The lethal effects of MW irradiation on insects, nematodes, fungi, and bacteria in withered pine trees were studied using 2450 MHz MWs with output powers at 0.6 and 5.9 kW. When the speckeled-longicorns of larva, prepupa, and pupa were placed in a plastic capsule and irradiated with 0.6 kW MWs, 25% of the larva longicorns died after 30 sec irradiation, and 90% of the larva longicorns died after 60 sec irradiation. The larva longicorns were more sensitive to the microwave lethal effect than the pupa longicorns. The temperatures attained at the core and under-bark of pine trees after the microwave irradiation were different, and the core temperature was higher than the under-bark temperature. This reflected the observed lethal effect, and longer irradiation time was required for killing the insects, nematodes, fungi, and bacteria which lived in the under-bark than in the core of the pine trees. The effective irradiation time was 45 sec for larve insects, 2 min for nematodes, and more than 5 min for fungi and bacteria. (1 reference)

0626 DISINFESTING PROCESS HERTZ ONLY INSECTS. *(E.)* Lowe, J. F. (Eur. Ed., *Design News*, 06190-Roquebrune-Cap Martin, France). *Des. News* 30(17):62-63, 1975.

A method has been developed to kill 100% of the living insects, grubs, eggs, and larvae in wheat by applying MW energy. The ability of the grain to germinate was unchanged. The process also prevented mold growth. Ionizing, IR, visible, UV and US radiation have all proved unsuccessful and/or uneconomical to use. The MW process involves heating the grain in a HF alternating field between a pair of capacitor plates to 63 C followed by rapid cooling to 45 C. Heating takes place simultaneously at all points within the material and is almost instantaneous. Steps in the process include precleaning and prewarming, MW exposure, cooling, and transfer to storage. Heat extracted during cooling is used for prewarming. This process should be suitable for flour, oats, corn, and packaged products. It is economical and environmentally acceptable as there are no chemical or radioactive residues. (No references)

0627 HISTOCHEMICAL AND ULTRASTRUCTURAL ANALYSIS OF THE EFFECT OF ELECTROMAGNETIC RADIATION ON RAT LIVER AND BRAIN. *(E.)* Robinson, N. (Dep. Anat., London Hosp. Med. Sch., United Kingdom), J. G. Nievel and J. Anderson. *Biochem. Soc. Trans.* 2(6):1359-1360, 1975.

Ultrastructural and histochemical effects of pulsed EMR on rat liver and brain were studied. White female Wistar rats (100 g) were exposed for 10 min to 27 MHz radiation at 300 and 500 pulses/min and duty cycles of 2.4 and 4%. The animals were sacrificed and liver and brain were rapidly excised. Light and electron microscopic studies were performed and the activities of various enzymes were determined. No significant microscopic changes were observed at either 300 or 500 pulses/min. No enzyme changes were seen in the brain. The activities of alkaline phosphatase, 5'-nucleotidase, isocitrate dehydrogenase, α-glycerophosphate dehydrogenase, lactate dehydrogenase, NADH-diaphorase, and monoamine oxidase did not change in the liver. However, rats irradiated at 500 pulses/min had decreased glucose-6-phosphate dehydrogenase and succinate dehydrogenase activities around the central veins of the liver; ATPase activity was lower around the bile canaliculi; and acid phosphatase was more diffuse in the cytoplasm of the exposed liver than in control. (1 reference)

0628 LONG TERM EFFECTS OF ELECTROMAGNETIC FIELDS ON PHYSARUM POLYCEPHALUM. *(E.)* Goodman, E. M. (Sci. Div., Univ. Wisconsin-Parkside, Kenosha), M. Marron and B. Greenebaum. *J. Cell Biol.* 63(2):117a, 1974.

The long term effects of ELF EMFs on the growth and development of *Physarum polycephalum* were studied. Cultures were continuously exposed to 75 or 60 Hz fields (2.0 G, 0.7 V/m) for up to 701 days. After 90-120 days a delay of 1-2 hr between successive mitoses in the cultures was noted. Cultures returned to control levels about 60 days after removal from the field. The ability to complete the sexual and asexual life cycles was not affected; however, subtle changes in gross morphology and a general slowdown of protoplasmic streaming were noted. (No references)

0629 THE INCREASED EFFECTIVENESS OF CANCER CHEMOTHERAPEUTIC AGENTS WHEN COMBINED WITH SIMULTANEOUS MICROWAVE IRRADIATION. *(E.)* Brent, R. L. (Jefferson Med. Coll., Philadelphia, Pa. 19107) and D. Hami. *Pediatr. Res.* 9(4):386, 1975.

A study was made of the ability to alter the effectiveness of drugs present in hyperthermic tissue when exposed to MW radiation. Methotrexate and 5-fluorouracil were administered to pregnant rats at LD/10 to LD/30 doses, and the rats were immediately exposed to MW radiation for 30 min with embryo tissues maintained at 42-43 C. The LD/50 dose of these drugs was significantly lowered in the hyperthermic embryos, indicating that MW radiation may be of use in increasing the effectiveness of the drug in the irradiated tissue. It could be utilized in situations in which a local increase in drug effectiveness may benefit the organism. (No references)

0630 COMPUTATION OF THE ELECTROMAGNETIC FIELDS AND INDUCED TEMPERATURES WITHIN A MODEL OF THE MICROWAVE-IRRADIATED HUMAN EYE. *(E.)* Taflove, A. (Dep. Electr. Eng., Technol. Inst., Northwestern Univ., Evanston, Ill.) and M. E. Brodwin. *IEEE Trans. Microwave Theory Tech.* MTT-23(11):888-896, 1975.

The use of experimental animals to establish a human

safety standard for MW radiation implies that the anatomy, physiology and electromagnetic environment of the animal can be related to that of humans. However, the role of tissue structure in determining MW absorption is possibly significant and heating potential contours may develop in different locations and at different magnitudes in man because of dimensional and structural differences in tissue anatomy. The absorbed power distribution pattern within a detailed model of the MW irradiated human eye with its bony orbit has been computed at 750 MHz and 1.5 GHz frequencies of planewave irradiation, and temperature distribution within the eye has been calculated. The fields are computed using a finite difference, time-domain solution of Maxwell's equations. A numerical solution of the heat conduction equation for the eyeball is also given, using the computed MW heating function as the source function. The heating potential due to irradiation at 750 MHz peaks at the muscle interface at the front of the eye and decreases with depth. At 1.5 GHz irradiation, a pronounced peak is found near the center of the eyeball and the potential also peaks strongly at the muscle interfaces below and in front of the eye. The frequency dependent position of the heating potential peak can be explained on the basis of distinct resonances of the eye scatterer and head as a whole. At lower frequency, the dimensions of the eye orbit are too small to support a wave concentration effect, but at higher frequencies a resonant behavior independent of possible concentration effects of the whole head can be supported. The heat conduction model developed has as its basic assumption that the chief cooling mechanism of the eye is the retinal blood supply localized at the surface of the eyeball. At 750 MHz irradiation, the peak temperature of 40.4 C is located at about the center of the eyeball. The lens temperature is much higher at 1.5 GHz because the surface cooling mechanism is less effective than for the shallow 750 MHz heating pattern. This is a strong indication that tissue thermodynamics must be considered when analyzing MW heating of organs. Comparison of these results with those obtained by Guy *et al.* for the rabbit eye indicates the possibility of relating MW heating patterns within the respective organs. A more detailed human model and computer runs for higher frequencies are needed. (25 references)

0631 BIOLOGIC AND CLINICAL EFFECTS OF LOW-FREQUENCY MAGNETIC AND ELECTRIC FIELDS. *(E.)* Llaurado, J. G. (Marquette Univ., Milwaukee, Wisc.), A. Sances, Jr., and J. H. Battocletti. (Springfield: C. C. Thomas, 1974), pp. ix-xi.

Ever increasing amounts of man made emanations from EM sources are introduced into the environment, often without consideration of harmful biological effects. As the number of sources increases, the potential for damage also grows. Evolution has equipped man with a reasonable tolerance for this radiation, but little quantitative information is available regarding the effects of these mechanisms upon living organisms. For this reason, a forum was assembled with a wide range of expertise in industry, government and in the life and physical sciences. The current state of knowledge on the effects of static and slow changing magnetic and electric fields on the communication processes in humans, animals, and plant life was examined in a symposium and series of workshops. This meeting was sponsored by the U.S. National Science Foundation in conjunction with the Neuroelectric Society, the International Institute for Medical and Biological Engineering, Marquette University, and The Medical College of Wisconsin. Twenty-three papers, most of which are abstracted in this issue of *Biological Effects of Electromagnetic Radiation* (CL 0632 - CL 0655), were presented and four workshops were held. These workshops included criteria and recommendations for a comprehensive research plan in each area to be generally applicable for research, industrial, and government use. (No references)

0632 ELECTROSTATIC FIELDS, ELECTROMAGNETIC FIELDS, AND IONS - MIND/BODY/ENVIRONMENT INTERRELATIONSHIPS. *(E.)* Beal, J. B. (World Inst., New York, N. Y.). *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 5-20.

The relationships between man and his EM environment are discussed. At a basic level, the cell wall is found to be folded and convoluted in a manner to serve as a semi-conductor. Cell components include organic semiconductors like liquid crystals that are hypersensitive to temperature changes, magnetic and electric fields, stress, ionizing radiation, and contamination. Many cells have a double outer membrane which functions as a capacitor with the characteristics of a leaky dielectric. At low frequencies, the cell membrane permeability to ions is enhanced, promoting electrochemical interactions. Detection of minute magnetic and ES fields which accompany biological activity may lead to such things as monitoring effects of the mind on physiological processes and early diagnosis of specific disease. The living cell is subject to the influence of EMFs that may induce a complex system of currents and act as indicators of environmental conditions. Any mechanism which, for example, disrupts the highly structured biowater within the cell will certainly disrupt the biological transfer of electrons. At a larger level, the brain receives input from the nervous system by means of electrical pulse generation and transmission through the nervous system. ESFs can influence the rate of generation by the nerves and a positive ESF can improve such things as brightness discrimination and alertness. One of the most sensitive areas of the brain to EMF effects is the hypothalamus. Damage to this area can increase sensitivity to field changes many times. Some aspects of the brain's electrical activity are related to intelligence, as sensory stimulation causes nonrandom change in EEG activity. Thus, our biorhythms react to EM and ES fields, LF radiation, ions and other unknown factors. (43 references)

0633 SOURCES, PROPAGATION, AMPLITUDE AND TEMPORAL VARIATION OF EXTREMELY LOW FREQUENCY

(0-100 Hz) ELECTROMAGNETIC FIELDS. *(E.)* Polk, C. (Dep. Electr. Eng., Univ. Rhode Island, Kingston). *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 21-48.

Information about natural background noise in the 10^{-3} Hz to 100 Hz frequency region is given. Nothing in this region of natural origin is thought to have any biological effect, and no such effects have ever been satisfactorily established. This is not surprising in terms of the extremely low amplitude of natural ELF noise in comparison with man-made noise and with the amplitude of steady geomagnetic and atmospheric electrical fields. The intensity of earth's magnetic field is not constant, even in the absence of solar disturbance, but exhibits a 'solar quiet daily variation' (Sq) about a 24 hr periodicity. This Sq changes with latitude and season and is also affected over long periods by trapped particles in the ionosphere. The largest variation occurs over the geomagnetic equator. In any attempt to relate biological changes to natural magnetic disturbances, it is necessary to consider that major magnetic storms are accompanied by other geophysical phenomena like meteorological effects and variation in cosmic rays which could also have biological effects. In the absence of local disturbances, the steady fair weather electric field would be essentially constant. However, temperature, relative humidity, ionized pollutants, naturally occurring ions, and ordinary clouds, as well as thunder clouds, can profoundly affect the electric field at ground level. Large deviations from the fair weather field are expected in the presence of fog, rain, or substantial clouds. At locations where local effects are minimal, a curve of diurnal variation is obtained with a minimum 18% below the mean and a maximum 15% above. Natural fluctuations of the geomagnetic field and the resulting earth currents called micropulsations also occur with periods between 600 sec and 0.2 sec. In measuring frequencies below 100 Hz, man-made noise must be suppressed as this is almost always much larger than natural fields and may frequently mask the noise due to natural phenomena. (77 references)

0634 CRITICAL REVIEW OF THE BIOLOGICAL EFFECTS OF ELECTRIC AND MAGNETIC FIELDS. *(E.)* Kaufman, G. E. (Sch. Med. Dent., Univ. Rochester, N. Y.) and S. M. Michaelson. *Biological and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr. and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 49-61.

A review of the biological effects of stationary electric and magnetic fields and of alternating fields with frequencies up to 100 Hz is presented. In no-contact electric fields, low frequency exposure may give rise to dangerous current densities in the body which are proportional to field strength and frequency. Soviet literature indicates biological effects of stationary and low frequency electric fields including physiological and morphologic changes. Neither animal experimentation nor clinical studies have provided evidence for a harmful effect of exposure in Western studies. Magnetic fields do exhibit biological effects, but it appears that man can tolerate short exposures to high magnetic fields without ill effects. Changes in the ECG and EEG of test animals have been seen, but the significance of these changes has not been established. Over a long period, there may be a gradual accumulation of physical and biochemical imbalances including growth retardation, hematologic changes, morphologic changes, and delayed wound healing. This may be due to inhibition of mitosis, and is of possible use in cancer therapy. Possible genetic effects have not been fully explored. A set of safety standards for human exposure to magnetic fields has been recommended, with whole body exposure of up to 2000 G for short periods of time allowed. The question of very weak fields needs to be studied due to lack of knowledge of the effects on man traveling in space and scientific interest in the possible physiologic role of the normal geomagnetic field. Little is known about the biological effects of alternating magnetic fields. (38 references)

0635 ELECTRIC AND MAGNETIC FIELDS PRODUCED BY COMMERCIAL POWER SYSTEMS. *(E.)* Miller, D.A. (IIT Res. Inst., Chicago, Ill.). *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 62-70.

The nature of electric and magnetic fields produced by commercial power systems is described and values of typical fields are reported. In the U.S., the ordinary commercial power frequency is 60 Hz, with specialized applications at 16-2/3 and 25 Hz. Electric energy is sent to substations by large transmission lines which operate at several hundred thousand volts line-to-line. Transmission is done with 3 phase circuits employing at least 3 wires balanced in that at each instant of time the sum of the current flow in a given direction along all 3 conductors is zero. Distribution substations feed the distribution lines used to send power to the customers. At the customer's location, a distribution transformer steps down the voltage to 120-240 V. The current flow gives rise to magnetic and electric fields in the earth and the differences of potential give rise to electric fields in the air surrounding the conductors. The values reported are typical of fields which have been present for several generations with no apparent ill effects. (6 references)

0636 PSYCHOLOGICAL EFFECTS OF MAGNETIC AND ELECTRIC FIELDS. *(E.)* Wilson, A. S. (Psychophysiol. Res. Lab., VA Center, Wood, Wisc.). *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 71-80.

A review of research on the effects of EMR on complex higher order behavior was undertaken. Psychological research on the influence of magnetic and electrical energy was found to have identified few tangible effects. The experimental efforts lacked a systematic approach to the examination of the variables involved, and the research has so far produced no data suggesting that a profound psychological hazard may be developing. (19 references)

0637 PROJECT SANGUINE: OVERVIEW AND STATUS OF THE NAVY'S ELF COMMUNICATIONS SYSTEM CONCEPT. *(E.)* Baker, R. E. (U.S. Naval Electron. Syst. Command, Washington, D.C.). *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 83-90.

Sanguine is a proposed reliable and survivable communication system for transmitting messages to submerged submarines and other U.S. Forces from a single transmitting location. The system will radiate ELF energy at less than 100 Hz. It has advantages of low atmospheric attenuation, low sea water attenuation and slight effect by disturbed propagation path. The transmitting antenna will excite EM waves in the spherical cavity bounded by the ionosphere and the earth's surface. The vertically polarized electric field has a small horizontal component which propagates downward through sea water and can be sensed by an electric field submarine antenna. The principal components are the insulated antenna cables, transmitter equipment, and terminal grounds. Messages from the Wisconsin Test Facility utilizing <1/2 W radiated power have been received in Norway and by a submerged submarine. An Environmental Compatibility Assurance Program (ECAP) was set up to assure minimal adverse environmental impact during construction and operations. The electric field produced by Sanguine is no greater than that produced by commercial power lines, and no harmful effects have yet been seen. (No references)

0638 BIOLOGICAL RESEARCH FOR EXTREMELY LOW FREQUENCY COMMUNICATIONS SYSTEMS. *(E.)* Rozzell, T. C. (Off. Naval Res., Arlington, Va.). *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 91-97.

There is concern about possible side effects on biological systems and the environment from ELF radiowaves. The Sanguine antenna is such an ELF transmitter. It is not known whether the ELF electromagnetic radiation produced at the low levels expected for a Sanguine system would produce measurable adverse reactions in biological systems. None of the studies made by the U.S. Navy have indicated this. The Navy's research program allows exposures to be made at field strength levels equal to and up to 100 times greater than the expected Sanguine levels. The experiments include animals, plants, and humans, and a continuing review of literature and research will be made to ensure minimal risk of biotic disturbances. (4 references)

0639 EVALUATION OF THE HEALTH OF PERSONNEL WORKING NEAR PROJECT SANGUINE BETA TEST FACILITY FROM 1971-1972. *(E.)* Krumpe, P. E. (Naval Med. Res. Unit No. 4, Great Lakes, Ill.) and M. S. Tockman. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 98-122.

Problem-oriented medical data were established for 24 personnel at Project Sanguine Beta Test Facility in 1971. These subjects were paired with control volunteers from Great Lakes, Ill. In follow-up examinations 1 yr later, 12 Sanguine employees were available and 9 of these matched controls for comparative analysis. At each exam, detailed medical histories and physical exams were performed along with specialized studies. These included psychometric testing; ECG; Masters test; EEG; electromyogram; nerve conduction velocity; slit lamp eye exams; chest, abdominal, and skull x-rays; audiogram; gynecologic evaluation of women; and blood, serum, urine, stool, and semen specimen exams. The test subject moved freely into and out of the EMFs, and the influence of shielding by buildings and vehicles was not measured. Periodic exposure to intense fields while working at or near the antenna and terminals was an uncontrolled variable also. Trends toward increasing or decreasing values during the interexamination period were tabulated; however, no effect due to the facility on test subjects was noted. No medical problems attributable to exposure were noted and no significant changes in constitutional symptoms, the endocrine system, neuromuscular, opthalmologic, cardiac, or hematologic exam, or psychological profiles were seen. No evidence of the neurasthenic syndrome was noted. In conclusion, no significant differences were observed between test and control subjects and the Sanguine employees did not appear to suffer any ill effects attributable to their ELF exposure during the 1 yr period studied. (22 references)

0640 MICROWAVE RADIOMETRIC TECHNIQUES: A MEANS TO EXPLORE THE POSSIBILITY OF COMMUNICATION IN BIOLOGICAL SYSTEMS. *(E.)* Bigu del Blanco, J. (Dep. Anat., Queen's Univ., Kingston, Ontario, Canada) and C. Romero-Sierra. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr. and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 123-136.

Biological systems are sophisticated generators and receptors of different energy forms which interact among themselves and with their surroundings. They generate EM, electric, and magnetic fields. Because of the possible role of EMFs in bioinformation transfer, the contribution of MW radiometry to the

question of information transfer between biological systems is studied. Radiometry is based on the fact that all bodies in the known physical universe emit EMR, and a reasonable amount of this radiation is in the MW region. Living systems have both a thermal emission spectrum and a nonthermal spectrum made up of a number of well-defined lines of emission and absorption due to discrete sources and sinks of EMR in the body. In a pilot study an X-band MW radiometer was constructed and experiments were conducted at 8.95 GHz. Natural MW emissions from human and animal subjects were measured. Results showed a large increase in natural MW emission relative to the background, corresponding to different states of stress or changes in the emotional, physiological, and pathological state. There are potential applications to biology and medicine as, for example, MW characteristics of damaged and malignant tissues are different from normal ones. MW radiometry may be a powerful tool in biocommunications as well. (10 references)

0641 EXTRA LOW FREQUENCY (ELF) ELECTROMAGNETIC RADIATION AS A BIOCOMMUNICATIONS MEDIUM: A PROTEIN TRANSRECEIVER SYSTEM. *(E.)* Cole, F. E. (Alton Ochsner Med. Found., New Orleans, La.) and E. R. Graf. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed., J. G. Llaurado, A. Sances, Jr. and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 137-146.

Questions still arise as to the type, availability, and operation of various forms of energy necessary for polypeptide synthesis on primitive earth. The theory has been presented that enormous amounts of EM energy arose from an ELF dependent, planetary resonance phenomenon. Sensitivity of biological systems to this spectral region would result as a consequence of this ELF dependent spontaneous generation of life, and this sensitivity would be augmented by eons of evolution. This evolutionary pressure is postulated to have fostered the development of a protein-mediated transreceiver system exquisitely sensitive to perturbations in this region. On earth, the molten core-ionosphere was envisioned to have functioned as an ELF oscillator with a 10 Hz eigenfrequency. The high intensity resonant magnetic fields penetrated the molten core, enhancing the fluctuating component of the earth's primary magnetic field and permitting an exponential increase in the strength of the 10 Hz field. An enormous electric disturbance would occur, permitting the formation of boundless quantities of organic compounds when the surface temperature was below 100 C. Evidence exists which suggests that the relationship between life and ELF fields still functions, hinting that a mechanism resides in the organism at the molecular level capable of interpreting and transmitting these signals. Such a transreceiver mechanism could be sensitive to and transmit almost unmeasurable quantities of radiated energy. The protein molecule could function as this transreceiver. Since protein makeup would have had to conform to the dynamics of the 10 Hz field, higher levels of construction would have EM structure reflecting these orienting forces and would be extremely sensitive to ELF electromagnetic fields. Subsequent evolution would enhance the fidelity of transmission and reception, especially between generically related forms. (10 references)

0642 COMMUNICATION IN BIRD FLOCKS: AN ELECTROMAGNETIC MODEL. *(E.)* Heppner, F. H. (Dep. Zool., Univ. Rhode Island, Kingston) and J. D. Haffner. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 147-162.

A hypothesis is presented to explain the apparently synchronous movements of certain species of birds while flying in flocks. Cluster formation characteristics of blackbirds and some small shore birds are composed of birds flying in close order with the flock in a spherical shape. Their movements are highly coordinated. In one 34 sec sequence of New York starlings the birds reversed directions 7 times, and each time all birds had changed directions within 1 sec. In another segment of rock doves most birds were setting their wings within 1/48 sec in preparation for a gliding turn. In a third film of mixed blackbirds, the signals for turning were undetectable so presumably reached all birds in less than 1/70 sec as the film was taken at 70 frames/sec. Two possible cases for leadership are considered: (1) a leader anywhere within the flock capable of transmitting a signal to the flock from any position within range of his transmission, or (2) a leaderless flock with all birds acting in concert as a 'superindividual'. Since the second case goes beyond any present evidence, the first possibility is tentatively accepted. The birds could conceivably communicate by sound, light, or EM systems. However, sound travels too slowly to reach all members of a flock essentially simultaneously, and it is doubtful whether sound could be heard over the background noise. Visual signals are not practical in a large flock where birds in the center would block the sight of birds on the periphery. If a visual relay system were employed, one would expect to see a wave of turning pass through the flock which is a function of the flock density and bird reaction time. The EM system would operate by the detection of an induced EMF surrounding the leader produced by electrical activity in the brain and neuromuscular system. It has been shown that bird feathers can act as EM detectors so the remaining problem is one of transmission. The leader bird may be able to develop currents in the long bones of his wings which could be transmitted to the rest of the flock. As a turn is made, differential stress would alter the transmitted signal which would furnish directional information to the other birds. The nervous system as a whole may be able to act as an antenna. The problem remains to prove the links experimentally. (24 references)

0643 LABORATORY SIMULATION OF EXTREMELY LOW FREQUENCY ELECTRIC AND MAGNETIC FIELDS. *(E.)* Valentino, A. R. (IIT Res. Inst., Chicago, Ill.). *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A.

Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 163-171.

The mechanisms by which the E-field induces current in organisms under test depend on differences in conductivity and the geometrics involved. Examples are given to establish a uniform electric field in a conductive media. The same magnitude and distribution of currents must be produced within the organism as those that would result from its exposure to the fields in the natural habitat. The amount of current which will flow through an animal will depend upon the electric field, separation of the two points of contact with earth, and the total resistance of the current path. Except for the level of the electric field and current flow, all other features of an electric field simulator must be identical for test and control samples. To establish a uniform magnetic field over a working volume simple magnetic field generating structures such as solenoids, Helmholtz coils, and multicoil structures have to be used. (No references)

0644 REINFORCEMENT OF TRANSIENT BRAIN RHYTHMS BY AMPLITUDE-MODULATED VHF FIELDS. *(E.)* Bawin, S. M. (Brain Res. Inst., Univ. California, Los Angeles), R. J. Gavalas-Medici, and W. R. Adey. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springlield: C. C. Thomas, 1974), pp. 172-186.

Effects of very weak fields on changes in learned or spontaneous behavior and interaction with auditory responses and with brain evoked responses are studied. Experiments with VHF (147 MHz), low intensity ($\leq$ 20 V/m) electric fields, amplitude-modulated over a wide, low frequency range (0-20 Hz) were conducted on chronically implanted, untrained cats at EMF intensities of about 1 mW/cm^2. The cats were implanted with bipolar electrodes in the caudate nucleus, centrum medianum, hippocampus, and presylvian gyrus. Eye movements were also monitored. Specific EEG patterns were selected in movement free epochs in different brain locations during two control sessions. The animals were trained for 10 sessions before being submitted to extinction until the return to control levels of performance. They were reconditioned for 4 sessions, then divided into two groups: (1) four animals were overtrained for 6 days than resubmitted to extinction in the absence of fields; (2) three animals were irradiated during overtraining and extinction. Performances were assessed by visual and spectral analyses. A group of untrained animals was used to test the effectiveness of the modulated VHF fields. All animals reacted similarly to the initial conditioning and subsequent extinction, and exhibited similar relearning curves up to day 5. Control cats maintained regular levels of performance during the 6 overtraining sessions but never exceeded their previous achievement. Extinctions were again rapid. The irradiated animals displayed irregular high performances and eventually all levels were equal or superior to the highest scores obtained during the first conditioning. During extinction they continued to perform with irregular, high performances during a minimum of 45 successive days before dropping back to operant levels. Subtle EEG changes took place with frequency bandwidths contracting into sharp peaks at the dominant frequencies of the responses. It is thought that the effects seen were the results of genuine biological transductions in the CNS rather than generalized thermal effects or artifactural injections of field voltages via electrodes. All effects were restricted to anatomically localized rhythms, frequency related to the assigned modulations, suggesting that the modulation frequency was indeed responsible for the EEG changes seen in all irradiated animals. The hypothesis is presented that amplitude modulated VHF fields can under these circumstances act as effective, contingent reinforcers. The mechanism of interaction is unknown, but a direct action of the fields on the CNS is favored with a working hypothesis based on the concepts of a 'greater membrane of brain cells.' (54 references)

0645 INSTRUMENTATION TECHNIQUES FOR MEASURING THE EFFECTS OF ELECTRIC AND MAGNETIC FIELDS ON INSECTS IN MOTION. *(E.)* Ferris, C. D. (Bioeng. Program, Univ. Wyoming, Laramie) and S. D. Hakes. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 187-201.

Instrumentation designed and constructed to examine the behavioral response of restrained and unrestrained insects subjected to electrical, magnetic, and EM fields is described. Common houseflies (*Musca domestica*) were used in the two experimental systems reported here. One system was designed to monitor an unrestrained colony of flies in an induced electric field while simultaneously comparing activity of the colony in a field free region. This system was a free flight enclosure with one region exposed to an electric field and a second region kept free of fields. A light sensing diode matrix was constructed on the floor of the enclosure and a light source formed the ceiling. When an insect intersected a vertical line between a light sensor and the plane of light, the intersection was observed and counted. A set of electrodes with appropriate power supplies established a field over half the matrix and a set of dummy electrodes was mounted across the other half. Fields of 5000-10,000 V/m were applied and the colony's activity recorded. The insects preferred the region of the electric field in a ratio of approximately 2:1. Activity was also related to time of day, even though light, temperature, and humidity were constant. The second system was designed to determine if there was any obvious effect on the wing beat characteristics of a tethered fly when subjected to an intense electric field. The insects were anesthesized, mounted on a splinter of bamboo with bayberry wax, and subjected to 1000-2000 V/m electric fields. Optical reflection from the wings using a photo diode which responded to the wing beat frequency was used. No observed change in frequency was observed between free and induced field experiments. In the presence of a magnetic field of 6000 gauss, the wing beat signal amplitude increased with a definite alteration of the spectral components. When free flight behavior was measured in a magnetic

field, there was little correlation between behavior and field free or induced periods. The experiments are designed to show the feasibility of the instrumentation developed and no experimental conclusions are drawn. (16 references)

0646 CONTROL OF VISUAL FATIGUE BY MEANS OF DC AND AC ELECTRIC FIELDS. *(E.)* Sugiyama, S. (Kwansei Gakuin Univ., Nishinomiya, Hyogo, Jap.). *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 202-207.

The author had previously found that visual function could be artificially depressed or facilitated by controlling the frequency of photic stimulus given to the eye. The visual threshold, represented by the CFF (critical flicker frequency), can be increased or decreased by control of the frequency component of the photic stimulus, indicating that the central nervous function is directly related to the frequency of light. It was found that CFF could be controlled in a facilitative or inhibitory way according to the polarity of a DC high voltage field, and that AC fields influenced the CFF. In current experiments, the effect of the frequency component of the photic stimulus on the CFF was examined. The CFF was already under the influence of AC and DC positive and negative electric fields. In the first experiment it was found that the inhibitory effect of a flickering light stimulus (CFF - 6 Hz) was neutralized by an AC (15 kV) electric field, indicating that fatigue of the visual system could be avoided by exposing the subject to an AC field. In the second experiment the cancellation effects of photic (CFF ± 6 Hz) and DC ($\mp$ 15 kV) electric field stimuli was investigated. No cancellation was seen, indicating that the photic and electric field stimuli whose directions were opposite always produce an inhibiting state of function of the visual system. In the third experiment, possible enhancement of effects produced by photic and electric field stimuli with the same directions were studied. Enhancement of the inhibitory effect was seen, but no enhancement of the facilitative effect was found. Thus, the visual system is influenced by an electric field. An AC field can neutralize excessive functioning caused by photic inhibitory stimulus. An inhibitory DC field can enhance inhibitory states caused by photic inhibitory stimulus, but does not cancel effects when photic and electric field stimuli of opposite direction are used. (2 references)

0647 A WESTERN VIEW OF ACUPUNCTURE. *(E.)* Shealy, C. N. (Pain Rehabil. Cent., La Crosse, Wisc.) and A. Prieto, Jr. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 211-219.

No correlation of neurophysiological pathways has been made with appropriate acupuncture points; however, such interactions are being studied. Investigation of the nervous systems has confirmed the possibility that almost all pathological process can be produced by some form of brain or nervous stimulation. Disease processes are influenced by psychosomatic distress. The severity of sympcoms and physical changes can be influenced by diet, heredity, drugs, toxins, infectious agents, etc. No single factor causes any disease. A variety of therapeutic aids can restore balance and health. Acupuncture plays a role as a safe treatment in trained hands and offers one method which aids in therapy. (21 references)

0648 A SCIENTIFIC EXPLANATION FOR THE RATIONALE OF ACUPUNCTURAL ANALGESIA. *(E.)* Kroger, W. S. (Inst. Compr. Med., Beverly Hills, Calif.). *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 220-226.

As yet no rationale for acupuncture has been validated. Many successful surgical operations have been performed in China with use of acupunctural analgesia (A.A.). There are subtle effects from the cultural factors particular to China, a regimented society, which aid in A.A.'s success there. Acupuncture becomes a kind of operant conditioning. In China, a dry run of an operation is often performed by the surgical team. Such preconditioning (autogenic training) helps to eliminate fear and tension. It helps to block the pain impulses from reaching the higher sensorium. The twirling needles supplant verbal or nonverbal suggestions used by hypnotherapists. There is no proof for the meridians or spots. Acupuncture in the environment in which it is used is the method of choice. More restraint should be used in regarding it as a qualified method in the U. S. (17 references)

0649 PHYSIOLOGIC EFFECTS OF CEREBRAL ELECTROTHERAPY CURRENTS. *(E.)* Rosenthal, S. H. (Univ. Texas Med. Sch., San Antonio) and D. F. Briones. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 227-230.

In treatment of patients with cerebral electrotherapy (CET) many experienced a transient mild euphoria and/or marked increase in sexual libido during the course of treatment. This suggests that CET may act by direct stimulation of the hypothalmus and/or pituitary area and may cause hormonal and biochemical changes. A series of pilot hormonal screening tests, including evaluation of serum thyroxine and serum T-3 resin uptake and 24 hr urine catecholamines and 17-ketosteroids, were performed. CET was given daily for 30 min at a frequency of 100/sec and 1 msec pulse duration. Serum thyroxine and T-3 resin uptake level were drawn on 41 subjects (20 males, 21 females) prior to their first treatment and following 4 standard

treatments. A definite transient rise in serum thyroxine was observed, but no significant change in T-3 resin uptake was seen. Of 20 males, 10 had rises of 0.5 µg % or more while 10 had no appreciable change. For 21 females the number of positive and negative changes was not appreciably different. Six males under 40 yr old were used in a study to measure 24 hr urinary catecholamines and 17-ketosteroids. Twenty-four hr urines were collected prior to beginning a course of CET and repeated 1 wk later after a series of 5 CET. All 6 subjects showed increases in urinary cathecholamines, with the average reading rising from 23.9 to 48.7 µg %/24 hr ($p \leq 0.02$). The average levels of 17-ketosteroids rose from 18.5 to 25.4 ng/24 hr. These studies indicate the presence of definite physiologic changes and suggest the possibility of a simple nontraumatic hypothalamic function test for neuroendocrinologists. Additional studies are underway. (4 references)

0650 SURFACE ELECTRICAL STIMULATION (TRANSCUTANEOUS) FOR THE RELIEF OF PAIN. *(E.)* Burton, C. (Temple Univ., Philadelphia, Pa.) and D. Maurer. *Biologic and Clinial Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 231-240.

A transcutaneous stimulator and electrode system was developed that allowed a high degree of pain relief. In designing the system, the major concerns were safety, efficacy, human engineering, reliability, and cost. The electrode system which was developed consisted of a silver loaded acrylic emulsion painted on the skin. While wet, a small carbon impregnated silicone pad was placed over the paint. A small connector pin could be inserted into a tail in the pad when dry. The epiconductive system is a low impedance, highly comformable, low profile transcutaneous electrode which is hypoallergenic. In tests on over 100 chronic intractable pain patients with various etiologies, the system had value in relief of pain. (11 references)

0651 FILTERED VERSUS UNFILTERED RF ENERGY FOR NERVE STIMULATION. *(E.)* Friedman, H. (Medtronic, Inc., Minneapolis, Minn.) and T. Williams. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr. and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 241-251.

This study was conducted to determine if the square waveform, used to stimulate peripheral nerves, is necessary. Four different waveforms were tried experimentally: unfiltered and unrectified RF burst, RF half wave rectified and ulfiltered, square wave rectified and filtered, and RF full wave rectified and unfiltered. A bipolar lead was wrapped around the sciatic nerve of a dog. The Achilles tendon was exposed and released from its insertion on the dog's calcaneus. The tendon was wired to a strain gauge force transducer in such a position that the muscle and tendon contracted isometrically parallel to the two bones of the lower leg. Constant voltage pulses stimulated the nerve, with a fixed monitored force of contraction, voltage, and current. Unrectified and unfiltered RF pulses were completely inadequate. The three rectified waveforms produced the same force of contraction if the average voltage remained the same, but the unfiltered waveform required 2-3 times more energy than the filtered one. On the other hand, filtering required an extra capacitor and using the unfiltered waveform reduced the size and cost of the receiver, increased reliability, and simplified manufacture. Long term testing is needed to determine the chronic effectiveness and safety of an unfiltered waveform on nerve tissue. (10 references)

0652 IN VIVO ELECTROPHYSIOLOGY OF TENDONS AND APPLIED CURRENT DURING TENDON HEALING. *(E.)* Kappel, D. A. (Kansas Univ. Med. Cent., Kansas City), S. Zilber and L. D. Ketchum. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed., J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 252-260.

In hand and extremity injuries, tendon repair is basic. As tendons are almost entirely collagen, the strength of healed wounds parallels the orientation and organization of collagen bundles in the healing interface. Mongrel 25 kg dogs were anesthesized and the flexor profundus tendon in the first digit of each hind paw was isolated. Two electrodes were attached to each tendon 2 cm apart and electrical measurements were performed during relaxation, stretch, after transection and repair, and after wound closure. In some dogs the electrode wires were then attached to an asymmetrical square wave stimulator supplying 100 mV, 60 mV positive-40 mV negative at 1 Hz for 3 hr/day, 5 days/wk. Healing was evaluated with hemaloxylin-eosin stain. Specific electrical properties in tendons previously seen *in vitro* were confirmed *in vivo*. Resting differences of potential of 7.5 mV were recorded along the longitudinal axes of the tendons. These resting potentials increased during active elongation and shortening and disappeared almost entirely when the tendons were severed. This effect may contribute to the realignment and eventual organization of collagen in the healing tendon. The change in the resting potential when the tendon is severed and repaired may be correlated with healing and return of strength and may serve as a guide for initiating rehabilitation. (6 references)

0653 WORKSHOP ON MAGNETIC-ELECTRIC FIELDS AND ENVIRONMENT. *(E.)* Franklin, D. L. (Scripps Clin. Res. Found., La Jolla, Calif.) and J. B. Beal. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 321-328.

Four broad problem areas were identified as pertaining to magnetic-electric field frequencies from DC to the MW range. No priority could be established for any one area as they are closely interrelated,

and it was recommended that they be developed concurrently. Area one defines critical unsolved problems: the lack of instrumentation to measure field effects and the responses of biologic systems, the lack of detailed information on environmental effects particularly in regions other than the MW area, the lack of models and standards required by complex interacting variables, and the lack of educational and communication needs, including interdisciplinary curricula. Area two defines a priority list of problems: method development, establishment of a range of system variations, determination of physical mechanisms for variations, and definition of field effects on living systems. The third area identifies researchers and institutions capable of handling these problems and identifies qualifications needed in this research. Area four defines the criteria for evaluation of research proposals. These include competent researchers, evaluation of scientific merit of work, imaginative solutions, clearly defined alternatives, and judgment of whether special recognition of broad implications of the biologic effects of EM fields is present. (5 references)

0654 WORKSHOP ON SOURCES AND SAFE LEVELS OF ELECTRIC AND MAGNETIC FIELDS. *(E.)* Kahn, A. R. (Medtronic, Inc., Minneapolis, Minn.), D. A. Miller and E. Postow. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (*Springfield: C. C. Thomas*, 1974), *pp.* 329-333.

The development of society has paralleled the utilization of energy, much of which is in the form of electricity. It is necessary to examine the possible effects of the electric power distribution system and other sources of low level electric and magnetic fields on biological systems. Only that portion of the frequency spectrum below 1 kHz is considered. No substantial evidence has been given to show that low frequency electric fields produce any deleterious effects on humans, but the possible need for safety standards should be investigated. To do this, the first step is to find biological effects believed to be caused by these fields. Then the threshold of the effects in terms of frequency, power, and other unique characteristics should be determined, and the potential hazard to humans evaluated. The time course of the effect must be determined and a decision made in regard to safety standards of the EM field. A system of priorities of possible CM hazards is recommended: (1) high voltage 60 Hz electric fields; (2) high voltage DC electric fields; (3) 60 Hz magnetic fields produced by buried superconducting transmission lines; and (4) 16 2/3, 25, 50 and 400 Hz fields. Other areas to consider are airport magnetic detection systems and library and department store merchandise detection devices. If a biological effect does exist, it will be very subtle, so multiple stress experiments, psychological, and behavioral experiments are strongly recommended along with the use of human volunteers and chronic studies. Classical biological experiments should be used only after an effect is demonstrated to investigate the mechanism of interaction and to understand the influence of EMR on biological processes. The lowest priority should be given to prospective and retrospective epidemiological studies. Joint biologic, behavioral, and engineering research teams are necessary for a successful program. (No references)

0655 WORKSHOP ON BIOLOGICAL EFFECTS OF ELECTRIC CURRENTS: ELECTRICAL STIMULATION AND THERAPY. *(E.)* Shealy, C. N. (Pain Rehabil. Cent., La Crosse, Wisc.) and A. Remond. *Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields*, ed. J. G. Llaurado, A. Sances, Jr., and J. H. Battocletti (Springfield: C. C. Thomas, 1974), pp. 334-337.

The widest chronic use of electric stimuli has been in the field of cardiac pacemakers, and the major concern in this technique is the lack of a standardized approach to their use. In other uses, electrical stimulation includes transcutaneous stimulation, which is at least partially effective in acute and chronic pain 75% of the time. Implantation of RF activated stimulators around peripheral nerves has had significant effectiveness in controlling pain, as has dorsal column stimulation. Brain stimulation by totally implanted units has shown intriguing success in the initial trials. Recommendations for further studies include: (1) hazards of long term stimulation; (2) evaluation of electrodes; (3) greater knowledge of effects of electrical energy; (4) systematic exploration of effects on body systems other than the nervous; (5) potential application to other disease processes; (6) better diagnostic tools for a variety of illnesses; (7) controlled randomized studies in the clinical use of electrotherapy; and (8) investigations to understand why therapy fails in some patients. (No references)

0656 INDUCTION THERMOCOAGULATION OF THE BRAIN--QUANTITATION OF ABSORBED POWER. *(E.)* Lin, J. C. (Dep. Rehabil. Med., Bioelectromagn. Res. Lab., Univ. Washington Sch. Med., Seattle). *IEEE Trans. Biomed. Eng.* BME-22(6):542-546, 1975.

RF electromagnetic field induction has been suggested as a simple, controllable, and repeatable technique to produce brain lesions. The procedure involves implanting a small metal seed in the brain and then introducing the head into an RF EM induction field. The seed is heated by the external field to produce a cerebral lesion. There is a lack of quantitative information regarding the amount of power absorption by the seed, the degree of tissue temperature elevation, and induction heating of other tissues of the body. A theoretical model was designed to study induction thermocoagulation as related to applied field strength, tissue electrical properties, and tissue geometry. The model is a cylindrical metal implant inside a spherical head containing homogeneous brain tissue throughout the sphere. Without any foreign object, the power deposition inside the sphere is a function of radius squared, increasing quadratically with distance away from the center. When a small cylindrical

metal implant is introduced, it may be assumed that the induced current in tissues surrounding the implant is unaltered. Calculations were made for an implant with a 1.0 mm radius and 5.0 mm length. Properties of the implant are that of 430 stainless steel and a 1 MHz operating frequency is chosen. The conductivity of the brain tissue is 0.263 mmho/m. It is found that power deposited in the metal implant is at least 2 orders of magnitude higher than that deposited elsewhere inside a 10 cm radius sphere. It is therefore possible to heat the therapeutic implant selectively. The power absorption throughout the head is highly dependent on location, so it may be possible to orient the head with respect to the applied magnetic field to shield heat sensitive areas. The problem of thermal consequences and tissue degeneration as a result of elevated temperature are not discussed. (12 references)

0657 NON-THERMAL RADIOWAVES AND GENETIC DAMAGE IN DROSOPHILA MELANOGASTER. *(E.)* Mittler, S. (Northern Illinois Univ., DeKalb). *Mutat. Res.* 31(5):316, 1975.

Adult Drosophila males were exposed to radiowaves produced at frequencies commonly used by amateur radio operators and various stages of spermatogenesis were tested for genetic damage. One group was exposed for 12 hr on the antenna of a 20 W transmitter to 146.34 MHz radiation at 62.5 V/m, and the second group was exposed for 12 hr to 29.00 MHz radiation from a 300 W transmitter. When testing for chromosome loss and non-disjunction, no genetic damage due to radiowave exposure was seen. (No references)

0658 A NOTE ON EMP SAFETY HAZARDS. *(E.)* Guy, A. W. (Bioelectromagn. Res. Lab., Dep. Rehabil. Med., Univ. Washington Sch. Med., Seattle). *IEEE Trans. Biomed. Eng.* BME-22(6):464-467, 1975.

EMP is a unique energy source which can produce far greater field strengths in man than can be produced by most sources of EM energy even though the absorbed energy density may be smaller. This is due to the relatively fast rate of change of field of the EMP. In this case, if concern is with limiting maximum field strength induced within the tissues, the time rate change of field is more important than the pulsewidth. The rise time, t_m, is the most important in terms of magnitude of the induced field, peak absorbed power density, and the energy density deposition. At this time the EMP safety standard can be based on previous experiments with man's exposure to typical radar pulses under the limitation of the ANSI standard (10 mW/cm^2) rather than relying on the definition of the upper limit of the electrical field intensity ($E_m = 194/(t_o)^{\frac{1}{2}}$ V/m) which has appeared in the *Federal Register*. (4 references)

0659 MAGNETOTACTIC BACTERIA. *(E.)* Blakemore, R. (Woods Hole Oceanogr. Inst., Mass.). *Science* 190(4212):377-379, 1975.

Magnetotaxis, a bacterial response to magnetic fields, has been found in at least 5 morphologically distinct types of bacteria in the vicinity of Woods Hole, Mass. The cells were characterized by two chains of 5-10 electron-opaque crystallike particles found to be internal cell components. The crystallike particles were often found within intracytoplasmic unit membranes arranged as vesicles about the periphery of the cells. The tendency of these particles to clump when outside the cell is consistent with the possibility that they may be a permanently magnetic substance. Within the particles, iron was the predominantly detectable element. Freely suspended killed cells frequently formed chains of up to 10 cells which acted as a single dipole in response to changes in the position of a nearby permanent magnet. Studies of the behavior of living and dead cells in uniform and nonuniform fields should contribute to an understanding of the magnetotactic mechanism. (5 references)

0660 PERCUTANEOUS RADIOFREQUENCY DENERVATION OF SPINAL FACETS. *(E.)* Shealy, C. N. (Pain Rehabil. Cent., S. C., La Crosse, Wisc.). *J. Neurosurg.* 43(4):448-451, 1975.

A technique for RF localization and coagulation of articular nerves supplying the spinal facets, based on Rees' closed surgical procedure, was developed. Following localization of puncture points under fluoroscopy and local anesthesia, No. 12 gauge thin-walled needles were introduced and a thermistor electrode (19 cm x 1.2 mm diameter) was inserted through one of the guide needles. After radiographic and electrical confirmation of desired electrode position, the RF generator was activated and the lesion temperature was raised over a 1-2 min period to 80 C with maintenance for 150 sec. The procedure was repeated at other involved levels after which the patient returned directly to his room, rested for 2 hr, and was then encouraged to start spinal exercises. Pain relief was usually obvious at completion of the RF lesions. The 207 patients followed for at least 6 mon were divided into 3 groups: (1) 57 who were previously unoperated, (2) 60 who had undergone previous operations without fusion, and (3) 90 patients who had undergone operations with spinal fusion. Patients on follow-up were asked about how much of the time they had pain, severity of pain, inhibition of physical activity, drug usage, and personality effects. No neurological complications were seen in these patients. For those in group 1, 79% achieved relief of pain, 41% in group 2, and 27% in group 3. Most late failures had a return of pain within 1 mon after the procedure. The high failure rate in groups 2 and 3 is related to the extensive scarring, often coupled with arachnoiditis, seen after so much surgery. This procedure is simple and safe and offers relief when there is no comparable alternative therapy. (9 references)

0661 A CASE OF PROLONGED, REVERSIBLE DEMENTIA ASSOCIATED WITH ABUSE OF ELECTROCONVULSIVE THERAPY. *(E.)* Regestein, Q. R. (Div. Psychiatr., Dep. Med., Peter Bent Brigham Hosp., Boston, Mass.),

B. J. Murawski, and R. P. Engle. *J. Nerv. Ment. Dis.* 161(3):200-203, 1975.

Confusion and amnesia following electroconvulsive therapy (ECT) usually lasts only a few weeks and clears completely thereafter. However, in some cases, memory disturbances may persist more than a year, particularly when large numbers of treatments are administered. There is much diversity of opinion about the number of ECT treatments indicated for psychiatric patients. A 57-yr-old housewife complained of abdominal and epigastric discomfort and insomnia. Her initiative deteriorated and she became inadequate at housework. Medical examination of the abdomen and upper GI tract were unrevealing and she was referred to a psychiatrist. ECT was given 3 times a wk for 2 mon, then 2 times a wk for 1 mon. She was discharged on amobarbitone and given ECT once a wk for 2 yr. She did no housework, slept, ate, and watched television all the time, had no initiative or spontaneity, and showed a profound memory deficit. Eventually an independent assessment was done despite warnings from her first psychiatrist, and ECT was stopped. She was reassessed monthly and drugs were gradually withdrawn. Over a period of months she began to converse, sensorium proved clearer, and fitful sleeping and pain returned. Eleven mon after cessation of ECT antidepressants were administered which relieved the remaining symptoms. Weekly ECT had caused a dense impairment in memory although lack of a clear history and mental status at the time of first presentation makes careful diagnosis of the original condition impossible. (18 references)

0662 SOME BIOCHEMICAL AND CYTOLOGICAL OBSERVATIONS ON THE EFFECT OF NONIONIZING (MICROWAVE) RADIATION. *(E.)* Dwivedi, R. S. (Dep. Bot., Howard Univ., Washington, D.C.), S. Ogunwuyi, and W. McCleod. *J. Cell Biol.* 63(2):90a, 1974.

The effects of 10 mW/cm^2 2450 MHz continuous and pulsed radiation on rabbits were studied. Results showed a decrease in levels of lactate dehydrogenase (LDG), glutamic oxalacetic transaminase (GOT), and alkaline phosphatase ever a 2 wk period of chronic radiation. Levels of α-1 globulin and α-2 globulin were elevated although total protein, albumin, and β-globulin remained constant. There were striking changes in the LDH isoenzymes of the serum and testes. Severe damage to testicular cells was seen, including complete degeneration of tubules and leydig cells. The damaging effects were at least practically reversible if the animals were allowed to recover for several wk. There was little difference in effects due to continuous *vs* pulsed radiation, indicating that damage was not only thermal. The results suggest that MW radiation is capable of producing serious alterations in the metabolism of various key proteins, especially after prolonged exposure. (No references)

0663 RECOMMENDATIONS FOR SPECIFYING EM WAVE IRRADIATION CONDITIONS IN BIOEFFECTS RESEARCH. *(E.)* Johnson, C. C. (Dep. Bioeng., Univ. Utah, Salt Lake City). *J. Microwave Power* 10(3):249-250, 1975.

Bioeffects research data, in terms of irradiation conditions, must be presented in a form suitable for comparison and evaluation. It is recommended that radiation conditions be reported in terms of the average and the localized absorbed W/kg in the sample. With this data it will be possible to extrapolate meaningfully to man for direct use in reassessing safety standards. The specific absorption rate (W/kg) in the tissue, P_L, is given by $P_L=(\sigma/2\rho)\bar{E}\cdot\bar{E}^*$ where σ is the tissue conductivity at the irradiation frequency, ρ is the tissue density, and $\bar{E}$ is the electric field strength in the tissue. Conventionally W/kg is measured in tissue by calorimetry, using thermography techniques or making point measurements of temperature rises with nonperturbing temperature probes. If the rise is linear with time, $P_L=4186c\Delta T/\Delta t$ where C is the tissue specific heat in cal/g C, Δt is the duration of radiation in seconds, and P_L=W/kg. It is strongly recommended that irradiation conditions be reported in terms of average and local W/kg. This information may be inferred from the following data: (1) specification of the incident wave intensity in mW/cm^2 if the radiation is planewave with E/H=377Ω; (2) description of specimen shape, dimensions, electric properties, and orientation with respect to E and H; and (3) description of specimen irradiation apparatus, specimen placement, presence of reflecting objects, etc. W/kg is the only common ground by which biological effects research can be compared, evaluated and utilized intelligently in the establishment of an irradiation safety standard. (No references)

0664 NONINVASIVE MICROWAVE MEASUREMENT OF RESPIRATION. *(E.)* Lin, J. C. (Dep. Electr. Eng., Wayne State Univ., Detroit, Mich.). *Proc. IEEE* 63(10):1530, 1975.

A technique using MW radiation to measure respiratory movements of man and animals was developed. Radiation (10 GHz) from an X-band standard gain horn is directed toward the chest of the subject and the reflection is detected and compared to the transmitted wave to give respiratory information. The method is simple, noninvasive, and requires no contact with the subject. Problems such as skin irritation, restriction of breathing, and loose electrode connections are eliminated, and use of ratio measurements make oscillator frequency unimportant. (2 references)

0665 EFFECTS IN RODENTS OF A 1-MONTH EXPOSURE TO MAGNETIC FIELDS (200-1200 GAUSS). *(E.)* Nahas, G. G. (Dep. Anesthesiol. Pathol., Coll. Physicians Surg., Columbia Univ., New York, N.Y.), H. Boccalon, P. Berryer, and B. Wagner. *Aviat., Space, Environ. Med.* 48(9):1161-1163, 1975.

An investigation was performed on the effects of continuous exposure to 200-1200 G magnetic fields. Microscopic observations were made of the capillaries of the mesoappendix of rats exposed to a 500 G field,

and a systematic histopathological study was performed of the major organs of rats exposed to magnetic fields of 200-1200 G for one mon. Cages containing 3 rats each were placed in a median position between 2 magnets so as to obtain a homogeneous magnetic field around the cages. Three control rats and 3 groups of 3 rats were exposed to 500 G for 6, 12, and 30 days, resp. Following exposure, capillary circulation was observed *in vivo* in the mesoappendix using 160x magnification. These capillaries were normal and showed no intravascular thrombosis regardless of exposure duration. Four groups of rats were exposed for 28-32 days to 0, 200, 400, and 1200 G fields. They were weighed before and after exposure and 24 hr urine specimens were collected following exposure. Twenty-four hr after exposure, blood samples were taken and all animals were sacrificed. Rats exposed to the magnetic field gained significantly more wt than controls. This wt gain was apparently related to field intensity. Final wt of brain, thymus, spleen, kidney, heart, liver, and testes was also significantly higher in exposed rats. Adrenals, ovaries, and lungs had the same final wt in all groups. There was no alteration in the vascular bed, no intravascular thrombosis, and no pathology of the artery walls in any group. Pneumonitis was found in all groups, including controls, and spleen congestion was found in both control and experimental animals: 2/6 controls were congested, 2/4 exposed to 200 G, 2/5 at 400 G, and 5/5 at 1200 G. No alteration in adrenal glands, liver, gonads or CNS tissue was found. There were no significant changes in hematocrit, WBC count, hemoglobin, or coagulation time. Exposure to the highest field used in this study produced no casualty or apparent ill effects. Further studies are needed of the effects of low intensity fields on growth and development. (19 references)

0666 THERMAL PROFILES OF NATIVE AND MICROWAVE-IRRADIATED DNA. *(E.)* Varma, M. M. (Bio-Environ. Eng. Sci., Howard Univ., Washington, D. C.) and E. A. Traboulay, Jr. *Mutat. Res.* 31(5):334, 1975.

Swiss male mice were irradiated for 30 min at 1.7 GHz with a power density of 50 mW/cm^2 to test for chemical changes in testicular DNA. A difference was seen between control and irradiated mice when measuring hyperchromicity and melting temperatures of DNA, supporting the possibility that MW irradiation causes strand separation. Carefully controlled experiments are needed to determine the degree of genetic damage. (No references)

0667 EFFECT OF A UNIFORM MAGNETIC FIELD ON LEUCOCYTES. STUDY OF PHAGOCYTOSIS. *(Fr.)* Bellossi, A. (Fac. Med. Pharm., Dakar, Senegal), M. Duclos, and G. Bellossi. *Bull. Soc. Med. Afr. Noire Lang. Fr.* 19(2):192-195, 1974.

The effect of exposure to a uniform magnetic field on phagocytosis of nonviable cells of baker's yeast by leukocytes was studied in blood samples taken from 49 randomly selected, presumably normal black African males and from patients with a variety of infections. The latter group included 25 patients with pyogenic bacterial infections, 30 with pulmonary tuberculosis, 29 with leprous infections, 20 with measles, and 7 with cerebral malaria. Plasma containing leukocytes was exposed to a magnetic field ranging in intensity from 4700 to 6300 gauss (mean 5500 gauss) for 3 hr at a temperature about 4 C above room temperature. After exposure to the magnetic field, the phagocytic index (ratio of the number of phagocytized yeast cells to polynuclear neutrophils) remained unchanged in 13 and increased in 36 of the controls. No correlation was found between adhesiveness and phagocytosis. Among the patients, exposure to the magnetic field increased the phagocytic index in patients with pyogenic bacterial infections. The phagocytic index decreased significantly after exposure to the magnetic field in patients with pulmonary tuberculosis and cerebral malaria but not in those with leprous infections. In patients with measles, the phagocytic index remained unchanged in 13 and decreased in 7 after exposure to the magnetic field. It is hypothesized that the magnetic field acts on DNA, particularly on regulatory genes. (9 references)

0668 COMBINED EFFECT OF A UNIFORM MAGNETIC FIELD AND NONIONIZING RADIATION ON LEUKOCYTES. *(Fr.)* Bellossi, A. (Fac. Med. Pharm., Dakar, Senegal), M. Duclos and J. de Certaines. *Bull. Soc. Med. Afr. Noire Lang. Fr.* 19(3):251-253, 1974.

Blood, taken from 85 presumably healthy black African men, selected randomly, was added to heparin and allowed to settle at room temperature. Plasma containing WBC was placed in glass slides holding 2.5 ml and was covered with a cover slip to prevent evaporation. One of these slides was placed in a magnetic field measuring 4000 to 6700 gauss (mean 5000 gauss) for 3 hr at 6.5 C above room temperature. The control was heated to the same temperature. Both samples were then exposed to radiation from a mercury-vapor lamp (2302 to 11,286 A) at 30 C for 30 min. Radiant energy, measured in the 2537 A band, was 2.8 mW/cm^2. A total and differential WBC was then performed on both samples and controls. The total WBC was significantly lower in samples exposed to UV radiation alone than in controls. In samples exposed to both the magnetic field and UV radiation, the decrease was of borderline significance. The differential WBC showed that these decreases were largely due to decreases in polynuclear neutrophils. No apparent changes occurred in polynuclear eosinophils, and there were too few polynuclear basophils and monocytes to draw any definite conclusions. These changes, which have previously been reported to occur in Caucasians, are attributed to changes in the structure of proteins and/or nucleic acids. (5 references)

0669 EFFECTS OF A UNIFORM MAGNETIC FIELD ON SERUM AND PLASMA. ELECTROPHORETIC STUDY OF THE PROTEINS. *(Fr.)* Bellossi, A. (Fac. Med. Pharm., Dakar, Senegal) and J. Demaille. *Bull. Soc. Med. Afr. Noire Lang. Fr.* 19(3):275-276, 1974.

Blood or plasma samples, taken from randomly selected, apparently healthy, black African males, were divided into 3 parts. One was placed in a uniform magnetic field measuring 4350 to 5900 Oe (mean 5100 Oe) for 3 hr at temperatures of 25 to 33 C (mean 29.5 C). The second was placed in an oven at the same temperature, and the third served as a control. The 3 samples were subjected to electrophoresis on the same strip of Phoroslide Millipore with pH 8.6 veronal buffer having an ionic strength of 0.075 for 20 min at 100 V. After staining with scarlet S, protein determinations were performed densitometrically. Using this method, protein determinations were performed on 23 serum and 21 plasma samples. Except for the β band in plasma, which included β-globulins and fibrinogen, there were no significant differences between partial correlation coefficients obtained for samples exposed to the magnetic field and those heated in the oven. A comparison of the mean percentages of proteins revealed that all serum globulins decreased and serum albumin increased after exposure to the magnetic field. However, the β band was denser in the exposed plasma samples than in the controls, while no appreciable change occurred in the α_1 band. No differences were observed in migration of serum albumin. If an ellipsoidal model is hypothesized, the changes observed could be accounted for by a decrease in the asymmetry of serum globulins and an increase in the asymmetry of fibrinogen after exposure to the magnetic field.
(5 references)

0670 PRELIMINARY STUDY OF THE EFFECT OF A CONSTANT MAGNETIC FIELD ON PROTEUS MIRABILIS. *(Fr.)* Bellossi, A. (Fac. Med. Pharm., Dakar, Senegal) and Castets. *Bull. Soc. Med. Afr. Noire Lang. Fr.* 19(3):342-345, 1974.

The ability of *Proteus mirabilis* to ferment glycerol, arabinose, ribose, xylose, galactose, glucose, fructose, trehalose, and N-acetylglucosamine was investigated in the API system 50 after application of a magnetic field measuring 3700 to 4500 gauss (mean 4150 gauss) for 2 hr at a mean temperature of 30 C. Controls were incubated for 2 hr at room temperature (mean 23.5 C). No statistically significant differences were found after 24 and 48 hr incubation in API system 50 tubes at 37 C. Fermentation of glycerol, D(-)-fructose, and ribose was initially more rapid in cultures exposed to a magnetic field, but fermentation of glycerol and D(-)-fructose was the same in experimental and control cultures and ribose fermentation occurred more slowly in experimental cultures after 48 hr. After 24 hr incubation, D(+)-xylose, galactose, and D(+)-trehalose fermentation proceeded more slowly in experimental cultures than in controls. After 48 hr, no differences were observed in the rate of xylose and galactose fermentation, while that of trehalose was slower in experimental cultures. The fermentation of D(-)-arabinose, D(-)-fructose, and N-acetylglucosamine proceeded at identical rates after 24 hr, but fermentation of D(-)-arabinose and D(-)-fructose was faster and that of N-acetylglucosamine was slower in experimental cultures after 48 hr. (11 references)

0671 EFFECT OF PULSED ELECTRICAL DISCHARGES IN MICROORGANISMS IN WATER. *(Rus.)* Pavlovich, S. A. (Kalinin Med. Inst., USSR), G. P. Osipov, P. P. Tofilo, and M. I. Voronkina. *Gig. Sanit.* (8):110-111, 1975.

Suspensions of *Escherichia coli, staphylococcus aureus,* and *Bacillus anthracis* in sterile tap water were exposed to high-voltage (50 kV), pulsed (1-2/sec), electrical discharges (capacitance 0.1-0.3 μF). Bacterial suspensions were placed in airtight, stainless steel cylinders with two openings: the operating electrode was immersed in one and the other was covered with a tube for a pipette so that samples could be removed after exposure to 1-120 successive pulsed discharges. These high-voltage, pulsed electrical discharges had an antibacterial effect. When a suspension containing 2 million *E. coli* in 1 ml tap water was exposed to one such discharge, 20% of the bacteria were killed; 10 impulses killed 84.6%, and 20 impulses killed all of the bacteria. *B. anthracis* was even more sensitive: one pulsed discharge killed 91% of the bacteria and 10 discharges killed all of them. Further experiments demonstrated that bacteria suspended in distilled water were more sensitive to these electrical discharges than those suspended in tap water, while bacteria suspended in saline solution were highly resistant. Exposure of river and tap water to high-voltage pulsed electrical discharges (capacitance 0.1 μF) revealed that tap water was completely sterilized by 20 discharges, but it required 60 discharges to kill 92% of the bacteria in river water. This is attributed to the higher bacterial count in river water and to the high concentration of salts and organic impurities which greatly reduce the antibacterial action of high voltage, pulsed electrical discharges.
(6 references)

0672 STUDY OF THE BIOLOGICAL EFFECTS OF PROLONGED EXPOSURE OF RATS TO MICROWAVE RADIATION HAVING INTENSITIES OF 5 TO 50 mW/cm^2. *(Ser.)* Dordevic, Z. (Inst. Aeronaut. Med., Zemun, Yugoslavia). *Vojnosanit. Pregl.* 32(1):51-53, 1975.

Experiments were performed on 480 male Wistar rats that were divided into two groups and exposed to: (1) 10 doses of MW radiation (5-50 mW/cm^2 for 2hr/-day) or (2) a single dose of 5-50 mW/cm^2 for 2 hr. The frequency of the MWs was 2400 MHz and the wavelength, 12 cm. Body weight and temperature were measured, and differential blood counts and ophthalmological examinations were performed before and after exposure of rats in group 1. These animals were then placed in a chamber under conditions simulating those found at an altitude of 11,000 m above sea level until they died. Rats in group 2 were sacrificed after exposure, histological examinations were performed on their tissues, and the contents of catecholamines were determined in their brains and hearts. The threshold dose which produced significant changes in the biological parameters measured was 10 mW/cm^2. Exposure of rats to this dose for 10 days increased rectal and axillary temperatures and produced leukopenia accompanied by relative neutrophilia and lymphopenia. The extent of

these changes increased with increasing doses of radiation. No changes occurred in the number of erythrocytes or platelets or in hemoglobin levels in any of the experimental animals. All rats, including those repeatedly exposed to 5 mW/cm^2 or more of radiation, also had decreased resistance to acute hypoxia. The absolute lethal dose for restrained rats was 30 mW/cm^2. Animals exposed to this dose developed motor excitation, clonic convulsions, and respiratory collapse and died within 2 hr. Immediately before death the rectal temperature increased to 44 C. Histological examinations performed on rats in group 2 demonstrated that death resulted from the thermal effect of MW radiation which caused thermoregulatory mechanisms to fail. Peripheral blood changes appeared to result from the stressor effect of MW radiation at intensities of 10 mW/cm^2 or higher. These changes were apparently caused by irritation of the hypothalamus, pituitary, and adrenals. No cataracts or other pathological changes were present in the eyes of any of the experimental animals. (No references)

0673 THE EFFECT OF UHF ELECTROMAGNETIC FIELDS ON THE VIABILITY OF PLEROCERCOIDS OF DIPHYLLOBOTHRIUM LATUM. *(Rus.)* Romanov, I. V. (S. M. Kirov Med. Inst., Gorky, USSR), M. Iu. Ulyanov, and Iu. V. Smirnov. *Med. Parazitol. (Mosk.)* 43(1): 108-109, 1974.

Plerocercoids of *Diphyllobothrium latum*, the fish tapeworm, were placed in petri dishes containing 10 ml physiological saline and were exposed to UHF radiation with a frequency of 39 MHz or 2189 MHz (field intensity of approximately 30-35 V/m) for 10 or 60 min and to radiation with a frequency of 2189 MHz and a field intensity of approximately 10 V/m for 10 or 60 min. Unexposed controls lived 2-3 days longer than plerocercoids exposed to the UHF fields. The survival time of irradiated plerocercoids decreased significantly with increasing exposure and depended on the frequency and wavelength of the radiation. To check the viability of irradiated plerocercoids, 6 irradiated with 2189 MHz for 60 min were fed to a dog. After 13 days the dog was autopsied and 2 immature tapeworms were found in the intestine: one was 30 cm long and the other, only 1.6 cm long. The latter specimen had an abnormal, degenerated strobila. (No references)

0674 CHANGES IN RAT TESTES CAUSED BY EXPOSURE TO A LOW FREQUENCY, PULSED ELECTROMAGNETIC FIELD. *(Rus.)* Ostrovskaya, I. S. (Kharkov Res. Inst. Ind. Hyg. Occup. Dis., USSR), L. N. Yashina, and G. I. Yevtushenko. *Vrach. Delo* (9):139-142, 1974.

Histological examinations and histochemical studies of ribo- and deoxyribo-nucleoprotein were performed on testes from 150 albino rats which had been exposed to a low frequency (7 kHz) pulsed EMF. The field intensity ranged from 0.4 to 72 kA/m, the duration of pulses was 130 μsec, and pulses were spaced 10 sec apart. Rats were divided into two groups and were exposed: (1) for 3 hr/day over 10-15 days or (2) for 30 min/day over 1-6 months. Pronounced morphological changes occurred in the testes of rats exposed to a field intensity of 72 kA/m for 10 days. These changes consisted of interstitial edema, plethora, dystrophic changes in cells of the seminiferous tubules, decreases in the number of sperm cells, and dystrophy and necrosis of spermatozoids. Similar changes were observed in rats exposed to 24 kA/m, but the extent of these changes depended upon the duration of exposure. Decreases had occurred in the ribonucleoprotein content of the protoplasm in first order spermatocytes, especially during growth and division. Damage to forming spermatozoids and spermatids was more pronounced in the testes of rats in group 2. These cells were swollen and often fused to form 'sperm balls' in the lumina of the tubules. No spermatozoids were found in most tubules, and those that were present had undergone dystrophic changes. Sertoli cell function appeared to be relatively unimpaired. The cytoplasm of Sertoli cells contained lipid granules which are considered by some investigators to result from phagocytosis of lipids from residual bodies formed during reductive division. These changes were most pronounced in rats exposed for 6 months; the testes in these animals were about half the size of those in controls. In group 2, morphological changes were found in rats exposed to field intensities as low as 2.4 kA/m. These findings confirm that the testes of rats are highly sensitive to low frequency, pulsed EMR. (No references)

0675 EFFECT OF ATP AND GLUTAMIC ACID ON OXIDATIVE PHOSPHORYLATION AND NITROGEN METABOLISM IN THE BRAIN AND LIVER OF RATS EXPOSED TO A PULSED ELECTROMAGNETIC FIELD. *(Ukr.)* Mishchenko, L. I. (Kharkov Res. Inst. Ind. Hyg. Occup. Health, USSR) and F. A. Kolodub. *Ukr. Biokhim. Zh.* 47(4):528-531, 1975.

ATP (1 mg/100 g/day) and glutamic acid (5 mg/100 g/day) were injected s.c. into nonirradiated rats and rats which were simultaneously exposed 15 times, for 3 hr at each session, to a pulsed EMF (frequency 7 kHz, field intensity 72 kA/m). Controls received 0.2 ml/day of physiological saline. Irradiation of rats significantly decreased the P/O coefficient by reducing the rate at which inorganic phosphate was esterified (by 33% in the brain and by 22% in the liver). Injection of ATP in nonirradiated rats significantly decreased the rate of O_2 uptake (by 13% in the brain and by 9% in the liver) and significantly increased the rate at which inorganic phosphate was esterified in the liver (by 18%). This resulted in a significant increase in the P/O coefficient. However, administration of ATP to irradiated rats had no effect on O_2 uptake and phosphorylation in either the brain or liver. This may be due to changes produced by irradiation in the structure of the mitochondrial membranes. Injection of glutamic acid into irradiated rats increased the rate at which inorganic phosphates were esterified in the brain and liver to values characteristic for controls.

No appreciable change occurred in oxidative processes. Irradiation significantly decreased the lactate content of the liver (by 32.2%), possibly by activating oxidative processes. In irradiated rats given ATP, lactate contents were decreased not only in the liver, but also in the brain (by 31%). No increase occurred in the creatine phosphate content of the brain in these rats. Irradiation significantly increased the content of ammonia in the brain (by 54%) and glutamine in the liver (by 32%); both of these values normalized after administration of ATP. Glutamic acid normalized the content of these metabolites in the brain and, to a lesser extent, in the liver. It is suggested that complete normalization of nitrogen metabolism in the liver might be prevented by its increased production of urea which has been shown to occur when animals are exposed to pulsed EMFs. (11 references)

0676 BEES EXPOSED TO HIGH VOLTAGES. *(Ger.)* Warnke, U. (Fachber. Biol. Univ. Saarbrucken, Germany) and R. Paul. *Umsch. Wiss. Tech.* 75(13): 415-416, 1975.

Abnormal behavior was induced in bee colonies in Styropore boxes by exposing them to electrical fields produced by high voltage generators at 50 Hz. This behavior could be reproduced under certain (unspecified) meteorological conditions. The bees became very restless when placed in an alternating field at a maximum intensity of 11 kV_{eff}/m. This can be attributed to the change in temperature. The bees also became very aggressive, not only toward outsiders, but even toward other bees in the colony and their own queen. Some of the bees that were attacked were stung to death. At lower field intensities (7 kV_{eff}/m), only some of the brood were fed; the workers no longer stored honey and pollen, and cells which had been filled with honey were emptied. If colonies had been placed in the Styropore box only a few days before they were exposed to the electrical field, bees went out again after a few days. However, if the bees had lived in these boxes for some time before exposure, they cemented up all tears and holes, including the flight hole. Within 5 days, the flight hole was completely closed, acute oxygen deficiency set in, and the entire colony suffocated. The temperature in the hive was so high that the wax melted. (8 references)

0677 AUTORADIOGRAPHIC ANALYSIS OF PROTEIN SYNTHESIS AND MEASUREMENTS OF NUCLEAR VOLUME IN WISH CELL CULTURES IRRADIATED WITH 3 GHz ELECTROMAGNETIC RADIATION. *(E.)* Szmigielski, S. (Inst. Aviat. Med., Warsaw, Poland) and M. Luczak. *Phys. Med. Biol.* 20(5):825-833, 1975.

The investigation aimed to evaluate the relationship between the amount of protein synthesis and nuclear volume in cells irradiated with MWs, and to determine the relation between time and inhibition and stimulation under these conditions. WISH cell cultures were irradiated 24 hr after passage with 3 GHz MWs for 30 min at intensities of 5 or 20 mW/cm^2. After 1, 4, 12 and 24 hr of exposure the cells were incubated with 5 μCi/ml of ^3H-glycine and autoradiographs were made using stripping film. The incorporation of the amino acid was measured for four groups, 0-10, 10-20, 20-40, and above 40 grains per cell. Karyometric analysis of irradiated cell cultures was performed 1, 4, 8, 12, 24 and 48 hr after exposure. In cultures irradiated at an intensity of 20 mW/cm^2, inhibition of protein synthesis with lowering of nuclear volume and enlargement of nucleoli was found one hr after irradiation. This was followed by increase in glycine incorporation 12 and 24 hr after irradiation with enlargement of nuclei. In cultures irradiated at an intensity of 5 mW/cm^2 stimulation of protein synthesis and enlargement of nuclei were seen 24 hr after irradiation. These results suggest that low intensity MWs stimulate metabolism of cells grown *in vitro*, although at higher intensities the phase of stimulation is preceded by a short period of inhibition in the culture viability. (26 references)

0678 MICROWAVE EFFECT ON RABBIT SUPERIOR CERVICAL GANGLION. *(E.)* Courtney, K. R. (Dep. Rehabil. Med., Sch. Med., Univ. Washington, Seattle), J. C. Lin, A. W. Guy, and C-K. Chou. *IEEE Trans. Microwave Theory Tech.* MTT-23(10):809-813, 1975.

An investigation was made to discover where precisely known doses of MW radiation would be applied to the nervous tissues of higher complexity, i.e., nervous tissue containing synoptic connections. The superior cervical ganglion of the rabbit was selected for excision and exposure to CW 2450 MHz fields within a temperature controlled waveguide environment. Absorbed power densities between 2 and 1000 W/kg failed to influence significantly transmission latencies of responses recorded from postganglionic fibers due to stimulation of either myelinated or unmyelinated fibers in the preganglionic trunk. (12 references)

0679 FOCUSSED MICROWAVE RADIATION: A TECHNIQUE TO MINIMIZE POST MORTEM CHANGES OF CYCLIC NUCLEOTIDES, DOPA AND CHOLINE AND TO PRESERVE BRAIN MORPHOLOGY. *(E.)* Guidotti, A. (Lab. Preclin. Pharmacol., Natl. Inst. Ment. Health, Washington, D. C.), D. L. Cheney, M. Trabucchi, M. Doteuchi, C. Wang, and R. A. Hawkins. *Neuropharmacology* 13(12):1115-1122, 1974.

An inexpensive high power (2 kW) MW radiator was developed which can be focussed on the mouse or rat head. It inactivates the brain enzymes in 0.5-2.5 sec, depending on size of animal, and allows measurement of brain concentrations of cyclic AMP, cyclic GMP, choline, DOPA, and various glucose metabolites which undergo rapid metabolism during the post mortem processes. The microwave fixation technique offers the advantage that the brain can be sliced with a freezing microtome to allow microdissection of various brain nuclei for neurochemical studies. Irradiation of the rat head for 0.5 sec produced death of

the animal, but complete denaturation of the brain proteins was achieved after only 1 sec of MW exposure. When compared to the freeze-blowing technique the metabolite concentrations are similar as well as the oxydoreductive state of tissue. The new MW technique, by allowing for microdissection, therefore establishes an important precondition for microchemical studies related to brain function. (29 references)

0680 SOME AUTONOMIC REACTIONS IN RABBITS EXPOSED TO A UNIFORM MAGNETIC FIELD. *(Rus.)* Klimovskaya, L. D. (No affil.) and N. P. Smirnova. *Kosm. Biol. Aviakosmicheskaya Med.* 9(3):18-22, 1975.

Exposure of rabbits to a uniform magnetic field (4500 Oe) for 3 hr significantly reduced the rate of respiration for 3 hr after exposure had ended. Arterial pressure decreased during exposure but normalized within 1 hr after exposure. Although the pulse did not change significantly, significant decreases were observed in some animals during exposure and for short periods thereafter. Before exposure to the magnetic field, injections of epinephrine (4 or 10 μg/kg i.v.) produced dose-dependent bradycardia and increases in blood pressure, but the effects on respiration varied greatly. Cardiovascular response to 10 μg/kg epinephrine was reduced when injections were performed 1-3 hr after exposure. Exposure to the magnetic field had no effect on cardiovascular changes produced by acetylcholine (20 μg/kv i.v.) or by electrical stimulation of the reticular formation in the midbrain (100/sec stimuli from a square-wave generator for 30 sec). Exposure of rabbits to the magnetic field before or after they had been subjected to accelerations of 6 or 10 g did not decrease cardiovascular or respiratory compensation in the animals. (6 references)

0681 HEATING PATTERNS PRODUCED IN HUMANS BY 433.92 MHz ROUND FIELD APPLICATOR AND 915 MHz CONTACT APPLICATOR. *(E.)* Lehmann, J. F. (Dep. Rehabil. Med., Univ. Washington Sch. Med., Seattle), B. J. DeLateur and J. B. Stonebridge. *Arch. Phys. Med. Rehabil.* 56(10):442-448, 1975.

Theoretically, 433.92 MHz MWs should selectively heat muscle more effectively than 915 MHz MWs, which is a frequency legal for diathermy use in the U.S. To test this, 20-45 yr old human volunteers were used to determine the temperature distribution produced by a 433.92 MHz round field applicator as compared to a 915 MHz contact applicator. The subjects were divided into 2 groups: those with ≤ 1 cm fat in the anterior thigh of the right leg and those with ≥ 2 cm fat. This portion of the thigh was scrubbed and temperature measuring probes were inserted up to a depth of 4-5 cm. All subjects were exposed to 433.92 MHz MWs at a power output of 55 W for 20 min. The difference between incident and reflected power was measured. At the end of 20 min exposure, the combined effect of continued heating with MWs and cooling by increased blood flow allowed the muscle temperatures to rise to therapeutic temperatures (≥ 40 C). Four of the five subjects had their highest recorded temperature in the muscle, while one had the highest temperature at the skin surface or in subcutaneous tissue. The effective depth of heating was on the average 2.4 cm from the interface into the muscle at 433.92 MHz and 2.5 cm at 915 MHz. In subjects with ≥ 2 cm fat the peak temperatures also occurred in the superficial muscle and were cooled by increased blood flow. After 20 min the highest temperature was found in the subcutaneous fat which is only slightly cooled. When the cooled contact 915 MHz applicator was used, temperatures at the skin surface were much lower, but the highest temperature still occurred in the subcutaneous fat layer. As no significant differences were found in using 433.92 MHz *vs* 915 MHz radiation, there is no reason to legalize the 433.92 MHz frequency for diathermy use in the U.S. (12 references)

0682 ADRENOCORTICOTROPHIC ACTIVITY OF THE PITUITARY UNDER THE EFFECT OF A UHF FIELD. *(Rus.)* Murashov, B. F. (D. I. Ulyanov Med. Inst., Kuibyshev, USSR), P. E. Krasnobaev, V. L. Goban, and V. A. Romanushko. *Gig. Tr. Prof. Zabol.* (3):36-38, 1975.

The ACTH activity of the blood was determined by Sayer's method in 82 men, aged 19 to 50 yr, who had worked with UHF generators fo 6 months to 11 yr. Controls consisted of 23 clinically normal subjects. The ACTH activity was significantly higher in workers exposed to UHF radiation (28.5 mg/100 ml) than in controls (value not given), suggesting that the low intensity UHF fields used in industry increase pituitary function. A single exposure of Wistar rats to a UHF field (wave length 12.62 cm, power flux densities of 0.1, 1, or 10 mW/cm^2) significantly increased ACTH activities, whereas a single exposure of rats to high intensity (100 mW/cm^2) UHF radiation for 30 min had no effect on the ACTH activity of their blood. When rats were exposed to low intensity (1 mW/cm^2) UHF radiation for 30 min/day for a relatively short period (10-20 days), the ACTH activity increased, but the increase was not statistically significant. The ACTH activity tended to decrease in rats irradiated under the same conditions for 30 days. Pituitary stimulation occurred in both nonirradiated and irradiated rats (1 mW/cm^2 for 30 min/day for 30 days) when 0.12 mg/kg of epinephrine was injected i.p. This indicates that exposure to UHF radiation in the range studied does not impair the ability of the pituitary-adrenal system to respond to epinephrine. The reversible functional changes observed in these experiments are probably caused by disorders in processes regulating secretion of ACTH. (10 references)

0683 EXPERIMENTAL STUDY OF SOME PROBLEMS ABOUT THE BIOLOGICAL EFFECT OF WATER EXPOSED TO A UNIFORM MAGNETIC FIELD. *(Rus.)* Stefanov, B. (Med. Acad., Varna, Bulgaria) and S. Solakova. *Gig. Sanit.* (8):70-72, 1975.

The body weight, rectal temperature, and blood were

investigated in 3 groups of albino rats fed (1) ordinary drinking water, (2) water exposed to a uniform magnetic field (induction 0.1 tesla), or (3) water exposed to a uniform magnetic field (induction 0.6 tesla). Rats in groups 2 and 3 were given 2.5 ml/day of 'magnetic' water p.o. through a stomach tube for 45 days and received the rest of their water in petri dishes. The most pronounced biological effects were observed in rats in group 2. After 45 days, significant decreases had occurred in the absolute weight gain; total serum protein; Na^+, and K^+; and rectal temperature. The number of reticulocytes in the blood increased significantly. There was a tendency for total blood cholesterol concentrations to decrease. None of these changes exceeded normal limits. (No references)

0684 DESTRUCTION OF SALMONELLAE ON POULTRY MEAT WITH LYSOZYME, EDTA, X-RAY, MICROWAVE AND CHLORINE. *(E.)* Teotia, J. S. (Dep. Anim. Sci., Colorado State Univ., Fort Collins) and B. F. Miller. *Poult. Sci.* 54(5):1388-1394, 1975.

Experiments were conducted to study the destruction of *S. senftenberg* 775W and *S. typhimurium* on poultry meat with lysozyme, EDTA, x-rays, MWs, and chlorine. A frozen stock culture of the microorganisms was incubated until it reached the stationary growth phase. It was then diluted in 0.1% sterile peptone water to a concentration of 5×10^5 to 8×10^5 viable cells/ml. *Small white turkey hen carcasses and medium size* drumsticks were placed in bags and covered with 500 ml aliquots of the contaminating fluid. The bag was shaken for 2 min and the fluid was poured off. The carcass was held in the closed bag at room temperature for 60 min before experimental treatment. Each carcass was aseptically transferred into a glass pan and covered with sterile Saran Wrap. They were irradiated in a MW oven for 1-10 min each, removed from the pan, and examined for any change in physical appearance. The test organism and other bacteria were destroyed in 120 sec on drumsticks and in 600 sec on broiler carcasses with MW irradiation. MW treatment produced partially cooked meat. If this cooking had no effect on shelf life, flavor, and acceptability by customers, it could be the quickest and cheapest means of destroying salmonella on poultry meat. (13 references)

0685 EXPERIENCE WITH MAGNETOTHERAPY FOR PAINFUL NEUROMAS IN STUMPS OF THE EXTREMITIES. *(Rus.)* Kucherenko, A. E. (Vinnitsa Med. Inst., USSR) and V. I. Shevchuk. *Vrach. Delo* (7):124-125, 1975.

Magnetotherapy was used to treat 42 World War II veterans, aged 48-75 yr, who had undergone amputations for gunshot wounds and fractures 29-32 yr previously. All of the patients had painful neuromas in the stumps of the extremities and severe phantom pain syndrome. The stump of the upper or lower extremity was placed between the poles of an electromagnet with an alternating magnetic field of 200-400 Oe for 15 min/day over a 20 day period. Pain was alleviated after the first session and edema after 3-4 days. Edema and inflammation disappeared completely after 10-11 days, sleep normalized, and neurotic reactions disappeared. To improve the results of therapy, magnetotherapy was continued even after the pain disappeared. Pain was completely alleviated in 37 patients. In 3 cases, there was no pain at rest, and slight pain was felt only when the neuroma was palpated. Two patients had no pain at rest, but a spastic sensation persisted in the phantom limb. Magnetotherapy proved superior to all of the methods tested so far. These include electrosleep, ultrasound, diodynamic currents, and electrophoresis combined with analgesics. The results of special tests indicate that magnetotherapy has an inhibitory effect on the CNS, a spasmolytic action on peripheral blood vessels, and analgesic and antiedemic actions. (No references)

0686 EFFECT OF A UNIFORM MAGNETIC FIELD ON ABSORPTION SPECTRA OF PROTEINS FROM ASCITES TUMOR S-37 AND HEMOGLOBIN FROM NORMAL AND TUMOR-BEARING ANIMALS IN VITRO. *(Rus.)* Aristarkhov, V. M. (Inst. Chem. Phys., Moscow, USSR), L. A. Piruzian and V. P. Tsybyshev. *Izv. Akad. Nauk SSSR [Biol.]* (6):917-920, 1974.

The effect of a uniform magnetic field (5000 Oe for 17 or 18 hr) on absorption spectra was studied in dilute solutions of ascites fluid proteins from animals [species unspecified] with ascites sarcoma S-37 in different stages of development and in dilute solutions of hemoglobin from normal animals and animals with ascites sarcoma S-37. Spectra were recorded 3 hr after removal of the solutions from the magnetic field. After exposure to the magnetic field, absorption spectra of ascites fluid protein from 7 day old sarcoma S-37 showed an increase in the intensity of absorption at 280 nm due to increased aggregation of protein molecules. When the spectrum of a nonexposed control solution was subtracted, 2 peaks appeared at 275 and 234 nm. The peak at 275 nm is probably caused by a tyrosyl group. Similar results were obtained when a technique was used which eliminated light scattering. Further investigations on protein from ascites sarcoma S-37 in different stages of development showed that exposure to the magnetic field generally, but not always, increased the intensity of absorption. These different results are attributed to differences in the state of ascites fluid proteins during tumor development. Exposure of a hemoglobin solution from normal animals to a constant magnetic field decreased the intensity of absorption and shifted the main peak at 413 nm toward a shorter wavelength. This indicates that the magnetic field causes profound structural changes in the hemoglobin molecule. In contrast, the magnetic field decreased the intensity of absorption only slightly in hemoglobin solutions from animals with 7 day old ascites sarcoma S-37, but the peak was still shifted. If the absorption spectrum for hemoglobin from tumor-bearing animals was plotted relative to that for hemoglobin from normal controls, similar results were obtained. No shift in the peak was observed when the same method was used to plot the spectrum for hemoglobin after exposure to the