30 msec pulse width) of 220 V were applied to the electrodes, corresponding to an external electrical field strength of 1.1×10^3 V/cm. The amount of adenosine triphosphate/chlorophyll generated by the external voltage pulses increased linearly with increasing numbers of pulses, and the yield of adenosine triphosphate was 7.6×10^{-3} mole/ mole of chlorophyll. Assuming that there existed one adenosine triphosphatase per 860 chlorophyll molecules, at least 6.5 adenosine triphosphate molecules were synthesized per adenosine triphosphatase by the external electrical pulses. Substances that inhibit the reaction of the adenosine triphosphatase inhibited adenosine triphosphate formation when the electrical field was applied, and substances that inhibit light-induced linear electron flow did not affect adenosine triphosphate formation, indicating that the measured adenosine triphosphate was not the result of artefacts. Hence, an artificial electrical potential difference alone was sufficient to generate phosphorylation with yields comparable to those induced by light under natural conditions. (27 refs.)

4831 MICROWAVE-INDUCED HEARING: SOME PRELIMINARY THEORETICAL OBSERVATIONS. (Eng.) Lin, J. C. (Electrical and Computer Engineering Dept., Wayne State Univ., Detroit, MI 48202). *J. Microwave Power* 11(3): 295-298; 1976.

A theoretic analysis of microwave-induced auditory sensation is presented. It is shown that the frequency of cochlear microphonics recorded from the round window of guinea pigs is the same as the fundamental frequency of vibration (50 kHz) of a spherical model of the guinea pig's head consisting only of brain matter. The model was exposed to pulsed microwave radiation at a frequency of 918 MHz. The auditory phenomenon is believed to arise from the rapid temperature rise in the brain as a result of microwave absorption. This negligible temperature rise, which occurs in a very short time, creates thermal expansion of the brain matter and launches the acoustic signal that is detected by the cochlea and is received by bone conduction. (8 refs.)

4832 HISTOMORPHOLOGICAL STUDY OF WOUND REGENERATION IN ANIMALS FOLLOWING LONG-TERM EXPOSURE TO LOW-INTENSITY MICROWAVES. (Eng.) Shaposhnikov, Yu. G. (Dept. Surgery, Central Postgraduate Medical Inst., Moscow, USSR); Yares'ko, I. F.; Vernigora, Yu. V. *Bull. Exp. Biol. Med.* 80(8): 988-990; 1976.

Wound regeneration was studied *in vitro* in guinea pigs following long-term exposure to low-intensity microwave irradiation. Linear wounds 5 cm long were incised down to the dermis in the dorsal region of 80 guinea pigs (30 of them controls) following exposure to 5 mW/cm^2 microwave irradiation (experimental group only). The animals were killed on days 3, 5, 7, 9, and 11 following wound incision. The skin flap containing the wound and postoperative scar was excised, and the wound area was investigated histologically. The wounds in the irradiated and nonirradiated groups healed by first intention. In the explants of the irradiated animals, killed on the third postoperative day, regeneration of the epithelium was stimulated and granulation tissue developed intensively in the lower parts of the tissue. Tensimetric readings (in g) of the scars were 220 ± 2.3 ($p<0.001$) for nonirradiated animals compared with 344 ± 2.7 ($p<0.001$) for the irradiated animals. In the explants of irradiated animals, killed on the fifth postoperative day, proliferating fibroblasts were rich in RNA, and an increased content of acid mucopolysaccharides was found in the ground substance indicating active synthesis of proteins, including collagen. In the explants of irradiated animals, killed on days 7 and 9, young connective tissue formed in the place of the granulation tissue, and it was more mature than in the unirradiated animals. In the eleventh-day explants, the wound edges were completely united throughout their depth in the irradiated and nonirradiated animals. In the irradiated animals the scar tissue differed only slightly from the surrounding connective tissue. However, in the lower parts of the tissue of the controls, the regenerating connective tissue was not yet mature. Tensimetric readings of the eleventh day explants were 1100 ± 2.7 for the controls compared with 1420 ± 2.6 ($p<0.001$) for the experimental group. It is concluded that microwave irradiation improved wound healing. (3 refs.)

4833 IMMUNOREACTIVE LUTEINIZING HORMONE RELEASING FACTOR IN PITUITARY STALK BLOOD FROM FEMALE RATS: SEX STEROID MODULATION OF RESPONSE TO ELECTRICAL STIMULATION OF PREOPTIC AREA OR MEDIAN EMINENCE. (Eng.) Sherwood, N. M. (Dept. Biology, Univ. Victoria, Victoria, British Columbia, Canada V8W 2Y2); Chiappa, S. A.; Fink, G. *J. Endocrinol.* 70: 501-511; 1976.

The effects of sex steroid hormones on the responsiveness of the neural mechanism responsible for the secretion of luteinizing hormone releasing factor (LH-RF) were examined in female Wistar rats. Responsiveness was determined at proestrus by measuring the increments in immunoreactive LH-RF of pituitary stalk blood produced by electrical stimulation of the medial preoptic area or median eminence. The stimulus used consisted of 30 sec trains of accurately balanced biphasic square-wave pulses with a frequency of 60 Hz, a pulse amplitude of 500 µA (1 mA peak-to-peak), and a pulse duration of 1 msec. Ovariectomy on the morning of diestrus reduced the LH-RF response to preoptic stimulation, while estradiol benzoate (OB; 2.5 or 10 µg) or testosterone propionate (TP; 2.5 mg) administered immediately after ovariectomy significantly augmented the response ($p<0.05$ and $p<0.05$, respectively). The facilitatory effect of TP was possibly due to its conversion to an aromatized derivative since 5α-dihydrotestosterone monobenzoate (2.5 mg) was ineffective. Progesterone (2.5 mg) did not facilitate preoptic responsiveness, and, when administered to animals ovariectomized at 12.00 hr of proestrus, reduced the LH-RF response at 18.00 hr the same day. Stimulation of the median eminence produced a significantly greater increment ($p<0.05$) in LH-RF than stimulation of the preoptic area. The facilitatory action of OB on the LH-RF response was less marked for median eminence compared with preoptic stimulation. The administration of the antiestrogen, ICI 46474 (0.5 mg), at 17.00 hr of dioestrus did not reduce preoptic responsiveness on the morning of the next day, suggesting that this compound does not act as an "antiestrogen" at the level of the preoptic area. It is concluded that, as assessed by the release of immunoreactive LH-RF, sex steroids facilitate the responsiveness of preoptic neurones to electrical stimulation. (57 refs.)

4834 POLARIZATION OF FUCOID EGGS BY STEADY ELECTRICAL FIELDS. (Eng.) Peng, H. B. (Dept. Biological Sciences, Purdue Univ., West Lafayette, IN 47907); Jaffe, L. F. *Dev. Biol.* 53: 277-284; 1976.

The effects of electrical fields on rhizoid initiation in fucoid eggs were investigated. *Pelvetia* eggs were exposed to steady electric fields from 5 hr after fertilization and were kept on for 12 hr. When the field was shut off, 95% germination was observed. Eleven batches of eggs responded by initiating rhizoids towards the positive electrode; two batches responded by growing towards the negative electrode; and three grew towards the negative one in small fields and towards the positive one in higher fields. Polarization, defined as the average cosine of the outgrowth directions, was proportional to field strength up to polarization values of 50% for the positive responses and 75% for the negative ones. A voltage drop of 6 mV/cell induced 10% polarization in the positively galvanotropic batches, while 3 mV/cell did this in the negative ones. It is concluded that both responses were mediated by faster calcium entry at the future growth point. It was faster there in positively galvanotropic eggs because the membrane potential, and therefore the driving force, was highest. In negatively galvanotropic eggs it was faster because depolarization induced an overbalancing increase in calcium permeability. (19 refs.)

4835 DIELECTRIC INCREMENT OF LOW MOLECULAR WEIGHT RNA IN DIOXANE AFTER APPLICATION OF STATIC ELECTRIC FIELDS. (Eng.) Galzigna, L. (Inst. Biological Chemistry, Univ. Padova, 35100 Padova, Italy); Garbin, L.; Pagura, C. *Biochim. Biophys. Acta* 447(2): 230-237; 1976.

Static electric fields were applied to an RNA solution to study changes of the permanent polarization of the RNA molecules. A soluble RNA with a molecular weight between 15,000 and 23,000 was extracted from calf thymus and chromatographically purified. The RNA was slightly soluble in dioxane (approximately 2.5 µg/ml) and RNA-dioxane solutions were used to fill a cell (452.02 pF capacitance) to which 5-60 kV/cm static electric fields were applied. The RNA solutions showed dielectric increments proportional to the strength of the applied field and to the RNA concentration. The existence of a hysteresis was proven, and the effect of the electric field on the RNA molecule might be related to a dielectric saturation phenomenon parallel to long-term changes of the molecule. The results suggest that it is possible to consider macromolecules analogous to those used in this experiment as devices suitable for the storage of a record of electric events for a considerable length of time. Further studies are in progress to quantitate the time-course of these processes and the type of structural transitions presented by the RNA in dioxane. (19 refs.)

4836 THE *IN VIVO* EFFECTS OF 2.45 GHz MICROWAVE RADIATION ON RABBIT SERUM COMPONENTS AND SLEEPING TIMES. (Eng.) Wangemann, R. T. (USA Environmental Hygiene Agency, Laser Microwave Div., Aberdeen Proving Ground, MD 21010); Cleary, S. F. *Rad. Environ. Biophys.* 13: 89-103; 1976.

The effects of relatively low power density microwave exposures on various serum components were studied in 6- to 10-mo-old Dutch rabbits weighing 2.09 ± 0.29 kg. Both continuous wave and pulsed mode 2-hr exposures at 2.45 GHz were used at power densities of 25, 10, and 5 mW/cm^2. Blood chemistry studies were performed on the following serum components: calcium, inorganic phosphate, glucose, blood urea nitrogen (BUN), uric acid, cholesterol, total protein, alkaline phosphatase, lactic dehydrogenase, and serum glutamic oxalic transaminase. Samples were taken prior to exposure, immediately postirradiation, and at 1, 2, and 7 days after exposure. Gross and histopathologic examinations were performed on representative samples of animals. Statistically significant and consistent changes were noted in glucose, BUN, and uric acid following microwave exposure. The response appeared to be dose-dependent with increases of 44% in animals exposed at 25 mW/cm^2, continuous wave (CW); 29% in animals exposed to 10 mW/cm^2, CW; and 18% in animals exposed at 5 mW/cm^2, CW. Other serum components did not show consistent variation from baseline values. Observed physiologic response, as well as rectal temperature measurements, indicated that the thermoregulatory capability of the rabbits was sufficient to compensate for the thermal burden at 5 and 10 mW/cm^2 but could be overridden by a 2-hr exposure at 25 mW/cm^2. Pathology findings included a mild, repairable nephrosis in animals exposed at a power density of 25 mW/cm^2. A further investigation of analeptic effects in phenobarbital-sedated rabbits at power densities varying from 5-50 mW/cm^2 resulted in a statistically significant decrease in sleeping times, apparently proportional to power densities below 15 mW/cm^2. It is concluded that the results of the blood chemistry and sleeping time experiments were consistent with a dose-dependent response to a nonspecific thermal stress at all power densities used. (9 refs.)

4837 MICROWAVE HAZARDS. (Eng.) Anonymous. (No affiliation given). *Lancet* 2(7977): 135; 1976.

The discrepancy between the microwave exposure standards of the United States and Western Europe and of Russia and Eastern Europe is discussed. Western concern over U.S. embassy diplomats in Moscow who were exposed to Soviet directed microwave beams is noted. However, it is pointed out that the exposure levels at the embassy, which had been as high as 30 µW/cm^{-2}, were lower than the U.S. and British exposure standard of 10 mW/cm^2. In Soviet usage, 10 mW/cm^{-2} is regarded as high-intensity radiation, and they claim that even low-intensity microwave radiation will lead to neurasthenia. Rather than to induce this syndrome, the author contends, it is more likely the Soviets sought to jam American listening devices. The author concludes that this affair serves to support the need for additional studies recommended by the World Health Organization on world-wide microwave exposure standards. (4 refs.)

4838 RADIO AND MICROWAVE RADIATION AND EXPERIMENTAL ATHEROSCLEROSIS. (Eng.) Sparks, H. V. (Dept. Physiology, Univ. Michigan Medical Sch., Ann Arbor, MI 48104); Mossman, D. L.; Seidel, C. L. *Atherosclerosis* 25: 55-62; 1976.

Aortic wall injury caused by radiofrequency and microwave irradiation and potential atherogenesis enhancement was studied in diet-induced atherosclerotic rabbits. Two sets of 16 New Zealand white rabbits were exposed to microwave (2.45 GHz) radiation at a power density of 20-30 mW/cm^2 for 4 hr a day, 5 days a week for 8 to 10 wk. Each set was divided into an experimental irradiated group and a control group. Following irradiation, the serum cholesterol concentrations, aortic wall cholesterol concentrations, and percentage of intimal surface involved in atherosclerotic lesions of the experimental animals did not differ significantly from the indices of age and weight matched controls. Continuous radiofrequency irradiation (1 MHz) for 8 to 11 wk with a field strength of 30 V/cm also failed to change these indices of atherogenesis. It is concluded that radiofrequency and microwave irradiation do not affect the course of diet-induced atherogenesis. (11 refs.)

4839 THRESHOLD EFFECTS OBSERVED IN CONFORMATION CHANGES INDUCED BY ELECTRIC FIELDS. (Eng.) Poerschke, D. (Max Planck Institut fur Biophysikalische Chemie, 34 Goettingen, W. Germany). *Biopolymers* 15(10): 1917-1928; 1976.

Single-stranded polynucleotides were used as model systems for the investigation of conformational changes induced by electric fields. It was demonstrated that the single-strand helix-coil transition in poly(A), poly(dA), and poly(C) can be induced by application of high electric fields. The transition was measured by UV absorbance using polarized light at an angle of 54.8° with respect to the vector of the electric field and by electrodichroism. A linear increase of the absorbance, reflecting the helix-to-coil transition, was observed at increasing field strength. When ions were added to the polymer, electric fields did not induce conformation changes, unless a threshold value of the electric field strength E_0 was exceeded. At field strengths above this threshold, the degree of transition was a linear function of the increase in field strength. The threshold values E_0 showed a linear increase with the logarithm of the ion concentration. Bivalent ions caused thresholds at much lower ion concentrations than monovalent ions. The shielding efficiency of ions was corrected to the binding affinity of these ions to the polymer. It is concluded that the conformation changes induced by the field and the existence of thresholds can be explained on the basis of dissociation field effects. Similar threshold effects may be expected for other macromolecules as well as for membrane structures and may be important in the regulation of bioelectricity. (28 refs.)

4840 COMBINATION RADIATION THERAPY AND LOCALIZED CURRENT FIELD HYPERTHERMIA OF SPONTANEOUS MALIGNANT NEOPLASMS OF ANIMALS. A PRECLINICAL STUDY (MEETING ABSTRACT). (Eng.) Day, P. W. (Univ. New Mexico, Sch. Medicine, Albuquerque, NM); Sternhagen, C. J.; Doss, J. D.; Edwards, S. *Int. J. Radiat. Oncol. Biol. Phys.* (Suppl. 1): 99; 1976.

One cat and two dogs with spontaneous malignant neoplasms were treated by combination radiation therapy and non-invasive localized current field (LCF) hyperthermia. The neoplastic area was covered by a copper pad surface electrode. A second large electrode was placed on the bottom of a saline water bath with an electrical resistivity of 500 ohms cm. The animal was then placed in the saline water bath until 25% of its surface was immersed with no direct contact of the second electrode. The first dog had a fibrosarcoma located on the right anterolateral nasopharynx. The tumor and surrounding area received 5 LCF treatments at 43°C for 30 min and 750 rads within 10 min of terminating hyperthermia. The animal showed no evidence of disease 3 mo post-treatment. The cat had a squamous cell carcinoma of long standing located in the medial canthus of the right eye. The tumor area received 4 LCF treatments at 43°C and 700 rads within 10 min of terminating hyperthermia. The tumor regressed for 12 wk with granulation type healing in the treatment area. The second dog had a fibrosarcoma located in the left posterolateral hard palate involving the left molar teeth. The tumor area and surrounding tissues received 4 LCF treatments at 43°C for 30 min and 750 rads within 10 min of the terminating hyperthermia. The tumor area regressed continuously for 8 wk at which time the owner had the animal euthanized. Previous to the combination hyperthermia and radiation study, 14 animals with spontaneous neoplasms were treated with LCF alone. Thirty-three percent of the cases have had no recurrence of disease for 1 to 3 yr following treatment; forty-five percent of the tumors regressed with the animal returning to normal function. (No refs.)

4841 PRELIMINARY CLINICAL RESULTS OF 433 MEGAHERTZ MICROWAVE THERAPY AND RADIATION THERAPY ON PATIENTS WITH ADVANCED CANCER (MEETING ABSTRACT). (Eng.) Hornback, N. B. (Dept. Radiation Therapy, Indiana Univ. Sch. Medicine, 1100 West Michigan St., Indianapolis, IN); Shupe, R.; Shidnia, H.; Joe, B. T.; Sayoc, E. M. *Int. J. Radiat. Oncol. Biol. Phys.* (Suppl. 1): 102-103; 1976.

Several patients with advanced head and neck and gynecologic cancers who failed to respond to surgery, radiation, and/or chemotherapy were treated with hyperthermia and low dose radiation therapy. Each daily dose of 100 to 200 rads to localized fields was preceded by 10 to 20 min of hyperthermia using a 433 MHz RF generator. Total dose varied from 2000 to 5000 rads, depending upon response and condition of the patient. Early treatment results confirmed the previously described synergism between thermal radiation and ionizing radiation as manifested by subjective and objective improvements of patients. (No refs.)

4842 THE EFFECT OF POST-RADIATION HYPERTHERMIA ON HUMAN SKIN AND TUMOR RESPONSE (MEETING ABSTRACT). (Eng.) Johnson, R. (Roswell Park Memorial Inst., Buffalo, NY); Dosi, K. S.; Song, S. Y.; Sandhu, T. S.; Boyle, D. *Int. J. Radiat. Oncol. Biol. Phys.* (Suppl. 1): 98; 1976.

Ten melanoma patients with multiple superficial metastases were treated with orthovoltage X-rays using 3-6 fractions in 2-3 wk. Regional heat was applied immediately after radiation for 2 hr at 41-42°C using a 2450 MHz microwave generator. Multiple control lesions were treated with identical field size and fractionation but varying total doses. Surface thermistors and intratumor 30 gauge needle thermocouples were used for thermometry together with a liquid crystal fibro-optic unit to monitor operating surface temperature. The skin responses were scored, and tumor responses recorded for 40 separate tumors. No skin reaction occurred in the areas exposed to heat alone to 41-42°C to a depth of 1 cm. The skin radiation reaction was significantly increased in the heated lesions. (No refs.)

4843 *IN VITRO* EPIPHYSEAL-PLATE GROWTH IN VARIOUS CONSTANT ELECTRICAL FIELDS. (Eng.) Brighton, C. T. (Dept. Orthopedic Surgery, Univ. Pennsylvania Sch. Medicine, Philadelphia, PA); Cronkey, J. E.; Osterman, A. L. *J. Bone Joint Surg. (Am.)* 58(7): 971-978; 1976.

The effect of electric fields on bone growth was studied in an *in vitro* epiphyseal-plate model, obtained from the costochondral junction of a 21-day-old male Sprague-Dawley rat. Explants were grown for 10 days at 0, 500, 1000, 1500, 2000, 2500, and 3000 V/cm. The percent total elongation of the epiphyseal-plate was significantly greater ($p<0.01$) at 500 V/cm than that of controls. The percent total elongation increased with each voltage increment, reached a maximum at 1500 V/cm ($p<0.0005$), and declined at higher voltage gradients. The percent elongation of the bone portion of the explants followed the same pattern. The percent elongation of the cartilage portion of the explants reached a maximum at 1500 and 2000 V/cm ($p<0.0005$) and became less than that of the control group at 2500 and 3000 V/cm ($p<0.01$ and $p<0.001$, respectively). The incorporation of ^{45}Ca was significantly increased over that of the control group only at 1500 V/cm ($p<0.005$), while the incorporation of ^{35}S was significantly increased over that of the control group at both 1000 ($p<0.01$) and 1500 ($p<0.05$) V/cm. The incorporation of ^{3}H-thymidine was significantly increased over that of the control group only at 1500 V/cm ($p<0.001$). Histologic examination revealed few discernible differences between the various experimental groups and the controls. Although the mechanism of action of the electrical field on bone growth is not known, the authors suggest that the voltage gradient, either directly or indirectly, incites a physiologic response of the growth-plate chondrocyte. (135 refs.)

4844 THE TRANSMISSION OF REFLEXES IN THE SPINAL CORD OF CATS DURING DIRECT IRRADIATION WITH MICROWAVES. (Eng.) McRee, D. I. (Natl. Inst. Environmental Health Sciences, Res. Triangle Park, NC); Wyatt, R. H.; Haseman, J. K.; Somjen, G. *J. Microwave Power* 11(1): 49-60; 1976.

The spinal cord of cats was directly exposed to continuous microwave radiation at a frequency of 2.45 GHz to study the effect of such radiation on reflex response and synaptic function. During initial pilot experiments, no obvious differences in electrophysiologic recordings taken before, during, or after irradiation by microwave energies (ranging from 1-10 mW/cm^2) were observed. Exposures varied from a few min to several hr. During a first series of more systematic experiments in which the intensity of incident radiation was always 10 mW/cm^2 and the duration of irradiation was varied both within and among experiments, there was a small but statistically significant enhancement of reflex transmission during periods of irradiation. However, these effects were not observed in a second more rigorous set of experiments where the incident power density was increased to 20 mW/cm^2, and all exposure and control periods were uniform (30 min duration). Temperature control proved to be inadequate in the second series of experiments, and an apparent within-period effect observed during these experiments might be attributable to temperature changes. The results appear to indicate that continuous microwave irradiation has no effect other than thermal on synaptic transmission; however, the experiments were not designed to test the effects of pulsed or modulated microwave fields. (12 refs.)

4845 PROSPECTS FOR EXPANSION OF INDUSTRIAL AND CONSUMER USES OF MICROWAVES. (Eng.) Osepchuk, J. M. *In: Fundamental and Applied Aspects of Nonionizing Radiation.* Michaelson, S. M.; Miller, M. W.; Magin, R.; Carstensen, E. L., eds. (New York: Plenum Press): pp. 411-432; 1974.

The present trends in industrial and consumer uses of microwaves were surveyed to assess potential hazards of microwave radiation. The interest in the microwave portion of the electromagnetic spectrum is related to its property of optimum coupling of energy to macroscopic objects of human interest. A survey of sources showed that electron tubes, though mature in technology, will continue to be the main sources of microwave power. However, there will be a large growth in low power solid-state sources for a growing number of low-power applications. The biggest growth market in noncommunication types of microwave applications is in consumer microwave ovens. Numerous industrial applications were reviewed, including those in the forest products, mining, chemicals, and agriculture industries. A few were selected for favorable expectations in market growth. The potential for microwave radiation hazards in this entire field is considered small and under strict government control. The problem of incidental interference, as with cardiac pacemakers was distinguished from direct biologic hazards and was shown to require standards on device susceptibility. With appropriate relation of personnel exposure to emission of microwave sources a high degree of safety is expected for microwave products and systems directed toward industrial and consumer use. (30 refs.)

4846 A NEW OCCUPATIONAL DISEASE? --OF DIPLOMATS. (Eng.) Berkley, C. (No affiliation given). *Med. Res. Eng.* 12(3): 3-7; 1976.

The potential radiation hazard produced by the considerable increase in the use of microwaves and radiofrequencies for communications and surveillance is reviewed with particular emphasis on the Soviet microwave bombardment of the U.S. embassy in Moscow. A variety of ailments of embassy personnel including headaches, tics, menorrhea, hematologic disorders, and cancer have been blamed on the microwave irradiation. Although microwaves are known to cause chromosomal abnormalities and hematologic effects, the irradiation of the embassy personnel has not been directly implicated in the development of the

ailments noted. However, there is growing concern among environmentalists and medical scientists that the proliferative use of microwave and other frequencies for communications may pose a potential radiation hazard to the general population. Radiation sources include megavolt transmitters, such as those in the troposphere scatter range and in microwave communications systems, television receivers, and high voltage power lines. A typical case is the microwave communications system used along many U.S. highways. Those who travel these highways regularly, such as truckers, are likely to be exposed to higher than average concentrations of microwave energy. A few milliwatts or even watts in a narrowly directed beam, away from human habitation, will probably not cause an appreciable hazard; however, concern should be given to the cumulative risk effect of a constantly increasing installed voltage. (89 refs.)

4847 ANALYSIS OF OCCUPATIONAL EXPOSURE TO MICROWAVE RADIATION. (Eng.) Czerski, P.; Siekierzynski, M. *In: Fundamental and Applied Aspects of Nonionizing Radiation.* Michaelson, S. M.; Miller, M. W.; Magin, R.; Carstensen, E. L., eds. (New York: Plenum Press): pp. 367-377; 1974.

The effects of occupational exposure to microwave radiation are reported. Headaches and fatigue disproportionate to effort showed incidences of 47 and 45%, respectively, among workers exposed to high levels (1-10 mW/cm^2) of microwave radiation, 30 and 34% in workers exposed to medium levels (hundreds of $\mu W/cm^2$ up to 1 mW/cm^2), and 30 and 30%, respectively, among workers exposed to low levels of radiation (tens of $\mu W/cm^2$) during the first year of work. These complaints disappeared for 2 yr, recurred during the period of 3-5 yr of work, and sometimes reappeared in certain individuals after 5 or 10 yr. Abnormally excessive sweating during the night had a similar time dependence and was found in 68.8% of workers exposed to high levels of microwave radiation, 33.4% of workers exposed to medium levels of radiation, and 22.5% of workers exposed to low levels of microwave radiation during the first year of work. Changes in blood pressure occurred only in workers exposed to high levels of microwave radiation. Diverse white blood cell responses were observed during the first year of work among workers exposed to low levels of microwave radiation; and after 10 yr, 10.5% of the workers in this group showed absolute lymphocytosis that was usually accompanied by monocytosis. Decreased cardiazole tolerance has also been observed in microwave workers. Although the intravenous administration of 500 mg of cardiazole does not provoke any brain wave changes in normal adult males, this same dosage has produced theta waves, theta discharges, spike discharges, and even convulsions in microwave workers with greater than 3 yr of exposure. (30 refs.)

4848 EVIDENCE OF MORPHOLOGICAL AND PHYSIOLOGICAL TRANSFORMATION OF MAMMALIAN CELLS BY STRONG MAGNETIC FIELDS. (Eng.) Malinin, G. I. (Biochemical Res. Lab., Res. Foundation of Children's Hosp., Washington, DC 20009); Gregory, W. D.; Morelli, L.; Sharma, V. K.; Houck, J. C. *Science* 194(4267): 844-846; 1976.

The effect of strong magnetic fields on eukaryotic cells in culture was studied. Cultures of heteroploid L-929 and diploid WI-38 cells frozen to 4.2 Kelvin and exposed for 4-8 hr to 5000 Oe magnetic fields were markedly inhibited in their growth as compared with controls. While controls had to be split at approximately 10-day intervals, there was no need to split experimental cultures for as long as 30-40 days. Moreover, the experimental cultures failed to maintain a consistent monolayer, leaving extensive free surfaces not covered by cells. In cultures grown on cover slips approximately 7 days after exposure to the magnetic field, morphologically distinct cells emerged and were propagated from generation to generation. In the case of L-929 cells, they were characterized by enlarged nucleoli and coarse chromatin, which jointly tended to form a symmetric intranuclear network. The cytoplasm of these cells was filled with tightly packed perinuclear granules that persisted throughout the cell cycle. Although the cytoplasm of WI-38 fibroblasts appeared to be free of granular material, it was enormously elongated. Four weeks after magnetic field exposure, contact inhibition was abolished in flask cultures. The observed transformations appeared to be due to magnetic field effects alone. (9 refs.)

4849 THE RESPONSE OF AN AMELANOTIC HAMSTER MELANOMA TO VARIOUS TREATMENT MODALITIES UTILIZING X-RAYS AND HYPERTHERMIA (MEETING ABSTRACT). (Eng.) Shupe, R. E. (Dept. Radiation Therapy, Indiana Univ. Sch. Medicine, 1100 West Michigan St., Indianapolis, IN 46202); Hornback, N. B.; Sayoc, E. *Int. J. Radiat. Oncol. Biol. Phys.* (Suppl. 1): 137-138; 1976.

The preliminary findings of a study utilizing hamsters that compared the effects of radiation alone with radiation and the addition of two forms of hyperthermia (microwave and infrared) is described. It was shown that when x-ray treatments alone were used no effects on tumor growth or reduction in tumor volume were noted, indicating a marked radioresistance against the tumor. However, delays in tumor growth were observed in groups treated with hyperthermia alone, and definite decrease in tumor volume was observed in hamsters using combinations of microwave hyperthermia and radiation therapy. Because of the increase in radiosensitivity with the use of hyperthermia (microwave therapy) and resultant greater survival times, this study formed the basis of an ongoing clinical study using combination of hyperthermia and x-ray therapy on patients with advanced cancer. (No refs.)

4850 ENHANCED UPTAKE OF ANTINEOPLASTIC AGENTS PRODUCED BY MICROWAVE-INDUCED TUMOR HYPERTHERMIA AND DIFFERENTIAL HYPOTHERMIA IN A MURINE GLIOMA (MEETING ABSTRACT). (Eng.) Sutton, C. H. (Dept. Neurological Surgery, Univ. Miami Sch. Medicine, Miami, FL 33152); Olinger, R.; Collazo, L. *Cryobiology* 13(6): 660; 1976.

An experimental model was devised to study the enhanced uptake of antineoplastic agents by microwave-induced hyperthermia and differential hypothermia in brain tumors. C57BL/6 mice were inoculated subcutaneously in both flanks with an experimental murine glioma, the Zimmerman ependymoblastoma. Microwave irradiation at 2450 MHz was employed to heat one flank tumor in each animal to 40, 41, or 42°C, while the remainder of the animal was cooled to 28°C by differential hypothermia. Tracer doses of either [^{3}H]cytosine arabinoside or [^{3}H]methotrexate were injected intraperitoneally. When concentrations of these agents were measured in heated and unheated tumors, and in other tissues, it was found that peak plasma concentrations of both agents were reached after 30 min. The greatest uptake of each agent during a 45-min period was obtained by heating tumors to 41°C. With both agents, the peak plasma concentrations achieved were two to three times greater in hypothermic than in normothermic mice. Higher concentrations were achieved in heated tumors using cytosine arabinoside than were achieved with methotrexate. These studies confirmed that the distribution of antineoplastic agents can be affected by temperature gradients. They demonstrate an enhanced accumulation of antimetabolites selectively in microwave-heated tumors in the presence of body-core hypothermia. It is concluded that microwave heating of tumors to 41°C for periods of 30-45 min after the parenteral administration of antineoplastic agents may prove beneficial in the chemotherapy of neoplasms that are sensitive to those agents. (No refs.)

4851 PRIMATE-PERFORMANCE ASSESSMENT FOLLOWING 3.2-GHZ EXPOSURES. (Eng.) Farrer, D. N.; Yochmowitz, M. G.; Jaeger, R. J.; Allen, S. J.; Wolfle, T. L. (USAF Sch. Aerospace Medicine, Aerospace Medical Div., Brooks Air Force Base, TX 78235). 14 pp., 1976. [available through the National Technical Information Service, Washington, D.C., Document No. AD A023495].

Performance data were obtained from two rhesus monkeys (*Macaca mulatta*) exposed to pulsed nonionizing electromagnetic radiation to assess possible performance decrements that might result in humans exposed to average power densities of about 1 mW/cm^2 during future airborne radar operations. The monkeys were exposed for 3 hr/day for 7 days to 3.2-GHz radiation (average transmitter power output of 200 W), which was modulated with square wave pulses (pulse width of 50 microsec) at a frequency of 4000 pulses/sec. The animals were evaluated in terms of their ability to use a control stick to maintain an equilibrium platform in a level position in the pitch axis. A comparison of their performance (as measured by the root-mean-square value of platform position) with that of eight control animals in a similar experiment revealed no decrement in performance as a result of the radiation exposure. Ophthalmic examinations completed 22 mo postexposure showed no abnormalities in the exposed animals. The level of radiation energies in this experiment was about 50 times higher than that expected for worst-case crew exposures during airborne radar operations. (13 refs.)

4852 ELF ELECTROMAGNETIC FIELD EFFECTS ON LIFE FORMS--BIBLIOGRAPHY. (Eng.) Formanek, V. C. (IIT Res. Inst., 10 West 35 St., Chicago, IL 60616. 181 pp; 1976. [available through National Technical Information Services, Washington, DC, Document No. AD-A023 094].

Four hundred references, many with accompanying abstracts, are contained in this bibliography of the world literature on the biologic effects of extremely low frequency electromagnetic fields. The bibliography emphasizes the following areas: (1) the biologic effects of alternating current (AC) electric and magnetic fields between 45-75 Hz; (2) the alpha-rhythm interaction of AC electric and magnetic fields between 1-15 Hz; (3) AC electric and magnetic field influences on patients with cardiac pacemakers; and (4) behavioral influences, such as, migration, orientation, and sensing-detection. Radiofrequency studies involving modulation frequencies in the 45-85 Hz region are also referenced. In addition, representative samples from the Eastern European literature are included. (400 refs.)

4853 STOMATAL RESPONSE TO MICROWAVE INDUCED THERMAL STRESSES. (Eng.) Barthakur, N. (Dept. of Agricultural Physics, Macdonald Campus of McGill Univ., Ste. Anne De Bellevue, Quebec, Canada HOA 1CO). *J. Microwave Power* 11(3): 247-254; 1976.

The stomatal responses of bean and water hyacinth leaves to microwave induced thermal stress was studied. Attached leaves of plants were heated inside a closed-circuit wind tunnel by microwave radiation at a frequency of 2450 MHz. The power density at the leaf surface could be varied from 0-200 mW/cm^2 with an oval-field applicator. Attached bean leaves responded to thermal stresses induced in darkness by lowering equilibrium leaf temperatures between 2-10°C in still air. The lowering of equilibrium leaf temperatures of exposed water hyacinth plants in darkness was even higher than 10°C in still air. The same behavior was also observed for leaves that were placed in an air stream. The observed phenomenon is explained as transpirational cooling when stomates are opened in darkness in response to absorbed microwave radiation and high leaf temperatures. (13 refs.)

4854 MICROWAVES SCORE TKO IN FIGHT AGAINST CANCER. (Eng.) Guy, A. W. (No affiliation given). *Microwaves* 15(9): 14, 16; 1976.

The use of microwave radiation for localized heating, either to kill malignant tumors or to make them more susceptible to X-ray therapy, is reviewed. In a study conducted at New York's Montefiore Hospital and Medical Center, the use of a newly developed microwave localized heating system resulted in a complete eradication of tumors and a 100% survival rate in a study employing six groups of mice; each group contained 12 tumor-bearing animals. The microwave device was a closed loop microwave generator operating at 2.45 GHz, and it featured a thermometer that was placed into the tumor. Some researchers caution, however, that the thermometer's presence in the test tumor could, in itself, change the heating pattern within the tumor and contribute to temperature nonuniformity. If heating is not sufficiently uniform, severe damage to normal tissue might occur in local heat spots; in inadequately heated regions, tumor growth might be enhanced. An alternative microwave heating device that produces a uniform (± 0.1°C) front-to-back temperature profile within the tumor has been proposed. The method reduces temperature gradients by surrounding a tumor with a material (bolus), similar in composition to the tumor tissue. Because the temperature gradient is distributed over a larger volume, a smaller temperature differential exists in the encapsulated tumor. Although the Montefiore study did not employ bolusing, it is pointed out that the 100% cure rate achieved in that experiment cannot be ignored. It is proposed that microwave radiation be used to complement X-rays and chemotherapy. This proposal is supported by a theory that contends X-rays fail to kill about 2-3% of hypoxic cancer cells. By heating the entire tumor with microwave radiation, some of these cells would become oxygen carrying and therefore susceptible to killing by X-rays. (No refs.)

4855 THE EFFECTS OF ELECTROMAGNETIC FIELDS ON THE NERVOUS SYSTEM. (Eng.) Chou, C. (Dept. Electrical Engineering, Univ. Washington, Seattle, WA 98105). *Ann Arbor, MI: University Microfilms International*, 76-17,430, 1975, 115 pp.

A series of experiments were performed *in vitro* to identify the effects of electromagnetic field radiation on the nervous system. In the first experiment, the effects of electromagnetic fields on the compound action potentials of both myelinated and unmyelinated nerves were studied. Isolated frog sciatic nerves, cat saphenous nerves, and rabbit vagus nerves and superior cervical ganglia were exposed to 2450 MHz microwave radiation at a constant temperature in an S band waveguide exposure system. The tissues were stretched through the waveguide either parallel or perpendicular to the electric field of the transverse electromagnetic mode. Compound action potentials of the nerves were recorded before, during, and after microwave irradiation. The results showed no effect other than thermal on the conduction characteristics of nerves and muscles at specific absorption rates of 0.3-1500 W/kg for continuous wave and 0.3-220 kW/kg peak for pulsed fields. No direct field stimulation or dependence on field polarization was observed during the irradiation. In the second experiment, the effects of electromagnetic fields on muscle contraction were studied. Rat diaphragm muscles were isolated and exposed to 2450 MHz microwaves at a specific absorption rate from 0.3-1500 W/kg for continuous wave and pulsed waves of 0.3-220 kW/kg peak for pulses of 1-10 μsec width. The results showed: (1) no change in amplitude and time course of single switch tensions as long as the temperature was kept constant, (2) a high power effect reproducible by changing the solution temperature, (3) no effect on tetanic contraction, and (4) no direct stimulation of muscle by microwave fields. In the final experiment, the mechanisms of the microwave auditory effect were investigated. The oscillation frequency of cochlear microphonics in the guinea pig skull induced by microwave radiation was compared with the oscillation frequency induced by laser pulses, as well as the bone-conducted acoustic stimuli provided by a piezoelectric crystal. A 50 kHz frequency was recorded for all three sources. Since the laser and piezoelectric crystal pulses provided only a mechanical disturbance to the skull, it was concluded that the microwave pulses also produced a mechanical disturbance. It is suggested that the mechanical disturbance was due to the thermal expansion pressure generated in the head. Additional research is necessary to further elucidate the microwave auditory effect. (70 refs.)

4856 TRANSIENT EFFECTS OF LOW-LEVEL MICROWAVE IRRADIATION ON BIOELECTRIC MUSCLE CELL PROPERTIES AND ON WATER PERMEABILITY AND ITS DISTRIBUTION. (Eng.) Portela, A.; Llobera, O.; Michaelson, S. M.; Stewart, P. A.; Perez, J. C.; Guerrero, A. H.; Rodriguez, C. A.; Perez, R. J. *In: Fundamental and Applied Aspects of Nonionizing Radiation.* Michaelson, S. M.; Miller, M. W.; Magin, R.; Carstensen, E. L., eds. (New York: Plenum Press): pp. 93-127; 1974.

Microwave radiation effects on passive and dynamic electrical properties and on cell water parameters were studied in muscle cells from muscles of the South American frog *Leptodactilus ocellatus*. Microwave exposure of 10 mW/cm^2 for a period of 120 min produced transient changes in membrane resistance, membrane capacitance, and the space constant. The electrical parameters related to the excitation and propagation of the action potential, the maximum rate of rise V+ and fall V- of the action potential, and the limiting membrane conductances (gNa and gK) were transiently altered. In addition, the peaks of sodium inward and potassium outward ionic currents, the net ionic charge accumulation per action potential, and the propagation velocity of the action potential were transiently altered. The water membrane permeability and the fraction of osmotically available cell volume were also transiently altered.

An analysis of these parameters revealed that the transient changes evoked by microwave radiation are larger in muscle cells from "winter frogs" than from "summer frogs." Seasonal differences in the observed transient microwave radiation effects were analyzed. It was concluded that microwave exposure to 10 mW/cm^2 did not produce permanent effects on electrical and cell water parameters. (32 refs.)

4857 DECREASE OF ACETYLCHOLINE RECEPTOR SYNTHESIS IN MUSCLE CULTURES BY ELECTRICAL STIMULATION. (Eng.) Shainberg, A. (Dept. of Life Sciences, Bar-Ilan Univ., Ramat-Gan, Israel); Burstein, M. *Nature* 264(5584): 368-369; 1976.

The effect of electrical stimulation on acetylcholine receptor synthesis by chick muscle cultures was investigated. Six-second (sec) trains of 1 msec square wave pulses with an interval between pulses of 200 msec were delivered to cultures every minute at a potential of 20 V. Pulse polarity was alternated for each train to prevent polarization. When the muscle cultures were stimulated electrically, the amount of acetylcholine receptors, as measured by labeled α-bungarotoxin binding, was reduced considerably in comparison with controls or tetrodotoxin-treated cells. There was no decrease in the amount of acetylcholine receptors in the presence of the protein synthesis inhibitor cycloheximide, suggesting that the electrical stimulation/sec did not inactivate the receptors. To measure the effect of electrical stimulation on receptor synthesis, existing cholinergic receptors were saturated with unlabeled α-bungarotoxin, and the rate of appearance of new receptors was measured by the binding of radioactive α-bungarotoxin after various periods of stimulation. Electrically stimulated cultures bound much less ^{125}iodine-labeled α-bungarotoxin than did control or tetrodotoxin-treated cultures, suggesting that the decrease in α-bungarotoxin binding as a result of electrical stimulation was due to a partial suppression in receptor synthesis rather than an inactivation of existing acetylcholine receptors or an increase in the rate of their turnover. Furthermore, since total protein synthesis and nucleic acid synthesis in stimulated cultures were similar to those in controls, the effect of electrical stimulation on acetylcholine receptor synthesis appeared to be specific rather than general, affecting the receptor synthesis machinery. (17 refs.)

4858 SOME CONSIDERATIONS CONCERNING THE USE OF MAGNETRON GENERATORS IN MICROWAVE BIOLOGICAL RESEARCH. (Eng.) Reno, V. R. (Naval Aerospace Medical Res. Lab., Bureau of Medicine and Surgery, Pensacola, FL 32512). 13 pp; 1975. [available through National Technical Information Services, Washington, DC, Document No. AD A013329].

Microwave fields produced for biologic studies by magnetron generators and traveling wave tube generators under different operating conditions were characterized. The field produced by the magnetron source operating at a frequency of 2450 MHz was 100% amplitude modulated (at a frequency of 120 Hz) due primarily to the unfiltered power supply used in the unit. The field generated by the traveling wave tube generator was not modulated to a significant degree. Measurements of the magnetron field taken with a National Bureau of Standards (NBS) sensor (electric energy density meter) and a Narda Microwave Corporation broadband isotropic radiation monitor showed that the latter instrument, which had a relatively slow response, tended to obscure field variations detected by the NBS instrument, which had a fast dynamic response. Field measurements during a simulation of microwave pulsing with the magnetron (pulse duration of 100 msec were made while the average output power per pulse was varied over the maximum-to-minimum obtainable range of 4.5 to 1 and indicated that the waveform was different depending on the average power level. Interpulse variations in waveform and in the time of pulse onset were also present at each power level except at maximum power where the pulse characteristics appeared more consistent. Thus, the microwave field incident on an experimental animal can differ depending on both the generator and the conditions of its operation, and these differences may not be apparent if the field is described only in terms of average power. (8 refs.)

4859 THE EFFECT OF CONTINUOUS EXPOSURE TO LOW FREQUENCY ELECTRIC FIELDS ON THREE GENERATIONS OF MICE: A PILOT STUDY. (Eng.) Marino, A. A. (Veterans Admin. Hosp., Irving Avenue and University Place, Syracuse, NY 13210); Becker, R. O.; Ullrich, B. *Experientia* 32(5): 565-566; 1976.

Three successive generations of Ha/ICR mice were studied to assess the possible impact of the continuous presence of a low frequency electric field. Mice were allowed to mate, gestate, deliver, and rear their offspring in a horizontal 60 Hz electric field of 100 V/cm. At maturity, randomly selected individuals from the first generation were similarly allowed to mate, gestate, deliver, and rear their offspring while being continuously exposed. Randomly selected mice from the second generation were then mated to produce the third generation. A parallel procedure was followed for a group of mice raised for three generations in a 60 Hz vertical electric field of 150 V/cm and for the control group raised for three generations in an ambient electric field. In the first generation, males and females reared in both the horizontal and vertical electric fields were significantly smaller than controls at 35 days postpartum. Larger depressions in average body weight were seen in the second generation at 35 days postpartum, while at 10 wk postpartum, the differences between the experimental and control weight narrowed considerably. A large mortality rate (mean =46.5%) occurred in the second and third generation vertical field mice during the 8-35 day postpartum