CURRENT LITERATURE

0001 EFFECT OF INDUCTOTHERMY ON PANCREATIC FUNCTION. *(Rus.)* Korepanov, A. M. (Izhevsk Med. Inst., USSR). *Vopr Kurortol Fizioter Lech Fiz Kult* 36:340-343, 1971.

Inductothermy was used to treat 365 patients, aged 18-50 yr, who had chronic cholangiohepatitis (obstructive jaundice (200), chronic gastritis associated with hypo- or achlorhydria (90), duodenal ulcers (40), diabetes mellitus (18) and chronic colitis (8). Except for 23 patients who received thermal doses, all patients were given oligothermal doses. Exposure time was 30 min for single doses and ranged from 20 to 60 min during courses of therapy. Under basal conditions and after stimulation of pancreatic activity by instillation of 30 ml 0.25% HCl through a duodenal sound, inductothermy significantly increased the volume of duodenal juice and its bicarbonate concentration and slightly increased its enzyme activity. Thermal doses, given to 23 patients, suppressed secretion and reduced enzyme activities in most patients. Courses of inductothermy (10-12 exposures), administered to 92 patients, produced symptomatic improvement in many patients, reduced the size of the liver in all 58 patients with hepatomegaly, and caused disappearance of mucus and WBC from the bile in 32 of 49 patients. Bicarbonate concentrations and lipolytic activity of the duodenal juice increased significantly. Significant decreases occurred in blood and urinary diastase values during therapy, but lipase activities did not change appreciably. Studies of the exocrine function of the pancreas performed on 53 patients, 18 of whom had diabetes mellitus, showed that inductothermy significantly increased blood sugar levels in patients with hypoglycemia and significantly decreased blood sugar levels in diabetics. No appreciable changes occurred in the glucose tolerance curves of the 30 patients tested. On the basis of these findings it is recommended that inductothermy in oligothermic doses be used in the treatment of patients with gastrointestinal disorders associated with disturbances in pancreatic function. (No references)

0002 USE OF CHEMICAL SUBSTANCE IN SUPERHIGH FREQUENCY ELECTROMAGNETIC RADIATION. (LITERATURE REVIEW). *(Rus.)* Koldaev, V. M. (I. P. Pavlov Med. Inst., Ryazan, USSR). *Farmakol Toksikol* 35:505-507, 1972.

Investigations have shown that radioprotective agents, biogenic amines, agents producing methemoglobin, and stimulants decreased the survival times of experimental animals exposed to SHF radiation, whereas chlorpromazine and sodium barbital increased the survival time. Administration of general and local anesthetics prevented low-intensity SHF radiation from affecting cardiac rhythm. Sublethal doses of epinephrine, strychnine, and pentylenetetrazole, administered after irradiation, decreased the number of animals that died, and pyridoxine improved circulation when animals were irradiated with 80 mW/cm^2. Although there is no specific treatment for damage produced by SHF radiation, camphor, valerian and bromine, glucose and ascorbic acid, and B vitamins have been used to treat acute damage in man while gentian infusion, strychnine, securinine, meprobamate, calcium gluconate, and others have been employed to treat chronic forms. Recurrences have sometimes developed 2 months to 1 yr later. Drugs used to diagnose damage produced by SHF radiation include those which stimulate various parts of the central nervous system, ergot derivatives, atropine, and others. (24 references)

0003 THERMAL AND ATHERMAL EFFECTS OF MICROWAVE RADIATION ON THE ACTIVITY OF GLUCOSE-6-PHOSPHATE DEHYDROGENASE IN HUMAN BLOOD. *(E.)* Belkhode, M. L. (Radiation Protection Bureau, Hlth. Protection Br., Dept. Natl. Health Welfare, Ottawa, Canada), D. L. Johnson and A. M. Muc. *Health Phys* 26:45-51, 1974.

Human blood and yeast glucose-6-phosphate dehydrogenase were treated with 2.8 GHz microwave radiation (CW, 1KHz square wave modulation) at an incident power density of between 500 mW/cm^2 and 1000 mW/cm^2. The power absorbed was observed to be 230 ± 70 mW/cm^3. This corresponds to absorbed energies of 35 and 62 J/cm^3 for the two treatment times used. Treatments were carried out at fixed temperatures of 37°, 46.7° and 49.7° C in such a way as to distinguish between thermal and athermal effects on the activity of glucose-6-phosphate dehydrogenase. Thermally induced reductions in relative activity of up to 80%, which were dependent on treatment period, were observed. The observed average athermal effect on the relative activity was $(0.4 \pm 1.8)\%$. This is not statistically significant. Thus, no athermal effect of microwave radiation on the activity of glucose-6-phosphate dehydrogenase was observed.

0004 DOSIMETRY STUDIES ON A UHF CAVITY EXPOSURE CHAMBER FOR RODENTS. *(E.)* Guy, A. W. (U. Washington Sch. Med., Seattle) and S. F. Korbel. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) May 1972, p 180-187.

The thermographic dosimetry technique was used to study the relationship between cavity fields and absorbed power characteristics of rats in a cavity-type exposure chamber. Cavity resonance was approximately 500 MHz with field patterns corresponding to degenerate TE_{105} and TE_{501} modes. The measured effective power density of 1 mW/cm^2 in the chamber was equivalent to an input power of 10 watts. Typically, the peak absorbed power density for 227 g phantom rats ranged from 3-70 mW/cm^3; in extreme cases it was as low as 0.35 mW/cm^3 and as high as 185 mW/cm^3, depending on the position and posture of the rats. In most positions simulating the

drinking rate, the peak absorption was very high in the limbs and nose of the phantom.

0005 MICROWAVE DEFREEZING OF CANINE KIDNEYS. *(E.)* Rajotte, R. (Surg. Med. Res. Inst., U. Alberta, Edmonton, Canada), W. A. G. Voss, J. B. Dossetor and C. R. Stiller. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) May 1972, p 178-179.

The use of fluorocarbon to progressively cool the canine kidney below the freezing point of water was investigated, using the vasculature to carry the cooling agent and microwave heating to thaw the organ. Freezing rates of 2 C/min were achieved. It was more difficult to achieve uniformity during defreezing. The fluorocarbon-loaded organ absorbs power rapidly at 2.45 GHz. For 50 g kidneys heated to 23 C, the internal temperature gradients were not more than 4 C, but with larger kidneys there were variations of $\pm$ 10 C. Disproportionate rapid heating of the ureter and slow heating of the renal papillae were occasional problems. Reimplantation of thawed kidneys was not a functional success.

0006 THE DIFFERENTIAL TEMPERATURE RISE AT HOT SPOTS GENERATED IN LOSSY SPHERES BY ELECTROMAGNETIC WAVES. *(E.)* Kritikos, H. (Moore Sch. Electric. Eng., U. Pennsylvania, Philadelphia) and H. Schwan. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) May 1972, p 194-195.

The heat potential generated by electromagnetic waves in a multilayered lossy sphere was investigated in the frequency region 10-10,000 MHz. The multilayer sphere was modeled after a human head with the layers having the electrical characteristics in succession of skin, fat, bone, and tissue. Small spheres (5 cm in radius) in the region 400-2800 MHz have hot spots generated near their center. Larger spheres (10 cm in radius) do not. The size of the hot spots is approximately a spherical region of diameter equal to a half wavelength. For the case of a 5-cm sphere, an incident field of 10 mW/cm^2, at 1000 MHz frequency, and a hot spot of 1 cm in radius, the maximum temperature rise is 0.580 C over the ambient. The temperature rise is a strong function of blood flow. For no blood flow the temperature rise is 0.90 C and for five times normal blood flow it is 0.210 C.

0007 MICROWAVE INTERACTION WITH THE AUDITORY SYSTEMS OF HUMANS AND CATS. *(E.)* Guy, A. W. (U. Washington Sch. Med., Seattle), E. M. Taylor, B. Ashleman and H. C. Lin. *Proc Int Microwave Symp* (IEEE, New York City, N.Y.) June 1973, p 321-323.

Recordings from elements of the auditory system of cats in response to pulsed microwaves, as well as determinations of thresholds of audibility of humans to the pulses, indicate that an auditory sensation may be elicited by pulse energies → 20 μJ/cm^2, regardless of average or peak power. Responses elicited in the round-window of the cat cochlea by radiation directly over the inferior temporal area had the same form as those elicited by acoustic click stimulus. By positioning the applicator at a variety of sites removed from the immediate auditory area, a unique series of potentials with increasing amplitudes was obtained; these potentials were produced by radiation in the X as well as the S band. The pulse characteristics for eliciting auditory effects in the cat are given for three different frequencies. Also shown are the thresholds of auditory responses in humans to 2450 MHz radiation at 3 pulses/sec. Significantly, the threshold energy for detection by one subject with normal hearing was approximately 1/3 to 1/4 of that required for another subject with sensorineural hearing impairment. Each individual pulse was heard as a distinct click with the sound originating within and near the back of the head. Short pulse trains were heard as chirps with tone corresponding to the pulse recurrence rate.

0008 MICROWAVE EFFECTS ON CENTRAL NERVOUS SYSTEM ATTRIBUTED TO THERMAL FACTORS. *(E.)* Taylor, E. M. (U. Washington, Seattle), A. W. Guy, B. Ashleman, and J. C. Lin. *Proc Int Microwave Symp* (IEEE, New York City, N.Y.) June 1973, p 316-317.

Elevation of thalamic temperature by the circulation of heated fluid through an exchanger applied to the base of the cat skull resulted in evoked potential changes comparable to those produced by microwave heating of the same magnitude (10W and 15W incident, 918 MHz continuous wave). In both cases the changes were in the nature of decreased latency of late components of the evoked potential. Nervous system changes resulting from microwave illumination heating were counteracted or reversed with concurrent cooling of the affected tissue. These results are evidence that the microwave effect on the central nervous system is a thermal phenomenon.

0009 EFFECT OF 2450 MHz MICROWAVE FIELDS ON PERIPHERAL NERVES. *(E.)* Chou, C. K. (U. Washington Sch. Med., Seattle) and A. W. Guy. *Proc Int Microwave Symp* (IEEE, New York City, N.Y.) June 1973, p 318-320.

There was no significant change in amplitude, conduction velocity, or excitability of frog and cat nerves exposed to continuous and pulsed 2450 MHz fields in a waveguide filled with temperature-controlled Ringer's solution. Absorbed power densities varied from 0.003 to 1.7 W/cc for continuous wave fields and 0.3 to 30 W/cc peal for pulsed fields. Frog action potential amplitude and latency were degraded at about 35 C, but

these temperature-sensitive characteristics were reversible. A temperature of 46 C caused irreversible damage to the cat nerve. When double stimulation pulses 1.2 millisec apart were used, the response due to the second pulse was in the relative refractory period of the first response. The characteristics of the second response were more sensitive to temperature changes. This indicates that a slight microwave-induced temperature rise in the peripheral nerve might alter firing patterns of neurons in the CNS.

0010 LENS OPACITIES IN EYES OF RABBITS FOLLOWING REPEATED DAILY IRRADIATION AT 2.45 GHz. *(E.)* Carpenter, R. L. (Northeastern Radiol. Hlth. Lab., Winchester, Mass.), E. S. Ferri, and G. J. Hagan. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) May 1972, p 167-168.

The development of lens opacities was studied in New Zealand White rabbits irradiated at 2.45 GHz 1 hr daily for 20 consecutive days. Six groups of 10 animals were irradiated at different power densities. Opacity formation in these groups occurred as follows: at 50 mW/cm^2, none; at 80 mW/cm^2, one; at 90 mW/cm^2, one; at 100 mW/cm^2, five; at 110 mW/cm^2, four; and at 120 mW/cm^2, eight. No animal irradiated once at 102 mW/cm^2 for up to 5-1/2 hr developed lens opacity. Thus, this microwave dose represents a power density well below the cataractogenic threshold for acute exposure of the rabbit eye, but daily repetition can cause lens opacities to develop.

0011 PSYCHOPHYSICAL DATA ON THE RF HEARING EFFECT. *(E.)* Frey, A. H. (Randomline Inc., Willow Grove, Pa.) and R. Messenger. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) May 1972, p 169-173.

A series of psychophysical studies was carried out with humans in a radiofrequency (RF) anechoic chamber. The RF carrier frequency was 1.245 GHz, and all energy measurements were taken with a half wave dipole located in the center of a subject's head. The maximum average power density at the head was 1.3 mW/cm^2. Perceived loudness, determined by the magnitude estimation technique, was a function of peak power density. The threshold peak power density calculated from test data is 80 mW/cm^2. A band of optimal pulse widths seems to exist for perception. There are also RF modulation characteristics which yield the perception of complex pitch. The data indicate that the RF hearing phenomenon is not due to a radiation pressure effect.

0012 THEORETICAL AND EXPERIMENTAL STUDIES OF MICROWAVE INDUCED CATARACTS IN RABBITS. *(E.)* Kramer, P. (U. Washington, Seattle), A. F. Emery, A. W. Guy and J. C. Lin. *Proc Int Microwave Symp* (IEEE, New York City, N.Y.) June 1973, p 265-267.

Power deposition patterns, temperature distribution patterns, and cataractogenesis thresholds were established in the eyes of rabbits exposed to localized near zone 2450 MHz radiation. The absorbed power distribution reached peak values in the vitreous body at about half-way between the lens and the retina with a mean of 0.92 mW/g for each mW/cm^2 incident power. In all cases maximum temperatures were localized in the retrolental area near the posterior surface of the lens. After a sub-threshold radiation dose of 100 mW/cm^2 for 60 min, the maximum temperature was 40.7 C. Radiation at 300 mW/cm^2 for 30 min indicated an inordinate rise to 46 C and a corneal temperature of 37.7 C. The earliest lens damages, consisting of posterior cortical banding and small vacuoles in the region of the posterior suture line, appeared within the 1st wk after exposure. These changes showed no progression at the lower level of irradiation. At the higher level the vacuoles increased in number and a distinct, well-circumscribed subcapsular opacity developed. These results are in good agreement with theoretical predictions.

0013 FURTHER EXPERIMENTS SEEKING EVIDENCE OF NONTHERMAL BIOLOGICAL EFFECTS OF MICROWAVE RADIATION. *(E.)* Liu, L. M. (Electr. Eng. Dept., Washington U., St. Louis, Mo.), G. W. Skewes, G. A. Lindauer, and F. J. Rosenbaum. *Proc Int Microwave Symp* (IEEE, New York City, N.Y.) June 1973, p 333-334.

Carpenter and Livstone's microwave experiments on beatle pupae were repeated and extended. The incidence of abnormality increased more than 3-fold with irradiation while the death rate remained essentially unchanged. The percentage of G3 abnormalities showed a particularly dramatic difference between experimental and control groups. The incidence of teratological damage was independent of specimen orientation, irradiation power level (10 mW-20mW), or whether the microwave power was pulse or continuous wave (CW). The incidence did depend on the energy absorbed and the pupa age when irradiated, as shown by results for a group receiving 10 mW for 2 hr *vs* 10 mW for 4 hr and by comparison of 2- and 5-day-old pupae irradiated at 20 mW CW for 2 hr.

0014 EFFECTS OF MICROWAVE IRRADIATION ON ENZYMES AND METABOLITES IN MOUSE BRAIN. *(E.)* Nelson, S. R. (U. Kansas Med. Ctr., Kansas City). *Radiat Res* 55:153-159, 1973.

After decapitation and exposure of the mouse head to microwave radiation, seven of the eight brain enzymes (hexokinase, aldlase, pyruvate kinase, P-fructokinase, lactate dehydrogenase, adenylate kinase, P-creatine kinase, and phosphorylase) studied were inactivated. The remaining enzyme, myokinase, retained about 10% of control activity. Brain metabolite levels were also altered by microwave radiation and these changes were used indirectly to

obtain information about the sensitivity of enzymes to heat inactivation. ATP hydrolyzing enzymes were relatively resistant to heat since inactivation was delayed long enough for half the available ATP to be used. P-creatine kinase was inactivated early during microwave treatment since P-creatine, usually depleted in seconds, was reduced only 30% in the anoxic brain. Hexokinase appeared most sensitive to heat since glucose, rapidly used in the anoxic brain, remained at control levels after microwave irradiation. Glycogen decrease and G-6-P elevation indicated brain phosphorylase was not immediately inactivated in the experimental mice. Low lactate levels in the anoxic, treated brains showed that the flow of glycolytic intermediates was quickly blocked at one or more steps between G-6-P and lactate. Since fructose diphosphate was depleted in brain from the irradiated, anoxic head, aldolase was resistant to early inactivation. The metabolite changes observed after the decapitated heads were irradiated were also observed when the heads of intact mice were treated, and the changes occurred in both cortex and subcortex of these mice.

0015 EFFECTS OF MICROWAVE RADIATION ON ENZYMES. *(E.)* Langley, J. B. (Georgia Inst. Technol., Atlanta), E. K. Yeargers, A. P. Sheppard, and G. K. Huddleston. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) Sept. 1973, 3B4/1-3B4/2.

Experiments were conducted to investigate the effects of microwave heating on lysozyme and trypsin as opposed to conventional heating. In one of the two experimental systems, the heating apparatus was a glass tube passing through a section of S-band waveguide parallel to the electric field. Microwave power was supplied from a continuous wave (CW) magnetron through a variable attenuator. A thermistor in the glass tube measured the temperature of the circulating liquid, with thermistor output controlling the a.c. power to a resistance heater in the other system. Through the a.c. power control system, the two volumes of enzyme solution underwent the same thermal cycle for the same amount of time. No statistically significant differences in deactivation were noted between enzyme solutions heated by microwave power and those heated by conventional means.

0016 MICROWAVE BIOLOGICAL EFFECTS UNDER REPRODUCIBLE DOSIMETRIC AND ENVIRONMENTAL CONDITIONS. *(E.)* Ginns, E. I. (U.S. Dept. Hlth., Educ. Welfare, Rockville, Md.), R. Rugh, H. S. Ho., W. Leach, L. Gillespie, R. Budd, and D. G. Hazzard. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) Sept. 1973, p 2B2/1-2B2/2.

The biological effects of 2.45 GHz microwave energy on CFI mice were investigated by exposing the mice to a power density of 100 mW/cm^2 in an environmentally controlled waveguide irradiation facility. Preliminary results suggest that as the Temperature-Humidity Index increases, there is a decrease in the lethal dose of microwave energy (THI, 69-83; absorbed dose, 160-85 cal/g; forward power, 7.0 watts) to 1- to 2-month-old mice. Results of testing juvenile and adult mice for sterility through two or three matings indicated that microwave radiation causes reduced litter size. *In utero* anomalies were determined by irradiating (absorbed doses, 6.1-9.3 cal/g) timemated mice on the 7th to 13th day of gestation. Fetuses dissected before delivery showed blood vessel dilation, hemorrhaging, stunting, and resorption plus evidence of exencephaly.

0017 CYTOGENETIC EFFECT OF MICROWAVE RADIATION ON CHINESE HAMSTERS. *(E.)* Everts, J. M. (Environmental Protection Agency, Eastern Environ. Radiat. Lab., Montgomery, Alabama), W. A. Herman, M. C. Colvin, C. R. Porter, and C. R. Philips. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) May 1972, p 139-142.

To determine whether there is a cytogenetic effect of microwaves, hamsters were irradiated in a calibrated anechoic chamber for varying time intervals up to 2 min at 200 mW/cm^2. Tissue cultures were prepared from kidney, lung, and thyroid tissue, scored for chromosome abnormalities after a 74 hr growth period, and compared with tissues from control animals. The overall average percentage of chromosome aberration increased from approximately 2.5% at 15-sec exposure to approximately 5.5% at 60-sec exposure and then dropped to about 3.5% at 12-sec exposure. This general trend held true for each tissue observed although the maximum percentage aberration varied slightly with different exposure times. The average percentage aberration in sham irradiated animals was about 10% for all exposure times. Rectal temperature increased significantly at the 120-sec exposure. The types of aberrations observed included chromatid breaks, chromosome breaks, dicentrics and fragments, rings, reconstitutions, and endo-reduplications. Whether such damage is primarily thermal in nature is uncertain, but the heat produced undoubtedly contributed to the observed effects.

0018 NON-CONTACT DETERMINATION OF TEMPERATURE CHANGES IN MICE DURING MICROWAVE IRRADIATION. *(E.)* Rotkovska, D. (Inst. Biophysics, Czechoslovak Acad. Sci., Brno). *Physiol Bohemoslov* 22(4):359-363, 1973.

Hairless male BFU mice were irradiated with microwaves at an output density of 260 mW/cm^2 (frequency 2,450 c/s, wavelength 12.5 cm). An AGA 680 thermovision camera was used to measure changes in their body temperature immediately following irradiation. Five minutes of irradiation raised the rectal temperatures of the mice an average of 2.6 C. The temperature increase varied in different parts of the body, being especially marked in the region of the heart and liver. The course of the tempera-

ture changes in the region of the tail during microwave irradiation indicated that the tail participates in the regulation of heat output in mice.

0019 GASTROINTESTINAL MOTOR ACTIVITY FOLLOWING EXPOSURE TO A HIGH-FREQUENCY ELECTRIC FIELD. *(E.)* Tansy, M. F. (Dept. Physiol., Temple U. Sch. Dentistry, Philadelphia, Pa.), F. M. Kendall, J. Chryzanowski, F. J. Hohenleitner and A. R. Kall. *Experientia* 27:1431-1432, 1971.

Adult male Sprague-Dawley rats were exposed for 30 minutes to a 60 MHz electric field between a pair of large condenser plates. The acetylcholine responsiveness of strips of their intestinal muscles in an isolated tissue bath was then evaluated, as were the differences in the incorporation of Evans Blue dye by various portions of the gastrointestinal tract at different intervals following exposure to the field. The muscle strips from the exposed animals showed a greatly increased strength of contraction in response to acetylcholine; this response persisted for 5 days following exposure. The colonic muscle strips from the exposed animals showed a decreased contractile response to acetylcholine. Two to 3 hours after exposure, the stomachs of the rats lost significantly more dye than did the stomachs of nonexposed controls. The colons of the exposed animals collected more dye than did those of the controls.

0020 DEPRESSION OF PHAGOCYTOSIS: A NON-THERMAL EFFECT OF MICROWAVE RADIATION AS A POTENTIAL HAZARD TO HEALTH. *(E.)* Mayers, C. P. (Dept. Path., U. Edinburgh, Scotland) and J. A. Habeshaw. *Int J Radiat Biol* 24(5):449-461, 1973.

The widespread use of microwave equipment presents potential hazards to health from inadvertent exposure. The hazards due to the heating effect of microwaves are well recognized. Recent evidence suggests that microwave radiation produces other biological effects that are not in any way due to heating. Experiments were performed to investigate the non-thermal effects of microwaves on the process of phagocytosis. Monolayer cultures of mouse macrophages on cover-slips were perfused with suspensions of human red blood cells while being exposed to microwave radiation of 2450 MHz frequency, at a power level of 50 mW/cm^2, under strict temperature control. Comparison of the phagocytic indices of the irradiated cultures with unirradiated control cultures demonstrated a marked depression of phagocytic activity. Further investigation showed that macrophage phagocytic activity was restored to normal if the radiation was discontinued. Relatively long periods of exposure to microwaves might be expected to affect the mechanism of cell-mediated immunity in superficial tissues, with consequent increased susceptibility to infections and suppression of the immunological surveillance mechanisms which might allow aberrant cell forms to develop.

0021 UNCERTAINTIES IN THE EVALUATION OF THE BIOLOGICAL EFFECTS OF MICROWAVE AND RADIOFREQUENCY RADIATION. *(E.)* Cleary, S. F. (Dept. Biophysics, Virginia Commonwealth U., Richmond). *Health Phys* 25:387-404, 1973.

Evaluation of the effects of microwave or radiofrequency (RF) radiation on biological systems and the risks attendant upon human exposure to such radiations is complicated by the complex nature of microwave absorption in tissue and the lack of molecular interaction mechanisms. The development of more sophisticated methods of dosimetry should lead to a better correlation between the parameters of the microwave field and the energy distribution within the absorber. Nonuniformities in the pattern of energy absorption and the consequent temperature variations within a body may play a significant role in the induction of low intensity reversible microwave effects. The concept of evaluating biological effects on the basis of average radiation-induced temperature increases is therefore subject to question. A review of microscopic or molecular interaction mechanisms indicates that the most probable radiation-induced alterations would involve the reversible disruption of systems of weak cooperative bonding leading to conformational changes in molecules or molecular assemblages. Although such effects might be dependent upon the wavelength of the radiation, there is no direct evidence for nonthermal molecular interactions in biological systems. It is possible that thermally enhanced molecular interactions may occur at relatively low radiation intensities. Such effects would not necessarily involve significant gross body heating and, as such, would provide a molecular basis for the suspected role of microwave or RF-induced nonuniform temperatures rises in biological systems.

0022 MICROWAVE RADIATION HAZARDS AROUND LARGE MICROWAVE ATENNA. *(E.)* Klascius, A. (Jet Propulsion Lab., California Inst. Technol., Pasadena). *Amer Ind Hyg Assoc J* 34(3):97-101, 1973.

The microwave radiation hazards associated with the use of large antennas become increasingly more dangerous to personnel as the transmitters go to ever higher powers. The near field area is of the greatest concern in that it may contain spill-over from subreflectors and reflections from nearly objects. Any curved or flat surface can collect microwave energy and reflect it. When an electromagnetic wave hits the surface of the human body, part of the energy is reflected and the remainder is transformed to heat within the tissues. Low level electromagnetic radiation causes difficulties that are primarily of a neurological nature, and nonthermal effects may cause changes in interneuron connections, the inactivation of certain viruses, changes in the growth and infective properties or bacteria, and changes in the course of cell division. Energy from spill over and side lobes coming from the antenna arriving at the same point in space in the same phase could result in energy densities two to four times

greater than would normally be there. A cranium structure located in such a field could act as a resonant cavity to absorb this energy to an even higher concentration. Centimeter wave meeting in phase will reinforce each other and create hot spots of microwave energy; these hot spots could reach the levels encountered inside a microwave oven. This phenomenon has been measured in front of and around several 26-meter antennas. The hot spots which were found will be the determining factor in delineating safe areas for personnel to work. Better techniques and instruments to measure these fields are needed for the evaluation of hazard areas.

0023 ELECTROMAGNETIC INTERACTIONS WITH BIOLOGICAL MATERIALS. *(E.)* Guy, A. W. (Sch. Med., U. Washington, Seattle). *Proc G-AP Int Symposium*, August 22-24, 1973, p 192-195.

Electromagnetic (EM) energy can produce biological damage through tissue heating at incident power levels of greater than 100 mW/cm^2. Studies in Eastern Europe and the Soviet Union have also indicated that thermal or athermal effects, especially on the central nervous system, might be produced by much lower power levels. Thus, in these countries, the safety standard for continuous 8 hour microwave exposure is 10 $\mu W/cm^2$, as opposed to 10 mW/cm^2 in the United States. The effects of low level EM radiation remain a subject of controversy in the United States. The fields induced in tissues by outside EM sources are complex functions of the types of sources, frequency, and subject size, and they may differ by many orders of magnitude depending on exposure conditions. Above 200 MHz, the combination of curved surfaces and high dielectric constant to tissues can produce very high localized and frequency dependent internal absorption deep in the tissues; below 200 MHz, the absorbed power in exposed subjects drops sharply with frequency. Internal fields and power absorption density may be directly measured *in vivo* by implanted electromagnetically transparent probes or indirectly measured in electrically equivalent phantom models of the subject and in the bodies of sacrificed animals. Measurements by these methods have shown power absorption density thresholds for various physical and psychological changes in humans and animals.

0024 MICROWAVE OVEN RADIATIONS: INFORMATION PAPER. *(E.)* Davis, J. A. (Flight Standards Technical Div., Dept. Transportation, Oklahoma City). *Engineering Report* AAC-213-7 (73-749-130A), 1973.

The tolerance of the body to the effects of microwave radiation depends on the amount of blood flow in the exposed area. Examples of low tolerance parts of the body include the eyes and testes; high intensity exposure to microwave energy can cause cataracts. Damage is likely to occur at power densities above 100 mW/cm^2 for whole body exposure for a time period of 6 minutes or longer; the American National Standards Institute has specified a maximum level of 10 mW/cm^2 for personnel exposure for 6 minutes or longer. Microwaves are also capable of inhibiting the action of demand pacemakers; if the heart should require stimulation while the pacemaker is inhibited by microwaves, the pacemaker would fail to pulse. The compatability of pacemakers and microwave ovens depends on limiting microwave radiations and reducing the susceptibility of the pacemakers. According to federal standards, microwave ovens manufactured after October 6, 1971 may not emit radiation in excess of 1 mW/cm^2 prior to sales nor radiation in excess of 5 mW/cm^2 throughout the useful life of the oven. Each oven must have a minimum of two safety interlocks, one of which must be concealed. The accumulation of dirt may also increase radiation hazards from microwave ovens. Present production model microwave ovens are equipped with door seals and interlock systems to prevent leakage. Guidelines are presented for the engineering evaluation of aircraft microwave oven installations.

0025 DUODENAL ULCER IN PERSONS OCCUPATIONALLY EXPOSED TO MICROWAVE RADIATION. *(E.)* Wroblewski, T. E. (Dept. Gen. Exp. Path., Med. Acad., Warsaw, Poland), K. Zarzecki and R. Denisiewicz. *Mater Med Pol* 5:209-212, 1973.

Studies were conducted on 93 patients with alimentary tract disorders who had been occupationally exposed to microwave radiation at densities of 10 to 100 mW/cm^2. Duodenal ulcers were found in 38% of these patients, with the greatest number of cases being found among patients aged 21 to 31 years who had been exposed to microwave radiation for 1 to 11 years. Neurotic symptoms were common among the patients with duodenal ulcer. The data indicate that vegetative neurosis plays an important role in the development of duodenal ulcer in persons exposed to high frequency radiation for long periods of time. The data also support the contention that microwave radiation causes a state of hypervagotonia, which plays an important role in the pathogenesis of duodenal ulcer.

0026 MICROWAVE HEATING OF THE UTERINE WALL DURING PARTURITION. *(E.)* Daels, J. (Dept. Obstetrics Gynecol., Marie Middelares Clinic, Ghent, Belgium). *Obstet Gynecol* 42(1): 76-79, 1973.

Microwave radiation at a dose of 80 to 100 MHz was applied to the uterine wall of 1000 patients during parturition. Of these patients, 962 reported a good analgesic effect in conjunction with an agreeable sensation of relaxation; 38 patients experienced only moderate attenuation. The microwave irradiation also significantly shortened the average duration of the dilation period during parturition. This shortening effect amounted to 108

minutes for primiparas and 43 minutes for multiparas, with the accerleration being localized mainly in the latent phase. The microwave treatment had no adverse effects on the neonate, and no important complications of the parturition or postpartum period were noted. The Apgar scores were significantly better among the irradiated patients than among a control group of patients.

0027 THE EFFECT OF CHRONIC, LOW-LEVEL MICROWAVE RADIATION ON THE TESTICLES OF MICE. *(E.)* Haidt, S. J. (Food Drug Admin., Bur. Radiol. Hlth., Rockville, Md.) and A. H. McTighe. *Proc Int Microwave Symp* (IEEE, New York City, N.Y.) June 1973, p 324-325.

Testicular damage occurred in 7 of 9 inbred mice exposed to 2.45 GHz continuous wave (CW) whole-body radiation at an average exposure of 6.5 mW/cm^2 for a total of 250 hr over a 2-month period. Rectal temperature remained unchanged following irradiation. Pathological examination showed various stages of tubular degeneration within lesions near the surface of the testicles. Within affected tubules, the cellular layers were disorganized and the normal spermatogenic cycle disrupted. In some cases, vaculose formation occurred and giant cells were present. The interstitium appeared congested and Setoli cells were prominent. Only 2 of 9 control animals showed similar testicular damage. Considering the spotty distribution of the damage, it is unlikely that infertility would result from chronic, low-level microwave radiation.

0028 CONTINUOUS EXPOSURE OF CHICKS TO ELECTROMAGNETIC FIELDS. *(E.)* Giarola, A. J. (Texas A. M. U., College Station) and W. F. Krueger. *Proc Int Microwave Symp* (IEEE, New York City, N.Y.) June 1973, p 337-338.

Homogeneity trials indicate that growth depressions previously reported in chicks exposed to a UHF field are from controlled environmental conditions. Power density measurements were obtained in a UHF facility operating at a frequency of 915 MHz. Measurements with an unloaded system yielded a value of approximately 550 $\mu W/cm^2$. Measurements with concentrated and spread loading (day-old-chicks) showed that power density decreases in proportion to loading. With spread loading, the maximum power density at the center of the cage was approximately 250 $\mu W/cm^2$. Water and feeder location may have been responsible for a "hot spot" at the center of the cage at a height of 9.5 cm from the floor. The power density at this point was equal to 900 $\mu W/cm^2$, more than 10 times smaller than the safe level of 10 mW/cm, which is based on thermal effects. It is concluded that the observed growth depressions resulted from "nonthermal" biological responses.

0029 THE EFFECT OF MICROWAVE RADIATION ON EVOKED TACTILE AND AUDITORY CNS RESPONSE IN CATS. *(E.)* Guy, A. W. (U. Washington Sch. Med., Seattle), J. C. Lin, and F. A. Harris. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) May 1972, p 120-124.

The evoked response of the thalamic somatosensory area and the thalamic auditory relay nuclei of the cat's brain was recorded with and without the presence of 915 MHz microwave radiation. The evoked responses were recorded continuously with microwaves alternately on and off for 15-min intervals over a total period of 6-12 hr. Stimuli were delivered once per sec. Decreases in amplitude and latency were generally accompanied by an increase in brain temperature caused by irradiation. Mean maximum absorbed power densities at which changes in amplitude and/or latency of tactile and auditory evoked responses were observed within the same range. Average temperature rises associated with these changes were around 1 C. This, together with the similarity of changes in the evoked potentials, strongly suggests that a thermal mechanism is responsible for the change. The mean threshold for latency and amplitude changes was about 5 mW/cm^3, corresponding to an incident power density of 5.9 mW/cm^2. To produce the same maximum absorbed power density in the human thalamus would probably require an incident plane wave power density of 10.1 mW/cm^2.

0030 EFFECT OF AN ULTRAHIGH-FREQUENCY ELECTROMAGNETIC FIELD ON PROCESSES OF ENERGY METABOLISM IN ANIMAL TISSUES. *(Rus.)* Mishchenko, L. I. (Inst. Ind. Hyg. Occupational Dis., Khar'kov, USSR). *Gig Tr Prof Zabol* 16:48-50, 1972.

The activity of oxidative phosphorylation, measured by the ratio of the decrease in phosphate to oxygen absorption, and the contents of AMP, ADP, and ATP were studied in the brain, heart, and liver of rats exposed to an ultrahigh-frequency (48 MHz) electromagnetic field. Rats were exposed for a total of 15-20 1-hr sessions to (1) an electrical field with an intensity of 800 volts/m or (2) a magnetic field with an intensity of 10 amps/m. Exposure to the ultrahigh-frequency electrical field significantly decreased the activity of oxidative phosphorylation in the heart, but had no appreciable effect on the brain or liver. The ATP content increased in the heart, while ATP and AMP contents tended to increase in the brain. These findings suggest that high-energy phosphate levels in the heart were maintained at an adequate level by an increase in the activity of compensatory mechanisms, primarily glycolytic ones. This is confirmed by the previous finding that the glycogen level decreased while lactate and pyruvate levels increased in the brain and blood of these animals. Changes in the brain can be accounted for by disturbances in the resynthesis of ATP from ADP. Exposure to the ultrahigh-frequency magnetic field increased coupling of oxidative phosphorylation and decreased the activity of oxidative processes in the brain. No appreciable changes occurred in oxidative phosphorylation in the heart or liver. The ATP content of the heart increased significantly and increases also occurred in the content of AMP in the brain (83%) and heart (30%). This might be due to a disturbance in the activity of processes, particularly deamination, in which AMP is broken down and may result

in changes in nitrogen metabolism. (7 references).

0031 EVALUATION OF EFFECTS OF THE MICROWAVE OVEN (915 AND 2450 MHz) AND RADAR (2810 AND 3050 MHz) ELECTROMAGNETIC RADIATION ON NON-COMPETITIVE CARDIAC PACEMAKERS. *(E.)* Bonney, C. H. (Radiobiol. Div., U.S.A.F. Sch. Aerospace Med., Brooks AFB, Tex.), P. L. Rustan, Jr. and G. E. Ford. *IEEE Trans Biomed Eng* BME-20(5):357-364, 1973.

Six cardiac pacemakers were implanted in canines of both sexes in which atrioventricular blocks had been surgically induced. The pacemaker pulse and the resulting ventricular depolarizations were monitored during exposure of the animals to microwave fields at frequencies of 915, 2450, 2810, and 3050 MHz. Aberrations in pacemaker function involved changes in rate (usually bradycardia with two instances of tachycardia) or complete inhibition (cut-off) of the pacemaker. At some modes, the pacemakers exhibited changes in function within a power-density "window"; exposure above or below the "window" produced no effects on pacemaker function. The following field parameters would be regarded as potential situations for complete pacemakers inhibition: 915-MHz-fields continuous- and sine-wave modulation at 120 Hz in field strengths over 75 V/m; and fields at either 2810 or 3050 MHz pulsed at a rate of 40 pulses per second or less with a field strength greater than 250 V/m.

0032 SANITARY HYGIENIC STUDIES OF WORKING CONDITIONS DURING HIGH-FREQUENCY HEATING. *(Rus.)* Nikogosian, S. V. (Erevan Med. Inst., USSR). *Zh Eksp Klin Med* 10(6):108-110, 1970.

Measurements were made of electromagnetic field intensities in working places where a variety of high-frequency generators were employed for heating. The generators produced frequencies ranging from 200-700 KHz and operated at 8-100 Kwatts. Field intensities ranged from 20 to 500 volts/m (for electrical components) and from 0.5 to 90 amps/m (for magnetic components). High field intensities resulted from lack of screening or inadequate screening of radiation sources (condensors, high-frequency transformers, feeder lines, inductors) and observation windows in the generator cabinet. The large differences in field intensities can be accounted for by differences in the designs of the generators. High field intensities were measured when an unscreened high-frequency transformer or condensor was located outside of the generator cabinet. Field intensities reached 350 volts/m and 90 amps/m near unscreened high-frequency transformers and 1600 volts/m and 10 amps/m near unscreened condensors. These values greatly exceed maximum permissible limits established in the Soviet Union (20 volts/m and 5 amps/m). (3 references)

0033 EFFECT OF A PULSED ULTRAHIGH FREQUENCY ELECTROMAGNETIC FIELD ON SERUM CHOLESTEROL CONCENTRATIONS IN RABBITS. *(Rus.)* Todorov, N. (Higher Med. Inst., Sofia, Bulgaria) and V. Draganov. *Patol Fiziol Eksp Ter* 17:53-54, 1973.

Serum cholesterol levels were measured in 31 Chinchilla rabbits before and 1, 2, and 3 hr after exposure to ultrahigh frequency pulsed current directed to the brain. A power of 30 watts was employed, and rabbits were exposed for 5 min. Ten nonirradiated rabbits served as controls. In irradiated rabbits the serum cholesterol levels increased from a mean of 94.0 mg/100 ml to a mean of 119.0 mg/100 ml 1 hr after irradiation. Cholesterol concentrations increased further to a mean of 125.0 mg/100 ml after 2 hr and returned to normal after 3 hr. These findings indicate that exposure of rabbits to pulsed short waves "knocks out" cholesterol from the brain and into the blood. (13 references)

0034 EFFECT OF ELECTROMAGNETIC FIELDS AND PARAFFIN APPLICATIONS ON PANCREATIC SECRETION. *(Rus.)* Korepanov, A. M. (No affiliation) and R. V. Bazhenova. *Kazan Med Zh* (6):79-80, 1973.

Spontaneous pancreatic secretion was measured in 161 patients (83 women and 78 men, aged 17-58 yr) before, during, and after application of paraffin or a single 30-min exposure to inductothermy or ultrahigh frequency (UHF) radiation directed over the pancreas. Patients had clinical signs of chronic cholangiohepatitis (118 cases), chronic gastritis with hypochlorhydria (31 cases), and duodenal ulcers (12 cases). Paraffin was applied at temperature of 50-55 C. Inductothermy (13:56 MHz) was given with a small disc inductor operated at 120-180 ma for oligothermal doses and at 250-300 ma for thermal doses. UHF radiation was generated with a UHF-4 apparatus operated at 40 watts for oligothermal doses and at 80 watts for thermal doses. While paraffin applications had no appreciable effect on pancreatic secretion, inductothermy and UHF radiation, administered in oligothermal doses, significantly increased the volume of pancreatic secretion and the carbonate alkalinity. Inductothermy significantly increased trypsin and diastase activities, while UHF radiation significantly increased lipase activity. Thermal doses of inductothermy and UHF radiation suppressed pancreatic secretion and, in the case of inductothermy, increased enzyme secretion. No relationship was found between the results obtained and the nature of the patient's disease. It is recommended that inductothermy and UHF radiation be used in oligothermal doses in the treatment of disorders in which exocrine pancreatic secretion is depressed. These procedures should not be used to treat patients with subclinical or latent pancreatitis, particularly since high-frequency electromagnetic radiation has been found to cause changes in the trypsin inhibitor system in the blood. (No references).

0035 HEALTH ASPECTS OF EXPOSURE TO ELECTROMAGNETIC FIELDS IN THE SUPERHIGH FREQUENCY RANGE. *(Rus.)* Troianskii, M. P. (No affiliation). *Gig Sanit* 37:87-92, 1972.

People may be exposed to high frequency, ultrahigh

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frequency, or superhigh frequency radiowaves from improperly designed generators or from powerful antennae systems. Superhigh frequency (microwave) radiation is the most common type because of the widespread use of this radiation in industry. More than 1000 foreign and Soviet articles have been devoted to the study of its biological effects on the nervous, cardiovascular, and other systems. These effects are cumulative and reversible because of the body's ability to adapt. Animal experiments have demonstrated that adaptation occurs most rapidly in the cerebral hemispheres but occurs much more slowly in other systems, particularly the digestive system. Decimeter waves are the most harmful. In the Soviet Union, the maximum permissible intensities for occupational exposure to the superhigh-frequency range (300-300,000 MHz) are: 10 μwatt/cm^2 for the entire work day, 100 μwatt/cm^2 for 2 hr exposure or less, and 1000 μwatt/cm^2 for 15-20 min/day exposure. The use of protective glasses is required. For subjects who are not occupationally exposed to microwave radiation and for the population surrounding sources of microwave radiation, the intensity of radiation should not exceed 1 μwatt/cm^2. (13 references)

0036 COMPARATIVE EVALUATION OF THE HEALTH OF WORKERS EXPOSED TO MICROWAVE RADIATION OF DIFFERENT INTENSITIES. *(Rus.)* Sadchikova, M. N. (Inst. Ind. Hyg. Occupational Dis., Moscow, USSR) and K. V. Nikonova. *Gig Tr Prof Zabol* 15:10-13, 1971.

Physical examinations were given to (1) 100 workers (83 men and 17 women) who had been exposed to high intensities (up to several milliwatts/cm^2) of microwave radiation for 1-10 yr and (2) 115 workers (91 men and 24 women) who had been exposed to less than several hundredths of a milliwatt/cm^2 for short periods over 1-10 yr. All of these workers were employed in the control, adjustment, and testing of equipment in radar stations; about 3/4 were less than 40 yr old, and about 80% had been employed in these stations for 5-10 yr. These results were compared to those obtained on 100 men who were less than 40 yr old, were employed in similar occupations, but had not been exposed to electromagnetic radiation. Clinical symptoms commonly found in workers exposed to microwaves included heaviness of the head, fatigue, somnolence, irritability, decreased memory, and cardialgia. These symptoms were most common and most pronounced in group (1). Autonomic vascular disorders occurred in both groups (1) and (2), but were more common in group (2). They consisted of dermographia, hyperhidrosis, labile arterial pressure with a tendency to hypertension, and vascular disorders of the retina. Hypertension was rare in all of the 3 groups examined. ECG tracings revealed that bradycardia and distrubances in intraventricular conduction were significantly more common in groups (1) and (2) than in controls. These findings confirm that exposure to microwaves, even at very low intensities, has a deleterious effect, particularly on the nervous and cardiovascular systems. (12 references)

0037 MICROWAVE THERAPY FOR PATIENTS WITH HYPERTENSION. *(Rus.)* Fastykovskii, A. D. (Kiev Inst. Postgrad. Med., USSR). *Vopr Kurorotol Fizioter Lech Fiz Kult* 37:317-320, 1972.

Microwaves, directed above shoulder level, were used to treat 63 patients with hypertension (stages I and II). Microwaves produced by a centimeter-wave generator and a rectangular emitter of the wave guide type were used at a power density of 0.09-0.18 watts/cm^2 for 10 min/day for a total of 12-15 sessions. With the exception of 6 patients who had severe hypertension and severe disturbances in cerebral or coronary blood flow and who were given doses of 20-30 watts for the first 3-4 days, all patients received doses of 45-50 watts. After completing the course of microwave therapy, headaches had disappeared in 28 and decreased in severity in 24 of 56 patients; noises in the ears had disappeared in 14 and decreased in intensity in 3 of 25 patients; angina pectoris had disappeared in 15, decreased in severity in 21, and remained unchanged in 4; dyspnea had disappeared in 15 and decreased in severity in 4 of 33 patients; sleep was normalized in 14 and improved in 13 of the 35 patients who had complained of difficulties. Increased pressure in the brachial arteries, which was observed in 58 patients before therapy, had normalized in 13, decreased in 39, and remained unchanged in 5. Asymmetry in arterial pressure disappeared in 15 of 32 patients. Microwave therapy also caused neurological improvement (tendon reflexes, tremors, Romberg's sign, dermographism, sucking reflex, Marinesco's reflex, etc.). Cardiac rhythm normalized in 17 of 24 patients who had initially had disturbances; signs of intraventricular disorders in conduction decreased in intensity in 27 of 31 patients; improvements occurred in myocardial contractility in 27 of 43 patients; the position of the electrical axis of the heart normalized in 9 of 29 patients; some decrease in enlargement of the left side of the heart occurred in 14 of 17 patients; and signs of chronic coronary insufficiency disappeared in 9 and decreased in severity in 30 of 49 patients. At discharge, 17 patients showed significant improvement, 22 had improved, 19 had improved slightly, and 3 remained unchanged. The best results were obtained on patients with stage I hypertension. (No references).

0038 CHANGES IN ELECTROGASTROGRAPHIC PARAMETERS IN PATIENTS WITH PEPTIC ULCERS AFTER COMBINED THERAPY IN WHICH MICROWAVE RADIATION WAS USED. *(Rus.)* Chistiakova, N. S. (Central Clin. Hosp., 4th Chief Administrative Office, Ministry Hlth., Moscow, USSR), L. A. Skurikhina, Z. K. Mamaeva and A. D. Arapova. *Vopr Kurortol Fizioter Lech Fiz Kult* 37:341-344, 1972.

Electrogastrograms (EGG) were traced before and after treatment in 40 patients and after simulated exposure to microwaves in 12 patients with gastric and duodenal ulcers. Most of these patients were men, aged 25-60 yr, who had exacerbations (37 cases) of acute, recurrent, or chronic peptic ulcers. Microwave therapy (no further details) and drugs (unspecified) were administered to 30 patients, while 10 received drugs alone. EGG changes were observed in 25 patients before treatment. They consisted of increases in amplitude in 18 and decreases in am-

plitude in 7. More than one-third of the tracings contained irregularities, arrhythmic variations, and pathologically deformed spikes. Increased electrical activity was observed in 12 of the 18 patients with recurrent duodenal ulcers, while decreases occurred primarily in patients with recurrent and chronic gastric and duodenal ulcers. After combined microwave and drug therapy, electrical activity had normalized in 14 and improved in 4 of the 19 patients who initially showed abnormalities; the rhythm also normalized in one-half of the patients in this group. Ulcer healing had occurred in all 14 patients in whom electrical activity normalized and in 3 of the 4 patients with improved EGG tracings. After drug treatment alone, EGG tracings normalized in only 1 and improved in 4 of 10 patients; small changes occurred in the biopotential and mean amplitude, and no appreciable change occurred in the rhythm. No changes in EGG biopotentials occurred in the patients subjected to "sham" microwave therapy. Two illustrative case reports are presented. (6 references)

0039 EFFECT OF ANTIOXIDANTS ON PROTEIN METABOLISM AFTER MICROWAVE IRRADIATION. *(Rus.)*

Koldaev, V. M. (I. P. Pavlov Med. Inst., Ryazan, USSR). *Vopr Kurortol Fizioter Lech Fiz Kult* 36:246-248, 1971.

To determine the effects of antioxidants on the concentrations of serum proteins and labile globulins after microwave irradiation, cystamine dihydrochloride (130 mg/kg i.p.) was injected in noninbred male albino rats 10 min before they were exposed to a single dose of microwave radiation (power density of 140-160 milliwatts/cm^2 for 12 or 24 min). Cystamine alone had no appreciable effect on serum protein concentrations, and radiation alone produced relatively minor changes in the concentrations of serum albumins and β-globulins. When cystamine was injected before 12-min exposure to microwave radiation, significant decreases were observed in the concentrations of serum albumins and α_1-globulins, while serum β- and γ-globulins were increased 3 min after radiation. Although serum albumin and α_2-globulin concentrations had almost normalized 24 hr after irradiation, the concentrations of other serum protein fractions still differed appreciably from control values. Similar results were obtained when rats were irradiated for 24 min. While cystamine alone had little effect on concentrations of labile globulins (primarily the β- and γ-globulin fractions) in the serum, 12-min exposure to microwaves increased labile globulin concentrations 1.35-fold 3 min after irradiation. Labile globulin concentrations increased 2-fold 3 min after irradiation and were still increased 1.6-fold 24 hr after irradiation when cystamine was injected before exposure to microwaves. Similar results were obtained when rats were exposed to microwaves for 24 min. These results indicate that greater changes occur in protein metabolism when cystamine is injected before irradiation than with irradiation alone. (4 references).

0040 MICROWAVE THERAPY IN THE COMBINED TREATMENT OF PATIENTS WITH ACUTE PNEUMONIA. *(Rus.)*

Nesmenianova, E. I. (Munic. Clin. Hosp., Vladivostok, USSR). *Vopr Kurortol Fizioter Lech Fiz Kult* 37:345-347, 1972.

Microwave therapy, combined with other forms of treatment (sulfonamides, antibiotics, cardiovascular agents, and vitamins), was administered to 79 patients (62 men and 17 women, aged 17-70 yr) with pneumonia. Complications were present in 8 cases: toxic hepatitis in 3 and intralobular pleuritis in 5. Associated diseases included coronary and cerebral atherosclerosis, chronic coronary insufficiency (stage I), hypertension combined with atherosclerosis, duodenal ulcers, periduodenitis, postgastrectomy syndrome and others. A control group of 30 pneumonia patients received the same treatment with the exception of microwave therapy. The microwave emitter, 14 cm in diameter, was placed 5-7 cm away from the chest. Patients were exposed for 15-20 min/day for 10-14 days using a flux of 50-60 watts. After irradiation the skin temperature had increased by 1-4 C. Symptomatic improvement, which occurred more rapidly than in the control group, was evident in most patients after 3-7 sessions of microwave therapy. After the course of therapy had been completed, radiological signs of pneumonia had disappeared in 56 of the 79 patients. Residual changes were observed in 23 patients including 3 chronic alcoholics, 4 who had been hospitalized late in the disease, and 7 with croupous pneumonia which developed against a background of chronic pneumonia. In the control group, radiological signs of pneumonia disappeared only after 15-17 days, even in those who had no complications. After completion of microwave therapy the minute respiratory volume, vital capacity, and maximum pulmonary ventilation had normalized 68-87% of the 69 patients in whom these values were measured. No deleterious changes occurred in the cardiovascular system, and improvement in the ECG occurred in 6 of 13 patients with signs of myocardial hypoxia. (3 references)

0041 THE ACTION MECHANISM OF MICROWAVE THERAPY IN OPHTHALMOLOGIC PRACTICE. *(Rus.)*

Grechushkina, V. A. (Helmholtz Inst. Eye Dis., Moscow, USSR). *Vopr Kurortol Fizioter Lech Fiz Kult* 37:337-341, 1972.

Small doses of microwaves were used to treat 19 patients with acute disturbances in retinal circulation and 51 patients with macular degeneration classified as senile degeneration (19 cases), congenital degeneration (5), central myopic chorioretinal degeneration (17), trauma (5), and degeneration due to other causes (5). Patients were exposed to microwaves for 15 min/day or on alternate days (up to 20 sessions) with doses which produced increases of 0.5-0.6 C in the eyes of rabbits but were unlikely to increase temperatures within the less sensitive human eye. In patients with disturbances in retinal circulation the rate at which bleeding and plasmmorrhagic were resolved and with which retinal edema disappeared were increased by microwave therapy. Visual acuity improved in 18 of the 19 patients. The best results were obtained in patients with vascular spasms and thrombosis of the central artery of the retina and its branches followed by patients with thrombosis in branches of the central vein of

the retina. Scotoma completely disappeared in seven patients and absolute scotoma became relative in five. Microwave therapy produced improvements in visual acuity in 49 of the 51 patients with macular degeneration; improvements in the nonirradiated eye occurred in 32 of the 41 patients with bilateral degeneration. Microwave therapy was most effective in patients with recent degeneration, and the best results were obtained on patients with recent traumatic bleeding in the macular region; no effect was observed in patients with macular fibrosis resulting from past bleeding. Absolute scotoma disappeared completely in 20 patients, became relative in 10, and was definitely less pronounced in 33. Bleeding was completely resorbed in 18 of 26 patients and was considerably reduced in its extent in five; two patients developed some greenish pigmentation. From measurements made on 56 patients from both groups it was shown that microwave therapy reduced arterial pressure by 5-10 mm Hg in normotensive patients and by 10-15 mm Hg in hypertensive patients. Increased intraocular pressure, which was detected in several patients before therapy, generally decreased by 3-4 mm Hg to normal values. In nine of the ten patients examined by rheoopthalmologic methods it was found that microwave therapy increased the volume pulse by an average of 50%, while only a 24% increase was observed in the nonirradiated eye. The index for the elasticity of the vascular walls increased by an average of 41% in the irradiated eye and only by 27% in the nonirradiated eye. Photocalibrometry, used to examine four patients from both groups revealed that arteries in the irradiated eye were dilated by 8-25μ. This dilatation reached a maximum 45-60 min after irradiation. These findings suggest that microwaves have a vasodilating action which improves retinal circulation and the blood supply of the retina.

0042 SIGNIFICANCE OF MICROTHERMAL EFFECTS DERIVED FROM LOW LEVEL UHF-MICROWAVE IRRADIATION OF THE HEAD: INDIRECT CALORIC VESTIBULAR STIMULATION. *(E.)* Lebovitz, R. M. (U. Texas Southwestern Med. Sch., Dallas). *J Theor Biol* 41:209-221, 1973.

Analysis of the effects of incident low level UHF microwave irradiation of the head suggests that biochemically significant microthermal effects are unlikely. However, small local thermal effects could be neurophysiologically significant. It is hypothesized that low level microwave radiation can lead to indirect input to the CNS via anomalous activity of sensory specializations in the vestibulo-cochlear apparatus. It is estimated that microwave irradiation at incident power densities of about 40 mW/cm^2 can be detected by humans via the vestibular coupling effect. If this is true, personnel who work with microwave equipment might be able to use this vestibular sensation as an early warning of possibly harmful exposure. This vestibular effect could probably mediate a variety of cardiorespiratory reflexes and evoked potentials in portions of the nervous system. It would offer an alternate explanation for many effects which are called "nonthermal or direct" effects of microwaves. In small animals microwaves might produce an intralabyrinthine resonance effect which would significantly increase the magnitude of the induced vestibular stimulus. (21 references)

0043 POSSIBLE MECHANISMS FOR THE BIOMOLECULAR ABSORPTION OF MICROWAVE RADIATION WITH FUNCTIONAL IMPLICATIONS. *(E.)* Rabinowitz, J. R. (New York U. Med. Ctr., New York, N.Y.). *Proc Int Microwave Symp* (IEEE, New York City, N.Y.) June 1973, p 314-315.

Theoretical analysis of the possible modes of molecular interaction with microwave radiation suggests that absorption of a microwave photon may interfere with stereospecific biomolecular processes. The absorption of the photon by a molecular segment would increase its rotational energy. As a result, the segment might be a state that is localized in more than one potential well, like states C and D, and re-emission of the photon may result in its rotation being localized in a well different from the initial well. Or the segment may be excited to a state like B, still confined to the same potential well but with enough energy to greatly increase the possibility of tunneling to another wall. Both of these effects lead to the same type of structural changes: covalent molecular structure remains unchanged but the relative position of one segment of the molceule with respect to the remainder of the molecule is altered. The effect of microwave radiation on stereospecific biomolecular processes would probably be frcquency dependent, and if allowed a long enough time, reversible.

0044 A NONPERTUBING TEMPERATURE SENSOR FOR MEASUREMENTS IN ELECTROMAGNETIC FIELDS. *(E.)* Rozzell, J. T. (Office Naval Res., Arlington, Va.), C. C. Johnson, C. H. Durney, J. L. Lord, and R. G. Olsen. *Proc Microwave Power Symp* (Inst. Microwave Power, Canada) Sept. 1973, p 2B4/1-2B4/2.

An electro-optical temperature measuring device which neither perturbs electromagnetic fields nor causes hot spots has been developed for use in monitoring temperature in biological systems during electromagnetic radiation. The probe is constructed entirely of dielectric material. A plastic sheath enclosed two fiberoptic bundles which transmit to and receive light from the top. A dielectric colorimetric temperature-sensitive tip alters the light reflected in the receiving fiberoptic bundle and provides a light level proportional to tip temperature. A pulsed gallium arsendide phosphide light-emitting diode (LED) is closely coupled to the proximal tip of the transmitting fiberoptic bundle. A silicon photodiode is coupled to the receiving fiberoptic bundle and generates a voltage proportional to reflected light level. The LED is pulsed at 200 Hz with a 10 microsec pulse length. A sample/holed circuit receives the reflected pulse height and generates a d.c. voltage which is detected and amplified.

0045 EFFECTS OF MODULATED VERY HIGH FREQUENCY FIELDS ON SPECIFIC BRAIN RHYTHMS IN CATS. *(E.)* Bawin, S. M. (Dept. Anat., U. California,

Los Angeles), R. J. Gavalas-Medici and W. R. Adey. *Brain Res* 58:365-384, 1973.

The effects of exposures to low intensity (1 mW cm^2 or less), very high frequency (VHF) (147 MHz) electrical fields, amplitude-modulated at biological frequencies (1-25 Hz), were studied on untrained and conditioned chronically implanted cats. The fields were applied between two aluminum plates (identical voltages, 180° phase shift) firmly anchored to the floor of an isolation booth, especially designed for use with VHF fields. The animals were restrained in a hammock, the longitudinal axis of the body being kept parallel to the field plates. EEG and EOG were recorded through a system of low pass filters on a Model 6 Grass electroencephalograph and an Ampex FR 1100 tape recorder; behavior was continuously observed through a closed circuit TV. A series of animals was operantly trained to produce specific transient brain rhythms following periodic (every 30 sec) presentations of a light flash stimulus. The levels of performance were established (visual and spectral analysis) during conditioning and extinction schedules for a series of cats submitted to VHF fields amplitude-modulated at the dominant frequencies of the selected transient patterns and for a control group in the absence of fields. The irradiated animals differed markedly from the control group in the rate of performance, accuracy (in terms of frequency bandwidth) of the reinforced patterns and resistance to extinction (minimum of 50 days *versus* 10 days). The specificity of the frequency of the modulation was tested on another group of untrained animals where spontaneous transient patterns were used to trigger for short epochs (20 sec following every burst) the VHF fields amplitude-modulated at various frequencies. The experimental results indicated clearly that the fields were acting as reinforcers (increasing the rate of occurrence of the spontaneous rhythms) only when modulated at frequencies close to the biologically dominant frequency of the selected intrinsic EEG rhythmic episodes.

0046 EFFECT OF VERY HIGH FREQUENCY (RADAR) ELECTROMAGNETIC RADIATION ON THE CENTRAL NERVOUS SYSTEM IN THE ALBINO RAT. ELECTROCORTICOGRAPHIC CHANGES. *(Fr.)* Bertharion, G. (St. Anne HIA, Toulon, France), B. Servantie and R. Joly. *C R Soc Biol (Marseille)* 165(9/10):1928-1930, 1971.

Profound changes were found in electrocorticographic tracings made on age- and weight-matched Charles River France rats exposed to very high frequency (VHF) radiation with a power flux density of 5 ± 2 mW/cm^2 for 7 days, 1 month or 5 months. Many paroxysmal bursts, consisting of the appearance of points and even point-wave complexes were found, particularly in the occipital lead. A pointed θ rhythm with some isolated slow waves appeared in the occipital lead; this may be a manifestation of brain damage. Paroxysmal bursts began to appear in both the frontal and occipital leads after 48 hr exposure to VHF radiation. Within 48-72 hr after the rats had been removed from the source of radiation, electrocorticographic tracings returned to normal in all irradiated animals. It is hypothesized that VHF radiation acts on the cortex, either directly or indirectly, by reticular stimulation. Exposure to VHF radiation may trigger an ascending activator system in the reticular formation which predominates over the descending inhibitor system. (No references)

0047 EFFECT OF HIGH-FREQUENCY ELECTROMAGNETIC FIELD UPON HAEMOPOIETIC STEM CELLS IN MICE. (^{59}Fe INCORPORATION/SPLEEN CELLS/BONE MARROW/SPLEEN-COLONY ASSAYS). *(E.)* Rotkovska, D. (Inst. Biophysics, Czechoslovak Acad. Sci., Brno) and A. Vacek. *Folia Biol (Praha)* 18(4):292-297, 1972.

The effect of a single, whole-body exposure to high frequency (2450 MHz) electromagnetic radiation (HFR) (intensity 100 mW/cm^2, wave length about 12.5 cm) for 5 min on spleen and bone marrow ^{59}Fe incorporation and endogenous and exogenous spleen colony assays was investigated in intact, adrenalectomized, and sham-operated 7-week-old female C57Bl mice. Exogenous spleen colony assays were performed 10 days after exposure to 700 r of x-rays followed, 2 hr later, by injection of donor spleen cells. Endogenous spleen colony counts were made in mice 10 days after exposure to x-rays preceded 14, 3, 2, and 1 day and 5 min by exposure to HFR. HFR caused a transient increase in ^{59}Fe incorporation by the bone marrow and spleen and in the number of exogenous spleen colonies. This increase was followed, 24 hr later, by a decrease and then a gradual increase. After 14 days ^{59}Fe incorporation in the spleen was significantly greater than in controls, but bone marrow values did not differ appreciably from control values. The number of exogenous spleen colonies was significantly higher in irradiated mice than in controls 48 and 72 hr after exposure. Statistically significant increases in the number of endogenous spleen colonies were observed only 14 days after exposure to HFR. No differences were found in the patterns of ^{59}Fe uptake by the spleen in intact, sham-operated, and adrenalectomized mice. Exposure to HFR protected mice against exposure to sublethal doses of x-rays (600 r). While only 14% of the controls survived for 30 days, exposure to HFR increased 30-day survival to 53%, 88%, and 90%, resp. when given 24 hr, 3 days, and 14 days, resp. before x-irradiation. These findings suggest that increased ^{59}Fe incorporation and the number of exogenous and endogenous spleen colonies are probably a reflection of intense regeneration of hematopoietic tissue caused by a loss of stem cells resulting from exposure to HFR. The adrenal gland is not directly involved in the action mechanism of early hemopoietic changes. (16 references)

0048 EFFECT OF A LOW-FREQUENCY IMPULSE MAGNETIC FIELD ON THE ACTIVITY OF OXIDATION-REDUCTION ENZYMES IN ALBINO RAT LIVER. (HISTOCHEMICAL STUDY). *(Rus.)* Iashina, L. N. (Inst. Industrial Hyg. Occupational Dis., Khar'kov, USSR). *Gig Tr Prof Zabol* 16:53-56, 1972.

Adult male Wistar rats were exposed to an impulse magnetic field with an intensity of 24 or 72 ka/m (300 or 900 oersteds, resp.), a frequency of 7 KHz, an impulse duration of 130 microsec, and an inter-