The relationship between what types of research are supported and the socio-political milieu of funding agencies is discussed. Past and future programs are used as examples of how emphasis is, or could be, altered by the changing philosophies of the federal establishment. An attempt is made to demonstrate how the operating philosophies of past decades have dampened the desire and ability to investigate electromagnetic energy coupling with biologic material. Some implications of adhering to these trends for the scientific community and for the public are outlined.

5342 AN INVESTIGATION OF THERMISTORS FOR TEMPERATURE MAPPING OF BIOLOGICAL SPECIMANS DURING EM RADIATION (MEETING ABSTRACT). *(Eng.)* Toler, J.; Burdette, E.; Seals, J.; Cain, F. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by the International Union of Radio Science & The U.S. Committee for URSI held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 6; 1977. (0 refs)

A series of experiments was undertaken to determine the suitability of bead thermistors as thermometric devices. Such devices have not been widely used for bioeffects studies because of the possibility of excessive interaction with electromagnetic (EM) fields. The accuracy and repeatability of temperature data provided by both standard and micro-miniature thermistors were examined. The thermistors had conventional leads, and the frequency of radiation was 2,450 MHz. Variables included EM field-strength, thermistor location, cannula configuration, and electrical properties of the implanting medium. The results reveal that, for many studies of biologic effects, bead thermistors provide accurate and repeatable temperature data.

5343 RESPONSE OF INSULATED ELECTRIC-FIELD PROBES IN MODELS OF HETEROGENEOUS BIOLOGICAL BODIES (MEETING ABSTRACT). *(Eng.)* Mousavinezhad, H.; Chen, K. M.; Nyquist, D. P. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 10; 1977. (0 refs)

The response of an idealized spherical metallic probe, insulated by a dielectric layer and immersed in a semiconducting biologic body (both spherical and concentric with the probe) was studied. The idealized probe was representative of more general electric-field probes. Analytic expressions for the effective diameter d_{eff} and equivalent impedance Z_{eq} of the probe were determined in terms of the radii and electric parameters of the insulating layer and of the finite body. Numeric results indicated that variations of the probe's parameters d_{eff} and Z_{eq} (calibration factor) were minimized by coating the probe with a relatively thick insulating layer of low permittivity. Comparison of theoretically calculated induced-power-density distribution with those measured by an insulated spheric probe in a finite volume of saline solution revealed excellent agreement at all locations in the solution. The relative constancy of the calibration factor for the insulated probe was therefore confirmed.

5344 CARBON ELECTRODES FOR CHRONIC EEG RECORDINGS IN MICROWAVE RESEARCH (MEETING ABSTRACT). *(Eng.)* Chou, C. K.; Guy, A. W. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 11; 1977. (0 refs)

Conventional metal electrodes can cause serious modification and intensification of rate of energy absorption in tissues during exposures of animals to microwaves. Carbon-impregnated Teflon with a conductivity close to that of tissue was implanted and maintained for 4 to 6 mo in rabbits at cortical and subcortical locations. The electroencephalogram (EEG) and its spectrum, as recorded from the carbon electrodes, were comparable to those recorded from conventional metal electrodes. Histologic examination showed good tissue compatability. Recordings during acute microwave radiation (2,450 MHz) at 100 mW/cm^2 showed no interference. The results indicate that carbon electrodes can be implanted chronically to record the EEG in animals during microwave radiation.

5345 VARIABILITY IN MICROWAVE MEASUREMENTS OF CATARACTOGENIC THRESHOLD (MEETING ABSTRACT). *(Eng.)* Hagan, G. J.; Donovan, G. L.; Carpenter, R. L. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: p. 13; 1977. (0 refs)

Measurements of identical microwave fields were performed under identical conditions using several different instruments. Measurements were made in a large, electrically anechoic chamber with continuous wave radiation at 2.45 GHz. The instruments tested were four Narda Model-8100 radiation meters with five Model-8122A probes, two Narda Model-8315 broadband-isotropic radiation monitors with Model-8323 probes, and one Holaday HI-1500 microwave survey meter. Power-density values yielded by two of the Narda-8100 meters, which were calibrated just before use, served as a standard of comparison for the other instruments, which had been calibrated at various times during the previous 20 mo. In the far-zone field, 150 cm from a horn antenna, each set of probes and meters that had been calibrated together,

were tested. Their readings varied 0.4 to 37.7% from the standard. Near-zone fields were measured 5 cm in front of the Director "C" dipole-antenna applicator of a Raytheon Microtherm diathermy unit. Readings of power density at this position with the Narda Model-8122A probes were significantly lower (30%) than those of the Model-8323 probes. The difference may have been due to the differing size of the probes' sensors or to a longitudinal (or radial) component in the field of the Director "C" that was not detected by the Model-8122A probe. Rotating a probe around its long axis and taking meter readings at each 90 degrees of rotation resulted in deviations that were more pronounced for measurements in the near-zone.

5346 MINIATURE ANECHOIC CHAMBER FOR CHRONIC EXPOSURE OF RODENTS TO PLANE-WAVE MICROWAVE FIELDS (MEETING ABSTRACT). *(Eng.)* Guy, A. W. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 16; 1977. (0 refs)

An economic system was developed for exposing large numbers of rodents to 2,450-MHz plane waves on a long-term basis without disturbing their normal living patterns. Individual miniaturized anechoic chambers provided a relatively constant and easily quantifiable coupling of microwave fields to each animal. A food-and-water dispensing system was designed to prevent the introduction of artifacts when the animal ate or drank.

5347 CIRCULARLY POLARIZED 2450-MHZ WAVEGUIDE SYSTEM FOR CHRONIC EXPOSURE OF RODENTS (MEETING ABSTRACT). *(Eng.)* Guy, A. W.; Wallace, J. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 17; 1977. (0 refs)

A system that was previously developed to expose a large number of rodents to 915-MHz circularly polarized fields was modified to operate at 2,450 MHz. Specially designed transducers were retrofitted to each end of the original exposure system, and the probes and hybrid transducers normally required to operate the system at the lower frequency were removed. The conversion of each exposure cell to another frequency of operation was accomplished in a few minutes. The performance of the cells at 2,450 MHz in terms of coupling efficiency and low input VSWR was found superior to that obtained at 915 MHz.

5348 IMPROVING FAR-FIELD UNIFORMITY IN NONIDEAL MICROWAVE ANECHOIC CHAMBERS BY ADDING ABSORPTIVE COLLAR TO FEEDHORN (MEETING ABSTRACT). *(Eng.)* Olsen, R. G.; Lotz, W. G. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 18; 1977. (0 refs)

Improved uniformity of far-field power density by the addition of microwave-absorbing feed-horn collars is described. The addition of an absorptive collar around the aperture reduces the unwanted interference resulting from the use of fixtures and/or instruments that must be located in the irradiation chamber. While the collar contributes some interference of its own, the net result is a significant improvement in the uniformity of the distribution of far-field power densities. Two microwave chambers were analyzed. One chamber contained video and lighting equipment; and the other, in addition, an overhead motorized x-y scanning apparatus. It is hypothesized that horn collars improve uniformity of radiation in the far-field by reducing side-lobe radiation.

5349 LONG-TERM MICROWAVE EXPOSURE OF MARINE ANIMALS MALS (MEETING ABSTRACT). *(Eng.)* McRee, D. I. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 19; 1977. (0 refs)

Long-term (1- to 2-mo) studies of the effects of microwaves on the behavior of the marine mollusc *Aplysia californicus*, were performed using three groups of animals (of four animals each) at three different microwave levels (20.0, 2.0, and 0.0 mW/g at 2,450 GHz continuous wave) within the same 25-gallon aquarium. The animals were placed in flat (less than 2-cm thick) plastic screen cages that were suspended at different distances (1.0 cm, 3.0 cm, and 15.0 cm with respect to the mid-cage plane) from the front window of the aquarium on which microwave energy was incident (from a standard gain horn located 1.2 m away). Microwave energy reflected from the front of the aquarium was controlled by the "Eccosorb" lining of the chamber. Since mollusc tissue is similar electrically to sea water (as confirmed by reflectometric measurements), no reflection occured within the aquarium, and the animals did not cast "absorption shadows" over one another. The specific absorption rate for any volume could be computed irrespective of the animals' location (or even their presence). This exposure system also provided thermal stability in the face of large inputs of microwave energy. The thermostatistically-regulated cooler built into the aquarium was able to dissipate a maximum of 1,000 W at a temperature swing of 2 C or less. Furthermore,

since the circulating sea water acted as an efficient heat exchanger, the steady-state temperature differences among groups of animals could be kept to 1 C or less. It is concluded that this system overcomes many of the dosimetric difficulties encountered in the long-term microwave radiation exposure of terrestrial animals.

5350 A SYSTEM FOR THE EXPOSURE OF LARGE NUMBERS OF SMALL LABORATORY ANIMALS TO 60-HZ ELECTRIC FIELDS (MEETING ABSTRACT). *(Eng.)* Kaune, W. T.; Decker, J. R.; Phillips, R. D.; Hjeresen, D. L. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 20; 1977. (0 refs)

Two systems for exposure and sham-exposure of large numbers of rats and mice to uniform vertical 60-Hz electric fields were constructed. The rat system contained four racks of four rectangular 1.0 x 2.2 m exposure-electrodes stacked vertically with a 0.41 m separation between adjacent electrodes. Any two of the four exposure racks could be energized to a maximum field strength of 150 kV/m. Each exposure electrode was equipped with 24 Lexan cages, each of which housed a single rat. The cage floor was a stainless steel screen that served as one electrode. The system for watering animals was contained entirely within the electrode and did not protrude above the cage's floor, thereby preventing distortion of the exposure field and electrical shock or discharge as the animals drank. The total capacity of the system was 288 rats. A similar system of two racks of five electrodes each was used to expose as many as 450 mice to fields at a maximum strength of 150 kV/m while sham-exposing an equal number. Measurements of the electric field revealed an overall uniformity within 4% over the area to be occupied by experimental animals. The field inside a Lexan cage was reduced by about 3%. No corona-discharge was detected. Measurements of ozone concentration in the rat and mouse exposure systems did not differ from background levels. Harmonic distortion was eliminated by damping and filtering the high-voltage supply. Animals housed in close proximity were partially shielded from the electric field; the total body current in a rat model was reduced by 35 ± 5% when rats were placed in adjacent cages.

5351 A SYSTEM FOR CONTINUOUS EXPOSURE OF MINIATURE SWINE TO 60-HZ ELECTRIC FIELDS (MEETING ABSTRACT). *(Eng.)* Gillis, M. F.; Allen, C. H.; Beamer, J. L.; Jeffs, T. W.; Decker, J. R.; Phillips, R. D. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 21; 1977. (0 refs)

A facility was constructed for the long-term study of effects of uniform vertical 60-Hz electric fields on miniature swine, including an environmentally similar enclosure for control animals maintained in a zero-level field. Exposure of this genealogically homogeneous generation was begun at 30 kV/m and progressed on a continuous basis as routine clinical data were gathered and special physiologic investigations were performed. From the first generation, a second was derived (exposed in utero) that was studied through development to adulthood. The colony, including controls, comprised 60 swine in individual stalls. A ground-level concrete pad formed the foundation, within which were flush-mounted or recessed receptacles for electrical power, water, and low-profile indirect-lighting fixtures. Two rows of contiguous swine stalls ran the length of the pad on either side of a central walkway and had electrically-grounded embossed steel flooring. The stalls were constructed of fiberglass-reinforced plastic (FRP) grating and nonconducting hardware. Over the pad and stalls was a quonset-type modular enclosure consisting of prefabricated panels held together by nylon bolts and sealed against moisture with silicone rubber and contact-cemented FRP strips. The panels consisted of two FRP sheets sandwiching a 5-cm layer of polyurethane foam, facilitating control of ambient environmental temperature. The panels also provided thermal insulation to prevent condensation of moisture, which might shield the animals from the field. Above the building were four parallel, large-diameter, cylindrical electrodes that, over the area occupied by swine, produced an unperturbed field of 30 kV/m when energized to 225 kV by a remotely located transformer. With the swine absent, the field 1 m above ground was constant in magnitude within 6% and, vertically, within 2% over the test area. Temperature, relative humidity, and electric-field strength were controlled and monitored continuously and automatically by instrumentation in a building outside a fence that surrounded the exposure facility. Environmental data were also recorded automatically by on-line computers that logged extrema and means over present intervals of time. The building also contained a small clinical facility and a video monitor that was connected to traveling video cameras for monitoring of experimental and control animals.

5352 POSSIBLE DETECTION IN VIVO OF LATENT VIRUSES IN TUMOR AND BACTERIAL CELLS AND THEIR INDUCTION BY MILLIMETER MICROWAVES (MEETING ABSTRACT). *(Eng.)* Webb, S. J. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 24; 1977. (0 refs)

The detection of latent viruses in vivo by microwave spectroscopy and the alteration of their effects on the behavior of cells following microwave radiation exposure were studied. Microwave and laser-Raman spectra of naturally-occurring tumor cells and of bacteria indicated that, as a result of active metabolic processes, resonances occur in vivo between 10^{10}-10^{11} Hz. The resonances were not present in inactive cells, dead cells, or homogenates of cells. The microwave absorption spectra of normal human mammary tissue contained five strong peaks between 65 and 95 GHz, four of which were present in mammary carcinoma tissue and in "normal" tissue from diseased patients. Each of these peaks, however, was split into two or three sub-peaks. In addition, the spectrum of carcinoma tissue contained a broad, double-spiked peak at 76 GHz. Similarly, the spectrum of normal cells from the kidney of the baby hamster (BHK) contained four major peaks between 65 and 95 GHz that became broadened and double-peaked as the cells were transformed into tumor cells by infection with mouse sarcoma virus (MSV). The spectrum of *Escherichia coli* K12 (ATCC 12345) also displayed four major peaks between 68 and 95 GHz, each of which became double- or triple-spiked when the microbe was lysogenized with a temporate lambda bacteriophage. The attenuation of frequencies depended, however, on the age and nutritive state of the cells. The laser-Raman spectra between 10 and 200 cm^{-1} of both the mammalian and bacterial cells also contained strong single peaks that shifted and became double- and triple-spiked when the cells were injected with latent or temporate viruses. This double-spiked nature of the Raman lines disappeared when BHK tumor cells were irradiated by microwaves at 76 GHz; the irradiation caused the cells to lose their oncogenic properties but not their viability. The same loss of double-spiked Raman lines occured when lysogenic bacterial cells were irradiated at 70.5 GHz; however, many of the prophages were induced, and lysis of cells resulted. The mechanism of prophage induction by microwaves did not appear to be thermal as no significant rise of temperature occurred. Irradiation of tumor cells resulted in loss of oncogenic characteristic but not viability. These results indicate that latent viruses may be detected in vivo by microwave spectroscopy and that their effects on the behavior of cells can be altered by exposure to microwave radiation at specific frequencies.

5353 MICROWAVE EFFECTS IN *DROSOPHILA MELANOGASTER* (MEETING ABSTRACT). *(Eng.)* Dardalhon, M.; Berteaud, A. J.; Averbeck, C. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 25; 1977. (0 refs)

Irradiation of *Drosophila melanogaster* in the free-field of millimeter (73 GHz) and centimeter (17 GHz) microwaves was performed. Wild-type Paris strain and the tumor strain δ-carrying melanotic tumors in the third larval stage, in the pupal stage, and as adults were used. Maximum route-mean-square power densities were 100 mW/cm^2 for 73-GHz energy and about 60 mW/cm^2 for microwaves at 17 GHz. After 2 hr of exposure to microwaves at either frequency, both the hatching rate and the development of irradiated eggs were normal. Survival rates at varying stages of development were not statistically different. The microwave treatment did not induce teratologic changes in adults or alterations in the incidence and multiplicity of tumors. When wild-type females that were exposed to microwaves at 17 GHz for 21 hr were crossed with untreated males, a marked increase in fertility was observed. Viability and incidence of tumors in descendents were not affected.

5354 EFFECTS OF MILLIMETER WAVES ON LIVING TISSUE (MEETING ABSTRACT). *(Eng.)* Gandhi, O. P.; Hill, D. W.; Partlow, L. M. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 26; 1977. (0 refs)

A solid-state computer-controlled system was devised for swept-frequency measurements of absorption spectra of biologic specimens over a range of frequencies from 26.5 to 90 GHz. Biologic preparations were held in a thin-walled (thickness less than $\lambda_g/100$ at the center frequency) rectangular glass tube inserted through a nonradiating slot in the narrow wall of the waveguide. The sample, filling the entire cross section of the waveguide, was of a thickness on the order of one-tenth of the free-space guide wavelength λ_g. Power levels that produced less than a 0.1 C temperature elevation during a 2-min period of irradiation were employed. The incident, reflected, and transmitted powers were measured, digitized, and stored at frequency intervals of 0.05 GHz. The absorption of the sample was then calculated and plotted using an on-line X-Y plotter. Measurements of the dielectric properties in this band of various biologic proparations are reported. Absorption spectra are presented for relevant biologic compounds (water, proteins, DNA, RNA, etc), biologic solutions (minimal essential medium, saline, Luria broth, etc.), and cell suspensions (normal and transformed cells, bacteria, yeast, etc.) in aqueous solutions. In addition, data concerning biologic action spectra are presented on the viability, growth, viral infectivity, and morphology of irradiated cells.

5355 MEASUREMENT OF THE ELECTRICAL PROPERTIES OF BIOLOGICAL LIQUIDS AT FREQUENCIES BETWEEN 1 AND 100 GHZ (MEETING ABSTRACT). *(Eng.)*

Grant, E. H. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 27; 1977. (0 refs)

Techniques for measuring the complex permittivity of biologic fluids between 1 and 100 GHz are described. The principal constituent of biologic liquids, water, has an attenuation coefficient approximating 0.2^{-1} cm at 2.45 GHz, which increases to more than 30 cm^{-1} at 70 GHz. The accompanying decrease in permittivity is from ∿80 to 11. These radical variations over a relatively small range of frequencies require the use of methods appropriate to liquids of low or medium loss (depending on ionic conductivity) at frequencies of a few GHz and, in contrast, require traveling wave techniques specifically devised for high-loss liquids at frequencies near 100 GHz. As an example of each type of technique, data were presented on blood at various concentrations of hemoglobin, as measured at 2 GHz, along with results for water, at 70 GHz. The measurements on blood were consistent with a hemoglobin hydration (bound water content) of 0.35. The values of permittivity at 70 GHz showed that water at 0 C has an infinite frequency permittivity of 5.05 ± 0.03 and a Cole-Cole distribution parameter attenuation coefficient of 0.05 ± 0.015 that decreases with temperature.

5356 ABSENCE OF ECG AND RESPIRATORY CHANGES IN TURTLES AND TORTOISES EXPOSED TO MICROWAVE FIELDS OF LOW DENSITY (MEETING ABSTRACT). *(Eng.)* Flanigan, W. F.; Lowell, W. R.; Seeley, R. L. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 31; 1977. (0 refs)

Six specimens each of *Chrysemus picta* (all females; 15.4-16.5 cm in length), *Gopherus agassizi* (1 male, 5 female; 17.2-24.2 cm), and *Terrapene carolina* (4 male, 2 female; 14.7-17.0 cm in length) were implanted with carbon-loaded Teflon electrodes for monitoring of electrocardiogram (ECG) and respiration. Electrode tips were inserted 2-3 mm between upper shell and underlying soft tissue. Following recovery, animals were restrained and individually exposed to continuous wave (CW) or to pulsed wave (PW) 960-MHz fields ($\vec{E}$ parallel to spine) at peak power densities of 0.1 mW/cm^2 (0.01-0.06 W/kg specific absorption rate, SAR), 3.0 mW/cm^2 (0.4-1.6 W/kg), 7.0 mW/cm^2 (0.9-3.8 W/kg), or 10.0 mW/cm^2 (1.3-5.5 W/kg). Groups of six animals (two/species) were randomly assigned to exposure periods of either 5, 30, or 90 min. Half of each group (one/species) was exposed to CW and half to PW radiation; 24 hr later, exposure condition was reversed. Exposure periods, each at a higher power level, were preceded by nonexposure periods of the same duration. Animals were habituated to restraint for 1 hr prior to the initial nonexposure period. Averaged heart rates and interrespiratory intervals between exposure periods and preceding nonexposure periods were not statistically different. Exposure trends at the levels of species and of specimens were not apparent. Absence of ECG-changes in intact animals contrasts with reports of bradycardia in hearts isolated for *C. picta* at an SAR of 2 W/kg when exposed to CW, 960-MHz radiation. It is suggested that compensatory mechanism(s) may be present in the intact animal to prevent bradycardia, or bradycardia may occur uniquely in the isolated-heart preparation.

5357 HEART-RATE MODIFICATION IN VIVO FROM IRRADIATION BY ELECTROMAGNETIC ENERGY (MEETING ABSTRACT). *(Eng.)* Eichert, E. S.; Frey, A. H. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 32; 1977. (0 refs)

Heart rate modification was studied in frogs *(Rana pipiens)* irradiated by pulse-modulated ultra high frequency (UHF) energy. One group of frogs received alternate 10-min periods of sham exposure and exposure that was synchronized to produce radiation of the heart during the rise of the R-wave of the electrocardiogram. Another group received alternate 10-min periods of sham exposure and exposure that was synchronized for radiation of the heart during the T-wave. The final group was used as an absolute control and received alternate periods of sham irradiation only. Modulated ultra-high-frequency energy at 1.25 GHz with a peak power of 50 mW/cm^2 and a pulse width of 5 μsec produced tachycardia when synchronized with the rise of the R-wave. Results on T-wave synchronization were inconclusive.

5358 INTERACTION OF THE NEURON WITH ALTERNATING CURRENT FIELDS (MEETING ABSTRACT). *(Eng.)* Musil, J. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by the International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 33; 1977. (0 refs)

To investigate the possibility of a direct interaction of electromagnetic waves and the neuron, a method was devised to study properties of the cell by means of models that treat the cell as a geometrically closed formation with distributed parameters. Specific properties of mono- and poly-frequency responses were verified experimentally. The properties were expressed in a form that permited determination of equivalent circuits.

5359 THE EFFECT OF ELECTROMAGNETIC ENERGY ON SPONTANEOUS CONTRACTIONS OF SMOOTH MUSCLE (MEETING ABSTRACT). *(Eng.)* Whitcomb, E. R.; Weil, C. M. *In: Abstracts of 1977 International Symposium*

on the Biological Effects of Electromagnetic Waves. Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 36; 1977. (0 refs)

The effect of radio frequency electromagnetic energy on the rate of spontaneous contractions of smooth muscle of isolated rat gut was measured. A segment of the duodenum was suspended in a 10-ml plastic tube that was mounted in a capacitive-plate exposure-device that operated at 1 GHz continuous wave. The gut segment was continuously bathed with modified Ringer's solution (pH 7.5, at 35 C) with a flow of 40 ml/min as pumped from a 400-ml reservoir. The preparation was equilibrated in Ringer's solution for 1 hr at 7 C and 1 hr at 36 C prior to recording. Gut segments from four male adult rats were used at each exposure level. The energy absorbed by the medium was calculated by measuring the temperature rise of the Ringer's solution in the plastic tube. Exposures were made at specific absorption rates of 0.8, 1.7, and 3.6 mW/g. For each trial, 500 contractions were recorded with the microwave generator in a stand-by position. This was followed by measuring 500 additional contractions during radiation at selected intensities. Isometric contractions were monitored by a Statham transducer and were recorded on magnetic tape. A data retrieval computer was used to plot the rate of contraction as an interval histogram pattern (IHP). The IHPs did not indicate any significant difference between the rate of contraction during the control and exposure periods. Therefore, exposure of isolated rat gut to radio frequency radiation did not produce a measurable effect on the spontaneous rate of smooth muscle.

5360 EFFECTS OF MICROWAVE RADIATION ON THE RAT'S PITUITARY-THYROID AXIS (MEETING ABSTRACT). *(Eng.)* Lu, S-T.; Lebda, N.; Michaelson, S. M. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 37; 1977. (0 refs)

Young adult rats (after acclimation to experimental procedures) were exposed to 2,450-MHz continuous wave radiation at 1 to 20 mW/cm^2 for 1 to 8 hr. The increase in colonic temperature of rats was found to be the most sensitive parameter measured. Elevation of temperature was observed in rats after exposure at 1 mW/cm^2 for 4 hr. Circulating thyrotropin (TSH) levels were depressed in rats exposed at 10 mW/cm^2 for 1 or 2 hr. However, the depression did not affect levels of circulating thyroxine (T_4) after as much as 8 hr of exposure at this power density. Rats exposed at 20 mW/cm^2 showed lower TSH levels than sham-exposed rats after 2 and 8 hr of radiation. The lower TSH levels were accompanied by T_4 depression after 4 and 8 hr exposure. Increased TSH levels were not observed. However, there was a transitory increase in T_4 levels in rats exposed at 1 mW/cm^2 for 4 hr. These observations indicate that exposure to microwaves can stimulate thyroidal activity and can suppress secretion of thyrotropic hormone through an "open-loop" mechanism as part of thermoregulatory activity.

5361 EFFECTS OF HYPOPHYSECTOMY AND DEXAMETHASONE ON THE RAT'S ADRENAL RESPONSE TO MICROWAVE IRRADIATION (MEETING ABSTRACT). *(Eng.)* Lotz, W. G.; Michaelson, S. M. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 38; 1977. (0 refs)

In an attempt to determine if microwave-induced increases in plasma corticosterone of rats are due to a primary stimulation of the adrenal gland, hypophysectomized and dexamethasone-pretreated rats were exposed to 2,450 MHz continuous wave radiation. The animals were exposed in the far field of a horn antenna for 60 min at 50, 60, or 70 mW/cm^2, with corresponding averaged absorption rates of 8.0, 9.6, or 11.2 W/kg. Immediately after exposure, the rats were decapitated; blood was collected; and colonic temperature was measured. Plasma samples were assayed for corticosterone. The increases of corticosterone that were present in intact and sham-hypophysectomized rats after a 60-min exposure at 60 mW/cm^2 (9.6 W/kg) were totally absent in hypophysectomized rats. The effect of dexamethasone on the corticosterone response to a 60-min exposure at 50 mW/cm^2 (8.0 W/kg) depended on the dose of dexamethasone. Administration of 5.6 or 10.0 µg/100 g of body mass effectively blocked the increases in corticosterone that were observed in sham-injected rats. The results indicate that the adrenal gland is not primarily stimulated by microwave exposure but is stimulated secondarily by adrenocorticotropic hormone that is secreted during exposure to microwave radiation.

5362 GROWTH HORMONE LEVELS OF RATS EXPOSED TO 2450-MHZ (CW) MICROWAVES (MEETING ABSTRACT). *(Eng.)* Lotz, W. G.; Michaelson, S. M.; Lebda, N. J. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 39; 1977. (0 refs)

Growth hormone (GH) was measured in plasma samples obtained from unanesthetized male rats exposed to 2,450-MHz continuous wave radiation. The rats were exposed in the far field of a standard gain horn-antenna for 30 or 60 min at power densities of 0, 13, 20, 30, 40, 50, or 60 mW/cm^2, or for 120 min at 0, 13, 20, 30, or 40 mW/cm^2. The averaged energy absorption rate, as measured calorimetrically with a 290-ml water load, was 0.16 W/kg absorbed per mW/cm^2 of incident radiation. Immediately after exposure, the rats (four exposed and two controls) were decapitated; their blood was collected; and colonic temperature was taken. GH was assayed by

radioimmunoassay. Significant increases in colonic temperature of the exposed rats were observed after all exposures of 13 mW/cm^2 or greater; larger increases were seen at each successively greater power density. For 30- and 60-min exposure, GH levels were lower than control values only at 50 and 60 mW/cm^2. For 120-min exposure, GH levels were lower than those of controls after exposures at 13 mW/cm^2 or higher, with progressively lower GH values observed at each successively greater power density. With respect to exposure duration, GH levels showed a trend toward lower values with longer exposure durations at each power density $\geq$ 13 mW/cm^2. In contrast, the GH levels of control animals were higher after 120 min than after the two shorter durations of sham-radiation. The effects of microwaves on GH-levels were, in general, physiologically analogous to the influence previously reported on the plasma corticosterone levels of rats.

5363 EFFECTS OF HANDLING AND SURGICAL TREATMENT OF CONVULSIVE LATENCIES AND MORTALITY OF TUMOR-BEARING RATS TO 2450-MHZ MICROWAVE RADIATION (MEETING ABSTRACT). *(Eng.)* Justesen, D. R.; Morantz, R. A.; Clark, M.; Reeves, D.; Mathews, M. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 40; 1977. (0 refs)

Hyperthermia as induced by 2,450-MHz whole-body radiation in a multi-mode cavity is being assayed as an experimental treatment of a surgically-seeded neoplasm in the brain of the Fischer-244 rat. The aim of this study was to produce the maximal elevation of brain temperature that is compatible with survival and non-debilitation. Sixty mature male rats were assorted in equal numbers to 1 of 12 possible treatments in a randomized factorial study that controlled for handling (minimal handling versus seven daily periods of "gentling" and exploration of inert cavity), radiation (0 or 100 mW/g dose rate), and surgical treatment (cage control vs. surgery with implanting of vehicle only vs. surgery with implanting of malignant glioma). The primary end-point was latency-to-convulsion. Secondary end-points were body temperature, mortality, and hygienic status of the animals as indexed by body mass. It was found that while handling reliably reduced variability of convulsive latencies of caged animals, it combined with the stresses of surgical treatment and radiation to produce severe debilitation. Additionally, acute mortality from radiation was zero in caged controls but approximated LD_{50} in surgically treated rats. The implication of these findings is that the stresses of near-concomitant handling, surgery, and radiation are additive; the practice of "gentling" can markedly limit the therapeutic dosage of radiation.

5364 CATARACTOGENIC RESPONSE OF RABBITS TO PULSED MICROWAVES OF HIGH-PEAK LOW-AVERAGE POWER (MEETING ABSTRACT). *(Eng.)* Ferri, E. S.; Foti, M. E. G. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 41; 1977. (0 refs)

The potential risk of lenticular damage following continuous microwave exposure was compared to that resulting from pulsed microwave irradiation. The cataractogenic threshold in response to pulsed microwave radiation at high peak low average powers and at a frequency of 2.9 GHz was ascertained. The threshold was compared to that obtained at a frequency of 2.45 GHz of continuous wave radiation. There were no significant differences between thresholds. It appears that no greater hazard to the eye is associated with radiation delivered via the pulsed mode as opposed to the continuous. A correlational analysis of three frequencies and their respective ocular reactions also is presented and interpolated. The energy distribution of focused microwaves behind a dielectric lens at a frequency of 2.9 GHz was contrasted with that obtained at 2.45 GHz and 10 GHz. Results further support the previous experimental conclusion that cataractogenic potential varies inversely with microwave frequency.

5365 RADIOFREQUENCY RADIATION DOSIMETRY HANDBOOK: DESCRIPTION OF THE SECOND EDITION (MEETING ABSTRACT). *(Eng.)* Durney, C. H.; Johnson, C. C.; Barber, P. W.; Massoudi, M. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 44; 1977. (0 refs)

The first edition of the Radiofrequency Radiation Dosimetry Handbook included specific absorption rate (SAR) data as a function of frequency for a variety of experimental animals and humans under various configurations both for plane waves and for a limited number of non-plane-wave fields. A second edition of the handbook will include experimental data, modeling, extended frequency range, scattering effects, data on biologic response to heating, and ground-plane effects.

5366 A TECHNIQUE FOR CALCULATING ABSORPTION OF RADIO-FREQUENCY IN MODELS OF MAN AT AND ABOVE THE RESONANT FREQUENCY (MEETING ABSTRACT). *(Eng.)* Iskander, M. F.; Durney, C. H.; Barber, P. W.; Massoudi, H. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 45; 1977. (0 refs)

A technique to calculate absorption of radio frequency energy by a nonspherical model of man is described.

The technique is based on combining an anticipated solution with the extended-boundary-condition method (EBCM). By utilizing an improvement in the convergence of the solution, the size of the matrix is reduced, and the ill-conditioning encountered at and above resonance is avoided. The required initial approximation can be obtained either from asymptotic techniques (e.g., geometric optics, GO) or from any other anticipated solution. The solution for an infinite cylinder, which agreed well with the GO solution at higher frequencies and with experimental results at intermediate frequencies as the initial approximation was calculated. On the basis of this initial assumption, an integral equation in terms of the equivalent currents on the dielectric surface was derived and reduced to a system of matrix equations using the orthogonality relations. Although the main matrix resembled that obtained using the straight-forward EBCM, tests using two different methods revealed that by improving the convergence by about 20 to 30%, the ill condition of the matrix could be avoided. Numeric results for the averaged specific absorption rate for a nonspherical model of man at and above the resonance frequency are presented graphically and are compared with available experimental data. In the frequency range where no data were available for comparison, the off-center test of validity was employed to check the accuracy of the numeric procedure. Advantages of the method as well as other possibilities to improve its convergence for use at yet higher frequencies are discussed.

5367 ABSORPTION CHARACTERISTICS OF A PROLATE SPHEROIDAL MODEL OF MAN AT AND NEAR RESONANT FREQUENCIES (MEETING ABSTRACT). *(Eng.)* Lee, H.; Tripathi, V. K. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 46; 1977. (0 refs)

Analytic and numeric techniques were used to solve for absorption characteristics of a prolate spheroidal model of man that consisted of homogenous biologic tissues as irradiated by plane waves at an arbitrary angle of incidence at and near the resonant frequencies. The problem was formulated by expanding the internal and scattered fields in terms of spherical and spheroidal vector-wave functions. The internal fields were then calculated by applying the boundary conditions and utilizing suitable techniques for computations. In terms of the spherical wave functions, solutions were obtained by matching the boundary conditions and combining the point-matching technique with a least-square fit for better accuracy. The accuracy of the computations was verified by solutions that computed goodness-of-fit of boundary conditions but at points other than those used to obtain coefficients. In terms of the spheroidal wave functions, the numeric solutions were obtained either by the point-matching technique or by defining auxiliary spheroidal-angle functions that resulted in coupled simultaneous equations for the coefficients of expansion. Numeric results for the relative absorption cross-section and for the internal distribution of absorption rates are presented for spheroids radiated by plane waves at and near resonant frequencies.

5368 INDEXING ABSORPTION OF ELECTROMAGNETIC ENERGY BY BIOLOGICAL OBJECTS WITH PROLATE SPHEROIDAL MODELS (MEETING ABSTRACT). *(Eng.)* Lin, J. C.; Wu, C-L. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 47; 1977. (0 refs)

Results are presented of computer calculations that made use of an expansion of the spheroidal wave function for wavelengths to and including the first reasonant frequencies. The results may serve as a guide for extrapolating data from laboratory animals to human beings, particularly with regard to peaks and averages of absorbed electromagnetic energy.

5369 APPLICATION OF IMPEDANCE-BOUNDARY CONDITIONS IN PROBLEMS OF MICROWAVE DOSIMETRY (MEETING ABSTRACT). *(Eng.)* Taylor, L. S.; Dao, T. H. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 48; 1977. (0 refs)

The mathematical basis and validity of approximate impedance-boundary conditions in microwave dosimetry problems are briefly reviewed, and the technique of application is discussed. The use of the method is illustrated by comparing the results obtained from the approximations with those obtained from complete solutions of Maxwell's equations in several cases, including point and line sources irradiating lossy dielectric half-spaces and plane waves irradiating lossy dielectric spheres and cylinders at arbitrary angles and polarizations. These analyses are then employed to derive a number of rule-of-thumb conclusions with regard to the deposition of microwave energy in biologic systems via geometries in which no exact solutions are available. These conclusions are compared with the results obtained from thermographic measurements of microwave absorption by phantom loads.

5370 GEOMETRICAL-OPTICS AND EXACT SOLUTIONS FOR INTERNAL FIELDS AND SARs IN A CYLINDRICAL MODEL OF MAN AS IRRADIATED BY AN ELECTROMAGNETIC PLANE WAVE (MEETING ABSTRACT). *(Eng.)* Massoudi, H.; Durney, C. H.; Johnson, C. C. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 49; 1977. (0 refs)

A geometric-optics approximation was used to calculate the specific absorption rate (SAR) in cylindrical models of man and of experimental animals that were irradiated by an electromagnetic plane wave at high frequencies. Comparison of the results with those for prolate spheroidal models showed that the relative absorption cross section of the prolate spheroidal and cylindrical models of man are essentially the same at frequencies above 20 GHz. The exact solution is given for the SAR in a lossy, infinitely long cylinder that was exposed to an electromagnetic plane wave in which the vector of the E-field was either perpendicular or parallel to the cylinder's long axis. Curves are presented that show the SAR as a function of frequency for cylindrical models of man and of animals. Comparison is made with a composite curve that was calculated from data on prolate spheroids and from other experimental and theoretic data. The exact solution for the SAR of a cylindrical model of animals and humans appears to be a good approximation at a range of frequencies just below the limit of geometric optics, therefore providing a means for calculating SARs within a range of frequencies where calculations were not previously available.

5371 ENERGY ABSORPTION BY BIOLOGICAL MODELS: CALCULATIONS BASED ON GEOMETRICAL OPTICS (MEETING ABSTRACT). *(Eng.)* Rowlandson, C. I.; Barber, P. W. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 50; 1977. (0 refs)

A technique based on geometric optics was used to calculate absorption characteristics for a prolate spheroidal model. The results provided asymptotes to which data on absorption at lower frequencies could be related. In the geometric-optics formulation, the surface of the prolate spheroid was approximated by small planer subareas. Parallel and perpendicular components of the incident wave were determined for each subarea and a transmission coefficient was calculated for each component. The energy transmitted into each subarea was assumed to be completely absorbed due to the small skin depth of lossy biologic bodies at millimeter wavelengths. The total energy absorbed by the prolate spheroid was found by summing over all subareas. Extensive validity testing for spheres with a radius equal to the minimum radius of curvature of a man-sized prolate spheroid indicated that the technique is applicable for frequencies at and above 60 GHz. Computer-generated results for different angles of incidence indicated a reversal of the behavior seen at lower frequencies. The results also indicate a slight increase in rate of energy absorption with increasing frequency. The increase was attributed to the decrease in permittivity with increasing frequency, which effectively resulted in a better impedance match between the spheroid and the surrounding free space.

5372 SOME RECENT RESULTS ON DEPOSITION OF ELECTROMAGNETIC ENERGY IN ANIMALS AND IN MODELS OF MAN (MEETING ABSTRACT). *(Eng.)* Gandhi, O. P.; Hagmann, M. J. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 51; 1977. (0 refs)

Results on deposition of electromagnetic energy in animals and models of man are presented. Frequencies at which individual parts of the body, such as, the arms and the head are at resonance were identified. For the first (geometric) resonance of the head at 470 MHz, 4.5 times the averaged value for the rest of the body was measured which corresponded to an absorption cross-section 3.1 times the physical cross-section. The experimental values agreed with numeric calculations based on a realistic model of man. The frequency for maximal energy deposition in the arms was 150 MHz with an absorption cross-section 2.3 times the physical cross-section. For certain length-to-width ratios, the enhancement in energy deposition was 30-40% higher than that for reflectors of infinite dimensions. These supergain combinations can exist for all corner angles between reflectors. Enhanced specific absorption rates (SARs) due to proximity to other biologic bodies were observed for two resonant, subresonant, or supraresonant targets close to one another. It was found that antenna theory may be used accurately to predict SARs. For two targets separated by 0.65 to 0.7 λ, the highest SAR, which was 170% of the free space value, was experimentally observed for anesthetized rats and for models of man for the $\hat{E} \parallel \hat{L}$ orientation. Higher enhancements of the SAR by factors as large as 2.5 are anticipated for the interposed bodies of three or more targets.

5373 NUMERICAL CALCULATIONS OF ELECTROMAGNETIC ENERGY DEPOSITION IN A REALISTIC MODEL OF MAN (MEETING ABSTRACT). *(Eng.)* Hagman, M. J.; Gandhi, O. P.; Durney, C. H. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 55; 1977. (0 refs)

A realistic model of man was obtained by using 180 cubical cells of various sizes for best-fit to the contour of the 50th percentile "standard man." Anatomic cross sections were used to determine the volume fraction of eleven types of tissue in each cell. Published properties of the tissues were used to calculate the volume-weighted complex permittivity of each cell. A moment-method solution of the electric-field integral equation with a pulse-function basis and delta functions were used for testing. Numeric solutions previously reported had a ratio of 239:1 for energy deposition in one pair

of adjacent cells at 10 MHz. The arrangement of cells in the present model caused the maximum ratio of energy deposition in a pair of adjacent cells to be 8:1 at the same frequency. Reduced cell-to-cell variation improved the accuracy of the pulse-function approximation. Accuracy was further improved by using a three-dimensional interpolation with the $\vec{E}$ values initially calculated for each cell to account for some of the variation of $\vec{E}$ within each cell. The interpolated value was integrated in calculating the specific absorption rate (SAR). Calculations using the model with the homogeneous approximation of two-thirds the complex permittivity of muscle gave SAR values within 20% of values calculated for prolate spheroid and ellipsoid models. Unlike earlier numeric models, the distribution of energy deposition agreed well with that found experimentally for homogeneous phantom models. When the inhomogeneous complex permittivities were used with the model, a change of less than 2% occurred in SAR, but the distribution of energy deposition was changed. Figures showing the calculated distribution of SARs in the model are presented.

5374 NUMERICAL CALCULATION OF ELECTROMAGNETIC ENERGY DEPOSITION IN MODELS OF MAN WITH GROUNDING- AND REFLECTOR-EFFECTS (MEETING ABSTRACT). *(Eng.)* Hagman, M. J.; Gandhi, O. P.; Durney, C. H. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 56; 1977. (0 refs)

Image theory was applied to calculate rates of deposition of electromagnetic energy in a realistic model of man in the presence of a ground or reflectors. The ground plane or reflectors had perfect conductivity and infinite extent. Moment-method solutions were found for the electric-field integral equation using a pulse function basis and delta functions for testing. The resonant frequency of man standing on a ground plane was one-half that of man in a free field. The specific absorption rate (SAR) of man on the ground plane at the reduced resonant frequency was within 2% of the SAR for man in free space at the free-field resonant frequency. At 10 MHz, the SAR for man standing on a ground plane was about seven times that found for the same model in the free field. The factor of enhancement in local energy deposition due to grounding varied throughout the model and had a maximum of about 60 in the area of the heel. Experimental results with phantom models and numeric calculations revealed the SAR at different frequencies at various separations from the ground plane. At 65 MHz the computed SAR was 4.87 times the free-field value when man was 0.1875 wavelengths in front of a flat reflector and 16.6 times the free-field value when man was 1.5 wavelengths in front of the axis of a 90° corner reflector. Antenna theory was used to calculate the ratio of effective area of a half-wave dipole with a reflector to that of the dipole in the free field. Such ratios were typically within 16% of the calculated values of enhancement of SAR due to reflector effects if man was near the resonant frequency. Numeric results for man at frequencies above resonance also are presented.

5375 INDUCED EM FIELDS IN HUMAN BODIES AND HEADS (MEETING ABSTRACT). *(Eng.)* Chen, K-M.; Mousavinezad, H.; Rukspollmuang, S.; Nyquist, D. P. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 57; 1977. (0 refs)

The internal electric field and the specific absorption rate (SAR) of electromagnetic (EM) energy as induced by EM waves up to 500 MHz in a realistic model of man were theoretically quantified based on the numeric solution of a tensor integral equation. Theoretic results were compared with existing experimental results and with a measured electric field in a scale model as determined by an insulated electric-field probe. The internal electric field and the SAR induced by microwaves in a model of the human head, which included the eyes and the brain, also were quantified. The SARs in the eyes and in the brain were found to be lower than that in the surrounding bony structure at the microwave range. The accuracy of numeric results was checked with Stratton's exact solutions of irradiated homogeneous dielectric spheres.

5376 FAR-FIELD MICROWAVE DOSIMETRIC MEASUREMENTS IN A MAN-SIZE PHANTOM (MEETING ABSTRACT). *(Eng.)* Olsen, R. G. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 60; 1977. (0 refs)

Measurements of microwave heating were made in a full-size, upright model of the human being. The model, encased in and supported by a two-part mold of polyurethane, was composed of simulated muscle and bone. The phantom muscle was composed of a gelling agent, NaCl, polyethylene powder, and water. The major bones of the body were simulated by resin-based molded replicas of human bones. The phantom was placed in the far-field of a standard gain horn inside an anechoic chamber. Initial irradiations were in the L-band (1.29 GHz); the source of pulsed microwave energy was a military radar unit (AN/TPS-1G). The averaged power density of incident energy at the phantom and along the horn's axis was approximately 14 mW/cm^2. A small, nonmetallic temperature probe was inserted into the phantom at various locations and depths. During irradiation, the time course of temperature changes was recorded to provide for calculation of microwave dose-rate at the probe's location. Irradiations of 10 min or less produced elevations that were less than one-

half a Celsius degree. Initial results revealed a predominant heating of the front surface with an uneven pattern. Microwave heating occurred at depths to 6 cm, but most of the incident energy was deposited within the first 2 cm of the phantom's frontal surface.

5377 DEVELOPMENT AND USE OF A CALORIMETER TO MEASURE SPECIFIC ABSORPTION RATES IN SMALL LABORATORY ANIMALS (MEETING ABSTRACT). *(Eng.)* Allen, S. J.; Hurt, W. D. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by the International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 61; 1977. (0 refs)

Two types of multiple-cell calorimetric systems were constructed—one for mice and one for rats—to measure specific absorption rates (SAR) in small laboratory animals. Thermistors were used to monitor a calorimeter's temperature. The current passed by thermistors was read out through a Monitor Labs Model-1200 scanner using a Data Precision Model-3500 digital multimeter with a BCD output fed into an H.P. Model 9830A computer. The system was small, relatively inexpensive and provided automatic calibration of thermistors, precise measurement of temperature, and a printout of whole-body SAR of each animal. Design and construction of the six-well calorimetric system is discussed. Experimental data obtained from irradiation of mice by 2.6-GHz fields in an 18-animal array are compared with those obtained from E-field measurements using the NBS-Model EDM-1B probe.

5378 ABSORPTION OF ELECTROMAGNETIC ENERGY BY PHANTOM MUSCLE-SPHERES AND BY BIRDS OF DIFFERING SIZE (MEETING ABSTRACT). *(Eng.)* Chou, C. K.; Guy, A. W. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 62; 1977. (0 refs)

Phantom muscle spheres (diameters 4, 6, 8, 12, and 16 cm) and birds (parakeets, quails, pigeons, chicken, turkeys) were exposed to far-field plane waves at power densities between 200 and 500 mW/cm^2 at 775, 915, and 2,450 MHz. Patterns of specific absorption rate (SAR) were determined by thermographic techniques for spheres and birds. Behavioral responses of birds were monitored. The SAR patterns in spheres were in good agreement with theoretic predications, while those of birds differed from those of spheres. Absorption in regions of the head and neck was much larger than in other parts of the body. The analogy of a bird to a sphere was not a good approximation, since objects shaped like birds and not those of simple geometry are needed for study of absorption. Behavioral response of birds to radiation varied. Threshold energy was determined for each bird at all three frequencies. The lowest power density at which radiation was detected by a rooster was 7 mW/cm^2 at 775 MHz.

5379 THE NUMBER AND SPACING OF ANIMALS SIMULTANEOUSLY EXPOSED TO MICROWAVES IN A FREE FIELD AFFECT THE DOSE RATE (MEETING ABSTRACT). *(Eng.)* Kinn, J. B. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 63; 1977. (0 refs)

Whole-body absorption of energy was measured in mice and rats exposed either to 2,450-MHz or to 425-MHz radiation. Dosimetric measurements were made with twin-well calorimeters on mice exposed to 2,450-MHz radiation in an anechoic chamber. Specific absorption rates (SARs) for rats exposed to 425-MHz fields in a (transverse electromagnetic mode transmission line (Crawford cell) were determined by power meters and by calculating the differences between forward, reflected, and transmitted power over intervals of time. For the 2,450-MHz exposures, mice were located in rectangular arrays of either 4, 9, or 25 animals with the separation-distance between animals halved for each increase in number of animal. The averaged SAR values for the different arrays were then compared. A positional dependence of dose rate was found to exist in the 25-mouse array. Rats were exposed in the Crawford cell to 425-MHz radiation with the number of animals increasing from 2 to 12 as separation-distance decreased. No relationship between separation-distance and averaged SAR for the 425-MHz exposures was found. It is concluded that the spacing between animals can affect SARs as can the position of an animal in the array.

5380 DEVELOPMENTAL EFFECTS OF MICROWAVES IN *TENEBRIO MOLITOR:* EXPERIMENTS TO DETECT POSSIBLE INFLUENCES OF RADIATION FREQUENCY AND OF CULTURING PROTOCOLS (MEETING ABSTRACT). *(Eng.)* Pickard, W. F.; Olsen, R. G. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 66; 1977. (0 refs)

Pupae of the darkling beetle, *Tenebrio molitor*, were exposed to microwaves in the far-field of a horn-irradiated temperature-controlled electrically anechoic chamber. Exposed and control pupae were then allowed to develop into adults and were examined to determine whether the irradiation correlated with an increased incidence of gross morphologic abnormalities. Pupae were derived either from a colony maintained on ground Purina dairy meal and sliced potatoes (colony-pupae) or from larvae purchased in an advanced instar and maintained on Kellog's Special-K and sliced potatoes (K-pupae). Control pupae from the colony developed into adults with a significantly lower incidence of developmental

abnormalities than did K-pupae controls. The following experiments were performed at 5.96 GHz. Pupae with the long axis of the body parallel to the electric field for 2 hr at 91 Vm^{-1} root mean square (rms) in a standing wave and at a nominal dose rate of 130 mW/g exhibited no effects in either population of pupae. Colony pupae parallel to the magnetic field for 2 hr at an H-field maximum of 1.53 A^{-1} rms in a standing wave distribution and at a nominal dose-rate of 54 mW/g, exhibited no effects, but a significant effect ($p = .034$) was observed in K-pupae. K-pupae parallel to the electric field of a traveling wave at 11 mW/cm^2 exhibited no effects after 13-hr exposure. Pupae antiparallel to the Poynting vector for 4 hr in a traveling wave (10.025 GHz at 5 mW/cm^2) exhibited no effects.

5381 THE EFFECT OF MICROWAVE POWER LEVEL ON TERATOGENESIS IN *TENEBRIO MOLITOR* (MEETING ABSTRACT). *(Eng.)* Green, D. R.; Rosenbaum, F. J.; Pickard, W. F. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 67; 1977. (0 refs)

Experimental results are presented that show the existence of a "power" window in which the teratogenic effect of microwaves on pupae of *Tenebrio molitor* is suppressed. Suppression in a waveguide occured at power levels near 80 mW at 9.0 GHz. By segregating pupae into two groups based on their external appearance, it was shown that organisms weakened by prior trauma or by developmental abnormalities were more susceptible to microwave-induced damage than were those of healthier appearance. Evidence of nonlinear processes in the thermoregulatory behavior of *T. molitor* was found.

5382 THE INFLUENCE OF MICROWAVES ON DEVELOPMENT OF THE RAT (MEETING ABSTRACT). *(Eng.)* Michaelson, S. M.; Guillet, R.; Heggeness, F. W. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 68; 1977. (0 refs)

To investigate whether exposure of the developing rats to microwaves may influence maturation, female Long-Evans rats were exposed for 1 hr to 2,450-MHz continuous wave (CW) radiation at 10- or 40 mW/cm^2 power densities on various days of gestation. The dams were permitted to give birth, and the offspring were studied for functional development through the 21-day nursing period. In another study, neonatal rats were exposed at 40 mW/cm^2 to 2,450 MHz, CW radiation for 5 min each day from days 1 to 6 postpartum. On day 7, the rats either were sacrificed, were exposed to 2,450-MHz CW radiation for a seventh time, or were injected with adrenocorticotropic hormone (ACTH). Among animals exposed in utero the metabolic response to a cold environment was greater among offspring of rats exposed during days 0 to 2 than among the sham-exposed animals. The offspring from rats exposed at 40 mW/cm^2 showed a significantly higher level of corticosterone than sham-exposed controls during the first 24 hr of life. Thyroxin level tended to be lower among 1-wk-old rats from dams exposed at 10 mW/cm^2 but increased during the wk 2 of life. Among pups from dams exposed at 40 mW/cm^2, there was a statistically significant increase in thyroxin level at 14 and 16 days of age. Brain mass in offspring of dams exposed at 40 mW/cm^2 during day 13 or 20 of gestation did not differ from sham-exposed counterparts. Adrenal wet mass and ratios of adrenal-to-body mass in 7-day-old rats were significantly higher in radiated animals. Following either exposure to microwaves or injection of ACTH on day 7, plasma corticosterone levels were moderately increased in radiated animals. Whether exposure to microwaves during gestational or early neonatal periods perturbs or actually modifies ontogeny of neuroendocrine responsiveness requires further investigation.

5383 REPEATED EXPOSURE TO MICROWAVES AND ENVIRONMENTAL TEMPERATURE AFFECT BODY GROWTH OF NEONATAL RATS (MEETING ABSTRACT). *(Eng.)* Lu, S.; Pettit, S.; Michaelson, S. M. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 69; 1977. (0 refs)

The effects of repeat exposure to microwave and environmental temperature on the body growth of neonatal rats was investigated. Rats were exposed repeatedly to 2,450-MHz continuous wave radiation at 20 or 40 mW/cm^2 and at 24 C or at 24 and 34 C in the absence of radiation, 1 hr daily for 5 days during wk 1 or 2 of life. A highly sensitive period occurred during wk 1 of life in which rate of growth was easily perturbed. Repeat exposure to "cold" (24 C relative to a neutral temperature of 34 C) depressed body growth. Microwave radiation at 20 mW/cm^2 counteracted the depressive effects of the "cold" environment. Radiation at a higher power density (40 mW/cm^2) accelerated growth. Although it is premature to judge whether acceleration of growth by microwave irradiation is beneficial in terms of early postnatal development, interaction between environmental temperature and early development is noteworthy.

5384 EFFECTS OF PRE-AND POST-NATAL EXPOSURES TO 918-MHZ MICROWAVE RADIATION ON DEVELOPMENT AND BEHAVIOR IN RATS (MEETING ABSTRACT). *(Eng.)* Johnson, R. B.; Mizumori, S.; Myers, D. E.; Guy, A. W.; Lovely, R. H. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 70; 1977. (0 refs)

Rats were exposed to 918-MHz continuous wave circularly-polarized guided microwaves at averaged power densities of 5 mW/cm^2 in two separate studies to determine the effects of pre- and postnatal exposures on development and behavior. In the first study, rats were exposed daily for 7 days, 3 hr/day on days 2-9 of life. No statistical differences existed between test animals and control on measures of body mass through maturity, eye-opening dates, thermoregulatory-circadian rhythm, or conditioning of an active avoidance response. In the second study, rats were exposed in utero for a total of 380 hr. The exposure produced slight but consistent differences in body mass at birth and in eye-opening dates. The exposure may have accelerated in utero development. Assessment of thermoregulatory capacity as well as active avoidance of adults revealed possible long-term developmental differences.

5385 EMBRYOTROPHIC EFFECTS OF PULSED ELECTROSTATIC FIELDS (MEETING ABSTRACT). *(Eng.)* Pafkova, H. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 71; 1977. (0 refs)

The effect of chronic electrostatic irradiation applied from days 1-17 of gestation was studied in mice. The structure of placentas and fetal sacks, the occurrence of resorptions, the number and structural integrity of dead fetuses, and the mass and structural integrity of mature infants were evaluated. Significant changes were observed in exposed materials indicating that a pulsed electrostatic field has an unfavorable influence on embryonic development, especially during earlier stages. The influence of pulsed electrostatic fields of differing repetition frequency and field-gradient on the development of the chicken embryo was also studied. As applied once during an early state of development, the field did not influence the vitality of embryos and had no teratogenic effects. However, the body mass of the exposed embryos was significantly lower than that of controls.

5386 EFFECTS OF CHRONIC EXPOSURE TO MICROWAVES AT LOW POWER DENSITIES ON THE MASS AND CRANIAL SIZE OF DEVELOPING CHICKEN EMBRYOS (MEETING ABSTRACT). *(Eng.)* Fisher, P.; Lauber, J. K.; Voss, W. A. G. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 72; 1977. (0 refs)

The effects of chronic, low power density microwave exposure on the mass and cranial size of developing chicken embryos were studied. Fertile eggs from an outbred flock of *Gallus gallus* were incubated in groups of 36 for 4 days in a Plexiglas and Styrofoam incubator. The incubator was located within an electrically anechoic chamber (27 dB return loss) and was connected to a remote custom-built environmental control unit. The eggs were irradiated in the far field, 1.68 m from a standard gain horn (10.2 x 12.4 cm) at a mean power density near 3.3 mW/cm^2. Power densities within the incubator varied between 1.4 and 6.2 mW/cm^2. At the end of each period of incubation, embryonic temperature was rapidly measured, in ovo, with a microthermocouple. The embryos were subsequently excised, measured for mass, and photographed. Nose-to-crown length was recorded, as an index of cranial size from a photographic enlargement. Radiation was found in most cases to affect significantly the mass and cranial size of 4- and 5-day embryos. The direction of the observed effects appeared to be temperature dependent. At an incubation temperature of 33.5 C, values were significantly higher ($P<.01$) except for day-5 masses, while at 35.1 C all values were significantly lower ($P<.05$) as compared with controls. Since either temperature is considerably below the optimum for incubation, the finding of smaller mass and size of cranium may indicate an adverse athermal effect of microwave irradiation at low power densities.

5387 PRELIMINARY STUDIES OF ELECTRIC AND MAGNETIC FIELDS AT 27 MHZ: FIELD SURVEYS AND RESPONSE OF BLOOD CELLS (MEETING ABSTRACT). *(Eng.)* Mild, K. H. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 77; 1977. (0 refs)

Human red blood cells were exposed for 3 hr in 27-MHz fields at strengths as high as 3,000 V/m. Leakage of potassium ions (K^+) from exposed cells did not differ from that of control cells maintained at the same temperature. In cells tested for changes of osmotic resistance that might result from a change in the amount of bound water, no difference was observed between exposed and control cells.

5388 QUANTITATIVE DETERMINATION OF THRESHOLD VALUES OF MAGNETOPHOSPHENES (MEETING ABSTRACT). *(Eng.)* Loevsund, P.; Oevberg, P. A.; Nilsson, S. E. G. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 81; 1977. (0 refs)

To determine whether phosphenes (visual images) originate in the retina, threshold values of magnetosphenes were quantitatively assessed in normal and color-blind human subjects under differing conditions of background illumination and dark adaptation. In production of phosphenes, the threshold of magnetic flux density was lowest near 20 Hz and was just above 10 mteslas at an ambient luminous intensity of 1.2 candelas/m^2. Thresholds differed in color-blind subjects. Some subjects

experienced after-images that persisted up to 30 min. Thresholds rose across time in the dark-sensitized eye. The data indicate that the retina is the site of generation of magnetophosphenes.

5389 THE EFFECT OF ELF ELECTRIC FIELDS ON HUMAN REACTION TIME AND CRITICAL FLICKER FREQUENCY (MEETING ABSTRACT). *(Eng.)* Sugiyama, S.; Mizuno, K. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 82; 1977. (0 refs)

Simple reaction time (motor response to a photic stimulus) and critical flicker frequency (CFF) were studied in five young men and women. Measures were recorded both in the absence and in the presence of a 20-Hz electric field that was applied by a conductive plate 20 cm above the subject's head. Three root mean square kV were applied to the overhead plate. The difference between means of reaction times (control = 250.7 msec; under exposure = 242.4 msec) was small but reliable ($p<.05$). Similar alterations of CFF were noted. It is concluded that the electric field is capable of influencing the central nervous system.

5390 SOME PECULIARITIES OF THE AUDITORY SENSATION EVOKED BY PULSED ELECTROMAGNETIC RADIATION (MEETING ABSTRACT). *(Eng.)* Tyazhelov, V. V.; Tigranian, R. E.; Khizhnyak, E. P.; Akoev, I. G. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 83; 1977. (0 refs)

Auditory sensations evoked by pulsed microwaves were investigated while observers' heads were irradiated at a frequency of 800 MHz and a power density not exceeding 2,000 mW/cm^2. The pulse repetition rate (PRR) was 0-10,000/sec and the pulse width (PW) was 5-30 μsec. The threshold of peak power in production of an auditory sensation was essentially flat from 1 to a value that ranged from 500 to 1,000 PPS. The threshold then rose and reached cut-off between 8,000 and 10,000 PPS. Attempts to produce a beat-frequency response in the observers through combined stimulation with microwaves and an auditory stimulus were successful but only when the latter exceeded 8 KHz. When observers slowly submerged their heads in water, they could still "hear" the microwaves but with diminishing loudness until the head was fully submerged. In other studies, a rise in the hearing threshold was noted when PWs were increasing toward 100 to 120 μsec. Observers reported that auditory sensations induced at these longer PWs had a lower pitch and appeared to originate from a different point in space. While thresholds were higher at longer PWs, some observers who were "deaf" to the "usual" shorter pulses were able to "hear" the microwaves. It is concluded that current models of radio frequency hearing will require further development.

5391 QUANTITATION OF EFFECTS OF CHRONIC MICROWAVE RADIATION ON MUSCLE CELL OSMOTIC STATE AND SELECTIVE MEMBRANE PERMEABILITY (MEETING ABSTRACT). *(Eng.)* Portela, A.; Guardado, M. I.; de Xammar Oro, J. R.; Brennan, M.; Trainotti, V.; Stewart, P. A.; Perez, R.; Rodriguez, C.; Gimeno, A.; Rozzell, T. C. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 84; 1977. (0 refs)

To investigate the effects of chronic microwave radiation on muscle cell osmotic state and selective membrane permeability, frogs were maintained under constant environmental conditions and subjected daily to irradiation by pulsed microwaves (10.41 cm wavelength) at a power density of 10 mW/cm^2 for 0.1 hr for 20, 40, 60, 80, or 100 days. At the end of each of these periods, frogs were sampled and dissected. Tibialas anticus muscles were cut in pairs from each frog and single-muscle fibers were isolated. Control and irradiated frogs were analyzed for: (a) change of cell volume as a response to an osmotic gradient: fraction of osmotically available cell water (Weff), cell-water permeability (Pw), and consequently, the cellular osmotic state; (b) cell membrane "mechanical resistance" and selective permeability to solute and solvent [$V = f(t)$], initial rate of cell-volume change as a function of isoosmolar concentration of probing molecules (dV/dt at $t = 0$) and Ciso, the concentration of probing molecules ($dV/dt = 0$ at $t = 0$); the Staverman reflection coefficients (d) and the membrane-equivalent pore radius (r in A); and (c) the maintenance of normal cell volume (Vd_o), inferred from the normal distribution of cell Na^+, K^+, Cl^- and water contents by normal activity of the Na-K pump. No changes were detected in any of these cellular parameters. Results indicate no muscle-cell cumulative effects for microwave exposure.

5392 IMMUNOLOGICAL AND HEMATOLOGICAL EFFECTS OF MICROWAVES AT LOW POWER DENSITIES (MEETING ABSTRACT). *(Eng.)* Shandala, M. G.; Rudnev, M. I.; Vinogradov, G. K.; Belonozhiko, N. G.; Gonchar, N. M. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 85; 1977. (0 refs)

Rats were intermittently exposed to ultra-high-frequency (UHF) energy for 30 days at power densities of 10, 50, or 500 $\mu W/cm^2$ to investigate the immunologic and hematologic effects of microwave irradiation at low power densities. Assays of blastic transformation of lymphocytes in conjunction with mito-

genic stimulation were performed on days 3, 7, 10, 14, 21, and 30 days. Exposures at 50 $\mu W/cm^2$ were associated with a downward trend in relative numbers of transformed T-cell lymphocytes. Exposures at 50 and 10 $\mu W/cm^2$ were associated with an initial augmentation of transformation that was followed by a reduction below control values. Rats were also observed for content of glycogen (G) and of alkaline phosphatase (AP) in neutrophils of peripheral blood. Increases of G and AP were observed during day 3 in animals exposed to 10 and 50 $\mu W/cm^2$, after which the values oscillated below and above control values. At 500 $\mu W/cm^2$, the content of G was substantially lower during the entire 30-day period; values of AP rose until day 7 and then exhibited the oscillation noted at lower power densities. Autoallergenic activity was observed at 500 $\mu W/cm^2$; specifically, antibodies of brain and liver were detected in rats, guinea pigs, and rabbits after exposure to UHF fields. It is concluded that exposure to UHF fields can induce a primary lesion in the immunologic system and can also result in autoimmune disease.

5393 PRELIMINARY RESULTS ON THE EFFECTS OF MICROWAVES ON THE RETICULO-HISTIOCYTIC SYSTEM (MEETING ABSTRACT). *(Eng.)* Miro, L.; Senelar, R.; Draussin, M.; Grasset, C.; Mion, H.; Coste, J. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 86; 1977. (0 refs)

To investigate the effects of microwave radiation on the reticulo-histiocytic system, 16 rabbits and 5 guinea pigs were exposed to 3.1-GHz microwaves for a total of 320 hr. The pulse repetition rate was 500/sec and the pulse width, 1 μsec. The experiment was carried out in an anechoic chamber at an averaged power density of 1.2 ± 0.2 mW/cm^2. Six rabbits and three guinea pigs served as controls. During sham radiation and radiation treatments, no differences in behavior of control and exposed animals were noted. Necropsy of brain, kidney, suprarenal glands, and liver revealed no thermal disturbance. Metabolic assays of reticulocytes revealed a lower colloidal hematocrit in exposed animals than in controls ($p<.05$), and uptake of colloidal ^{198}Au by Kupfer hepatic cells was slower in exposed animals ($p<.05$). The mitotic activity of spleen, thymus, and lymph node cells was significantly higher in exposed animals, and these organs also exhibited greater infiltration by lymphocytes. Titers of gamma globulin were increased significantly 8 days after exposure to microwave irradiation. The data indicate that prolonged irradiation of the mammal by pulsed microwaves at 1.2 mW/cm^2 results in augmented metabolism of reticulocytes and an increased presence of circulating components of the immunologic system.

5394 EFFECTS OF MICROWAVE EXPOSURE ON IMMUNOCOMPETENT CELLS (MEETING ABSTRACT). *(Eng.)* Czerski, P.; Wiktor-Jedrzeijczak, W. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 87; 1977. (0 refs)

The effects of microwave exposure on immunocompetent cells are reviewed. Microwave-induced depression of phagocytic activity of macrophages and granulocytes has been reported. Impaired release of granulocytes and ability of irradiated animals to combat bacterial infections also have been described. A dramatic improvement in survival of mice infected with herpes viruses has been reported, with the effect dependent on schedule of irradiation. An increased production of protein in the cells of the reticuloendothelial system (thymus, spleen, and liver) of mice exposed to microwaves has been described. Single or repeated exposures of mice have led to an increase in vivo in the percentage of Ig^+, Ig^+CR^+, and plaque-forming cells among splenic lymphoid cells. Changes in the kinetics of immunoglobulin M production in irradiated mice have been demonstrated; the direction of the change is highly dependent on schedule of irradiation. Transient peripheral lymphocytosis has been seen in many species following irradiation. That in vivo maturation and function of lymphocytes are dependent on energy dose and schedule of irradiation is well documented. However, it is not known whether these effects are mediated or direct cellular effects. The answer may lie in the observation that microwave-induced lymphoblastoid transformation in vitro occurs and that lymphoid cells exposed to microwaves in vitro respond normally to T- and B-cell mitogens.

5395 PATTERNS OF CHANGE IN BEHAVIORAL REACTIONS TO LOW POWER DENSITIES OF MICROWAVES (MEETING ABSTRACT). *(Eng.)* Shandala, M. G.; Rudnev, M. I.; Navakatian, M. A. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 88; 1977. (0 refs)

Randomly bred albino rats were exposed to 2,375-MHz microwave radiation at power densities of 10 or 50 $\mu W/cm^2$, 7 hr/day, for 90 days to assess changes in behavioral reactions. Behavioral measures involving a photically-and sonically-cued avoidance reaction, open-field exploratory activity, and threshold of electric shock to the feet, were obtained on days 10, 20, 30, 60, and 90 of exposure. After 10 days, acquisition of the aversive habit by exposed rats was more rapid (mean number of trials at 10 $\mu W/cm^2$ = 14.2, and at 50 $\mu W/cm^2$ = 18.0) than that by controls (mean number of trials = 24.2). The differences between exposed groups and controls were reliable

(both $p<.05$). After 20 days the differences were negligible and by day 90 they were reliably reversed (mean number of trials by controls = 17.3; respective means at 10 and 50 $\mu W/cm^2$ = 35.2 and 55.7 trials; all three means differed at $p<.05$). Activity of the three groups in the open-field apparatus differed little on day 10 but was significantly depressed by day 90 in both exposed groups. Thresholds of behavioral reaction to electrical shock were lower in exposed rats on day 10 but eventually rose and were higher on day 90. The data indicate the existence of phase-dependent changes in several behavioral endpoints in rats repeatedly exposed at 10 and 50 $\mu W/cm^2$; an initial phase of central nervous excitation is subsequently followed by inhibition.

5396 QUANTUM MECHANICAL APPROACHES TO THE MECHANISM OF INTERACTION OF MICROWAVES WITH LIVING SYSTEM (MEETING ABSTRACT). *(Eng.)* Czerski, P.; Achimowicz, J. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 3, 1977: pp. 89; 1977. (0 refs)

The effects of microwave radiation on the nervous system, the immunocompetent and blood-forming cell systems, and on cell division, cell membrane, chromosomes and bacteria are reviewed and explained in terms of quantum mechanical theory. A generally applicable explanation is based on the Frohlich phenomenon of long-term energy storage in macromolecules and the emerging theory of collective phenomena, as developed by Frohlich, Cope, and others. Superconductivity in biologic systems and multiphoton activation are also considered. Approaches to experimental verification of proposed theory are discussed.

5397 THRESHOLD ENERGY FOR HEARING MICROWAVE PULSES OF 10- TO 500-μs DURATION (MEETING ABSTRACT). *(Eng.)* Chou, C. K.; Guy, A. W. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, Va on October 30, 1977-November 4, 1977: pp. 92; 1977. (0 refs)

Evoked responses from the brainstem were recorded from guinea pigs to study the threshold of microwave hearing. Microwaves (generated by a klystron) at 918 MHz with a pulse-width between 10 and 500 μsec were fed into a cylindrical waveguide that was used to radiate the guinea pig's head. For pulses <30 μsec, the threshold was independent of the absorbed energy per pulse. As the pulse-width increased, the energy required to reach threshold also increased. For pulses >70 μsec the threshold was independent of the peak power density. The dependence of the threshold energy of the hearing effect on the microwave pulse-width agreed well with the prediction of the thermal-expansion theory.

5398 MIDDLE-EAR IMPAIRMENT AND MICROWAVE HEARING (MEETING ABSTRACT). *(Eng.)* Chou, C. K.; Galambos, R. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 93; 1977. (0 refs)

Amplitude and latency of maximum brainstem evoked responses (BERs), as recorded from guinea pigs, were obtained for acoustic and microwave stimuli under various stimulus intensities. The effects of external-ear blocking, middle-ear damping, and middle-ear destruction on the BER were studied. Results show that only when the inner ear (cochlea) is intact is the animal capable of hearing pulsed microwaves.

5399 EIGHTH-NERVE DERIVED, SINGLE-NEURON RESPONSES TO ACUTE MICROWAVE RADIATION OF THE HEAD (MEETING ABSTRACT). *(Eng.)* Lebovitz, R. M.; Seaman, R. L. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 94; 1977. (0 refs)

The influence of pulse-modulated (PM) and continuous wave (CW) microwave radiation (MWR) on eight-nerve-related afferent systems was studied during acute exposures of cats. MWR at 915 MHz was applied to the head via a diathermy-type plane-wave applicator, while activity of a single neuron was recorded via glass micropipettes filled with 2 M NaCl. The responses of single auditory units to PM-MWR and to traditional acoustic stimuli were compared with respect to response threshold, response latency, and form of the probability distribution of post-stimulus firing times. In general, the responses to acoustic "click" stimuli and to PM-MWR were similar, differing only in amplitude. The PM-MWR influence on single auditory units appeared to originate from a mechanical interaction with portions of the auditory apparatus peripheral to the basilar membrane. However, the threshold of averaged microwave dose rate was several orders of magnitude below the current thermal-safety standard. Pulsed, not averaged, parameters of MWR appeared to be more significant in determining the nature of the response. From these data an estimate of the relative efficiency and mechanical nature of the PM-MWR effects could also be derived, establishing the basis for a novel communications channel. Similar comparisons of the responses of vestibular single units to CW-MWR and to traditional vestibular stimulation were performed. A MWR-mediated stimulation of cells innervating the semicircular canals, which was consistent with the hypothesis of a microwave-induced caloric vestibular stimulation was demonstrated. The threshold for vestibular activation via CW-MWR exceeded the dose rate at which thermal effects would be expected in the head of the test animal. However, the basis for a new method for

clinical diagnosis of labyrinthine functioning was established. A major improvement in the coupling efficiency of this interaction could be achieved by appropriate selection of geometric and radiation parameters (such as frequency and/or modulation characteristics). A significant finding is that reliable spike-train (firing-time) data can be obtained coincident with exposure to MWR.

5400 THE EFFECT OF MICROWAVES ON CRAYFISH NEURONS (MEETING ABSTRACT). *(Eng.)* Matsumoto, G.; Yamaura, I. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 95; 1977. (0 refs)

The effects of microwaves on the neuro-impulse frequency were studied in spontaneously discharging neurons in isolated abdominal ganglia and in the slowly adapting stretch-receptor neuron of the American fresh water crayfish. A few seconds of microwave irradiation (11 GHz) of the abdominal ganglia decreased acutely the spontaneous discharge frequency, which was nearly constant (within 20 impulses/sec) in the normal steady-state. The effect was observed when tissue temperature was elevated by microwave radiation more than 0.5 C; with smaller temperature changes, the effect was seldom detected. The pattern of the neuronal response to microwave radiation was characterized by inhibitory-on and excitatory-off responses, which were commonly observed in the nervous system. Simulation of the neuron's behavior indicates that the response pattern is composed of the superimposing of two responses. The results compare well with the static and dynamic characteristics of thermal stimulation of *Aplysia* neurons. The detailed sequential relationship between changes of tissue temperature and impulse frequency was clearly revealed when microwaves at 2.45 GHz were modulated by M-sequential signals. The results indicate that the impulse frequency of the crayfish neuron is a function of the temperature change of the tissue.

5401 MICROWAVE EFFECTS OF NERVE VITALITY (MEETING ABSTRACT). *(Eng.)* McRee, D. I. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 96; 1977. (0 refs)

To study the effects of microwaves on nerve vitality, paired sciatic nerves from large specimens of *Rana pipiens* were exposed in a waveguide system. The exposed nerve crossed the waveguide near (within 2 mm) the proximal (to the microwave source) surface of the surrounding Ringer's solution; whereas, the control nerve was positioned 5-cm distal to the surface and was essentially unexposed. Applying a maximum incident continuous wave power (at 2,450 GHz) of 1 W or less led to very slow rises of temperature (<2 C/hr), which registered almost equally (within 0.1 C) at corresponding points on each nerve. Both nerves were stimulated with twin pulses (separated by a 5-msec interval) at a repetition rate of 50 pulses per sec to elicit a maximal (Group A) compound action potential (CAP), followed (at the outset) by a CAP of about half-maximal size. During 1- to 4-hr of exposure periods, the nerve was first observed to undergo a prolongation of its refractory period and, later on, severe decreases in the maximal CAP size. During the same periods the control nerve showed little change in these characteristics. The microwave-specific effects appear to be due to an interference with neural regulatory mechanisms rather than a direct effect on the excitation process.

5402 THE VISUALLY-EVOKED ELECTROCORTICAL RESPONSE OF THE GUINEA PIG AFTER MICROWAVE-INDUCED HYPERTHERMIA (MEETING ABSTRACT). *(Eng.)* Bruce-Wolfe, V.; Mathews, M.; Justesen, D. R. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 97; 1977. (0 refs)

Latencies of an early component (N_1) of the visually-evoked electrocortical response (VER) of four young guinea pigs were observed as a function of brain and rectal temperature. Descending series of measurements within a daily session (where rectal temperature was initially elevated to more than 42.5 C by 2,450-MHz energy at an averaged dose rate of 30-40 mW/g) yielded a number of single or multiple VERs as temperature fell across time. Ascending series across several daily sessions, where rectal temperatures were elevated above baselines in increments of 1 to 1.5 C per day, were also conducted. The previously reported curvilinear relationship between body temperature and latency of VER was verified in two of the animals during descending series. However, the function was consistently (and negatively) monotonic for all of the data based on ascending series, i.e., the shortest latencies were observed at 42.5 C. The implication is that nonlethal elevation of body temperature to a level between 42.5 and 43.0 C resulted in a reversible alteration of neuronal function, presumably of chemical origin. Comparisons of brain and rectal temperatures from baseline measures revealed that the former were consistently below the latter by as much as 2 C, but the difference narrows as temperature was increased by microwave radiation.

5403 EFFECTS OF UHF ENERGY ON THE CENTRAL NERVOUS SYSTEM: DEMONSTRATION OF TRANSIENT ELECTROENCEPHALOGRAPHIC (EEG) ABNORMALITIES IN RATS (MEETING ABSTRACT). *(Eng.)* Klein, M. J.; Milhaud, C. L. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science

& The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 98; 1977. (0 refs)

It was previously found that chronic exposure of rats to 2,450-MHz microwave radiation at a power density of 3-5 mW/cm^2 induced changes in cerebral electrogenesis that varied among individuals: 25% of irradiated subjects exhibited electroencephalographic (EEG) abnormalities, 30% showed questionable recordings, and 45% presented a normal EEG. To select sensitive subjects, i.e., those with disturbed electrogenesis after exposure, a special pharmacologic technique of electrobiologic signal detection was developed. In the first acute experimental run, the technique revealed a transient aspect of the previously described abnormalities. Initially, the EEG was questionable for 72% of the irradiated animals, 50% of which had abnormal EEGs between min 5-20 of experimentation. The latter percentage gradually decreased, and the EEG progressed toward normality. At min 50, only questionable EEG recordings persisted and in only 25% of the irradiated subjects. The results are discussed as a function of the possible effect of microwaves on cortical and subcortical structures. It is hypothesized that the transient paroxysmal elements that define abnormality are a sign of either functional disturbance or of other dysfunctions due to metabolic or toxic factors.

5404 MODELS OF LONG-RANGE ORDER IN CEREBRAL MACROMOLECULES: EFFECTS OF ELF, VHF AND UHF FIELDS IN CALCIUM BINDING (MEETING ABSTRACT). *(Eng.)* Bawin, S. M.; Sheppard, A. R.; Adey, W. R. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 100; 1977. (0 refs)

The effects of electromagnetic fields on the rate of calcium exchange between isolated chick or cat cerebral tissue were investigated. Previous studies indicated that the isolated tissue responds to stimulation by an extremely low frequency (ELF) field within a narrow-frequency band (6-20 Hz) and in an "amplitude window" (5-100 V/m). Amplitude modulation of a weak 147-MHz field (0.8 mW/cm^2) also elicited a response but only in the same narrow, low-frequency modulation window (6-20 Hz). In a third series of experiments, the root mean square amplitude of a 450-MHz field that was modulated at 16 Hz varied from 0.1 to 5 mW/cm^2. Increased efflux of calcium occurred only at intensities between 0.1 and 1.0 mW/cm^2, defining an "amplitude window" in addition to that noted for ELF. It is hypothesized that membrane-surface charge-sites behave "coherently" over a considerable area and that a coherent patch may be triggered to change its state by a very weak trigger at a point. The triggering event may occur at the boundary between such a patch and a noncoherent surround.

5405 TWO PARAMETERS AFFECTING RADIATION-INDUCED CALCIUM EFFLUX FROM BRAIN TISSUE (MEETING ABSTRACT). *(Eng.)* Blackman, C. F.; Elder, J. A.; Weil, C. M.; Benane, S. G.; Eichinger, D. C. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 101; 1977. (0 refs)

An attempt was made to verify and extend the finding of changes in the binding of calcium to the surface of brain tissue during exposure to non-ionizing electromagnetic radiation. The cerebral cortex of newborn chicks, separated at the mid-line to provide a treatment/control pair, was labeled in vitro with radioactive calcium. The treated tissue was exposed in a Crawford chamber to 147-MHz radiation that was amplitude modulated at selected frequencies between 3 and 30 Hz at power densities between 0.5 and 2 mW/cm^2. Compared with nonirradiated controls, a statistically significant increase in calcium efflux ($p<.05$) was found when frequency of amplitude modulation was 16 Hz and averaged power density of radiation approximated 0.75 mW/cm^2. The data support the concept and location of the previously reported frequency "window" as well as power-density window in which calcium efflux is enhanced due to exposure to amplitude-modulated radiation.

5406 ACTIVITY OF MEMBRANE-BOUND ENZYMES EXPOSED TO AMPLITUDE-MODULATED 2450-MHZ RADIATION (MEETING ABSTRACT). *(Eng.)* Allis, J. W.; Fromme, M. L. *In: Abstracts of 1977 International Symposium on the Biological Effects of Electromagnetic Waves.* Sponsored by The International Union of Radio Science & The U.S. Committee for URSI, held at Airlie, VA on October 30, 1977-November 4, 1977: pp. 102; 1977. (0 refs)

Membrane-bound enzyme systems were irradiated with amplitude modulated microwave radiation in a spectrophotometric apparatus where enzyme activity was measured during irradiation. The enzymes investigated were cytochrome oxidase, a key enzyme in the electron transport chain located in the inner membrane of mitochondria, and adenosine triphosphatase (ATPase) from red blood cell membrane, which is involved in maintaining the sodium-potassium balance of the cell. These enzyme systems were prepared from rat tissue and were subjected to 2,450-MHz radiation that was amplitude modulated at 16, 30, 90, and 120 Hz, which resulted in a specific absorption rate of 26 W/kg. Temperature was controlled at 25 ± 0.5 C for all experiments. Irradiations were begun immediately after initiation of the reaction and continued for several min, while the reaction rate was being monitored. Cytochrome oxidase activity was measured directly by monitoring the change in absorbance of its substrate, cytochrome c, at 550 nm. ATPase activity was measured using a coupled enzyme system in which the rate of conversion of ATP to adenosine diphosphate was followed at 340 nm by stoichiometric oxidation of nicotinamide adenine dinucleotide phosphate. Pyruvate kinase and lac-