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# Biological Effects of Radiofrequency Radiation

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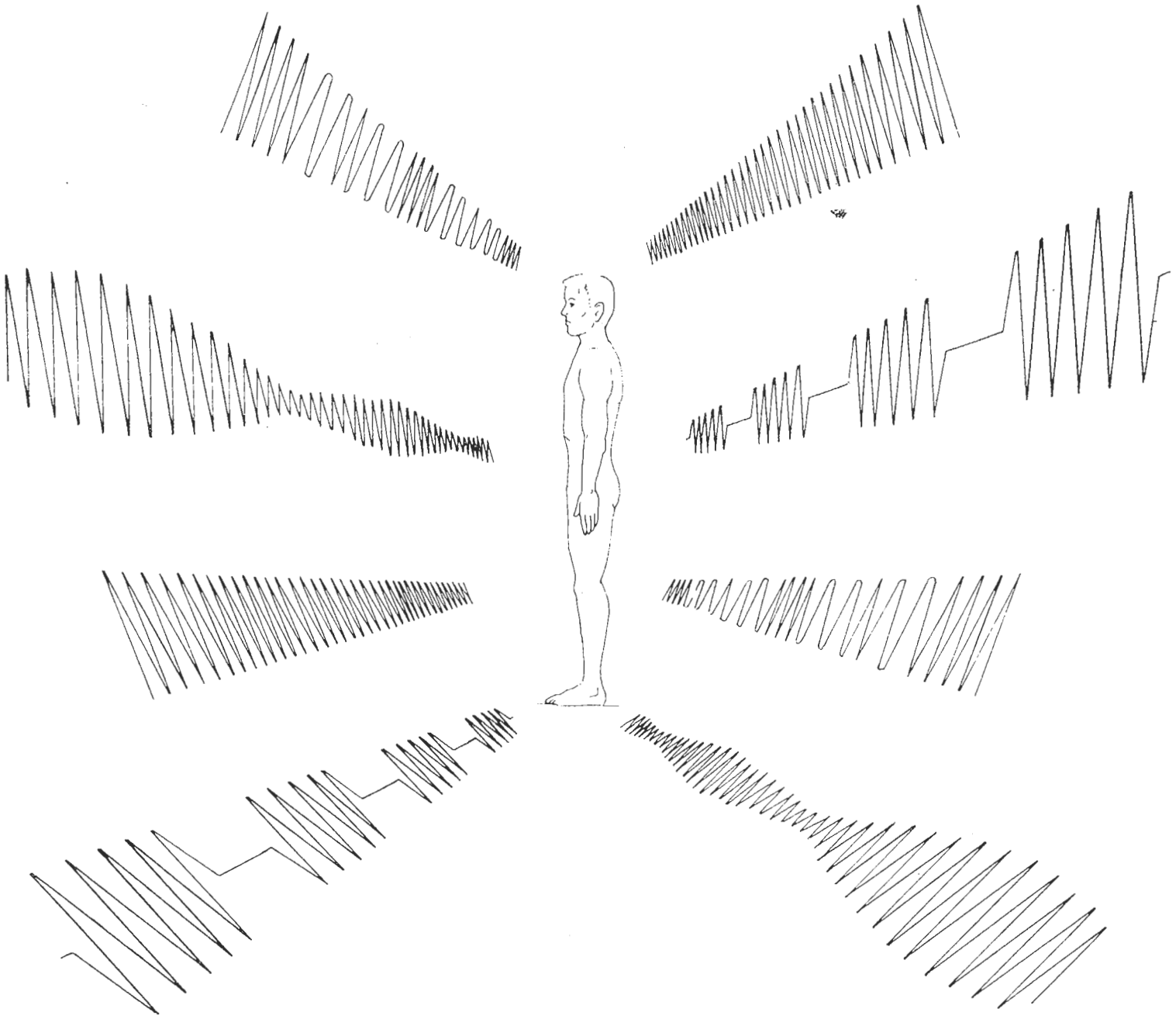

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# Biological Effects of Radiofrequency Radiation

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## 5.7 Endocrine, Physiological and Biochemical Effects

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### *5.7.1 Endocrine Effects*

The endocrine system in coordination with the nervous system is a major regulatory system in the body. Alterations in the function of the neuroendocrine system often reflect the efforts on the part of the animal to maintain homeostasis when subjected to stressful internal and external stimuli. Detection of changes in the endocrine system is a sensitive means of analyzing the animal's responses either to direct stimulation of the endocrine organs themselves or to stimulation of the CNS.

Animals exposed to a wide variety of stimuli generally respond with a rather specific pattern of physiologic changes, usually referred to as the general adaptation syndrome, and the stimuli that can provoke the syndrome are usually called stressors. An increase in the concentration of corticosteriods in the blood above that which would normally occur at that time of day in the absence of a stimulus is considered by many to be an indicator of an animal's response to stress. Such an increase results when an internal or external stimulus, either chemical, physical, or emotional, excites neurons of the hypothalamus to release corticotropin-releasing hormone, which drives the pituitary to release adrenocorticotropic hormone (ACTH). This hormone then stimulates the adrenal cortex to secrete corticosteroids. Among the strongest stressful stimuli are surgery, anesthesia, cold, narcosis, burning, high environmental temperature, and rough handling or restraint.

The thyroid gland plays a principal role in regulating basal metabolism, as well as in generating metabolic heat in the tissues. Changes in thyroid activity can result from changes in thyroid-stimulating hormone from the hypothalamic-hypophyseal system and/or increased metabolic activity of the thyroid gland due to heating. Direct interaction with the CNS could also produce changes in thyroid activity. Moderate or gradual heating results in a reduction of thyroid hormone; rapid or marked elevation of body temperature results in an increase in thyroid activity. The effects of RF radiation on the endocrine system are discussed below and summarized in Table 5-19.

Thyroid function of rats following exposure to 2450-MHz (CW) microwaves at 10, 20, and 25 mW/cm$^2$ (SARs estimated at 0.25 W/kg per mW/cm$^2$) for 4 or 16 h was studied by Parker (1973). No effects on thyroid gland function were found at these exposures. However, at 15 mW/cm$^2$ (SAR estimated at 3.75 W/kg), exposure for a longer period (60 h) was reported to produce a significant decrease in serum-protein-bound iodine, thyroxine, and thyroid/serum iodine ratio. A significant rectal temperature increase (1.7°C) was reported at 25 mW/cm$^2$, but not at lower power densities.

Magin *et al.* (1977a,b) irradiated the surgically exposed thyroid gland of anesthetized dogs with 2450-MHz (CW) microwaves using a waveguide applicator at power densities of 72, 162, and 236 mW/cm$^2$ (SARs from 58 to 190 W/kg) for 2 h. One thyroid was irradiated while the other was used as a control. Tissue temperatures of 39, 41, and 45°C were maintained in the thyroid at the three power densities. They reported an increased release of thyroxine (TH) and triiodothyronine (T3) at all power densities, which showed that the thyroid gland in the dog can be stimulated directly by microwave heating.

Milroy and Michaelson (1972) exposed rats to 2450-MHz microwaves at 1, 10, and 100 mW/cm$^2$ (SAR = 0.25 W/kg per mW/cm$^2$) for single exposures of 10, 20, 30, and 45 min and at 1 and 10 mW/cm$^2$, 8 h/day, for 8 weeks, and reported no effect on T3 levels, thyroxine levels, or on the uptake of radioactive iodine. No rectal temperature increase was observed at 10 mW/cm$^2$ or less. At 100 mW/cm$^2$ there was a constant rise in rectal temperature throughout exposure, up to 42°C at the end of the exposure period. Histopathological examination of the thyroid glands also showed no effect from the exposure.

An increased production of thyroid hormone in rabbits as measured by increased incorporation of $^{131}$I and increased radioactivity per gram of thyroid (verified by autoradiography) was reported by Barański *et al.* (1972). The animals were exposed for 3 h/day for 4 months to 10-cm (3-GHz, PW) microwaves at an average incident power density of 5 mW/cm$^2$ (SAR estimated at 0.25 to 0.75 W/kg). They reported no increase in body temperature or thyroid temperature. (The pulse parameters were not given, so peak power density cannot be calculated.)

Lu *et al.* (1977) reported serum thyroxine levels in rats exposed to 2450-MHz microwaves at 1, 5, 10, and 20 mW/cm$^2$ (0.25, 1.25, 2.5, and 5 W/kg) for 1, 2, 4, or 8 h. Decreased thyroxine levels were observed at 20 mW/cm$^2$ following 4- and 8-h exposures. The thyroxine values at shorter exposures and lower power densities were not significantly different from the sham values, except for an increase after 4 h at 1 mW/cm$^2$, which appears to be a chance variation, since at both higher and lower power densities and at longer and shorter periods of exposure no effect was detected. There were small but statistically significant rectal temperature increases at 1 mW/cm$^2$ after 4 h, at 5 mW/cm$^2$ after 1 and 2 h, and at 10 mW/cm$^2$ after 2 and 4 h of exposure. The increases were in the range of 0.2 to 0.56°C. The lack of correlation between power density, exposure time, and rectal temperature increase, along with the small rectal

Paff *et al.* (1963), working with the isolated embryonic chicken heart, were unable to detect changes in heart rate during exposure to 24,000-MHz (PW) radar fields. They did, however, detect effects on the electrocardiogram (ECG), including abnormal P and T waves from 3-min exposures at 74 mW/cm$^2$.

Frey and Seifert (1968) showed that 10-$\mu$s pulses at a carrier frequency of 1.425 GHz given at a synchronous period with the ECG (220 ms after the P wave) resulted in tachycardia or heart arrhythmia in the isolated frog heart. The peak power density was 60 mW/cm$^2$ (average power density ~ 0.6 $\mu$W/cm$^2$). Liu *et al.* (1976) reported no effect on heart rate with isolated frog hearts or in hearts irradiated *in situ* in a similar study. The *in situ* hearts were exposed to 100-$\mu$s pulses of either 1.42 or 10 GHz, and the isolated frog hearts were exposed to 100-$\mu$s pulses of 1.42 GHz. The pulse was delivered on the rising phase of the R-wave from the ECG, which as somewhat similar to, but not exactly the same as, the 200-ms delay following the P-wave used by Frey and Seifert. (The R-wave follows the P-wave by about 200 ms.) The peak and average power densites of 320 mW and 32 $\mu$W were also considerably higher than those used by Frey and Seifert. These factors, plus differences in the manner of preparing the isolated hearts (Liu *et al.* curarized the frogs, whereas Frey and Seifert decapitated the frogs), make it difficult to compare the results of the two studies.

Clapman and Cain (1975), however, tried to replicate the study of Frey and Seifert using similar pulse widths (10 $\mu$s), peak and average power densities (60 mW/cm$^2$ and 0.6 $\mu$W/cm$^2$), carrier frequency (1.42 GHz), and method of isolating the frog heart; they reported no change in heart rate. Also, no heart rate changes were found when they conducted studies with a different peak power (5.5 W/cm$^2$), frequency (3 GHz), and pulse widths (2 and 150 $\mu$s). Clapman and Cain were able to produce an increased heart rate with 20-mA current pulses synchronized 200 ms after the P-wave peak.

The results of microwave exposure on the cardiovascular system (Table 5-22) indicate that whole-body exposure of sufficient intensity to produce heating also produces an increase in heart rate similar to that which would be expected from heating alone. In the isolated heart there appears to be a stimulation of the autonomic nervous system from microwave exposure at levels where very little heating would be expected (1 to 2 W/kg). Low levels of synchronized PW microwaves (0.6 to 32 mW/kg) apparently are ineffective in producing detectable alterations in heart rate.

### *5.7.5 Biological Effects of Low Frequency Modulation of RF Radiation*

Interest in the biological effects of low frequency modulation of RF radiation stems from reports of changes caused by exposure to electric and magnetic fields in the sub-ELF range (0 to 30 Hz). It has been reported that exposure to low-frequency electric fields changes the reaction time in humans (Konig and Ankermuller 1960; Hamer 1968; Konig 1971) and in monkeys (Gavalas; *et al.* 1970; Gavalas-Medici and Day-Magdaleno 1976), and alters circadian activity in human beings (Wever 1973). Friedman *et al.* (1967) observed that magnetic fields modulated at low frequencies also change reaction time in human beings.

Two other studies that provide important background information are reported by Kaczmarek and Adey (1973, 1974). In the first report, they described release of calcium ions and $\gamma$-aminobutyric acid (GABA) from the cerebral cortex of cats in response to small changes in the extracellular concentration of calcium. In 1974, they demonstrated release of calcium ions and GABA from the cat cortex in response to low intensity electric currents, pulsed at 200 Hz, applied directly to the cerebral cortex. Thus, extracellular calcium and electric current have similar effects on the release of GABA and calcium ions from brain tissue.

The studies of (1) behavioral changes in animals and human beings induced by low frequency signals and (2) biochemical changes in the cat brain caused by electric currents led to a study of the influence of electric fields on EEG patterns associated with a conditioned behavioral response in cats (Bawin *et al.* 1973). To increase the penetration of the signals into the tissue, they chose an RF carrier wave of 147 MHz, which was amplitude modulated at sub-ELF frequencies (e.g., 3 to 14 Hz). Alterations were observed in the rate of performance, accuracy of reinforced patterns, and resistance to extinction in learned behavior of the exposed animals compared to controls, indicating that the fields were acting as reinforcers. In order to determine whether these effects were mediated via peripheral receptors or occurred as a result of changes induced directly on the CNS, experiments were designed to examine the effects of modulated RF carrier waves on brain tissue *in vitro*.

#### 5.7.5.1 Calcium Ion Efflux *In Vitro*: A Fundamental Finding

The association of calcium ions with brain tissue was selected as the biochemical marker to examine the influence of modulated RF fields because calcium ion efflux has been shown to be sensitive to electric currents applied directly to brain tissue *in vitro*, and because calcium ions have a prominent role in many biochemical and biophysical processes (e.g., cellular membrane integrity and function, enzyme cofactor, putative second messenger for the conduction of extracellular signals to the nucleus of the cell, neural tissue excitation and secretion of transmitter

substances at synapses). The first report of the influence of modulated RF fields on excised brain tissue was Bawin *et al.* (1975), who showed that a 20-min exposure of chick brain tissue *in vitro* to a 147-MHz field at 1 to 2 mW/cm² (SAR estimated at 0.002 W/kg) caused enhanced efflux of calcium ions, but only if the field was sinusoidally amplitude modulated at frequencies of 6, 9, 11, 16, or 20 Hz. Maximal efflux was measured at 16 Hz. Modulation frequencies of 0, 0.5, 3, 25, and 35 Hz were ineffective. This frequency-specific response, which occurred while the 147-MHz carrier field was maintained at the same power density, indicates that the field-induced efflux of calcium ions was not due to heating of the samples.

In another report, Bawin *et al.* (1978) exposed chick brain tissue for 20 min to 450-MHz fields, amplitude modulated at 16 Hz, at 0.75 mW/cm² (SAR estimated at 0.0035 W/kg) under a variety of chemical conditions. The results demonstrated that (a) the enhanced efflux of calcium ions is not highly sensitive to the external calcium concentration, (b) bicarbonate appears to be important for enhanced efflux, (c) lowering the pH from 7.6 to 6.8 in the presence of bicarbonate may enhance the magnitude of efflux, and (d) lanthanum causes a reversal to field-induced retardation of calcium ion efflux.

Corroboration of the frequency-specific response described by Bawin and co-workers was provided by Blackman *et al.* (1979), who showed that 16-Hz amplitude modulation of 147-MHz carrier waves caused enhanced efflux in chick brain tissue *in vitro*, whereas modulation frequencies of 3, 9, and 30 Hz did not. Although the data had large variances, an unusual intensity response was described, i.e., only 0.83 mW/cm² (SAR estimated at 0.0014 W/kg) produced a statistically significant efflux enhancement (intensity values are corrected based on discussion in Blackman *et al.* 1980a); power densities (0.11, 0.55, 1.11 and 1.38 mW/cm²) below and above the effective value did not cause efflux. In a later report, Blackman *et al.* (1980a) used a revised statistical model and experimental procedure to reduce the influence of the large sample variance. An intensity response identical to their earlier result was found. However, when the distance between samples was halved, the range of intensities that produced enhanced efflux increased to include 0.55, 0.83, 1.11 and 1.38 mW/cm², whereas lower and higher values of 0.11 and 1.66 mW/cm² were ineffective. In addition, an intensity region from 0.55 to 1.11 mW/cm² caused enhanced efflux when 9 Hz was used as the modulation frequency. These data, obtained with a more rigorous experimental protocol, provided additional support for the results of Bawin *et al.* (1975) and Blackman *et al.* (1979); however, the explanation for the dependence on sample spacing awaited further developments.

Joines *et al.* (1981) examined the dependence on sample spacing by calculation of the electrical coupling between the samples; for similicity the samples were modeled as spheres. They found that increased electrical interaction between the more closely packed spheres produced a broader range of internal field strengths within each sphere. Thus, if a given internal field strength were necessary to cause enhanced efflux, the chance would be greater for that internal field strength to occur in closely coupled samples exposed to a specific range of incident intensities. Joines *et al.* (1981) found this result to be consistent with the experimental findings in Blackman *et al.* (1980a). Thus a potential artifact was shown to be a logical result of the experimental procedures.

The intensity response observed by Blackman *et al.* (1979) with modulated 147-MHz carrier waves was confirmed by Sheppard *et al.* (1979) with 450-MHz carrier waves, modulated at 16 Hz; calcium-ion efflux was enhanced at 0.1 and 1.0 mW/cm² but not at 0.05, 2.0, or 5.0 mW/cm². (The estimated SAR at 1.0 mW/cm² is 0.0047 W/kg.) The results of these two reports show that the intensities producing calcium-ion efflux from chick brain tissue *in vitro* are within the range of 0.1 to 1.38 mW/cm² for modulated 147-MHz and 450-MHz carrier waves.

The apparent carrier-frequency independence of effective intensities was tested with a 50-MHz carrier wave, amplitude modulated at 16 Hz. Enhanced efflux of calcium ions occurred within two intensity regions (between 1.44 and 1.67, and at 3.64 mW/cm²; SARs were 0.0013 and 0.0035 W/kg, respectively) separated by intensities of no effect, including 0.72 mW/cm² (Blackman *et al.* 1980b). These effective intensity values were different from the corresponding values of 147-MHz radiation; thereby indicating a dependence on carrier frequency. In addition this result revealed the existence of more than one range of effective intensities.

The apparent discrepancy in effective power densities at the three different carrier frequencies (50, 147, and 450 MHz) has been resolved by the finding that efflux is dependent on the electric field strength within the tissue and not on incident intensity (Joines and Blackman 1980). The calculation to transform the incident intensity to internal field strength was based on an empirical model described by Joines *et al.* (1981). With the data available at 50 and 147 MHz, the model was used to predict intensities that would produce both alterations and no alterations in calcium-ion efflux; some predictions were tested and found to be valid (Blackman *et al.* 1981). These reports described two intensity ranges that appear effective for enhanced efflux at both 50 and 147 MHz, identified the internal electric field strength rather than incident intensity as the important exposure parameter, and showed the

importance of frequency-dependent complex permittivity values of brain tissue in the conversion of incident intensity to internal field strength. The exposures at 50 and 147 MHz caused no generalized heating of the sample. The maximum temperature rise was calculated to be <0.0004°C, and SAR calculated at each carrier frequency was <0.0014 W/kg (Blackman *et al.* 1980b).

Subsequent to the critique by Athey (1981) that the simple spherical model used by Joines and Blackman (1980) was too idealized, these authors showed that a layered sphere model produced relationships between incident intensities at 50, 147, and 450 MHz and internal field strengths that were also consistent with the experimental results (Joines and Blackman 1981). The success of the initial, simple models to predict intensity regions of both field-induced efflux enhancement and no enhancement demonstrates the utility of the approach. More refinements in the models are necessary before the experimental situation is realistically described.

Shelton and Merritt (1981), who used different procedures from those described by Bawin *et al.* (1975), Blackman *et al.* (1979, 1980a,b), and Sheppard *et al.* (1979) reported no change in calcium-ion efflux from rat brain. Brain tissue, labeled *in vitro* with radioactive calcium, was irradiated at 1 GHz, pulse-modulated with square waves at 16 or 32 Hz (0.5, 1.0, 2.0, and 15 mW/cm$^2$). In a second report, Merritt *et al.* (1982) exposed rat brain tissue labeled *in vivo* with radioactive calcium to microwave radiation, pulse modulated at 16 Hz (20-ms pulse width). The intensities for the 1-GHz carrier frequency were 1 mW/cm$^2$ (SAR = 0.29 W/kg) and 10 mW/cm$^2$ (SAR = 2.9 W/kg); and for the 2.45-GHz carrier frequency, 1 mW/cm$^2$ (SAR = 0.3 W/kg). In addition, animals labeled with radioactive calcium were exposed for 20 min to 2.06-GHz radiation at one of 17 different combinations of intensity and pulse repetition rate: 0, 0.5, 1.0, 5.0, 10.0 mW/cm$^2$ (SAR was 0.24 W/kg per mW/cm$^2$); and 0, 8, 16, 32 Hz (pulse width was 10 ms). After exposure, brain tissue was analyzed for radioactivity. No statistically significant field-induced enhancement of calcium-ion efflux or change of calcium content in the brain tissue was found. The reason for these negative findings is not known; however, the use of square wave rather than sine wave modulation, the different biological preparation, and different medium composition are factors that may have influenced the outcome.

### 5.7.5.2 Additional CNS Studies

The reports of field-induced calcium-ion efflux from chick brain tissue *in vitro* have led to other CNS studies. Synaptosomes, prepared from rat cerebra and labelled with radioactive calcium, were exposed for 10 min at 0.5 mW/cm$^2$ to 450-MHz fields, amplitude modulated at 0, 16, or 60 Hz (Lin-Liu and Adey 1982). Only 16 Hz affected the efflux kinetics of calcium ions. Although the SAR can be estimated as low, an exact value cannot be unequivocally established because the exposure chamber may have been operated in a multimodal condition. (See Weil *et al.* 1981.) Nevertheless, this result is modulation dependent, and it is unlikely that heating is involved as a causative agent.

Similar field-induced efflux enhancement has been reported in a live animal. Adey *et al.* (1982) exposed awake, immobilized cats to 450-MHz fields, amplitude modulated at 16 Hz, at 3.0 mW/cm$^2$ (SAR = 0.29 W/kg). The release of calcium ions from the cortex was observed as a function of time. Irradiation for 60 min caused episodes of enhanced efflux lasting 20 to 30 min and extending into the postexposure period. Although focusing on a different component of the efflux kinetics than that studied by Lin-Liu and Adey (1982), these results demonstrate that RF fields modulated at 16 Hz can cause changes in both a subcellular membrane system and in the live mammal. Thus, the field-induced phenomenon is not restricted to an avian species nor to *in vitro* preparations.

Recently, Dutta *et al.* (1984) observed field-induced enhancement of calcium ions from cells of human origin. Monolayer cultures of human neuroblastoma cells were exposed for 30 min at ten SARs from 0.01 to 5.0 W/kg to 915-MHz fields, with or without sinusoidal amplitude modulation (80 percent) at frequencies between 3 and 30 Hz. Significant increases in the efflux of calcium ions occurred at two SARs (0.05 and 1.0 W/kg). The increased efflux at 0.05 W/kg was dependent on the presence of 16-Hz modulation but not at the higher value. Exposure at modulation frequencies between 3 and 30 Hz (SAR = 0.05 W/kg) revealed a peak in the response at 16 Hz. Although the effective SAR (0.05 W/kg) for 16-Hz modulation is more than 38 times greater than the SARs for enhanced efflux of calcium ions from chick brain tissue *in vitro,* the low-frequency response pattern was similar to that reported by Bawin *et al.* (1975) and Blackman *et al.* (1979). The relation of enhanced efflux with unmodulated fields at 1.0 W/kg with the effects of modulated fields is not known at this time; however, it is not due to a temperature increase in the sample because enhancement was not found at SARs of 2.0 and 5.0 W/kg.

The effect of modulated RF fields on the EEG was investigated by Takashima *et al.* (1979). Rabbits were exposed 2 h daily for 6 weeks to 1.2 MHz, amplitude modulated at 15 Hz, or 5 MHz amplitude modulated at 14 Hz. Following exposure, the EEG was recorded with scalp electrodes and, when compared to the pretreatment EEG pattern, was found to be altered with enhanced low-frequency components and decreased high-frequency components. The EEG pattern returned to the pretreatment pattern after

several weeks postexposure. Although the electric field intensity was given as 500 V/m, with an error factor as large as 2, the important aspect of the results was that unmodulated fields of similar intensity had no effect on the EEG pattern. The absence of metallic electrodes in the animal during exposure avoids the major criticism of earlier studies that reported field-induced changes in EEG patterns (Gavalas *et al.* 1970; Bawin *et al.* 1973).

Sagan and Medici (1979) studied the influence of 450-MHz fields, sinusoidally amplitude modulated at either 3 or 16 Hz, on locomotor activity in young chickens. The experiments were performed in a plastic, modified Skinner box with light beams to monitor activity; the complete apparatus was placed in an anechoic chamber and exposed in the far field. The authors found no statistically significant change in performance during or immediately after a 23-min exposure at 1 or 5 $mW/cm^2$ (SAR estimated at 0.2 and 1.0 W/kg). They concluded that the lack of a field-induced response could be due to the use of modulation frequencies not present in the chicken's EEG during performance on the particular (fixed-time schedule) task. An alternative possibility, based on the multiple-intensity ranges observed for field-induced calcium-ion efflux, is that the two intensities used in this study may have been outside the effective ranges.

In summary, four groups (Adey *et al.*; Blackman *et al.*; Dutta *et al.*; Takashima *et al.*) have shown that RF fields, sinusoidally modulated at sub-ELF frequencies, especially 16 Hz, cause CNS changes in different *in vitro* preparations and in the live animal. Many of these studies have been analyzed in reviews (Adey 1981; Blackman *et al.* 1981; Greengard *et al.* 1982; Myers and Ross 1981). It is generally agreed that both the mechanism of interaction and the physiological consequences of these changes are yet to be established.

### 5.7.5.3 Non-CNS Studies

The effects of exposure of pancreatic tissue and T-lymphocytes to RF fields, sinusoidally amplitude modulated at low frequencies, have been examined. An increase of calcium-ion efflux from rat pancreatic tissue exposed *in vivo* at 2 $mW/cm^2$ for 1 to 2.5 h at 147 MHz, modulated at 16 Hz (estimated SAR $<$ 0.075 W/kg), has been reported by Albert *et al.* (1980). However, the efflux was not accompanied by a change in protein secretion, which is normally associated with calcium mobilization in the pancreas. The authors attributed the lack of protein secretion to a limitation imposed by the exposure conditions, i.e., a relatively small volume of medium was available to the tissue for normal metabolic activity.

In another *in vitro* assay, the cytotoxic activity of mouse T-lymphocytes was suppressed by a 2-h exposure (1.5 $mW/cm^2$) to 450-MHz fields, modulated at frequencies between 16 and 100 Hz (Lyle *et al.* 1983). Peak suppression occurred at 60-Hz modulation, with smaller effects at 16, 40, 80, and 100 Hz. The exposed cells recovered full cytotoxic activity 12.5 h after the termination of exposure. This result demonstrated an inhibitory but reversible effect on a cell-mediated immune response by modulation frequencies.

### 5.7.5.4 Sinusoidal ELF and Sub-ELF Signals

Most of the studies reviewed above demonstrate an absolute requirement for low-frequency sinusoidal modulation of the RF carrier wave in order for the signal to be effective biologically. For completeness, several reports are mentioned that describe biological effects of exposure to low frequencies in the absence of an RF carrier wave. Bawin and Adey (1976, 1977) exposed chick and cat cerebral tissue for 20 min to 1, 6, 16, 32 or 75 Hz at electric field gradients of 5, 10, 56, and 100 $V_{p-p}/m$ in air. Only two frequencies, 6 and 16 Hz, caused a reduction in calcium-ion efflux at 10 and 56 V/m for the chick tissue, and at 56 V/m for the cat tissue. Because all other combinations produced no field-induced responses, the authors described "amplitude and frequency windows" for calcium-ion efflux. Electric field gradients within the tissue were estimated to be $10^{-5}$ V/m. The field-induced reduction in efflux is in contrast to the enhancement caused by modulated RF carrier waves. Nevertheless, the frequency dependence observed in the two studies was similar, which suggests an interaction with a common substrate as the site of interaction.

Blackman *et al.* (1982) used chick brain to study the influence of 16-Hz signals at 15 intensities between 1 and 70 $V_{p-p}/m$ on the efflux of calcium ions. Two intensity regions that included 5, 6, and 7.5 V/m and 35, 40, 45, and 50 V/m caused enhanced efflux. No field-induced effects were seen below (1, 2, and 3.5 V/m), between (10, 20, and 30 V/m), or above (60 and 70 V/m) the two effective intensity regions. Moreover, 1- and 30-Hz signals at 40 V/m caused no change in efflux. This finding is consistent with the reports of multiple-intensity regions of enhanced efflux caused by modulated RF radiation (Blackman *et al.* 1980b, 1981). In addition to the intensity response, the frequency dependence corroborated reports by Bawin and Adey (1976) for low-frequency signals, and by Bawin *et al.* (1975) and Blackman *et al.* (1979) for modulated RF fields.

In these two low-frequency studies, the cause of the slight difference in effective intensities is unknown. The major disagreement in the results of Bawin and Adey (1976) and Blackman *et al.* (1982) is the direction of the change in efflux; the latter authors state that the "cause may be found in the slightly different preparations and procedures used in the two laboratories."

Several research groups have reported biological changes induced by low-frequency, sinusoidally oscillating magnetic fields. The myxomycete *Physarum polycephalum* has a longer mitotic cycle and reduced respiration rate after chronic exposure to 2.0-gauss magnetic fields at 75 Hz (Goodman *et al.* 1979). Human fibroblasts in culture exposed to sinusoidally varying magnetic fields for a wide range of frequencies (15 Hz to 4 kHz) and amplitudes (0.25 to 5.6 gauss) exhibit enhanced DNA synthesis (Liboff *et al.* 1984). Fruit flies *(Drosophila melanogaster)* preferred not to deposit eggs in a 10-gauss, sinusoidally varying 50-Hz magnetic field; similar exposure during development of the egg produced less viable eggs and pupae in the exposed samples than in controls (Ramirez *et al.* 1983). These results suggest that low-frequency, sinosoidally varying fields may alter fundamental biological processes.

Low-frequency, pulsed magnetic fields have also been reported to produce alterations in diverse biological systems. These systems include the developing chick embryo (Delgado *et al.* 1982; Ubeda *et al.* 1983), *Drosophila* egg laying and mortality (Ramirez *et al.* 1983), the de-differentiating amphibian red blood cell (Chiabrera *et al.* 1979), transcription in the *Dipteran* chromosome (Goodman *et al.* 1983), nerve cells in culture (Dixey and Rein 1982), and mouse bone cells in culture (Luben *et al.* 1982). Many of these studies used an intricate pulsed waveform, which has been used in therapeutic devices for bone nonunions. All the studies used pulse repetition rates below 500 Hz, with most below 100 Hz. Recently, Liboff *et al.* (1984) questioned the need for the particular wave shapes because it appears that the essential element is the low-frequency field.

#### 5.7.5.5 Summary

Many reports of effects of RF fields that are amplitude modulated at very low frequencies have not been independently corroborated. The major exception is calcium-ion efflux from chick brain tissue *in vitro* at intensity levels far below those that cause heating. This exception, combined with the results of studies of brain biochemistry and EEGs in animals and with synaptosomes and human neuroblastoma cells in culture, provides evidence that CNS tissue from several species, including human beings, is affected by low-intensity RF fields sinosuoidally amplitude modulated at specific low frequencies (Table 5-23). The physiological significance of these field-induced effects is not established.

### *5.7.6 Unresolved Issues*

In addition to the CNS-related changes, amplitude-modulated RF fields have been reported to alter an immune response and a pancreatic tissue function. These reports with diverse biological systems are without apparent connection to each other except for the physical agent causing the change. The biological effects of frequency-modulated RF radiation, e.g., FM radio signals, are not known. The reports cited above of Merritt and co-workers indicate that pulsed square-wave modulation may not cause calcium-ion efflux, whereas data from the Bawin *et al.* and Blackman *et al.* studies show that sine wave modulation is effective.

No report has yet described a mechanism of action in sufficient detail to identify the conditions necessary and sufficient to explain unequivocally calcium-ion efflux in the brain or the other biological changes caused by modulated RF fields. The response to specific frequencies and intensities is unusual and at present unexplained. This response to amplitude-modulated RF radiation or to sub-ELF signals alone may be a true field effect at a very low SAR and at biologically relevant frequencies, i.e., in the range of frequencies normally present in the EEG. The frequency-specific nature of the responses provides evidence against heat as the underlying cause. The unusual, multiple-intensity-range response challenges standard dose-response analyses, and by its very nature, may prohibit the invocation of threshold levels.

Other areas of unresolved issues include comparisons of CW vs. PW microwaves under identical exposure conditions. Such studies would help determine if the differences seen by Wangemann and Cleary (1976) were due to different exposure conditions or to the irradiation parameters (CW or PW). There is also a paucity of information on the effects of RF radiation at different frequencies, particularly at frequencies of environmental importance. Studies at different frequencies would help to determine the reasons for differences in effects at similar SARs. Such studies might help explain why Wangemann and Cleary (1976) reported serum chemistry changes in rabbits at 0.8 W/kg (2450 MHz), and why Lovely *et al.* (1977) reported no change in serum chemistry values in rats at 1 W/kg (918 MHz).

There are also data such as those reported by Boggs *et al.* (1972) where the results from microwave heating to a predetermined temperature are different from those resulting from the same temperature produced by other means of heating. Perhaps there are differences in the uniformity of heating or in the rate of heating which would account for these differences. In addition, a study by Deficis *et al.* (1979) reported elevated serum triglyceride and $\beta$-lipoprotein levels in mice exposed to 2450 MHz at 1.5, 3.3, or 4 mW/cm$^2$, but not at 1 mW/cm$^2$. Because the exposures were conducted in a multimodal cavity, SAR values were not reported and cannot be predicted. If this study is repeated, particular attention should be given to dosimetry. An alternative is to

make or report dosimetric measurements in the exposure system used.

The reported effects on thyroid function at 3.75 W/kg for 60 h contrasted with no effect at 6.25 W/kg for 16 h (Parker 1973) suggests that the total amount of energy absorbed may also be an important consideration. Additional studies could define further the relative importance of dose rate compared with total dose.

**Table 5-23. Summary of Studies Concerning Biological Effects of Low Frequency Modulation of RF-Radiation**

| Effects | Species | RF (MHz) | Modulation (Hz) | Intensity ($mW/cm^2$) | Time (min) | SAR (W/kg) | Reference |
|---|---|---|---|---|---|---|---|
| Altered calcium-ion efflux in brain tissue *in vitro* | | | | | | | |
| frequency specificity | Chicken | 147 | 6-20 | 1-2 | 20 | 0.002* | Bawin *et al.* (1975) |
| influence of pH and lanthanum | Chicken | 450 | 16 | 0.75 | 20 | 0.0035* | Bawin *et al.* (1978) |
| frequency and intensity specificity | Chicken | 147 | 16 | 0.83 | 20 | 0.0014* | Blackman *et al.* (1979) |
| intensity specificity and sample spacing | Chicken | 147 | 9, 16 | 0.83 | 20 | 0.0014* | Blackman *et al.* (1980a) |
| theoretical analysis of sample spacing | Chicken | 147 | 16 | 0.83 | 20 | 0.0014 | Joines *et al.* (1981) |
| intensity specificity | Chicken | 450 | 16 | 0.1-1 | 20 | 0.0005-0.005* | Sheppard *et al.* (1979) |
| two intensity ranges | Chicken | 50 | 16 | 1.5<br>3.6 | 20 | 0.0013<br>0.0035 | Blackman *et al.* (1980b) |
| theoretical analysis of RF dependence | Chicken | 50<br>147<br>450 | 16 | — | 20 | ~0.001 | Joines and Blackman (1980); Athey (1981); Joines and Blackman (1981) |
| test of predictions of theoretical analyses | Chicken | 147 | 16 | 0.37<br>0.49 | 20 | 0.0006<br>0.0008 | Blackman *et al.* (1981) |
| no effect for pulse modulation | Rat | 1000 | 16*, 32* | 0.5-15 | 20 | 0.15-4.35 | Shelton and Merritt (1981) |
| no effect for pulse modulation | Rat | 1000<br>2450 | 16*<br>8*, 16*, 32* | 1, 10<br>1 | 20 | 0.29-2.9<br>0.3 | Merritt *et al.* (1982) |
| change in calcium efflux kinetics in synaptosomes | Rat | 450 | 16 | 0.5 | 10 | — | Lin-Liu and Adey (1982) |
| frequency and intensity specificity in cultured neuroblastoma cells | Human being | 915 | 16 | — | 30 | 0.05 | Dutta *et al.* (1984) |
| Altered calcium-ion efflux in brain tissue *in vivo* | | | | | | | |
| no effect for pulse modulation | Rat | 2060 | 8*, 16*, 32* | 0.5-10 | 20 | 0.12-2.4 | Merritt *et al.* (1982) |
| change in efflux kinetics from awake animal | Cat | 450 | 16 | 3 | 60 | 0.29 | Adey *et al.* (1982) |
| Changed EEG patterns | Rabbit | 1.2<br>5.0 | 15<br>14 | 500 V/m<br>500 V/m | 120 x 6wk<br>120 x 6wk | —<br>— | Takashima *et al.* (1979) |
| No change in behavior | Chicken | 450 | 3, 16 | 1, 5 | 23 | 0.2, 1.0* | Sagan and Medici (1979) |
| Suppressed T-lymphocyte activity | Mouse | 450 | 16-100 | 1.5 | 120 | — | Lyle *et al.* (1983) |
| Altered calcium ion efflux in pancreatic slices *in vitro* | Rat | 147 | 16 | 2 | 60-150 | <0.075 | Albert *et al.* (1980) |

*Est. SAR.
*Square wave.

## *References*


Abramson, D.I., A.J. Harris, and P. Beaconsfield. 1957. Changes in Peripheral Blood Flow Produced by Short-Wave Diathermy. Arch. Phys. Med. Rehab., 38:369-376.

Adair, E.R. 1971. Displacements of Rectal Temperature Modify Behavioral Thermoregulation. Physiol. Behav., 7:21-26.

Adair, E.R. 1976. Autonomic Thermoregulation in Squirrel Monkey when Behavioral Regulation is Limited. J. Appl. Physiol., 40:94-700.

Adair, E.R. 1981. Microwaves and Thermoregulation. In: USAF Radiofrequency Radiation Bioeffects Research Program—A Review, J.C. Mitchell, ed. Review 4-81, USAF School of Aerospace Medicine, San Antonio, Texas. pp.145-158.

Adair, E.R., and B.W. Adams. 1980a. Microwaves Induce Peripheral Vasodilation in Squirrel Monkey. Science, 207:1381-1383.

Adair, E.R., and B.W. Adams. 1980b. Microwaves Modify Thermoregulatory Behavior in Squirrel Monkey. Bioelectromagnetics, 1:1-20.

Adair, E.R., and B.W. Adams. 1982a. Adjustments in Metabolic Heat Production by Squirrel Monkeys Exposed to Microwaves. J. Appl. Physiol., 52(4): 1049-1058.

Adair, E.R., and B.W. Adams. 1982b. Behavioral Thermoregulation in the Squirrel Monkey: Adaptation Process During Prolonged Microwave Exposure. Behav. Neurosci., 97:49-61.

Adair, E.R., D.E. Spiers, J.A.J. Stolwijk, and C.B. Wenger. 1983. Technical Note: On Changes in Evaporative Heat Loss that Result from Exposure to Nonionizing Electromagnetic Radiation. J. Microwave Power, 18(2):209-211.

Adey, W.R. 1981. Ionic Nonequilibrium Phenomena in Tissue Interactions With Electromagnetic Fields. In: Biological Effects of Nonionizing Radiation, K.H. Illinger, ed. ACS Symposium Series, 157:271-297.

Adey, W.R., S.M. Bawin, and A.F. Lawrence. 1982. Effects of Weak Amplitude-Modulated Microwave Fields on Calcium Efflux From Awake Cat Cerebral Cortex. Bioelectromagnetics, 3:295-307.

Airborne Instruments Laboratory. 1956. An Observation on the Detection by the Ear of Microwave Signals. Proc. IRE, 44 (Oct.):2A.

Alam, M.T., N. Barthakur, N.G. Lambert, and S.S. Kasatiya. 1978. Cytological Effects of Microwave Radiation in Chinese Hamster Cells *In Vitro*. Can. J. Genet. Cytol., 20:23-30.

Albert, E.N. 1977. Light and Electron Microscopic Observations on the Blood-Brain Barrier after Microwave Irradiation. In: Symposium on Biological Effects and Measurement of Radio Frequency/ Microwaves, D.G. Hazzard, ed. HEW Publication (FDA) 77-8026, Rockville, Maryland. pp. 294-304.

Albert, E.N. 1979a. Current Status of Microwave Effects on the Blood-Brain Barrier. J. Microwave Power, 14:281-285.

Albert, E.N. 1979b. Reversibility of Microwave-Induced Blood-Brain Barrier Permeability. Radio Sci., 14:323-327.

Albert, E.N., and M. DeSantis. 1975. Do Microwaves Alter Nervous System Structure? Ann. N.Y. Acad. Sci., 247:87-108.

Albert, E.N., and M. DeSantis. 1976. Histological Observations on Central Nervous System: In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 299-310.

Albert E.N., and J.M. Kerns. 1981. Reversible Microwave Effects on the Blood-Brain Barrier. Brain Res., 230:153-164.

Albert, E., C. Blackman, and F. Slaby. 1980. Calcium Dependent Secretory Protein Release and Calcium Efflux During RF Irradiation of Rat Pancreatic Tissue Slices. In: Ondes Electromagnetiques et Biologie, A.J. Berteaud and B. Servantie, eds. Paris, France. pp. 325-329.

Albert, E.N., M.F. Sherif, and N.J. Papadopoulos. 1981a. Effect of Non-ionizing Radiation on the Purkinje Cells of the Uvula in Squirrel Monkey Cerebellum. Bioelectromagnetics, 2:241-246.

Albert, E.N., M.F. Sherif, N.J. Papadopoulos, F.J. Slaby, and J. Monahan. 1981b. Effect of Nonionizing Radiation on the Purkinje Cells of the Rat Cerebellum. Bioelectromagnetics, 2:247-257.

Alfsen, A., and A.J. Berteaud, eds. 1976. Water and Biological Systems, International Colloquia of the National Center for Scientific Research, No. 246, Paris, France. 321 pp.

Allen, S.J., W.D. Hurt, J.H. Krupp, J.A. Ratliff, C.H. Durney, and C.C. Johnson. 1976. Measurement of Radiofrequency Power Absorption in Monkeys, Monkey Phantoms, and Human Phantoms Exposed to 10-50 MHz Fields. In: Biological Effects of Electromagnetic Waves, Vol. II, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8011, Rockville, Maryland. pp. 83-95.

Allis, J.W. 1975. Irradiation of Bovine Serum Albumin with a Crossed-Beam Exposure-Detection System. Ann. N.Y. Acad. Sci., 247:312-322.

Allis, J.W., and M.L. Fromme. 1979. Activity of Membrane-Bound Enzymes Exposed to Sinusoidally Modulated 2450-MHz Microwave Radiation. Radio Sci., 14(6S):85-91.

Allis, J.W., M.L. Fromme, and D.E. Janes. 1976. Pseudosubstrate Binding to Ribonuclease During Exposure to Microwave Radiation at 1.70 and 2.45 GHz. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 366-376.

Allis, J.W., C.F. Blackman, M.L. Fromme, and S.G. Benane. 1977. Measurement of Microwave Radiation Absorbed by Biological Systems, 1, Analysis of Heating and Cooling Data. Radio Sci., 12(6S):1-8

Altman, P.L., and D.S. Dittmer. 1972. Growth. In: Biological Handbook, Fed. Am. Soc. Exp. Biol., Washington, D.C. pp. 537-538.

American Conference of Governmental Industrial Hygienists. 1983. TLV's—Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1980. American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio.

Ames, B.N., J. McCann, and E. Yamasaki. 1975. Methods for Detecting Carcinogens and Mutagens with the *Salmonella*/Mammalian-Microsome Mutagenicity Test. Mutat. Res., 31:347-364.

Anderstam, B., Y. Hamnerius, S. Hussain, and L. Ehrenberg. 1983. Studies of Possible Genetic Effects in Bacteria of High Frequency Electromagnetic Fields. Hereditas, 98:11-32.

ANSI. 1974. An American National Standard, Safety Level of Electromagnetic Radiation with Respect to Personnel (C95.1-1974). American National Standards Institute, New York, New York.

ANSI. 1982. American National Standard Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz-100 GHz (ANSI C95.1-1982). American National Standards Institute, New York, New York.

Appleton, B. 1973. Results of Clinical Surveys of Microwave Ocular Effects. HEW Publication (FDA) 73-8031. U.S. Dept. of Health, Education, and Welfare, Rockville, Maryland. 13 pp.

Appleton, B., and G.C. McCrossan. 1972. Microwave Lens Effects in Humans. Arch. Ophthal., 88:259-262.

Appleton, B., S.E. Hirsch, and P.V.K. Brown. 1975. Investigation of Single Exposure Microwave Ocular Effects at 3000 MHz. Ann. N.Y. Acad. Sci., 247:125-134.

Arber, S.L. 1976. Effect of Microwaves on Resting Potential of Giant Neurons of Mullusk *Helix Pomatia*. Electronnaya Obrabotka Materialov, 6:78-79.

Aschoff, J. 1981. Thermal Conductance in Mammals and Birds: Its Dependence on Body Size and Circadian Phase. Comp. Biochem. Physiol., 69A: 611-619.

Ashman, R.B., and A.J. Nahmias. 1978. Effect of Incubation Temperature on Mitogen Responses of Lymphocytes from Adult Peripheral Blood and from Cord Blood. Clin. Exp. Immunol., 33:319-326.

Aslan, E.E. 1970. Electromagnetic Radiation Survey Meter. IEEE Trans. Instrum. Meas., IM-19:368-372.

Aslan, E. 1976. A Low Frequency H-Field Radiation Monitor. In: Biological Effects of Electromagnetic Waves, Vol. II, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8011, Rockville, Maryland. pp. 229-238.

Aslan, E. 1979. The Maturing of Electromagnetic Radiation Hazard Instruments. Microwave J., 22:83-90.

Athey, T.W. 1981. Comparison of RF-Induced Calcium Efflux From Chick Brain Tissue at Different Frequencies: Do the Scaled Power Density Windows Align? Bioelectromagnetics, 2:407-409.

Atkinson, R.M. 1975. Screening Medicines for Teratogenicity: Problems of Interpretation. In: Teratology: Trends and Applications, C.L. Berry and D.E. Poswillo, eds. Springer-Verlag, New York, New York. pp. 136-146.

Austin, G.N., and S.M. Horvath. 1954. Production of Convulsions in Rats by High Frequency Electrical Currents. Am. J. Phys. Med., 33:141-149.

Barański, S. 1971. Effect of Chronic Microwave Irradiation on the Blood Forming System of Guinea Pigs and Rabbits. Aerospace Med., 42:1196-1199.

Barański, S. 1972a. Effect of Microwaves on the Reactions of the White Blood Cells System. Acta Physiol. Polon., 23:685-695.

Barański, S. 1972b. Histological and Histochemical Effect of Microwave Irradiation on the Central

Nervous System of Rabbits and Guinea Pigs. Am. J. Phys. Med., 51(4):182-191.

Baraǹski, S., and P. Czerski. 1976. Biological Effects of Microwaves. Dowden, Hutchinson, and Ross, Stroudsburg, Pennsylvania. 234 pp.

Baraǹski, S., and Z. Edelwejn. 1968. Studies on the Combined Effect of Microwaves and Some Drugs on Bioelectric Activity of Rabbit Central Nervous System. Acta Physiol. Polon., 19:31-41.

Baraǹski, S., and Z. Edelwejn. 1974. Pharmacologic Analysis of Microwave Effects on the Central Nervous System in Experimental Animals. In: Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, K. Ostrowski, M.L. Shore, C. Silverman, M.J. Suess, and B. Waldeskog, eds. Polish Medical Publishers, Warsaw, Poland. pp. 119-127.

Baraǹski, S., K. Ostrowski, and W. Stodolnik-Baranska. 1972. Functional and Morphological Studies of the Thyroid Gland in Animals Exposed to Microwave Irradiation. Acta Physiol. Polon., 23:1029-1039.

Barber, D.E. 1962. The Reaction of Luminous Bacteria to Microwave Radiation Exposures in the Frequency Range of 2608.7-3082.3 Mc. IEEE Trans. Biomed. Electronics, BME-9:77-80.

Barber, P.W., O.P. Gandhi, M.J. Hagmann, and I. Chatterjee. 1979. Electromagnetic Absorption in a Multi-Layered Model of Man. IEEE Trans. Biomed. Eng., BME-26(7):400-405.

Barnes, F.S., and C.J. Hu. 1977. Model for Some Nonthermal Effects of Radio and Microwave Fields on Biological Membranes. IEEE Trans. Microwave Theory Techniques, MTT-25:742-746.

Barron, C.I., and A.A. Baraff. 1958. Medical Considerations of Exposure to Microwaves (Radar). J. Am. Med. Ass., 168:1194-1199.

Barron, C.I., A.A. Love, and A.A. Baraff. 1955. Physical Evaluations of Personnel Exposed to Microwave Emanations. J. Aviat. Med., 26:442-452.

Bassen, H. 1977. Internal Dosimetry and External Microwave Field Measurement Using Miniature Electric Field Probes. In: Symposium on Biological Effects and Measurement of Radio Frequency/ Microwaves, D.G. Hazzard, ed. HEW Publication (FDA) 77-8026, Rockville, Maryland. pp. 136-151.

Bassen, H., M. Swicord, and J. Abita. 1975. A Miniature Broad-Band Electric Field Probe. Ann. N.Y. Acad. Sci., 247:481-493.

Bassen, H., P. Herchenroeder, A. Cheung, and S. Neuder. 1977a. Evaluation of an Implantable Electric-Field Probe Within Finite Simulated Tissues. Radio Sci., 12(6S): 15-25.

Bassen, H., W. Herman, and R. Hoss. 1977b. EM-Probe with Fiber Optic Telemetry System. Microwave J., 20:35-47.

Bassett, H.L., H.A. Ecker, R.C. Johnson, and A.P. Sheppard. 1971. New Techniques for Implementing Microwave Biological Exposure Systems. IEEE Trans. Microwave Theory Techniques, MTT-19(2):197-204.

Bawin, S.M., and W.R. Adey. 1976. Sensitivity of Calcium Binding in Cerebral Tissue to Weak Environmental Electric Fields Oscillating at Low Frequency. Proc. Natl. Acad. Sci. USA, 73:1999-2003.

Bawin, S.M., and W.R. Adey. 1977. Calcium Binding in Cerebral Tissues. In: Symposium on Biological Effects and Measurement of Radio Frequency/ Microwaves, D.G. Hazzard, ed. HEW Publication (FDA) 77-8026, Rockville, Maryland. pp. 305-313.

Bawin, S.M., R.J. Gavalas-Medici, and W.R. Adey. 1973. Effects of Modulated Very High Frequency Fields on Specific Brain Rhythms in Cats. Brain Res., 58:365-384.

Bawin, S.M., L.K. Kaczmarek, and W.R. Adey. 1975. Effects of Modulated VHF Fields on the Central Nervous System. Ann. N.Y. Acad. Sci., 247:74-81.

Bawin, S.M., W.R. Adey, and I.M. Sabbot. 1978. Ionic Factors in Release of $^{45}Ca^{2+}$ From Chicken Cerebral Tissue by Electromagnetic Fields. Proc. Natl. Acad. Sci. USA, 75:6314-6318.

Belkhode, M.L., D.L. Johnson, and A.M. Muc. 1974a. Thermal and Athermal Effects of Microwave Radiation on the Activity of Glucose-6-Phosphate Dehydrogenase in Human Blood. Health Phys., 26:45-51.

Belkhode, M.L., A.M. Muc, and D. L. Johnson. 1974b. Thermal and Athermal Effects of 2.8 GHz Microwaves on Three Human Serum Enzymes. J. Microwave Power, 9:23-29.

Belsher, D.R. 1975. Development of Near-Field Electric Energy Density Meter Model EDM-2. HEW Publication (NIOSH) 75-140, U.S. Department of Health, Education, and Welfare, Public Health Service, Cincinnati, Ohio. 61 pp.

Ben-Hur, E., M.M. Elkind, and B.V. Bronk, 1974. Thermally Enhanced Radio-response of Cultured Chinese Hamster Cells: Inhibition of Repair of Sublethal Damage and Enhancement of Lethal Damage. Radiat. Res., 58:38-51.

Benzinger, T.H. 1969. Heat Regulation: Homeostasis of Central Temperature in Man. Physiol. Rev. 49:671-759.

Berman, E., and H.B. Carter. 1984. Decreased Body Weight in Fetal Rats After Irradiation with 2450-MHz (CW) Microwaves. Health Phys., 46:537-542.

Berman, E., J.B. Kinn, and H.B. Carter. 1978. Observations of Mouse Fetuses after Irradiation with 2.45 GHz Microwaves. Health Phys., 35:791-801.

Berman, E., H.B. Carter, and D. House. 1980. Tests of Mutagenesis and Reproduction in Male Rats Exposed to 2450-MHz (CW) Microwaves. Bioelectromagnetics, 1:65-76.

Berman, E., H.B. Carter, and D. House. 1981. Observations of Rat Fetuses after Irradiation with 2450-MHz (CW) Microwaves. J. Microwave Power, 16(1):9-13.

Berman, E., H.B. Carter, and D. House. 1982. Observations of Syrian Hamsters after Exposure to 2450-MHz Microwaves. J. Microwave Power, 17(2):107-112.

Bermant, R.I., D.L. Reeves, D.M. Levinson, and D.R. Justesen. 1979. Classical Conditioning of Microwave-Induced Hyperthermia in Rats. Radio Sci., 14(6S):201-207.

Bingham, P.M., R.H. Baltz, L.S. Ripley, and J.W. Drake. 1976. Heat Mutagenesis in Bacteriophage T4: The Transversion Pathway. Proc. Natl. Acad. Sci. USA 73(11):4159-4163.

Bini, M., A. Checcucci, A. Ignesti, L. Millanta, N. Rubino, C. Camici, G. Manao, and G. Ramponi. 1978. Analysis of the Effects of Microwave Energy on Enzymatic Activity of Lactate Dehydrogenase (LDH). J. Microwave Power, 13:95-99.

Birenbaum, L., G.M. Grosof, S.W. Rosenthal, and M.M. Zaret. 1969a. Effect of Microwaves on the Eye. IEEE Trans. Biomed. Eng., BME-16:7-14.

Birenbaum, L., I.T. Kaplan, W. Metlay, S.W. Rosenthal, H. Schmidt, and M.M. Zaret. 1969b. Effect of Microwaves on the Rabbit Eye. J. Microwave Power, 4:232-243.

Birenbaum, L., I.T. Kaplan, W. Metlay, S.W. Rosenthal, and M.M. Zaret. 1975. Microwave and Infra-Red Effects on Heart Rate, Respiration Rate and Subcutaneous Temperature of the Rabbit. J. Microwave Power, 10:3-18.

Blackman, C.F., and J.A. Black. 1977. Measurement of Microwave Radiation Absorbed by Biological Systems, 2. Analysis by Dewar-Flask Calorimetry. Radio Sci., 12(6S):9-14.

Blackman, C.F., S.G. Benane, C.M. Weil, and J.S. Ali. 1975. Effects of Nonionizing Electromagnetic Radiation on Single-Cell Biologic Systems. Ann. N.Y. Acad. Sci., 247:352-366.

Blackman, C.F., M.C. Surles, and S.G. Benane. 1976. The Effect of Microwave Exposure on Bacteria: Mutation Induction. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 406-413.

Blackman, C.F., J.A. Elder, C.M. Weil, S.G. Benane, D.C. Eichinger, and D.E. House. 1979. Induction of Calcium-Ion Efflux from Brain Tissue by Radio-Frequency Radiation: Effects of Modulation Frequency and Field Strength. Radio Sci., 14(6S): 93-98.

Blackman, C.F., S.G. Benane, J.A. Elder, D.E. House, J.A. Lampe, and J. M. Faulk. 1980a. Induction of Calcium-Ion Efflux from Brain Tissue by Radiofrequency Radiation: Effect of Sample Number and Modulation Frequency on the Power-Density Window. Bioelectromagnetics, 1:35-43.

Blackman, C.F., S.G. Benane, W.T. Joines, M.A. Hollis, and D.E. House. 1980b. Calcium-Ion Efflux from Brain Tissue: Power-Density Versus Internal Field-Intensity Dependencies at 50 MHz RF Radiation. Bioelectromagnetics, 1:277-283.

Blackman, C.F., W.T. Joines, and J.A. Elder. 1981. Calcium Ion Efflux Induction in Brain Tissue by Radiofrequency Radiation. In: Biological Effects of Nonionizing Radiation, K.H. Illinger, ed. ACS Symposium Series, 157:299-314.

Blackman, C.F., S.G. Benane, L.S. Kinney, W.T. Joines, and D.E. House. 1982. Effects of ELF Fields on Calcium-Ion Efflux From Brain Tissue In Vitro. Radiat. Res., 92:510-520.

Blasberg, R.G. 1979. Problems of Quantifying Effects of Microwave Irradiation on the Blood-Brain Barrier. Radio Sci., 14(6S):335-344.

Blecha, F., R.A. Barry, and K.W. Kelley. 1982. Stress-Induced Alterations in Delayed-Type Hypersensitivity to SRBC and Contact Sensitivity to DNFB in Mice. Proc. Soc. Exp. Biol. Med., 169:239-246.

Blevins, R.D., R.C. Crenshaw, A.E. Hougland, and C.E. Clark. 1980. The Effects of Microwave Radiation and Heat on Specific Mutants of *Salmonella typhimurium* LT2. Radiat. Res., 82:511-517.

Bligh, J. 1973. Temperature Regulation in Mammals and Other Vertebrates. In: Frontiers of Biology, Vol. 5. North American Holland Research Monograph.

Bligh, J., and K.G. Johnson. 1973. Glossary of Terms for Thermal Physiology. J. Appl. Physiol., 35:941-961.

Boggs, R.F., A.P. Sheppard, and A.J. Clark. 1972. Effects of 2450 MHz Microwave Radiation on Human Blood Coagulation Processes. Health Phys., 22:217-224.

Bowler, K. 1972. The Effect of Repeated Applications of Heat on Spermatogenesis in the Rat: A Histological Study. J. Reprod. Fertility, 28:325-333.

Bowman, R.R. 1970. Quantifying Hazardous Electromagnetic Fields: Practical Considerations. NBS Technical Note 389, U.S. Department of Commerce, National Bureau of Standards, Boulder, Colorado. 15 pp.

Bowman, R.R. 1976. A Probe for Measuring Temperature in Radio-Frequency-Heated Material. IEEE Trans. Microwave Theory Techniques, MTT-24:43-45.

Bradley, L.M., and R.I. Michell. 1981. Differential Effects of Glucocorticoids on the Functions of Helper and Suppressor T Lymphocytes. Proc. Natl. Acad. Sci. USA, 78:3155-3159.

Brodeur, P. 1977. The Zapping of America. W.W. Norton and Co., New York, New York. 343 pp.

Brown, J.L. 1975. The Evolution of Behavior. W.W. Norton and Co., New York, New York, 761 pp.

Bullard, R.W. 1971. Temperature Regulation. In: Physiology, 3rd ed., E.E. Seklurt, ed. Little, Brown & Co., Boston, Massachusetts. pp. 651-667.

Burton, A.C. 1939. The Range and Variability of the Blood Flow in the Human Fingers and the Vasomotor Regulation of Body Temperature. Am. J. Physiol., 127:437-453.

Buss, M.E., and S.A. Henderson. 1971. Induced Bivalent Interlocking and the Course of Meiotic Chromosome Synapsis. Nature New Biol., 234: 243-246.

Cabanac, M., and B. Dib. 1983. Behavioral Responses to Hypothalamic Cooling and Heating in the Rat. Brain Res., 264:79-87.

Cahill, D.F. and J.A. Elder, eds. 1983. Biological Effects of Radiofrequency Radiation. External review draft. EPA-600/8-83-026A. Available from National Technical Information Service (NTIS No. PB83 161550), Springfield, Virginia 22161. 582 pp.

Cain, C.A., and W.J. Rissmann. 1978. Mammalian Auditory Responses to 3.0 GHz Microwave Pulses. IEEE Trans. Biomed. Eng., BME-25:288-293.

Cairnie, A.B., and K.E. Leach. 1980. Quantitative Studies of Cytological Damage in Mouse Testis Produced by Exposure to Heat. Can. J. Genet. Cytol., 22:93-102.

Cairnie, A.B., D.A. Hill, and H.M. Assenheim. 1980a. Dosimetry for a Study of Effects of 2.45-GHz Microwaves on Mouse Testes. Bioelectromagnetics, 1:325-336.

Cairnie, A.B., L.F. Prud'homme-Lalonde, R.K. Harding, and M. Zuker. 1980b. The Measurement of Rectal and Testis Temperature in Conscious Mice, with Observations on the Effect of Direct Heating. Phys. Med. Biol., 25(2):317-322.

Carlisle, H.J., and D.L. Ingram. 1973. The Effects of Heating and Cooling the Spinal Cord and Hypothalamus on Thermoregulatory Behavior in the Pig. J. Physiol., 231:353-364.

Carlson, N.R. 1980. Physiology of Behavior, 2nd ed. Allyn and Bacon, Inc., Boston, Massachusetts. 748 pp.

Carpenter, R.L. 1979. Ocular Effects of Microwave Radiation. Bull. N.Y. Acad. Med., 55:1048-1057.

Carpenter, R.L., and C.A. Van Ummersen. 1968. The Action of Microwave Radiation on the Eye. J. Microwave Power, 3:3-19.

Carpenter, R.L., D.K. Biddle, and C.A. Van Ummersen. 1960a. Biological Effects of Microwave Radiation, with Particular Reference to the Eye. In: Proc. Third International Conference on Medical Electronics, London. Medical Electronics, Part III. pp. 401-408.

Carpenter, R.L., D.K. Biddle, and C.A. Van Ummersen. 1960b. Opacities in the Lens of the Eye Experimentally Induced by Exposure to Microwave Radiation. IRE Trans. Med. Electronics, 7:152-157.

Carpenter, R.L., G.J. Hagan, and G.L. Donovan. 1977. Are Microwave Cataracts Thermally Caused? In: Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves, D.G. Hazzard, ed. HEW Publication (FDA) 77-8026, Rockville, Maryland. pp. 352-379.

Carroll, D.R., D.M. Levinson, D.R. Justesen, and R.L. Clarke, 1980. Failure of Rats to Escape from a Potentially Lethal Microwave Field. Bioelectromagnetics, 1:101-115.

Carslaw, H.S., and J.C. Jaeger. 1959. Conduction of Heat in Solids. Clarendon Press, Oxford, England. pp. 230-231.

Catania, A.C., ed. 1968. Contemporary Research in Operant Behavior. Scott, Foresman, Glenview, Illinois. 358 pp.

Catravas, G.N. 1976. Styrofoam Cages for Rats used in Microwave Research: Coating with Quinine. Health Phys., 31:68-69.

Catravas, G.N., J.B. Katz, J. Takenaja, and J.R. Abbott. 1976. Biochemical Changes in the Brain of Rats Exposed to Microwaves of Low Power Density. J. Microwave Power, 11:147-148.

Chamness, A.F., H.R. Scholes, S.W. Sexauer, and J.W. Frazer. 1976. Metal Ion Content of Specific Areas of the Rat Brain after 1600 MHz Radio Frequency Irradiation. J. Microwave Power, 11:333-338.

Chang, B.K., A.T. Huang, and W.T. Joines. 1981. Microwave Treatment of Intracerebral L1210 Leukemia: Schedule-Dependent Partial Reversal of the Effects of Methotrexate. Bioelectromagnetics, 2:77-80.

Chappuis, P., P. Pittet, and E. Jequier. 1976. Heat Storage Regulation in Exercise During Thermal Transients. J. Appl. Physiol., 40:384-392.

Chatterjee, I., M.J. Hagmann, and O.P. Gandhi. 1980. Electromagnetic Energy Deposition in an Inhomogeneous Block Model of Man for Near-Field Irradiation Conditions. IEEE Trans. Microwave Theory Techniques, MTT-28:1452-1459.

Chen, K.C., and C.J. Lin. 1978. A System for Studying Effects of Microwaves on Cells in Culture. J. Microwave Power, 13:251-256.

Chen, K.M., and B.S. Guru. 1977. Induced EM Fields Inside Human Bodies Irradiated by EM Waves up to 500 MHz. J. Microwave Power, 12(2):173-183.

Chernovetz, M.E., D.R. Justesen, N.W. King, and J.E. Wagner. 1975. Teratology, Survival, and Reversal Learning after Fetal Irradiation of Mice by 2450-MHz Microwave Energy. J. Microwave Power, 10(4):391-409.

Chernovetz, M.E., D.R. Justesen, and A.F. Oke. 1977. A Teratological Study of the Rat: Microwave and Infrared Radiations Compared. Radio Sci., 12(6S): 191-197.

Chernovetz, M.E., D.R. Justesen, and D.M. Levinson, 1979. Acceleration and Deceleration of Fetal Growth of Rats by 2450-MHz Microwave Radiation. In: Electromagnetic Fields in Biological Systems, S.S. Stuchly, ed. Ottawa, Canada. pp. 175-193.

Chiabrera, A., M. Hinsenkamp, A.A. Pilla, J. Ryaby, D. Ponta, A. Belmont, F. Beltrame, M. Grattarola, and C. Nicolini. 1979. Cytofluorometry of Electromagnetically Controlled Cell Dedifferentiation. J. Histochem. Cytochem., 27:375-381.

Chou, C.K., and R. Galambos. 1979. Middle-Ear Structures Contribute Little to Auditory Perception of Microwaves. J. Microwave Power, 14:321-326.

Chou, C.K., and A.W. Guy. 1979. Microwave-Induced Auditory Responses in Guinea Pigs: Relationship of Threshold and Microwave-Pulse Duration. Radio Sci., 14(6S):193-197.

Chou, C.K., R. Galambos, A.W. Guy, and R.H. Lovely. 1975. Cochlear Microphonics Generated by Microwave Pulses. J. Microwave Power, 10:361-367.

Chou, C.K., A.W. Guy, and R. Galambos. 1976. Microwave-Induced Auditory Response: Cochlear Microphonics. In: Biological Effects of Electromagentic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 89-103.

Chou, C.K., A.W. Guy, and R. Galambos. 1977. Characteristics of Microwave-Induced Cochlear Microphonics. Radio Sci., 12(6):221-227.

Chou, C.K., A.W. Guy, K.R. Foster, R. Galambos, and D.R. Justesen. 1980a. Holographic Assessment of Microwave Hearing. Science, 209:1143-1144.

Chou, C.K., L.F. Han, and A.W. Guy. 1980b. Microwave Radiation and Heart-Beat Rate of Rabbits. J. Microwave Power, 15:87-93.

Chou, C.K., A.W. Guy, and R. Galambos. 1982. Auditory Perception of Radio-Frequency Electromagnetic Fields. J. Acoust. Soc. Am., 71(6):1321-1334.

Christensen, D.A. 1977. A New Nonperturbing Temperature Probe Using Semiconductor Band Edge Shift. J. Bioeng., 1:541-545.

Christman, C.L., H.S. Ho, and S. Yarrow. 1974. A Microwave Dosimetry System for Measured Sampled Integral-Dose Rate. IEEE Trans. Microwave Theory Techniques, MTT-22(12):1267-1272.

Clapman, R.M., and C.A. Cain. 1975. Absence of Heart Rate Effects in Isolated Frog Heart Irradiated with Pulsed Modulated Microwave Energy. J. Microwave Power, 10:411-419.

Cleary, S.F. 1980. Microwave Cataractogenesis. Proc. IEEE, 68:49-55.

Cleary, S.F., and B.S. Pasternack. 1966. Lenticular Changes in Microwave Workers: A Statistical Study. Arch. Environ. Health, 12:23-29.

Cleary, S.F., B.S. Pasternack, and G.W. Beebe. 1965. Cataract Incidence in Radar Workers. Arch. Environ. Health, 11:179-182.

Cleary, S.F., and R.T. Wangemann. 1976. Effect of Microwave Radiation on Pentobarbital-Induced Sleeping Time. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 311-322.

Cogan, D.G., S.J. Fricker, M. Lubin, D.D. Donaldson, and H. Hardy. 1958. Cataracts and Ultra-High-Frequency Radiation. A.M.A. Arch. Ind. Health, 18:299-302.

Cohen, B.H., A.M. Lilienfeld, S. Kramer, and L.C. Hyman. 1977. Parental Factors in Down's Syndrome: Results of the Second Baltimore Case-Control Study. In: Population Cytogenetics—Studies in Humans, E.B. Hook and I.H. Porter, eds. Academic Press, New York, New York. pp. 301-352.

Constant, P.C., Jr. 1967. Hearing EM Waves. Digest of the Seventh International Conference on Medical and Biological Engineering, B. Jacobson, ed. Department of Medical Engineering, Karolinska Institute, Stockholm, Sweden. p. 349.

Cook, H.F. 1952. The Pain Threshold for Microwave and Infra-Red Radiations. J. Physiol., 118:1-11.

Cooper, J.R., F.E. Bloom, and R.H. Roth. 1982. The Biochemical Basis of Neuropharmacology, 4th ed. Oxford University Press, New York, New York. 367 pp.

Corelli, J.C., R. J. Gutmann, S. Kohazi, and J. Levy. 1977. Effects of 2.6-4.0 GHz Microwave Radiation on *E. coli* B. J. Microwave Power, 12:141-144.

Crawford, M.L. 1974. Generation of Standard FM Fields Using TEM Transmission Cells. IEEE Trans. Electromagnetic Compatibility, EMC-16:189-95.

Crosbie, R.J., J.D. Hardy, and E. Fessender. 1963. Electrical Analog Simulation of Temperature Regulation in Man. In: Temperature, Its Measurement and Control in Science and Industry, Part III, J.H. Hardy, ed. Reinhold Publ., New York, New York. Ch. 55, p. 627.

Crosby, E.C., T. Humphrey, and E.W. Lauer. 1962. Correlative Anatomy of the Nervous System. The Macmillan Company, New York, New York.

Czerski, P. 1975. Microwave Effects on the Blood-Forming System with Particular Reference to the Lymphocyte. Ann. N.Y. Acad. Sci., 247:232-242.

Czerski, P., M. Sierkierzynski, and A. Gidynski. 1974. Health Surveillance of Personnel Occupationally Exposed to Microwaves. I. Theoretical Considerations and Practical Aspects. Aerospace Med., 45:1137-1142.

Daily, L., Jr., K.G. Wakim, J.F. Herrick, E.M. Parkhill, and W.L. Benedict. 1950a. The Effects of Microwave Diathermy on the Eye of the Rabbit. Am. J. Ophthalmol., 35:1001-1017.

Daily, L., Jr., K.G. Wakim, J.F. Herrick, E.M. Parkhill, and W.L. Benedict. 1950b. The Effects of Microwave Diathermy on the Eye. Am. J. Ophthalmol., 33:1241-1254.

D'Andrea, J.A., O.P. Gandhi, and R.P. Kesner, 1976. Behavioral Effects of Resonant Electromagnetic Power Absorption in Rats. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland, pp. 257-273.

D'Andrea, J.A., O.P. Gandhi, and J.L. Lords. 1977. Behavioral and Thermal Effects of Microwave Radiation at Resonant and Nonresonant Wavelengths. Radio Sci., 12:251-256.

D'Andrea, J.A., O.P. Gandhi, J.L. Lords, C.H. Durney, C.C. Johnson, and L. Astle. 1979. Physiological and Behavioral Effects of Chronic Exposure to 2450-MHz Microwaves. J. Microwave Power, 14:351-362.

D'Andrea, J.A., O.P. Gandhi, J.L. Lords, C.H. Durney, L. Astle, L.J. Stensaas, and A.A. Schoenberg. 1980 Physiological and Behavioral Effects of Prolonged Exposure to 915 MHz Microwaves. J. Microwave Power, 15(2):123-135.

Dardalhon, M., D. Averbeck, and A.J. Berteaud. 1979. Determination of Thermal Equilavent of Millimeter Microwaves in Living Cells. J. Microwave Power, 14:307-312.

Dardalhon, M., D. Averbeck, and A.J. Berteaud. 1980. Action des Ondes Centimetriques Seules ou Combinees avec les Rayons Ultra Violets sur les Cellules Eucaryotiques. In: URSI International Symposium Proceedings, Ondes Electromagnetiques et Biologie, A.J. Berteaud and B. Servantie, eds. Paris, France. pp. 17-24.

Dardalhon, M., D. Averbeck, and A.J. Berteaud. 1981. Studies on Possible Genetic Effects of Microwaves in Procaryotic and Eucaryotic Cells. Radiat. Environ. Biophys. 20:37-51.

Davidson, J.A., P.A. Kondra, and M.A.K. Hamid. 1976. Effects of Microwave Radiation on Eggs, Embryos and Chickens. Can. J. Anim. Sci., 56:709-713.

Deficis, A., J.C. Dumas, S. Laurens, and G. Plurien. 1979. Microwave Irradiation and Lipid Metabolism in Mice. Radio Sci., 14(6S):99-101.

Deichmann, W.B., E. Bernal, F. Stephens, and K. Landeen. 1963. Effects on Dogs of Chronic Exposure to Microwave Radiation. J. Occupational Med., 5:418-425.

Deichmann, W.B., J. Miale, and K. Landeen. 1964. Effect of Microwave Radiation on the Hemopoietic System of the Rat. Toxicol. Appl. Pharmacol., 6:71-77.

Delgado, J.M.R., J. Leal, J.L. Monteagudo, and M. Garcia-Gracia. 1982. Embryological Changes Induced by Weak, Extremely Low Frequency Electromagnetic Fields. J. Anat., 134:533-551.

de Lorge, J.O. 1976. The Effects of Microwave Radiation on Behavior and Temperature in Rhesus Monkeys. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 158-174.

de Lorge, J. 1979. Disruption of Behavior in Mammals of Three Different Sizes Exposed to Microwaves: Extrapolation to Larger Mammals. In: Electromagnetic Fields in Biological Systems, S.S. Stuchly, ed. Ottawa, Canada. pp. 215-228.

de Lorge, J. 1979. Operant Behavior and Rectal Temperature of Squirrel Monkeys During 2.45-GHz Microwave Irradiation. Radio Sci., 14(6S):217-225.

de Lorge, J.O., and C.S. Ezell. 1980. Observing-Responses of Rats Exposed to 1.28- and 5.62-GHz Microwaves. Bioelectromagnetics, 1:183-198.

Dietzel, F. 1975. Effects of Electromagnetic Radiation on Implantation and Intrauterine Development of the Rat. Ann. N.Y. Acad. Sci., 247:367-376.

Dietzel, F., and W. Kern. 1970. Abortion Following Ultra-Short-Wave Hyperthermia: Animal Experiments. Arch. Gynak., 209:237-255.

Dietzel, F., W. Kern, and R. Steckenmesser. 1972. Deformity and Intrauterine Death after Short-Wave Therapy in Early Pregnancy in Experimental Animals. Munch. Med. Wchschr., 114:228-230.

Diffrient, N., A.R. Tilley, and J.C. Bardagjy. 1974. Humanscale 1/2/3. The MIT Press, Boston, Massachusetts.

Dill, D.B., E.F. Adolph, and C.G. Wilber, eds. 1964. Adaptation to the Environment. In: Handbook of Physiology, Williams and Wilkins Co., Baltimore, Maryland.

Dixey, R., and G. Rein. 1982. $^{3}$H-noradrenaline Release Potentiated in a Clonal Nerve Cell Line by Low-Intensity Pulsed Magnetic Fields. Nature, 296:253-256.

Djordjevic, Z., and A. Kolak. 1973. Changes in the Peripheral Blood of the Rat Exposed to Microwave Radiation (2400 MHz) in Conditions of Chronic Exposure. Aerospace Med., 44:1051-1054.

Djordjevic, Z., N. Lazarevic, and V. Djokovic. 1977. Studies on the Hematologic Effects of Long-Term, Low-Dose Microwave Exposure. Aviat. Space Environ. Med., 48:516-518.

Djordjevic, Z., A. Kolak, M. Stojkovic, N. Rankovic, and P. Ristic. 1979. A Study of the Health Status of Radar Workers. Aviat. Space Environ. Med., 50:396-398.

Drost-Hansen, W., and J.S. Clegg, eds. 1979. Cell-Associated Water, Academic Press, New York, New York. 440 pp.

Dumansky, J.D., and M.G. Shandala. 1974. The Biologic Action and Hygienic Significance of Electromagnetic Fields of Superhigh and Ultrahigh Frequencies in Densely Populated Areas. In: Biologic Effects and Health Hazards of Microwave Radiation. P. Czerski, K. Ostrowski, M.L. Shore, C. Silverman, M.J. Suess, and B. Waldeskog, eds. Polish Medical Publishers, Warsaw, Poland. pp. 289-293.

Durney, C.H. 1980. Electromagnetic Dosimetry for Models of Humans and Animals: A Review of Theoretical and Numerical Techniques. Proc. IEEE, 68(1):33-40.

Durney, C.H., C.C. Johnson, P.W. Barber, H. Massoudi, M.F. Iskander, J.L. Lords, D.K. Ryser, S.J. Allen, and J.C. Mitchell. 1978. Radiofrequency Radiation Dosimetry Handbook, 2nd ed. Report SAM-TR-78-22, USAF School of Aerospace Medicine, Brooks Air Force Base, Texas. 141 pp.

Durney, C.H., M.F. Iskander, H. Massoudi, and C.C. Johnson. 1979. An Empirical Formula for Broad-Band SAR Calculations of Prolate Spheroidal Models of Humans and Animals. IEEE Trans. Microwave Theory Techniques. MTT-27(8):758-763.

Durney, C.H., M. F. Iskander, H. Massoudi, S.J. Allen, and J.C. Mitchell. 1980. Radiofrequency Radiation Dosimetry Handbook, 3rd ed. Report SAM-TR-80-32, USAF School of Aerospace Medicine, Brooks Air Force Base, Texas. 136 pp.

Dutta, S.K., W.H. Nelson, C.F. Blackman, and D.J. Brusick. 1979a. Lack of Microbial Genetic Response to 2.45-GHz CW and 8.5 to 9.6-GHz Pulsed Microwaves. J. Microwave Power, 14:275-280.

Dutta, S.K., M.A. Hossain, H.S. Ho, and C.F. Blackman. 1979b. Effects of 8.6-GHz Pulsed Electromagnetic Radiation on an *Escherichia coli* Repair-Deficient Mutant. In: Electromagnetic Fields in Biological Systems, S.S. Stuchly, ed. Edmonton, Canada. pp. 76-95.

Dutta, S.K., W.H. Nelson, C.F. Blackman, and D.J. Brusick. 1980. Cellular Effects in Microbial Tester Strains Caused by Exposure to Microwaves or Elevated Temperatures. J. Environ. Pathol. Toxicol., 3:195-206.

Dutta, S.K. A. Subramoniam, B. Ghosh, and R. Parshad. 1984. Microwave Radiation-Induced Calcium Ion Efflux From Human Neuroblastoma Cells in Culture. Bioelectromagnetics, 5:71-78.

Dwyer, M.J., and D.B. Leeper, 1978. A Current Literature Report on the Carcinogenic Properties of Ionizing and Non-Ionizing Radiation. II. Microwave and Radiofrequency Radiation. DHEW Publication (NIOSH) No. 78-134, Cincinnati, Ohio. 28 pp.

Edelwejn, Z. 1968. Attempt at Evaluation of the Functional State of Brain Synapses in Rabbits Exposed Chronically to the Action of Microwaves. Acta Physiol. Polon., 19:791-799.

Edwards, G.S., M.L. Swicord, and C.C. Davis. 1983. Microwave Absorption Characteristics of Highly Purified *E. coli* DNA. Abstract #A-5, 5th Annual Scientific Session, The Bioelectromagnetics Society, 12-17 July, Boulder, Colorado (available from The Bioelectromagnetics Society, One Bank Street Suite 307, Gaithersburg, Maryland 20878). p. 3.

Edwards, M.J. 1974. The Effects of Hyperthermia on Pregnancy and Prenatal Development. In: Experimental Embryology and Teratology, Vol. 1, D.H.M. Woollam and G.M. Morriss, eds. Paul Elek, London, England. pp. 90-133.

Edwards, W.P., and H.S. Ho. 1975. RF Cavity Irradiation Dosimetry. IEEE Trans. Microwave Theory Techniques, MTT-23(3):311-313.

Ehrenberg, L., B. Anderstam, S. Hussain, and Y. Hamnerius. 1983. Statistical Aspects of the Design of Biological Tests for the Detection of Low Genotoxic Activity. Hereditas, 98:34-41.

Elder, J.A., and J.S. Ali. 1975. The Effect of Microwaves (2450 MHz) on Isolated Rat Liver Mitochondria. Ann. N.Y. Acad. Sci., 247:251-262.

Elder, J.A., J.S. Ali, M.D. Long, and G.E. Anderson, 1976. A Coaxial Air Line Microwave Exposure System: Respiratory Activity of Mitochondria Irradiated at 2-4 GHz. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 352-365.

Elizondo, R.S. 1973. Local Control of Eccrine Sweat Gland Function. Fed. Proc. 32:1583-1587.

Ellis, F.P., H.M. Ferres, A.R. Lind, and P.S.B. Newling. 1960. The Upper Limits of Tolerance of Environmental Stress. In: Physiological Responses to Hot Environments. Spec. Report, Series No. 298. Med. Res. Council, London. pp. 158-179.

Ely, T.S., and D.E. Goldman. 1956. Heat Exchange Characteristics of Animals Exposed to 10-cm Microwaves. IRE Trans-Med. Electronics, February, pp. 38-43.

Ely, T.S., D.E. Goldman, and J.Z. Hearon. 1964. Heating Characteristics of Laboratory Animals Exposed to Ten-Centimeter Microwaves. IEEE Trans. Biomed. Eng., 11:123-137.

Emery, A.F., R.E. Short, A.W. Guy, and K.K. Kraning. 1976. The Numerical Thermal Simulation of the Human Body When Undergoing Exercise or Nonionizing Electromagnetic Irradiation. Trans. ASME, J. Heat Transfer, 98:284-291.

Epidemiology Work Group. 1981. Guidelines for Documentation of Epidemiologic Studies. Am. J. Epidemiol., 114:609-613.

Fahim, M.S., Z. Fahim, R. Der, D.G. Hall, and J. Harman. 1975. Heat in Male Contraception (Hot Water 60°C, Infrared, Microwave, and Ultrasound). Contraception, 11(5):549-562.

Federal Register. 1983a. Health Assessment Document on the Biological Effects of Radiofrequency Radiation. Fed. Reg., 48 (No. 141, July 21, 1983):33345.

Federal Register. 1983b. Science Advisory Board, Subcommittee on the Biological Effects of Radiofrequency Radiation; Open Meeting. Fed. Reg., 48 (No. 171, September 1):39688.

Federal Register. 1984. Science Advisory Board, Biological Effects of Radiofrequency Radiation Subcommittee; Open Meeting. Fed. Reg., 49 (No. 3, January 5):662-663.

Fermi, E., J.R. Pasta, and S. Ulam. 1965. Studies of Non Linear Problems. In: Collected Works of Enrico Fermi, Vol. II. University of Chicago Press, Chicago, Illinois. pp. 978-988.

Ferri, E.S., and G.J. Hagan. 1976. Chronic Low-Level Exposure of Rabbits to Microwaves. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 129-142.

Flynn, R.J. 1968. Exencephalia: Its Occurrence in Untreated Mice. Science, 160:898-899.

Folk, G.E., Jr. 1974. Textbook of Environmental Physiology, 2nd ed. Lea and Febiger, Philadelphia, Pennsylvania. 466 pp.

Follenius, M., G. Brandenberger, S. Oyono, and V. Candas. 1982. Cortisol as a Sensitive Index of Heat-Intolerance. Physiol. Behav., 29:509-513.

Foster, K.R., and E.D. Finch. 1974. Microwave Hearing: Evidence for Thermoacoustic Auditory Stimulation by Pulsed Microwaves. Science, 185:256-258.

Frankel, J.M. 1959. Effects of Restraint on Rats Exposed to High Temperature. J. Appl. Physiol., 14:997-999.

Frey, A.H. 1961. Auditory System Response to Radio Frequency Energy. Aerospace Med., 32:1140-1142.

Frey, A.H. 1962. Human Auditory System Response to Modulated Electromagnetic Energy. J. Appl. Physiol., 17:689-692.

Frey, A.H. 1963. Some Effects on Human Subjects of Ultra-High-Frequency Radiation. Am. J. Med. Electron., 2:28-31.

Frey, A.H. 1967. Brain Stem Evoked Responses Associated with Low-Intensity Pulsed UHF Energy. J. Appl. Physiol., 23:984-988.

Frey, A.W., and E. Coren. 1979. Holographic Assessment of Hypothesized Microwave Hearing Mechanism. Science, 206:232-234.

Frey, A.H., and S.R. Feld. 1975. Avoidance by Rats of Illumination with Low Power Nonionizing Electromagnetic Energy. J. Comp. Physiol. Psychol., 89:183-188.

Frey, A.H., and R. Messenger. 1973. Human Perception of Illumination with Pulsed Ultrahigh-Frequency Electromagnetic Energy. Science, 181:356-358.

Frey, A.H., and E. Seifert. 1968. Pulse Modulated UHF Illumination of the Heart Associated with Change in Heart Rate. Life Sci., 7:505-512.

Frey, A.H., S.R. Feld, and B. Frey. 1975. Neural Function and Behavior: Defining the Relationship. Ann. N.Y. Acad. Sci., 247:433-439.

Friedman, H.L. 1981. Are Chronic Exposure to Microwaves and Polycythemia Associated? New England J. Med., 304:357-358.

Friedman, H., R.O. Becker, and C.H. Bachman. 1967. Effect of Magnetic Fields on Reaction Time Performance. Nature, 213:949-950.

Froehlich, J.P. 1969. Information Transmittal and Communicating Systems. Holt, Rinehart, and Winston, New York, New York. 274 pp.

Fröhlich, H. 1968. Long Range Coherence and Energy Storage in Biological Systems. Int. J. Quant. Chem., 2:641-649.

Fröhlich, H. 1975. The Extraordinary Dielectric Properties of Biological Materials and the Action of Enzymes. Proc. Natl. Acad. Sci. USA, 72:4211-4215.

Gage, M.I. 1979a. Behavior in Rats after Exposures to Various Power Densities of 2450 MHz Microwaves. Neurobehav. Toxicol., 1:137-143.

Gage, M.I. 1979b. Microwave Irradiation and Ambient Temperature Interact to Alter Rat Behavior Following Overnight Exposure. J. Microwave Power, 14:389-398.

Gage, M.I., E. Berman, and J.B. Kinn. 1979. Videotape Observation of Rats and Mice During an Exposure to 2450 MHz Microwave Radiation. Radio Sci., 14(6S):227-232.

Gale, C.C. 1973. Neuroendocrine Aspects of Thermoregulation. Annu. Rev. Physiol., 35:391-430.

Gale, C.C., M. Mathews, and J. Young. 1970. Behavioral Thermoregulatory Responses to Hypothalamic Cooling and Warming in Baboons. Physiol. Behav., 5:1-6.

Gandhi, O.P. 1980. State of the Knowledge for Electromagnetic Absorbed Dose in Man and Animals. Proc. IEEE, 68(1):24-32.

Gandhi, O.P., E.L. Hunt, and J.A. D'Andrea. 1977. Deposition of Electromagnetic Energy in Animals and in Models of Man with and without Grounding and Reflector Effects. Radio Sci., 12(6S):39-47.

Gandhi, O.P., M.J. Hagmann, and J.A. D'Andrea. 1979. Part-Body and Multi-Body Effects on Absorption of Radio-Frequency Electromagnetic Energy by Animals and by Models of Man. Radio Sci., 14(6S):15-21.

Gavalas, R.J., D.O. Walter, J. Hamer, and W.R. Adey. 1970. Effect of Low-Level, Low-Frequency Electric Fields on EEG and Behavior in Macaca Nemestrina. Brain Res., 18:491-501.

Gavalas-Medici, R., and S.R. Day-Magdaleno. 1976. Extremely Low Frequency, Weak Electric Fields Affect Schedule-Controlled Behavior of Monkeys. Nature, 261:256-258.

Ginoza, W., and R.C. Miller, 1965. Kinetics of X-Ray and Heat Inactivation of ΦX174 RF-DNA. Proc. Natl. Acad. Sci. USA, 54:551-558.

Ginoza, W., C.J. Hoelle, K.B. Vessey, and C. Carmack. 1964. Mechanisms of Inactivation of Single-Stranded Virus Nucleic Acids by Heat. Nature, 203(4945):606-609.

Ginzburg, V.L. 1968. The Problem of High Temperature Superconductivity. Contemp. Phys., 9:355-374.

Goldblith, S.A., and D.I.C. Wang. 1967. Effect of Microwaves on *Escherichia coli* and *Bacillus subtilus*. Appl. Microbiol., 15:1371-1375.

Goldstein, L., and Z. Sisko. 1974. A Quantitative Electroencephalographic Study of the Acute Effects of X-Band Microwaves in Rabbits. In: Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, K. Ostrowski, M.L. Shore, C. Silverman, M.J. Suess, and B. Waldeskog, eds. Polish Medical Publishers, Warsaw, Poland. pp. 128-133.

Goodman, E.M., B. Greenebaum, and M.T. Marron. 1979. Bioeffects of Extremely Low-Frequency Electromagnetic Fields. Radiat. Res., 78:485-501.

Goodman, R., C.A. L. Bassett, and A.S. Henderson. 1983. Pulsing Electromagnetic Fields Induce Cellular Transcription. Science, 220:1283-1285.

Gordon, C.J. 1982a. Effects of Ambient Temperature and Exposure to 2450-MHz Microwave Radiation on Evaporative Heat Loss in the Mouse. J. Microwave Power, 17:145-150.

Gordon, C.J. 1982b. Open-Loop Gain of Evaporative Heat Loss During Radiant Heat Exposure in the Mouse. Am. J. Physiol. 242:R275-R279.

Gordon, C.J. 1982c. Effect of Heating Rate of Evaporative Heat Loss in the Microwave-Exposed Mouse. J. Appl. Physiol., 53(2):316-323.

Gordon, C.J. 1982d. Rewarming Mice from Hypothermia by Exposure to 2450-MHz Microwave Radiation. Cryobiology, 19:428-434.

Gordon, C.J. 1983a. Behavioral and Autonomic Thermoregulation in Mice Exposed to Microwave Radiation. J. Appl. Physiol., 55:1242-1248.

Gordon, C.J. 1983b. Influence of Heating Rate on Control of Heat Loss from the Tail in Mice. Am. J. Physiol., 244:R778-R784.

Gordon, C.J. 1983c. Effect of 2450 MHz Microwave Exposure on Behavioral Thermoregulation in Mice. J. Thermal Biol., 8:315-319.

Gordon, C.J. 1983d. A Review of Terms for Regulated vs. Forced Neurochemical-Induced Changes in Body Temperature. Life Sci., 32:1285-1295.

Gordon, C.J. 1983e. Note: Further Evidence for an Inverse Relation Between Body Mass and Sensitivity to Radio-frequency Electromagnetic Radiation. J. Microwave Power, 18:377-383.

Gordon, C.J., and E.C. White. 1982. Distinction Between Heating Rate and Total Heat Absorption in the Microwave-Exposed Mouse. Physiol. Zool., 55(3):300-308.

Gordon, R.G., R.B. Roemer, and S.M. Horvath. 1976. A Mathematical Model of the Human Temperature Regulatory System - Transient Cold Exposure Response. IEEE Trans. Biomed. Eng., BME-23:434-444.

Gordon, Z.V. 1970. Biological Effect of Microwaves in Occupational Hygiene. Israel Program for Scientific Translations, Jerusalem, Israel. NASA TT F-633, TT 70-50087; NTIS N71-14632. 101 pp.

Gournay, L.S. 1966. Conversion of Electromagnetic to Acoustic Energy by Surface Heating. J. Acous. Soc. Amer., 40:1322-1330.

Grant, E.H., S.E. Keefe, and S. Takashima. 1968. The Dielectric Behavior of Aqueous Solutions of Bovine Serum Albumin from Radiowave to Microwave Frequencies. J. Phys. Chem., 72:4373-4380.

Grant, E.H., R.J. Sheppard, and G.P. South. 1978. Dielectric Behaviour of Biological Molecules in Solution. Oxford University Press, Oxford, England. 237 pp.

Greene, F.M. 1975a. Development of Electric and Magnetic Near-Field Probes. NBS Technical Note 658 (COM-75-50161), U.S. Department of Commerce, National Bureau of Standards, Boulder, Colorado. 47 pp.

Greene, F.M. 1975b. Development of Magnetic Near-Field Probes. HEW Publication (NIOSH) 75-127, U.S. Department of Health, Education, and Welfare, Public Health Service, Cincinnati, Ohio. 28 pp.

Greene, F.M. 1976. Development of an RF Near-Field Exposure Synthesizer (10 to 40 MHz). HEW Publication (NIOSH) 76-160. U.S. Department of Health, Education, and Welfare, Public Health Service, Cincinnati, Ohio. 36 pp.

Greengard, P., W.W. Douglas, A.C. Nairn, E.J. Nestler, and J.M. Ritchie. 1982. Effects of Electromagnetic Radiation on Calcium in the Brain. USAF School of Aerospace Medicine, Report Number SAM-TR-82-15. 113 pp.

Grell, R.F. 1971. Heat-Induced Exchange in the Fourth Chromosome of Diploid Females of Drosophila Melanogaster. Genetics, 69:523-527.

Grundler, W., and F. Keilmann. 1980. Frequency Fine-Tuning Studies of Microwave Influenced Yeast Growth (Abstract). Presented at the International Symposium on Electromagnetic Waves and Biology, Jouy-en-Josas, France, June 30-July 4, 1980. p. 4.

Grundler, W., and F. Keilmann. 1983. Sharp Resonances in Yeast Growth Prove Nonthermal Sensitivity to Microwaves. Phys. Rev. Lett., 51:1214-1216.

Grundler, W., F. Keilmann, and H. Fröhlich. 1977. Resonant Growth Rate Response of Yeast Cells Irradiated by Weak Microwaves. Phys. Lett., 62A:463-466.

Guillet, R., and S.M. Michaelson. 1977. The Effect of Repeated Microwave Exposure on Neonatal Rats. Radio Sci., 12(6S):125-129.

Gunn, S.A., T.C. Gould, and W.A.D. Anderson. 1961. The Effect of Microwave Radiation on Morphology and Function of Rat Testis. Lab. Invest., 10(2): 301-314.

Gutman, R., and B.K. Chang. 1982. Effect of Moderate Hyperthermia on the Mitogen Response of Mouse and Hamster Lymphocytes *In Vitro*. In: Biomedical Thermology, M. Gautherie and E. Albert, eds. Alan R. Liss, Inc., New York. pp. 75-84.

Guy, A.W. 1971. Analyses of Electromagnetic Fields Induced in Biological Tissues by Thermographic Studies on Equivalent Phantom Models. IEEE Trans. Microwave Theory Techniques, MTT-19(2):205-214.

Guy, A.W. 1975. Correspondence on D.R. Justesen's "Prescriptive Grammar for the Radiobiology of Nonionizing Radiation." J. Microwave Power, 10(4):358-359.

Guy, A.W. 1977. A Method for Exposing Cell Cultures to Electromagnetic Fields under Controlled Conditions of Temperature and Field Strength. Radio Sci., 12(6S):87-96.

Guy, A.W. 1979. Miniature Anechoic Chamber for Chronic Exposure of Small Animals to Plane-Wave Microwave Fields. J. Microwave Power, 14(4):327-338.

Guy, A.W., and C.K. Chou. 1976. System for Quantitative Chronic Exposure of a Population of Rodents to UHF Fields. In: Biological Effects of Electromagnetic Waves, Vol. II, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8011, Rockville, Maryland. pp. 389-410.

Guy, A.W., and S.F. Korbel. 1972. Dosimetry Studies of a UHF Cavity Exposure Chamber for Rodents. Summaries of Presented Papers for 1972 Microwave Power Symposium, Ottawa, Canada. Int.

Microwave Power Institute, Edmonton, Alberta. pp. 180-193.

Guy, A.W., J.F. Lehmann, J.A. McDougall, and C.C. Sorensen. 1968. Studies on Therapeutic Heating by Electromagnetic Energy. In: Thermal Problems in Biotechnology, American Society of Mechanical Engineers, United Engineering Centers, New York, New York. pp. 26-45.

Guy, A.W., C.C. Johnson, J.C. Lin, A.F. Emery, and K.K. Kraning. 1973. Electromagnetic Power Deposition in Man Exposed to High Frequency Fields and the Associated Thermal and Physiologic Consequences. Doc. No. SAM-TR-73-13 (NTIS AD-776 821), USAF School of Aerospace Medicine, Brooks Air Force Base, Texas. 71 pp.

Guy, A.W., J.C. Lin, P.O. Kramar, and A.F. Emery. 1974. Quantitation of Microwave Radiation Effects on the Eyes of Rabbits at 2450 MHz and 918 MHz. Office of Naval Research, Arlington, Virginia. (NTIS AD-A007 521). 39 pp.

Guy, A.W., J.C. Lin, P.O. Kramar, and A.F. Emery. 1975a. Effect of 2450-MHz Radiation on the Rabbit Eye. IEEE Trans. Microwave Theory Techniques, MTT-23:492-498.

Guy, A.W., C.K. Chou, J.C. Lin, and D. Christensen. 1975b. Microwave-Induced Acoustic Effects in Mammalian Auditory Systems and Physical Materials. Ann. N.Y. Acad. Sci., 247:194-215.

Guy, A.W., M.D. Webb, and J.A. McDougall. 1975c. A New Technique for Measuring Power Deposition Patterns in Phantoms Exposed to EM Fields of Arbitrary Polarization: Example the Microwave Oven. Microwave Power Symposium Proc., Waterloo, Ontario, Canada. pp. 36-47.

Guy, A.W., M.D. Webb, and C.C. Sorenson. 1976. Determination of Power Absorption in Man Exposed to High Frequency Electromagnetic Fields by Thermographic Measurements on Scale Models. IEEE Trans. Biomed. Eng., BME-23(5):361-371.

Guy, A.W., M.D. Webb, and J.A. McDougall. 1977. RF Radiation Absorption Patterns: Human and Animal Modeling Data. HEW Publication (NIOSH) 77-183, U.S. Department of Health, Education, and Welfare, Public Health Service, Cincinnati, Ohio. 67 pp.

Guy, A.W., M.D. Webb, A.F. Emery, and C.K. Chou. 1978. Determination of the Average SAR and SAR Patterns in Man and Simplified Models of Man and Animals Exposed to Radiation Fields from 50-2450 MHz and the Thermal Consequences (Abstract). Symposium on the Biological Effects of Electromagnetic Waves, XIX General Assembly, International Union of Radio Science, Helsinki, Finland. p. 13.

Guy, A.W., J. Wallace, and J.A. McDougall. 1979. Circularly Polarized 2450-MHz Waveguide Systems for Chronic Exposure of Small Animals to Microwaves. Radio Sci., 14(6S):63-74.

Guy, A.W., C.K. Chou, R.B. Johnson, and L.L. Kunz. 1980a. Study of Effects of Long-Term, Low-Level RF Exposure on Rats: A Plan. Proc. IEEE, 68(1):92-97.

Guy, A.W., P.O. Kramar, C.A. Harris, and C.K. Chou. 1980b. Long-Term 2450-MHz CW Microwave Irradiation of Rabbits: Methodology and Evaluation of Ocular and Physiologic Effects. J. Microwave Power, 15:37-44.

Hagan, G.J., and R.L. Carpenter. 1976. Relative Cataractogenic Potencies of Two Microwave Frequencies (2.45 and 10 GHz). In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 143-155.

Hagmann, M.J., and O.P. Gandhi. 1979. Numerical Calculation of Electromagnetic Energy Deposition in Models of Man with Grounding and Reflector Effects. Radio Sci., 14(6S):23-29.

Hagmann, M.J., O.P. Gandhi, and C.H. Durney. 1979a. Numerical Calculation of Electromagnetic Energy Deposition for a Realistic Model of Man. IEEE Trans. Microwave Theory Techniques, MTT-27(9):804-809.

Hagmann, M.J., O.P. Gandhi, J.A. D'Andrea, and I. Chatterjee. 1979b. Head Resonance: Numerical Solutions and Experimental Results. IEEE Trans. Microwave Theory and Techniques, MTT-27(9): 809-813.

Hamburger, S., J.N. Logue, and P.M. Silverman, 1983. Occupational Exposure to Nonionizing Radiation and an Association with Heart Disease: An Exploratory Study. J. Chronic Disease, 36:791-802.

Hamer, J. 1968. Effects of Low Level, Low Frequency Electric Fields on Human Reaction Time. Commun. Behav. Biol., 2(5) Part A:217-222.

Hammel, H.T. 1968. Regulation of Internal Body Temperature. Annu. Rev. Physiol., 30:641-710.

Hamnerius, Y. 1983. Exposure Systems for Studies of the Effects of Electromagnetic Fields on Biological Systems. Hereditas, 98:48-59.

Hamnerius, Y., H. Olofsson, A. Rasmuson, and B. Rasmuson. 1979. A Negative Test for Mutagenic Action of Microwave Radiation in *Drosophila melanogaster*. Mutat. Res., 68:217-223.

Hamrick, P.E. 1973. Thermal Denaturation of DNA Exposed to 2450 MHz CW Microwave Radiation. Radiat. Res., 56:400-404.

Hamrick, P.E., and B.T. Butler. 1973. Exposure of Bacteria to 2450 MHz Microwave Radiation. J. Microwave Power, 8:227-233.

Hamrick, P.E., and S.S. Fox. 1977. Rat Lymphocytes in Cell Culture Exposed to 2450 MHz (CW) Microwave Radiation. J. Microwave Power, 12:125-132.

Hamrick, P.E., and D.I. McRee. 1975. Exposure of the Japanese Quail Embryo to 2.45-GHz Microwave Radiation During the Second Day of Development. J. Microwave Power, 10:211-221.

Hamrick, P., and D.I. McRee. 1980. The Effect of 2450 MHz Microwave Irradiation on the Heart Rate of Embryonic Quail. Health Phys., 38:261-268.

Hamrick, P.E., and J.G. Zinkl. 1975. Exposure of Rabbit Erythrocytes to Microwave Radiation. Radiat. Res., 62:164-168.

Hamrick, P.E., D.I. McRee, P. Thaxton, and C.R. Parkhurst. 1977. Humoral Immunity of Japanese Quail Subjected to Microwave Radiation During Embryogeny. Health Phys., 33:23-33.

Hardy, J.D. 1949. Heat Transfer. In: Physiology of Heat Regulation, L.H. Newburgh, ed. W.B. Saunders, Philadelphia, Pennsylvania. pp. 78-108.

Hardy, J.D., and P. Bard. 1974. Body Temperature Regulation. In: Medical Physiology, 13th ed., V.B. Mountcastle, ed. C.V. Mosby Co., St. Louis, Missouri. pp. 1305-1342.

Hardy, J.D., A.T. Milhorat, and E.F. Dubois. 1941. Basal Metabolism and Heat Loss of Young Women at Temperatures from 22°C to 35°C. J. Nutr., 21:383-404.

Hardy, J.D., H.G. Wolff, and H. Goodell. 1967. Pain Sensations and Reactions. Hafner Publishing Co., New York, New York. Chapter X.

Harrison, G.H., J.E. Robinson, D. McCulloch, and A.Y. Cheung. 1980. Comparison of Hyperthermal Cellular Survival in the Presence or Absence of 2.45 GHz Microwave Radiation. In: Ondes Electromagnetiques et Biologie, A.J. Berteaud and B. Servantie, eds. Paris, France. pp. 41-45.

Hart, J.S. 1971. Rodents. In: Comparative Physiology of Thermoregulation, Vol. II, G.C. Whittow, ed. Academic Press, New York, New York. pp. 1-149.

Heller, J.H. 1970. Cellular Effects of Microwave Radiation. In: Biological Effects and Health Implications of Microwave Radiation, S.F. Cleary, ed. HEW Publication BRH/DBE 70-2. Bureau of Radiological Health, Rockville, Maryland. pp. 116-121.

Henderson, H.M., K. Hergenroeder, and S.S. Stuchly. 1975. Effect of 2450 MHz Microwave Radiation on Horseradish Peroxidase. J. Microwave Power, 10:27-35.

Hendler, E. 1968. Cutaneous Receptor Response to Microwave Irradiation. In: Thermal Problems in Aerospace Medicine, J.D. Hardy, ed. Technivision Services, Maidenhead, England. pp. 149-161.

Hendler, E., J.D. Hardy, and D. Murgatroyd. 1963. Skin Heating and Temperature Sensation Produced by Infra Red and Microwave Irradiation. In: Temperature: Its Measurement and Control in Science and Industry. Part 3, Biology and Medicine, C.M. Herzfeld, ed. Reinhold, New York, New York. pp. 211-230.

Hensel, H. 1973. Neural Processes in Thermoregulation. Physiol. Rev., 53:948-1017.

Heynick, L.N., P. Polson, and A. Karp. 1977. A Microwave Exposure System for Primates. Radio Sci., 12:103-110.

Hinde, R.A. 1970. Animal Behavior: A Synthesis of Ethology and Comparative Psychology, 2nd ed. McGraw-Hill, New York, New York. 876 pp.

Hizal, A., and Y.K. Baykal. 1978. Heat Potential Distribution in an Inhomogeneous Spherical Model of a Cranial Structure Exposed to Microwaves Due to Loop or Dipole Antennae. IEEE Trans. Microwave Theory Techniques, MTT-26(8):607-612.

Hjeresen, D.L., S.R. Doctor, and R.L. Sheldon. 1979. Shuttlebox Side Preference as Mediated by Pulsed Microwave and Conventional Auditory Cues. In: Electromagnetic Fields in Biological Systems, S.S. Stuchly, ed. Ottawa, Canada. pp. 194-214.

Ho, H.S. 1975. Dose Rate Distribution in Triple-Layered Dielectric Cylinder with Irregular Cross Section Irradiated by Plane Wave Sources. J. Microwave Power, 10(4):421-432.

Ho, H.S. 1978. Effect of Plexiglas Animal Holders on Microwave Energy Absorption. IEEE Trans. Biomed. Eng., BME-25(5):474-476.

Ho, H.S., and W.P. Edwards. 1977a. Dose Rate and Oxygen Consumption Rate in Mice Confined in a Small Holder During Exposure to 2450 MHz Radiation. Radiat. Environ. Biophys., 14:251-256.

Ho, H.S., and W.P. Edwards. 1977b. Oxygen-Consumption Rate of Mice under Differing Dose Rates of Microwave Radiation. Radio Sci., 12(6S):131-138.

Ho, H.S., and W.P. Edwards. 1979. The Effect of Environmental Temperature and Average Dose Rate of Microwave Radiation on the Oxygen-Consumption Rate of Mice. Radiat. Environ. Biophys. 16:325-338.

Ho, H.S., and M. McManaway. 1977. Heat-Dissipation Rate of Mice after Microwave Irradiation. J. Microwave Power, 12:93-100.

Ho, H.S., E.I. Ginns, and C.L. Christman. 1973. Environmentally Controlled Waveguide Irradiation

Facility. IEEE Trans. Microwave Theory Techniques, MTT-21:837-840.

Ho, H.S., M.R. Foster, and M.L. Swicord. 1976. Microwave Irradiation Apparatus Design and Dosimetry. In: Biological Effects of Electromagnetic Waves, Vol. II, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8011, Rockville, Maryland. pp. 423-434.

Hollaender, A. 1971. Chemical Mutagens, Principles and Methods for Their Detection. Vols. 1, 2, and 3. Plenum Press, New York, New York.

Honig, W.K., and J.E.R. Staddon, eds. 1977. Handbook of Operant Behavior. Prentice-Hall, Englewood Cliffs, New Jersey. 689 pp.

Hossain, M., and S.K. Dutta. 1982. Comparison of Bacterial Growth to High-Intensity Microwave Exposure and Conventional Heating. Bioelectromagnetics, 3:471-474.

Huang, A.T., and N.G. Mold. 1980. Immunologic and Hematopoietic Alterations by 2450-MHz Electromagnetic Radiation. Bioelectromagnetics, 1:77-87.

Huang, A.T., M.E. Engle, J.A. Elder, J.B. Kinn, and T.R. Ward. 1977. The Effect of Microwave Radiation (2450 MHz) on the Morphology and Chromosomes of Lymphocytes. Radio Sci., 12(6S):173-177.

Hunt, E.L., and R.D. Phillips. 1972. Absolute Physical Dosimetry for Whole Animal Experiments. Digest of Papers of the Microwave Dosimetry Workshop, Atlanta, Georgia. pp. 74-77.

Hunt, E.L., N.W. King, and R.D. Phillips. 1975. Behavioral Effects of Pulsed Microwave Radiation. Ann. N.Y. Acad. Sci., 247:440-453.

Hunter, W.S., K.R. Holmes, and R.S. Elizondo. 1981. Thermal Balance in Ketamine-Anesthetized Rhesus Monkey *Macaca mulata*. Am. J. Physiol., 241:R301-R306.

IEEE Microwave Theory and Techniques Society. 1980. Symposium on Electromagnetic Dosimetric Imagery, Washington, D.C. Institute of Electrical and Electronic Engineers.

Illinger, K.H. 1970. Molecular Mechanisms for Microwave Absorption in Biological Systems. In: Biological Effects and Health Implications of Microwave Radiation, S.F. Cleary, ed. BRH/DBE 70-2. Bureau of Radiological Health, Rockville, Maryland. pp. 112-115.

Illinger, K.H. 1982. Spectroscopic Properties of *In Vivo* Biological Systems: Boson Radiative Equilibrium with Steady-State Nonequilibrium Molecular Systems. Bioelectromagnetics, 3:9-16.

Iskander, M.F., C.H. Durney, H. Massoudi, and C.C. Johnson. 1979. Approximate Calculation of SAR for Planewave Irradiation of Man Model Near a Ground Plane. In: Electromagnetic Fields in Biological Systems, S.S. Stuchly, ed. International Microwave Power Institute, Edmonton, Alberta, Canada. pp. 304-323.

Iskander, M.F., P.W. Barber, C.H. Durney, and H. Massoudi. 1980. Irradiation of Prolate Spheroidal Models of Humans in the Near Field of a Short Electric Dipole. IEEE Trans. Microwave Theory Techinques, MTT-28(7):801-807.

Ismailov, E. Sh. 1971. Mechanism of Effects of Microwaves on Erythrocyte Permeability for Potassium and Sodium Ions. Biol. Nauki, 3:58-60 (English trans.: JPRS 72606, Jan. 12, 1979, pp. 38-41).

Ismailov, E. Sh. 1977. Infrared Spectra of Erythrocyte Ghosts in the Region of the Amide I and Amide II Bands on Microwave Irradiation. Biophysics, 21:961-963 (trans. of Biofizika 21:940-942, 1976).

Ismailov, E. Sh. 1978. Effect of Ultrahigh Frequency Electromagnetic Radiation on the Electrophoretic Mobility of Erythrocytes. Biophysics, 22:510-516 (trans. of Biofizika 22:493-498, 1977).

Jensh, R.P. 1979. Biological Effects of 6 GHz Microwave Irradiation. Final Report, GTEL Grant 08000-1106. 131 pp.

Jensh, R.P. 1980. Behavioural Teratology: Application in Low Dose Chronic Microwave Irradiation Studies. In: Neural and Behavioural Teratology (Vol. 4, Advances in the Study of Birth Defects), T.V.N. Persaud, ed. University Park Press, Baltimore, Maryland. pp. 135-162.

Jensh, R.P., J. Ludlow, W.H. Vogel, T. McHugh, I. Weinberg, and R.L. Brent. 1979. Studies Concerning the Effects of Non-Thermal Protracted Prenatal 915 MHz Microwave Radiation on Prenatal and Postnatal Development in the Rat. XIV International Symposium on the Applications of Microwave Energy, IMPI, Paris, France. pp. 99-101.

Johansen, K. 1963. Cardiovascular Dynamics in the Amphibian, *Amphiuma tridactylum Cuvier*. Acta Physiol. Scand., 60:1-82.

Johnson, C.C. 1975. Recommendations for Specifying EM Wave Irradiation Conditions in Bioeffects Research. J. Microwave Power, 10(3):249-250.

Johnson, C.C., and A.W. Guy. 1972. Nonionizing Electromagnetic Wave Effects in Biological Materials and Systems. Proc. IEEE, 60:692-718.

Johnson, R.B., D.E. Meyers, A.W. Guy, R.H. Lovely, and R. Galambos. 1976. Discriminative Control of Appetitive Behavior by Pulsed Microwave Radiation in Rats. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 238-247.

Johnson, R.B., S. Mizumori, and R.H. Lovely. 1978. Adult Behavioral Deficit in Rats Exposed Prenatally to 918-MHz Microwaves. In: Developmental Toxicology of Energy-Related Pollutants. D.D. Mahlum, M.R. Sikov, P.L. Hackett, and F.D. Andrew, eds. DOE Symposium Series 47, Washington, D.C. pp. 281-299.

Joines, W.T., and C.F. Blackman. 1980. Power Density, Field Intensity, and Carrier Frequency Determinants of RF-Energy-Induced Calcium Ion Efflux from Brain Tissue. Bioelectromagnetics 1:271-275.

Joines, W.T., and C.F. Blackman. 1981. Equalizing the Electric Field Intensity Within Chick Brain Immersed in Buffer Solution at Different Carrier Frequencies. Bioelectromagnetics, 2:411-413.

Joines, W.T., C.F. Blackman, and M.A. Hollis. 1981. Broadening of the RF Power-Density Window for Calcium-Ion Efflux from Brain Tissue. IEEE Trans. Biomed. Eng., BME-28:568-573.

Justesen, D.R. 1975. Toward a Prescriptive Grammar for the Radiobiology of Non-Ionising Radiations: Quantities, Definitions, and Units of Absorbed Electromagnetic Energy—An Essay. J. Microwave Power, 10(4):343-356.

Justesen, D.R. 1980. Microwave Irradiation and Blood-Brain Barrier. Proc. IEEE, 68:60-67.

Justesen, D.R., D.M. Levinson, R.L. Clarke, and N.W. King. 1971. A Microwave Oven for Behavioural and Biological Research: Electrical and Structural Modifications, Calorimetric, Dosimetry, and Functional Evaluation. J. Microwave Power, 6:237-258.

Justesen, D.R., D.M. Levinson, and L.R. Justesen. 1974. Psychogenic Stressors are Potent Mediators of the Thermal Response to Microwave Irradiation. In: Biologic Effects and Health Hazards of Microwave Irradiation, P. Czerski, K. Ostrowski, M.L. Shore, C. Silverman, M.J. Suess, and B. Waldeskog, eds. Polish Medical Publishers, Warsaw, Poland. pp. 134-140.

Justesen, D.R., H.A. Ragan, L.E. Rogers, A.W. Guy, D.L. Hjeresen, W.T. Hinds, and R.D. Phillips. 1978. Compilation and Assessment of Microwave Bioeffects. A Selective Review of the Literature on Biological Effects of Microwaves in Relation to the Satellite Power System (SPS). PNL-2634. U.S. Department of Energy, Washington, D.C. 65 pp.

Justesen, D.R., E.R. Adair, J.C. Stevens, and V. Bruce-Wolfe. 1982. A Comparative Study of Human Sensory Thresholds: 2450-MHz Microwaves vs Far-Infrared Radiation. Bioelectromagnetics, 3:117-125.

Kaczmarek, L.K., and W.R. Adey. 1973. The Efflux of $^{45}Ca^{2+}$ and [$^{3}$H]$\gamma$-Aminobutyric Acid from Cat Cerebral Cortex. Brain Res., 63:331-342.

Kaczmarek, L.K., and W.R. Adey. 1974. Weak Electric Gradients Change Ionic and Transmitter Fluxes in Cortex. Brain Res., 66:537-540.

Källén, B., G. Malmquist, and U. Moritz. 1982. Delivery Outcome Among Physiotherapists in Sweden: Is Non-Ionizing Radiation a Fetal Hazard? Arch. Environ. Health, 37:81-85.

Kandel, E.R., and J.H. Schwartz, eds. 1981. Principles of Neural Science. Elsevier North Holland, Inc., New York, New York. 749 pp.

Kantor, G., and T.C. Cetas. 1977. A Comparative Heating-Pattern Study of Direct-Contact Applicators in Microwave Diathermy. Radio Sci., 12(6S):111-120.

Kaplan, J.N. 1981. Study of the Lethal Effects of Microwaves in the Developing Squirrel Monkey. Final Report for Contract No. 68-02-3210, U.S. Environmental Protection Agency, Health Effects Research Laboratory, Research Triangle Park, North Carolina. 54 pp.

Kaplan, I.T., W. Metlay, M.M. Zaret, L. Birenbaum, and S.W. Rosenthal. 1971. Absence of Heart-Rate Effects in Rabbits During Low-Level Microwave Irradiation. IEEE Trans. Microwave Theory Techniques MTT-19:168-173.

Kaplan, J., P. Polson, C. Rebert, K. Lunan, and M. Gage. 1982. Biological and Behavioral Effects of Prenatal and Postnatal Exposure to 2450-MHz Electromagnetic Radiation in the Squirrel Monkey. Radio Sci.: 17(5S):135S-144S.

Keilmann, F. 1978. Nonthermal Microwave Resonances in Living Cells. In: Coherence in Spectroscopy and Modern Physics, F.T. Arecchi, R. Bonifacio, and M.O. Scully, eds. NATO Advanced Study Institute Series: Series B, Physics, Vol. 37. Plenum Publishing Corp., New York, New York. pp. 347-360.

Keller, S.E., J.M. Weiss, S.J. Schleifer, N.E. Miller, and M. Stein. 1983. Stress-Induced Supression of Immunity in Adrenalectomized Rats. Science, 221:1301-1304.

Kerslake, D. McK., and J.L. Waddell. 1958. The Heat Exchange of Wet Skin. J. Physiol., 141:156-163.

Keys, A. 1970. Coronary Heart Disease in Seven Countries. American Heart Association Monograph No. 29. pp. 1-198.

King, N.W., D.R. Justesen, and A.D. Simpson. 1970. The Photo-Lickerandum: A Device for Detecting the Licking Response with Capability for Near-Instantaneous Programming of Variable Quantum

Reinforcement. Behav. Res. Meth. Instrument., 2:125-129.

King, N.W., D.R. Justesen, and R.L. Clarke. 1971. Behavioral Sensitivity to Microwave Irradiation. Science, 172:398-401.

Kinn, J.B. 1977. Whole-Body Dosimetry of Microwave Radiation in Small Animals: The Effect of Body Mass and Exposure Geometry. Radio Sci., 12(6S):61-64.

Kinn, J.B., G.E. Anderson, and W.M. Kozel. 1984. A Microcomputer Controlled Calorimeter. J. Microwave Power, In Press.

Kirkwood, J.G., and J.B. Schumaker. 1952. The Influence of Dipole Moment Fluctuations on the Dielectric Increment of Proteins in Solution. Proc. Natl. Acad. Sci., 38:855-862.

Kitsovskaya, I.A. 1964. The Effect of Centimeter Waves of Different Intensities on the Blood and Hemopoietic Organs of White Rats. Gigiena Truda Prof Zabolev, 8:14-25.

Kleiber, M. 1972. A New Newton's Law of Cooling? Science, 178:1283-1285.

Kleiber, M. 1975. The Fire of Life. An Introduction to Animal Energetics, rev. ed. R.E. Krieger, Huntington, New York. 453 pp.

Kling, J.W., and L.A. Riggs, eds. 1971. Woodworth and Schlosberg's Experimental Psychology, 3rd ed. Holt Rinehart and Winston, New York, New York. 1279 pp.

Konig, H. 1971. Biological Effects of Extremely Low Frequency Electrical Phenomena in the Atmosphere. J. Interdiscipl. Cycle Res., 2:317-323.

Konig, H., and F. Ankermuller. 1960. Uber den Einfluss besonders nieder-frequenter elektrischer vorgange in der Atmosphare auf den Menschen. Naturwissenschaften, 21:486-490.

Konorski, J. 1967. Integrative Activity of the Brain. The University of Chicago Press, Chicago, Illinois. 531 pp.

Kramar, P.O., A.F. Emery, A.W. Guy, and J.C. Lin. 1975. The Ocular Effects of Microwaves on Hypothermic Rabbits: A Study of Microwave Cataractogenic Mechanisms. Ann. N.Y. Acad. Sci., 247:155-165.

Kramar, P.O., C. Harris, A.W. Guy, and A.F. Emery. 1976. Mechanism of Microwave Cataractogenesis in Rabbits. In: Biological Effects of Electromagnetic Waves, Vol. 1, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 49-60.

Kramar, P., C. Harris, A.F. Emery, and A.W. Guy. 1978. Acute Microwave Irradiation and Cataract Formation in Rabbits and Monkeys. J. Microwave Power, 13:239-249.

Kremer, F., Chr. Koschnitzke, L. Santo, P. Quick, and A. Poglitsch. 1983. The Non-thermal Influence of Millimeter Wave Radiation on the Puffing of Giant Chromosomes. Abstract #H-2, 5th Annual Scientific Session, The Bioelectromagnetics Society, 12-17 July, Boulder, Colorado (available from The Bioelectromagnetics Society, One Bank Street, Suite 307, Gaithersburg, Maryland 20878). p. 56.

Kritikos, H.N., and H.P. Schwan. 1975. The Distribution of Heating Potential Inside Lossy Spheres. IEEE Trans. Biomed. Eng., BME-22(6):457-463.

Krupp, J.H. 1977. Thermal Response in *Macaca Mulatta* Exposed to 15- and 20-MHz Radiofrequency Radiation. Report No. SAM-TR-77-16, USAF School of Aerospace Medicine, Brooks Air Force Base, Texas. 10 pp.

Lancranjan, I., M. Maicanescu, E. Rafaila, I. Klepsch, and H.I. Popescu. 1975. Gonadic Function in Workmen with Long-Term Exposure to Microwaves. Health Phys., 29:381-383.

Lappenbusch, W.L., L.J. Gillespie, W.M. Leach, and G.E. Anderson. 1973. Effect of 2450-MHz Microwaves on the Radiation Response of X-Irradiated Chinese Hamsters. Radiat. Res., 54:294-303.

Lebovitz, R.M., and R.L. Seaman. 1977. Microwave Hearing: The Response of Single Auditory Neurons in the Cat to Pulsed Microwave Radiation. Radio Sci. 12(6S)229-236.

Lehmann, J.F., A.W. Guy, J.B. Stonebridge, and B.J. deLateur. 1978. Evaluation of a Therapeutic Direct-Contact 915-MHz Microwave Applicator for Effective Deep-Tissue Heating in Humans. IEEE Trans. Microwave Theory Techniques, MTT-26:556-563.

Lehninger, A.L. 1975. Biochemistry, 2nd ed. Worth Publishers, Inc., New York, New York. pp. 143-144, 875-876.

LeVeen, H.H., S. Wapnick, V. Piccone, G. Falk, and N. Ahmed. 1976. Tumor Eradication by Radiofrequency Therapy. Response in 21 Patients. J. Am. Med. Ass., 235:2198-2200.

Levinson, D.M., A.M. Grove, L.R. Clarke, and D.R. Justesen. 1982. Photic Cuing of Escape by Rats from an Intense Microwave Field. Bioelectromagnetics, 3:105-116.

Liboff, A.R., T. Williams, Jr., D.M. Strong, and R. Wistar, Jr. 1984. Time-Varying Magnetic Fields: Effect on DNA Synthesis. Science, 223:818-820.

Liburdy, R.P. 1977. Effects of Radio-Frequency Radiation on Inflammation. Radio Sci., 12(6S):179-183.

Liburdy, R.P. 1979. Radiofrequency Radiation Alters the Immune System: Modulation of T- and B-Lymphocyte Levels and Cell-Mediated Immunocompetence by Hyperthermic Radiation. Radiat. Res., 77:34-46.

Liburdy, R.P. 1980. Radiofrequency Radiation Alters the Immune System. II. Modulation of *In Vivo* Lymphocyte Circulation. Radiat. Res., 83:66-73.

Lilienfeld, A.M., J. Tonascia, S. Tonascia, C.A. Libauer, and G.M. Cauthen. 1978. Foreign Service Health Status Study—Evaluation of Health Status of Foreign Service and Other Employees from Selected Eastern European Posts. Final Report, Contract No. 6025-619073 (NTIS PB-288163), Dept. of State, Washington, D.C. 436 pp.

Lin, J.C. 1977. Theoretical Calculation of Frequencies and Thresholds of Microwave-Induced Auditory Signals. Radio Sci., 12:237-242.

Lin, J.C. 1978. Microwave Auditory Effects and Applications. Charles C. Thomas, Springfield, Illinois. 221 pp.

Lin, J.C., and M.F. Lin. 1980. Studies on Microwave and Blood-Brain Barrier Interaction. Bioelectromagnetics, 1:313-323.

Lin, J.C., and M.F. Lin. 1982. Microwave Hyperthermia-Induced Blood-Brain Barrier Alterations. Radiat. Res., 89:77-87.

Lin, J.C., and W.D. Peterson, Jr. 1977. Cytological Effects of 2450 MHz CW Microwave Radiation. J. Bioeng., 1:471-478.

Lin, J.C., A.W. Guy, and C.C. Johnson. 1973. Power Deposition in a Spherical Model of Man Exposed to 1-20 MHz Electromagnetic Fields. IEEE Trans. Microwave Theory Techniques, MTT-21(12):791-797.

Lin, J.C., H.I. Bassen, and C.L. Wu. 1977. Perturbation Effect of Animal Restraining Materials on Microwave Exposure. IEEE Trans. Biomed. Eng., BME-24(1):80-83.

Lin, J.C., J.C. Nelson, and M.E. Ekstrom. 1979a. Effects of Repeated Exposure to 148-MHz Radio Waves on Growth and Hematology of Mice. Radio Sci., 14:(6S)173-179.

Lin, J.C., M.J. Ottenbreit, S. Wang, S. Inoue, R.O. Bollinger, and M. Fracassa. 1979b. Microwave Effects on Granulocyte and Macrophage Precursor Cells of Mice *In Vitro*. Radiat. Res., 80:292-302.

Lindahl, T., and B. Nyberg. 1974. Heat-Induced Deamination of Cytosine Residues in Deoxyribonucleic Acid. Biochemistry, 13(16):3405-3410.

Lin-Liu, S., and W.R. Adey. 1982. Low Frequency Amplitude Modulated Microwave Fields Change Calcium Efflux Rates from Synaptosomes. Bioelectromagnetics, 3:309-322.

Liu, L.M., F.J. Rosenbaum, and W.F. Pickard. 1976. The Insensitivity of Frog Heart Rate to Pulse Modulated Microwave Energy. J. Microwave Power, 11:225-232.

Liu, L.M., F.G. Nickless, and S.F. Cleary. 1979. Effects of Microwave Radiation on Erythrocyte Membranes. Radio Sci., 14(6S):109-115.

Livingston, G.K., C.C. Johnson, and L.A. Dethlefsen. 1979. Comparative Effects of Water-Bath- and Microwave-Induced Hyperthermia on Survival of Chinese Hamster Ovary (CHO) Cells. Radio Sci., 14(S):117-123.

Lobanova, E.A. 1974. The Use of Conditioned Reflexes to Study Microwave Effects on the Central Nervous System. In: Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, K. Ostrowski, M.L. Shore, C. Silverman, M.J. Suess, and B. Waldeskog, eds. Polish Medical Publishers, Warsaw, Poland. pp. 110-118.

Lotz, W.G. 1982. Hyperthermia in Rhesus Monkeys Exposed to a Frequency (225 MHz) near Whole-Body Resonance. Naval Med. Res. Devel. Com. MF58. 524.02C-009, Naval Aerospace Medical Research Laboratory, Pensacola, Florida.

Lotz, W.G., and S.M. Michaelson. 1978. Temperature and Corticosterone Relationships in Microwave-Exposed Rats. J. Appl. Physiol., 44:438-445.

Lotz, W.G., and S.M. Michaelson. 1979. Effects of Hypophysectomy and Dexamethasone on Rat Adrenal Response to Microwaves. J. Appl. Physiol: Respirat. Environ. Exercise Physiol., 47:1284-1288.

Lotz, W.G. and R.P. Podgorski. 1982. Temperature and Adrenocortical Responses in Rhesus Monkeys Exposed to Microwaves. J. Appl. Physiol., 53(6): 1565-1571.

Lovely, R.H., D.E. Myers, and A.W. Guy. 1977. Irradiation of Rats by 918-MHz Microwaves at 2.5 mW/cm$^2$: Delineating the Dose-Response Relationship. Radio Sci., 12(6S):139-146.

Lu, S., N. Lebda, S.M. Michaelson, S. Pettit, and D. Rivera. 1977. Thermal and Endocrinological Effects of Protracted Irradiation of Rats by 2450-MHz Microwaves. Radio Sci., 12:147-156.

Lu, S., N. Lebda, S. Pettit, and S.M. Michaelson. 1981. Microwave-Induced Temperature, Corticosterone, and Thyrotropin Interrelationships. J. Appl. Physiol.: Respirat. Environ. Exercise Physiol., 50:399-405.

Luben, R.A., C.D. Cain, M.C.-Y. Chen, D.M. Rosen, and W.R. Adey. 1982. Effects of Electromagnetic Stimuli on Bone and Bone Cells In Vitro: Inhibition of Responses to Parathyroid Hormone by Low-

Energy Low-Frequency Fields. Proc. Natl. Acad. Sci. USA, 79:4180-4184.

Lyle, D.B., P. Schechter, W.R. Adey, and R.L. Lundak. 1983. Suppression of T-Lymphocyte Cytotoxicity Following Exposure to Sinusoidally Amplitude-Modulated Fields. Bioelectromagnetics, 4:281-292.

Machle, W., and T.F. Hatch. 1947. Heat: Man's Exchanges and Physiological Responses. Physiol. Rev., 27:200-227.

MacLeod, J., and R.S. Hotchkiss. 1941. The Effect of Hyperpyrexia Upon Spermatozoa Counts in Men. Endocrinology, 28:780-784.

Magin, R.L., S. Lu, and S.M. Michaelson. 1977a. Stimulation of Dog Thyroid by Local Application of High Intensity Microwaves. Am. J. Physiol., 233:E363-E368.

Magin, R.L., S. Lu, and S.M. Michaelson. 1977b. Microwave Heating Effect on the Dog Thyroid Gland. IEEE Trans. Biomed. Eng., BME-24:522-529.

Majewska, K. 1968. Investigations on the Effect of Microwaves on the Eye. Pol. Med. J., 7:989-994.

Manikowska, E., J.M. Luciani, B. Servantie, P. Czerski, J. Obrenovitch, and A. Stahl. 1979. Effects of 9.4 GHz Microwave Exposure on Meiosis in Mice. Experientia, 35:388-390.

Manikowska-Czerska, E., P. Czerski, and W.M. Leach. 1983a. Effects of 0.915 and 9.4 GHz CW Microwaves on Meiosis in Male Mice. Abstract #H-3, 5th Annual Scientific Session, The Bioelectromagnetics Society, 12-17 July, Boulder, Colorado (available from The Bioelectromagnetics Society, One Bank Street, Suite 307, Gaithersburg, Maryland 20878). p. 57.

Manikowska-Czerska, E., P. Czerski, and W.M. Leach. 1983b. Dominant Lethal Testing after Exposure of Mice to 0.915 GHz Microwaves. Abstract #H-4, 5th Annual Scientific Session, The Bioelectromagnetics Society, 12-17 July, Boulder, Colorado (available from The Bioelectromagnetics Society, One Bank Street, Suite 307, Gaithersburg, Maryland 20878). p. 57.

Marmor, J.B., N. Hahn, and G.M. Hahn. 1977. Tumor Cure and Cell Survival after Localized Radiofrequency Heating. Cancer Res., 37:879-883.

Mathur, D.S., M.A. Aman, and K.R. Sarkar. 1980. Induction of Maternal Haploids in Maize Through Heat Treatment of Pollen. Current Sci., 49:744-746.

Mayers, C.P., and J.A. Habeshaw. 1973. Depression of Phagocytosis: A Non-Thermal Effect of Microwave Radiation as a Potential Hazard to Health. Int. J. Radiat. Biol., 24:449-461

McAfee, R.D., R. Braus, Jr., and J. Fleming, Jr. 1973. The Effect of 2450 MHz Microwave Irradiation on the Growth of Mice. J. Microwave Power, 8:111-116.

McAfee, R.D., A. Longacre, Jr., R.R. Bishop, S.T. Elder, J.G. May, M.G. Holland, and R. Gordon. 1979. Absence of Ocular Pathology after Repeated Exposure of Unanesthetized Monkeys to 9.3 GHz Microwaves. J. Microwave Power, 14:41-44.

McLaughlin, J.R. 1953. A Survey of Possible Health Hazards from Exposure to Microwave Radiation. Hughes Aircraft Corp., Culver City, California.

McLees, B.D., E.D. Finch, and M.L. Albright. 1972. An Examination of Regenerating Hepatic Tissue Subjected to Radio-Frequency Irradiation. J. Appl. Physiol., 32:78-85.

McNiven, D.R., and D.J. Wyner. 1976. Microwave Therapy and Muscle Blood Flow in Man. J. Microwave Power, 11:168-170.

McRee, D.I., and P.E. Hamrick. 1977. Exposure of Japanese Quail Embryos to 2.45-GHz Microwave Radiation During Development. Radiat. Res., 71:355-366.

McRee, D.I., G.K. Livingston, and G. MacNichols. 1978. Incidence of Sister Chromatid Exchange in Bone Marrow Cells of the Mouse Following Microwave Exposure (Abstract). In: Symposium on Electromagnetic Fields in Biological Systems, IEEE/IMPI, Ottawa, Canada. pp. 15-16.

McRee, D.I., R. Faith, E.E. McConnell, and A.W. Guy. 1980a. Long-Term 2450-MHz CW Microwave Irradiation of Rabbits: Evaluation of Hematological and Immunological Effects. J. Microwave Power, 15:45-52.

McRee, D.I., M. Galvin, C. Hall, and M. Lieberman. 1980b. Microwave Effects on Embryonic Cardiac Tissue of Japanese Quail. In: Ondes Electromagnetiques et Biologie, A.J. Berteaud and B. Servantie, eds. Paris, France. pp. 79-84.

McRee, D.I., G. MacNichols, and G.K. Livingston. 1981. Incidence of Sister Chromatid Exchange in Bone Marrow Cells of the Mouse Following Microwave Exposure. Radiat. Res., 85:340-348.

Merritt, J.H., R.H. Hartzell, and J.W. Frazer. 1976. The Effect of 1.6 GHz Radiation on Neurotransmitters in Discrete Areas of the Rat Brain. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 290-298.

Merritt, J.H., A.F. Chamness, R.H. Hartzell, and S.J. Allen. 1977. Orientation Effects on Microwave-Induced Hyperthermia and Neurochemical Correlates. J. Microwave Power, 12:167-172.

Merritt, J.H., A.F. Chamness, and S.J. Allen. 1978. Studies on Blood-Brain Barrier Permeability after Microwave-Radiation. Radiat. Environ. Biophys., 15:367-377.

Merritt, J.H., W.W. Shelton, and A.F. Chamness. 1982. Attempts to Alter $^{45}Ca^{2+}$ Binding to Brain Tissue with Pulse-Modulated Microwave Energy. Bioelectromagnetics, 3:475-478.

Michaelson, S.M., and H.P. Schwan. 1973. Comparative Aspects of Radiofrequency and Microwave Biomedical Research. IEEE Int. Microwave Symp., Boulder, Colorado. pp. 330-332.

Michaelson, S.M., R.A.E. Thomson, and J.W. Howland. 1961. Physiologic Aspects of Microwave Irradiation of Mammals. Am. J. Physiol., 201:351-356.

Michaelson, S.M., R.A.E. Thomson, L.T. Odland, and J.W. Howland. 1963. The Influence of Microwaves on Ionizing Radiation Exposure. Aerospace Med., 34:111-115.

Michaelson, S.M., R.A.E. Thompson, M.Y. El Tamami, H.S. Seth, and J. W. Howland. 1964. The Hematologic Effects of Microwave Exposure. Aerospace Med., 35:824-829.

Michaelson, S.M., R. Guillet, and F.W. Heggeness. 1978. Influence of Microwave Exposure on Functional Maturation of the Rat. In: Developmental Toxicology of Energy-Related Pollutants, D.D. Mahlum, M.R. Sikov, P.L. Hackett, and F.D. Andrew, eds. DOE Symposium Series 47, Washington, D.C. pp. 300-316.

Mickey, G.H., and L. Koerting. 1970. Chromosome Breakage in Cultured Chinese Hamster Cells Induced by Radiofrequency Treatment. Environ. Mutagen Soc., 3:25-26.

Mikolajczyk, H. 1976. Microwave-Induced Shifts of Gonadotropic Activity in Anterior Pituitary Gland of Rats. In: Biological Effects of Electromagnetic Waves, C.C. Johnson and M.L. Shore, eds. U.S. DHEW (FDA) 77-8010, Rockville, Maryland. pp. 377-383.

Milham, S., Jr. 1982. Mortality from Leukemia in Workers Exposed to Electrical and Magnetic Fields. New England J. Med., 307:249.

Milroy, W.C., and S.M. Michaelson. 1972. Thyroid Pathophysiology of Microwave Radiation. Aerospace Med., 43:1126-1131.

Miro, L., R. Loubiere, and A Pfister. 1974. Effects of Microwaves on the Cell Metabolism of the Reticulo-Histocytic System. In: Biological Effects and Health Hazards of Microwave Radiation, P. Czerski, K. Ostrowski, M.L. Shore, C. Silverman, M.T. Suess, and B. Waldeskog, eds. Polish Medical Publication, Warsaw, Poland. pp. 89-97.

Mitchell, D.S., W.G. Switzer, and E.L. Bronaugh. 1977. Hyperactivity and Disruption of Operant Behavior in Rats after Multiple Exposure to Microwave Radiation. Radio Sci., 12(6S):263-271.

Mittler, S. 1976. Failure of 2- and 10-Meter Radio Waves to Induce Genetic Damage in *Drosophila melanogaster*. Environ. Res., 11:326-330.

Mittler, S. 1977. Failure of Chronic Exposure to Nonthermal FM Radio Waves to Mutate *Drosophila*. J. Heredity, 68:257-258.

Mittler, S. 1979. Hyperthermia and Radiation-Induced Dominant Lethals and Chromosome Loss in Female *Drosophila melanogaster*. J. Heredity, 70:81-82.

Moe, K.E., R.H. Lovely, D.E. Meyers, and A.W. Guy. 1976. Physiological and Behavioral Effects of Chronic Low Level Microwave Radiation in Rats. In: Biological Effects of Electromagnetic Waves, Vol. I., C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 248-256.

Monahan, J.C., and H.S. Ho. 1976. Microwave Induced Avoidance Behavior in the Mouse. In: Biological Effects of Electromagnetic Waves, Vol. I., C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 274-283.

Monahan, J.C., and H.S. Ho. 1977. The Effect of Ambient Temperature on the Reduction of Microwave Energy Absorption by Mice. Radio Sci., 12(6S):257-262.

Monahan, J.C., and W.W. Henton. 1979. The Effect of Psychoactive Drugs on Operant Behavior Induced by Microwave Radiation. Radio Sci., 14(6S):233-238.

Monjan, A.A. 1981. Stress and Immunologic Competence: Studies in Animals. In: Psychoneuroimmunology, R. Ader, ed. Academic Press, New York, New York. pp. 185-228.

Montgomery, L.D. 1972. A Simulation of Heat Transfer in Man Under Immersed Conditions. Doctoral Thesis, UCLA, Los Angeles, California.

Montgomery, L.D. 1974a. A Model of Heat Transfer in Immersed Man. Ann. Biomed. Eng., 2:19-46.

Montgomery, L.D. 1974b. Analytic Model for Assessing the Thermal Performance of Scuba Divers. J. Hydronautics, 8:108-115.

Montgomery, L.D. 1975. Biothermal Simulation of Scuba Divers. Aviat. Space Environ. Med., 46(6):814-818.

Moore, H.A., R. Raymond, M. Fox, and A.G. Galsky. 1979. Low-Intensity Microwave Radiation and the Virulence of *Agrobacterium tumefaciens* Strain B6. Appl. Environ. Microbiol., 37:127-130.

Morishima, H.O., B. Glaser, W.H. Niemann, and L.S. James. 1975. Increased Uterine Activity and Fetal Deterioration During Maternal Hyperthermia. Am. J. Obstet. Gyn., 121:531-538.

Morris, W., ed. 1976. The American Heritage Dictionary of the English Language. Houghton Mifflin Company, Boston, Massachusetts. 1550 pp.

Muller, H.J., and E. Altenburg. 1919. The Rate of Change of Hereditary Factors in Drosophila. Proc. Soc. Exp. Biol. Med., 17:10-14.

Mumford, W.W. 1961. Some Technical Aspects of Microwave Radiation Hazards. Proc. IRE, 49:427-447.

Mumford, W.W. 1969. Heat Stress Due to RF Radiation. Proc. IEEE, 57:171-178.

Muraca, G.J., E.S. Ferri, and F.L. Buchta. 1976. A Study of the Effects of Microwave Irradiation of the Rat Testes. In: Biological Effects of Electromagnetic Waves, Vol. I., C.C. Johnson and M.L. Shore, eds. DHEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 484-494.

Myers, R.D., and D.H. Ross. 1981. Radiation and Brain Calcium: A Review and Critique. Neurosci. Biobehav. Rev., 5:503-543.

NCRP. 1981. Radiofrequency Electromagnetic Fields, Properties, Quantities and Units, Biophysical Interaction and Measurements. NCRP Report No. 67, March 1, 1981. National Council on Radiation Protection and Measurements Publications, Washington, D.C. 134 pp.

Nelson, A.J.M., and J.A.G. Holt. 1978. Combined Microwave Therapy. Med. J. Aust., 2:88-90.

Nieset, R.T., R. Baus, Jr., R.D. McAfee, J.J. Friedman, A.S. Hyde, and J.D. Fleming, Jr. 1958. Review of the Work Conducted at Tulane University. In: Proc. Second Tri-Service Conference on Biological Effects of Microwave Energy. (NTIS AD 131 477). pp. 202-214.

O'Connor, M.E. 1980. Mammalian Teratogenesis and Radio-Frequency Fields. Proc. IEEE., 68:56-60.

Odland, L.T. 1973. Radio-Frequency Energy: A Hazard to Workers? Ind. Med. Surg. 42:23-26.

Ogilvie, D.M., and R.H. Stinson. 1966. The Effect of Age on Temperature Selection by Laboratory Mice *(Mus musculus)*. Can. J. Zool., 44:511-517.

Olcerst, R.B., S. Belman, M. Eisenbud, W.W. Mumford, and J.R. Rabinowitz. 1980. The Increased Passive Efflux of Sodium and Rubidium from Rabbit Erythrocytes by Microwave Radiation. Radiat. Res., 82:244-256.

Oldendorf, W.H. 1970. Measurement of Brain Uptake of Radiolabeled Substances Using a Tritiated Water Internal Standard. Brain Res., 24:372-376.

Oliva, S.A., and G.N. Catravas. 1977. A Multiple-Animal Array for Equal Power Density Microwave Irradiation. IEEE Trans. Microwave Theory Techniques, MTT-25(5):433-436.

Olsen, R.G., and W.C. Hammer. 1980. Microwave-Induced Pressure Waves in a Model of Muscle Tissue. Bioelectromagnetics, 1:45-54.

Olsen, R.G., J.L. Lords, and C.H. Durney. 1977. Microwave-Induced Chronotropic Effects in the Isolated Rat Heart. Ann. Biomed. Eng., 5:395-409.

Oscar, K.J., and T.D. Hawkins. 1977. Microwave Alteration of the Blood-Brain Barrier System of Rats. Brain Res., 126:281-293.

Oscar, K.J., S.P. Gruenau, M.T. Folker, and S.I. Rapoport. 1981. Local Cerebral Blood Flow after Microwave Exposure. Brain Res., 204:220-225.

Paff, G.H., R.J. Boucek, R.E. Nieman, and W.B. Deichmann. 1963. The Embryonic Heart Subjected to Radar. Anat. Rec., 147:379-385.

Palmbald, J. 1981. Stress and Immunologic Competence: Studies in Man. In: Psychoneuroimmunology, R. Ader, ed. Academic Press, New York. pp. 228-257.

Parker, L.N. 1973. Thyroid Suppression and Adrenomedullary Activation by Low-Intensity Microwave Radiation. Am. J. Physiol., 224:1388-1390.

Paulsson, L-E., Y. Hamnerius, and W.G. McLean. 1977. The Effects of Microwave Radiation on Microtubules and Axonal Transport. Radiat. Res., 70:212-223.

Pavlov, I.P. 1960. Conditioned Reflexes (Translated by G.V. Anrep). Dover Publications, New York, New York. 430 pp.

Pay, T.L., E.C. Beyer and C.F. Reichelderfer. 1972. Microwave Effects on Reproductive Capacity and Genetic Transmission in *Drosophila melanogaster*. J. Microwave Power, 7:75-82.

Pay, T.L., F.A. Andersen, and G.L. Jessup, Jr. 1978. A Comparative Study of the Effects of Microwave Radiation and Conventional Heating on the Reproductive Capacity of *Drosophila melanogaster*. Radiat. Res., 76:271-282.

Pazderova, J., R. Fisher, J. Formanek, J. John, E. Lucas, and V. Stýblová 1969. Health State of Workers Exposed to Long-Term Electromagnetic Radiation of Order of Meter Waves. (In Czech.) Pracov. Lek., 21:346-361.

Pazderova-Vejlupkova, J., and M. Josifko. 1979. Changes in the Blood Count of Growing Rats Irradiated with a Microwave Pulse Field. Arch. Environ. Health, 34:44-50.

Pellon, J.R., K.M. Ulmer, and R.F. Gomez. 1980. Heat Damage to the Folded Chromosome of *Escherichia coli* K-12. Appl. Environ. Microbiol., 40(2):358-364.

Pennes, H.H. 1948. Analysis of Tissue and Arterial Blood Temperatures in the Resting Human Forearm. J. Appl. Physiol., 1:93-122.

Peterson, D.J., L.M. Partlow, and O.P. Gandhi. 1979. An Investigation of the Thermal and Athermal Effects of Microwave Irradiation on Erythrocytes. IEEE Trans. Biomed. Eng., BME-26:428-436.

Peto, R., M.C. Pike, P. Armitage, N.E. Breslow, D.R. Cox, S.V. Howard, N. Mantel, K. McPherson, J. Peto, and P.G. Smith. 1976. Design and Analysis of Randomised Clinical Trails Requiring Prolonged Observation of Each Patient. I. Introduction and Design. Br. J. Cancer, 34:585-612.

Peto, R., M.C. Pike, P. Armitage, N.E. Breslow, D.R. Cox, S.V. Howard, N. Mantel, K. McPherson, J. Peto, and P.G. Smith. 1977. Design and Analysis of Randomized Clinical Trials Requiring Prolonged Observation of Each Patient. II. Analysis and Examples. Br. J. Cancer, 35:1-39.

Phillips, R.D., N.W. King, and E.L. Hunt. 1973. Thermoregulatory, Cardiovascular and Metabolic Response of Rats to Single or Repeated Exposures to 2450 MHz Microwaves. 1973 Microwave Power Symp., Int. Microwave Power Inst., Edmonton, Canada. pp. 3B35/1-3B35/4.

Phillips, R.D., E.L. Hunt, and N.W. King. 1975a. Field Measurements, Absorbed Dose, and Biologic Dosimetry of Microwaves. Ann. N.Y. Acad. Sci., 247:499-509.

Phillips, R.D., E.L. Hunt, R.D. Castro, and N.W. King. 1975b. Thermoregulatory, Metabolic, and Cardiovascular Response of Rats to Microwaves. J. Appl. Physiol., 38:630-635.

Pickard, W.F., and Y.H. Barsoum. 1981. Radio-Frequency Bioeffects at the Membrane Level: Separation of Thermal and Athermal Contributions in the Characeae. J. Membrane Biol. 61:39-54.

Pickard, W.F., and F.J. Rosenbaum. 1978. Biological Effects of Microwaves at the Membrane Level: Two Possible Athermal Electrophysiological Mechanisms and a Proposed Experimental Test. Math. Biosci., 39:235-253.

Pollack, H. 1979. Epidemiologic Data on American Personnel in the Moscow Embassy. Bull. N.Y. Acad. Med., 55:1182-1186.

Pollak, M. 1965. On the Dielectric Dispersion of Polyelectrolytes with Application to DNA. J. Chem. Phys., 43:908-909.

Prausnitz, S., and C. Süsskind. 1962. Effects of Chronic Microwave Irradiation on Mice. IRE Trans. Biomed. Electron., 9:104-108.

Preskorn, S.H., W.D. Edwards, and D.R. Justesen. 1978. Retarded Tumor Growth and Greater Longevity in Mice after Fetal Irradiation by 2450-MHz Microwaves. J. Surg. Oncol., 10:483-492.

Presman, A.S., and N.A. Levitina. 1962. Nonthermal Action of Microwaves on Cardiac Rhythm. Communication I. A Study of the Action of Continuous Microwaves. Bull. Exp. Biol. Med., 53:36-39.

Preston, E., and G. Prefontaine. 1980. Cerebrovascular Permeability to Sucrose in the Rat Exposed to 2,450-MHz Microwaves. J. Appl. Physiol., 49:218-223.

Preston, E., E.J. Vavasour, and H.M. Assenheim. 1979. Permeability of the Blood-Brain Barrier to Mannitol in the Rat Following 2450 MHz Microwave Irradiation. Brain Res., 174:109-117.

Prince, J.E., L.H. Mori, J.W. Frazer, and J.C. Mitchell. 1972. Cytologic Aspect of RF Radiation in the Monkey. Aerospace Med., 43:759-761.

Prohofsky, E.W., K.C. Lu, L.L. Van Zandt, and B.F. Putnam. 1979. Breathing Modes and Induced Resonant Melting of the Double Helix. Phys. Lett., 70A:492-494.

Pucak, G.J., C. S. Lee, and A.S. Zaino. 1977. Effects of Prolonged High Temperature on Testicular Development and Fertility in the Male Rat. Lab. Anim. Sci., 27(1):76-77.

Puska, P., J. Tuomilehto, J. Salonen, A. Nissinen, J. Virtamo, S. Björkqvist, K. Koskela, L. Neittaanmäki, T. Takalo, T. Kottke, J. Mäki, P. Sipilä, and P. Varvikko. 1978. The North Karelia Project: Evaluation of a Comprehensive Community Programme for Control of Caradiovascular Diseases in 1972-1977 in North Karelia, Finland. Research Institute for Community Health, University of Kuopio, Kuopio, Finland. 449 pp.

Rabinowitz, J.R. 1973. Possible Mechanisms for the Biomolecular Absorption of Microwave Radiation with Functional Implications. IEEE Trans. Microwave Theory Techniques, MTT-21:850-851.

Rama Rao, G., C. A. Cain, J. Lockwood, and W.A.F. Tompkins. 1983. Effects of Microwave Exposure on the Hamster Immune System. II. Peritoneal Macrophage Function. Bioelectromagnetics, 4:141-155.

Ramirez, E., J.L. Monteagudo, M. Garcia-Garcia, and J.M.R. Delgado. 1983. Oviposition and Development of Drosophila Modified by Magnetic Fields. Bioelectromagnetics, 4:315-326.

Rand, R.P., A.C. Burton, and T. Ing. 1965. The Tail of the Rat, in Temperature Regulation and Acclimatization. Can. J. Physiol. Pharmacol., 43:257-267.

Rapoport, S.I. 1976. Blood-Brain Barrier in Physiology and Medicine. Raven Press, New York, New York. 316 pp.

Reaves, T.A., Jr. 1977. Gain of Thermosensitive Neurons in the Preoptic Area of the Rabbit, *Oryctolagus cuniculus*. J. Thermal Biol., 2:31-33.

Reno, V.R. 1974. Microwave Reflection, Diffraction, and Transmission Studies of Man. Report NAMRL-1199. Naval Aerospace Medical Research Laboratory, Pensacola, Florida. 39 pp.

Richardson, A.W., T.D. Duane, and H.M. Hines. 1948. Experimental Lenticular Opacities Produced by Microwave Irradiations. Arch. Phys. Med., 29:765-769.

Riddle, M.M., R. J. Smialowicz, and R.R. Rogers. 1982. Microwave Radiation (2450-MHz) Potentiates the Lethal Effect of Endotoxin in Mice. Health Phys., 42:335-340.

Riley, V. 1981. Psychoneuroendocrine Influences on Immunocompetence and Neoplasia. Science, 212:1100-1109.

Rissmann, W.J., and C.A. Cain. 1975. Microwave Hearing in Mammals. Proc. Natl. Elec. Cong., 30:239-244.

Roberti, B., G.H. Heebels, J.C. M. Hendricx, A.H.A.M. de Greef, and O.L. Wolthuis. 1975. Preliminary Investigations of the Effects of Low-Level Microwave Radiation and Spontaneous Motor Activity in Rats. Ann. N.Y. Acad. Sci., 247:417-424.

Roberts, N.J., Jr. 1979. Temperature and Host Defense. Microbiol. Rev.,43:241-259.

Roberts, N.J., Jr., and R.T. Steigbigel. 1977. Hyperthermia and Human Leukocyte Functions: Effects on Response of Lymphocytes to Mitogen and Antigen and Bactericidal Capacity of Monocytes and Neutrophils. Infect. Immun., 18:673-679.

Robinette, C.D. and C. Silverman. 1977. Causes of Death Following Occupational Exposure to Microwave Radiation (Radar) 1950-1974. In: Symposium on Biological Effects and Measurements of Radiofrequency/Microwaves, D.G. Hazzard, ed. HEW Publication (FDA) 77-8026, Rockville, Maryland. pp. 338-344.

Robinette, C.D., C. Silverman, and S. Jablon. 1980. Effects upon Health of Occupational Exposure to Microwave Radiation (Radar). Am. J. Epidemiol., 112:39-53.

Rogers, P., and A. Matossian-Rogers. 1982. Differential Sensitivity of Lymphocyte Subsets to Corticosteroid Treatment. Immunology, 46:841-848.

Rosenthal, S.W., L. Birenbaum, I.T. Kaplan, W. Metlay, W.Z. Snyder, and M.M. Zaret. 1976. Effects of 35 and 107 GHz CW Microwaves on the Rabbit Eye. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 110-128.

Roszkowski, W., J.K. Wrembel, K. Roszkowski, M. Janiak, and S. Szmigielski. 1980. The Search for an Influence of Whole-Body Microwave Hyperthermia on Anti-Tumor Immunity. J. Cancer Res. Clin. Oncol., 96:311-317.

Rotkovska, D., and A. Vacek. 1972. Effect of High-Frequency Electromagnetic Field Upon Haemopoietic Stem Cells in Mice. Folia Biologica (Praha), 18:292-297.

Rotkovska, D., and A. Vacek. 1975. The Effect of Electromagnetic Radiation on the Hematopoietic Stem Cells of Mice. Ann. N.Y. Acad. Sci., 247:243-250.

Rotkovska, D., and A. Vacek. 1977. Modification of Repair of X-Irradiation Damage of Hemopoietic System of Mice by Microwaves. J. Microwave Power, 12:119-123.

Rozzell, T.C., C.C. Johnson, C.H. Durney, J.L. Lords, and R.G. Olsen. 1974. A Nonperturbing Temperature Sensor for Measurements in Electromagnetic Fields. J. Microwave Power, 9(3):241-249.

Rudnev, M., A. Bokina, N. Eksler, and M. Navakatikyan. 1978. The Use of Evoked Potential and Behavioral Measures in the Assessment of Environmental Insult. In: Multidisciplinary Perspectives in Event-Related Brain Potential Research, D.A. Otto, ed. EPA-600/9-77-043, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. pp. 444-447.

Rudge, A.W. 1970. An Electromagnetic Radiation Probe for Near-Field Measurements at Microwave Frequencies. J. Microwave Power, 5(3):155-174.

Ruggera, P.S. 1976. E- and H-Field Instrumentation and Calibration below 500 MHz. In: Biological Effects of Electromagnetic Waves. Vol. II, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8011, Rockville, Maryland. pp. 281-296.

Rugh, R. 1976a. Are Mouse Fetuses Which Survive Microwave Radiation Permanently Affected Thereby? Health Phys., 31:33-39.

Rugh, R. 1976b. The Relation of Sex, Age, and Weight of Mice to Microwave Radiation Sensitivity. J. Microwave Power, 11(2):127-132.

Rugh, R., and M. McManaway. 1976. Anesthesia as an Effective Agent Against the Production of Congenital Anomalies in Mouse Fetuses Exposed to Electromagnetic Radiation. J. Exp. Zool., 197:363-368.

Rugh, R., and M. McManaway. 1977. Mouse Fetal Sensitivity to Microwave Radiation. Cong. Anom., 17:39-45.

Rugh, R., E.I. Ginns, H.S. Ho, and W.M. Leach. 1974. Are Microwaves Teratogenic? In: Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, K. Ostrowski, M.L. Shore, C. Silverman, M.J. Suess, and B. Waldeskog, eds. Polish Medical Publishers, Warsaw, Poland. pp. 98-107.

Rugh, R., E.I. Ginns, H.S. Ho, and W.M. Leach. 1975. Responses of the Mouse to Microwave Radiation During Estrous Cycle and Pregnancy. Radiat. Res., 62:225-241.

Rukspollmuang, S., and K.M. Chen. 1979. Heating of Spherical Versus Realistic Models of Human and Infrahuman Heads by Electromagnetic Waves. Radio Sci., 14(6S):51-62.

Ruppin, R. 1979. Electromagnetic Power Deposition in a Dielectric Cylinder in the Presence of a Reflecting Surface. IEEE Trans. Microwave Theory Techniques, MTT-27(11):910-914.

Sagan, P.M., and R.G. Medici. 1979. Behavior of Chicks Exposed to Low-Power 450-MHz Fields Sinusoidally Modulated at EEG Frequencies. Radio Sci., 14(6S):239-245.

Sams & Co. 1981. Reference Data for Radio Engineers. Howard W. Sams & Co., Inc., New York, New York. Chapter 1.

Sanders, A.P., D.J. Schaefer, and W.T. Joines. 1980. Microwave Effects on Energy Metabolism of Rat Brain. Bioelectromagnetics, 1:171-181.

Sanza, J.N., and J. de Lorge. 1977. Fixed Interval Behavior of Rats Exposed to Microwaves at Low Power Densities. Radio Sci., 12(6S):273-277.

Satinoff, E., and R. Hendersen. 1977. Thermoregulatory Behavior. In: Handbook of Operant Behavior, W.K. Honig and J.E. Staddon, eds. Prentice Hall, Englewood Cliffs, New Jersey. pp. 153-173.

Saunders, R.D., S.C. Darby, and C.I. Kowalczuk. 1983. Dominant Lethal Studies in Male Mice after Exposure to 2.45 GHz Microwave Radiation. Mutat. Res., 117:345-356.

Schlagel, C.J., K. Sulek, H.S. Ho, W.M. Leach, A. Ahmed, and J.N. Woody. 1980. Biological Effects of Microwave Exposure. II. Studies on the Mechanisms Controlling Susceptibility to Microwave-Induced Increases in Complement Receptor-Positive Spleen Cells. Bioelectromagnetics, 1:405-414.

Schmidt-Nielsen, K. 1964. Desert Animals. Physiological Problems of Heat and Water. Oxford University Press, New York. 277 pp.

Schmidt-Nielsen, K. 1972. How Animals Work. Cambridge University Press, New York, New York. 114 pp.

Schmidt-Nielsen, K. 1975. Scaling in Biology: The Consequences of Size. J. Exp. Zool., 194:287-308.

Schmidt-Nielsen, K. 1979. Animal Physiology: Adaptation and Environment, 2nd ed. Cambridge University Press, Cambridge, Massachusetts. 560 pp.

Schmidt-Nielsen, K., B. Schmidt-Nielsen, S.A. Jarnum, and T.R. Houpt. 1957. Body Temperature of the Camel and Its Relation to Water Economy. Am. J. Physiol., 188:103-112.

Scholander, P.F., R. Hock, V. Walters, F. Johnson, and C. Irving. 1950. Heat Regulation in Some Arctic and Tropical Mammals and Birds. Biol. Bull., 99:237-258.

Scholl, D.M., and S.J. Allen. 1979. Skilled Visual-Motor Performance by Monkeys in a 1.2-GHz Microwave Field. Radio Sci., 14(6S):247-252.

Schrot, J., J.R. Thomas, and R.A. Banvard. 1980. Modification of the Repeated Acquisition of Response Sequences in Rats by Low-Level Microwave Exposure. Bioelectromagnetics, 1:89-99.

Schwan, H.P. 1957. Electrical Properties of Tissue and Cell Suspensions. Adv. Biol. Med. Phys., 5:147-209.

Schwan, H.P. 1965. Electrical Properties of Bound Water. Ann. N.Y. Acad. Sci., 125:344-354.

Schwan, H.P., and K.R. Foster. 1980. RF-Field Interactions with Biological Systems: Electrical Properties and Biophysical Mechanisms. Proc. IEEE, 68:104-113.

Schwan, H.P., and K.Li. 1956. Hazards Due to Total Body Irradiation by Radar. Proc, IRE, 44:1572-1581.

Schwan, H.P., A. Anne, and L. Sher. 1966. Heating of Living Tissues. Report NAEC-ACEL-534, U.S. Naval Air Engineering Center, Philadelphia, Pennsylvania. 30 pp.

Schwarz, G. 1967. On Dielectric Relaxation Due to Chemical Rate Processes. J. Phys. Chem., 71:4021-4030.

Schwarz, G. 1972. Dielectric Relaxation of Biopolymers in Solution. Adv. Mol. Relaxation Processes, 3:281-295.

Schwarz, G., and J. Seelig. 1968. Kinetic Properties and the Electric Field Effect of the Helix-Coil Transition of Poly ($\gamma$-Benzyl L-Glutamate) Determined from Dielectric Relaxation Measurements. Biopolymers, 6:1263-1277.

Scientific American. 1979. The Brain. Sci. Am., 241(3):1-252.

Seaman, R.L., and H. Wachtel. 1978. Slow and Rapid Responses to CW and Pulsed Microwave Radiation by Individual *Aplysia* Pacemakers. J. Microwave Power, 13:77-86.

Segal, A.S., and R.L. Magin. 1982. Microwaves and the Blood-Brain Barrier: A Review. J. Bioelectricity, 1:351-398.

Servantie, B., G. Bertharion, R. Joly, A. Servantie, J. Etienne, P. Dreyfus, and P. Escoubet. 1974. Pharmacologic Effects of a Pulsed Microwave Field. In: Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, K. Ostrowski, M.L. Shore, C. Silverman, M.J. Suess, and B. Waldeskog, eds. Polish Medical Publishers, Warsaw, Poland. pp. 36-45.

Shacklett, D.E., T.J. Tredici, and D.L. Epstein. 1975. Evalution of Possible Microwave-Induced Lens Changes in the United States Air Force. Aviat. Space Environ. Med., 46:1403-1406.

Shah, S.A., and J.A. Dickson, 1978a. Effect of Hyperthermia on the Immune Response of Normal Rabbits. Cancer Res., 38:3518-3522.

Shah, S.A., and J.A. Dickson. 1978b. Effect of Hyperthermia on the Immuno-competence of VX2 Tumor-Bearing Rabbits. Cancer Res., 38:3523-3531.

Shandala, M.G., M.I. Rudnev, and M.A. Navakatian. 1977. Patterns of Change in Behavioral Reactions to Low Power Densities of Microwaves (Abstract). International Symposium on the Biological Effects of Electromagnetic Waves (URSI), Airlie, Virginia. p. 88.

Shelton, W.W., Jr., and J.H. Merritt. 1981. In Vitro Study of Microwave Effects on Calcium Efflux in Rat Brain Tissue. Bioelectromagnetics, 2:161-167.

Sheppard, A.R., S.M. Bawin, and W.R. Adey. 1979. Models of Long-Range Order in Cerebral Macromolecules: Effect of Sub-ELF and of Modulated VHF and UHF Fields. Radio Sci., 14(6S):141-145.

Sher, L.D. 1970. Interaction of Microwave and RF Energy on Biological Material. In: Electronic Product Radiation and the Health Physicist. Report BRH/DEP 70-26, HEW, Bureau of Radiological Health, Rockville, Maryland. pp. 431-462.

Sheridan, J.P., B.P. Gaber, F. Cavatorta, and P.E. Schoen. 1979. Molecular Level Effects of Microwaves on Natural and Model Membranes: A Raman Spectroscopic Investigation (Abstract). Joint Meeting of USNC/URSI and the Bioelectromagnetics Society, Seattle, Washington. p. 468.

Sherins, R.J., D. Brightwell, and P.M. Sternthal. 1977. Longitudinal Analysis of Semen in Fertile and Infertile Men. In: The Testes in Normal and Infertile Men, P. Troen and H.R. Nankin, eds. Raven Press, New York, New York. pp. 473-488.

Shore, M.L., R.P. Felten, and A. Lamanna. 1977. The Effect of Repetitive Prenatal Low-Level Microwave Exposure on Development in the Rat. In: Symposium on Biological Effects and Measurement of Radio Frequency/Microwaves, D.G. Hazzard, ed. HEW Publication (FDA) 77-8026, Rockville, Maryland. pp. 280-289.

Siekierzynski, M., P. Czerski, H. Milczsret, A. Gidynski, C. Czarnecki, E. Dziuk, and W. Jedrzejczak. 1974a. Health Surveillance of Personnel Occupationally Exposed to Microwaves. II. Functional Disturbances. Aerospace Med. 45:1143-1145.

Siekierzynski, M., P. Czerski, A. Gidynski, S. Zydecki, C. Czarnecki, E. Dziuk, and W. Jedrezejczak. 1974b. Health Surveillance of Personnel Occupationally Exposed to Microwaves. III. Lens Translucency. Aerospace Med., 45:116-1148.

Siems, L.L., A.J. Kosman, and S.L. Osborne. 1948. A Comparative Study of Short Wave and Microwave Diathermy on Blood Flow. Arch. Phys. Med., 29:759-764.

Sigler, A.T., A.M. Lilienfeld, B.H. Cohen, and J.E. Westlake. 1965. Radiation Exposure in Parents of Children with Mongolism (Down's Syndrome). Bull. J. Hopkins Hosp., 117:374-399.

Silverman, C. 1979. Epidemiologic Approach to the Study of Microwave Effects. Bull. N.Y. Acad. Med., 55:1166-1181.

Silverman, C. 1980. Epidemiologic Studies of Microwave Effects. Proc. IEEE, 68:78-84.

Skinner, B.F. 1953. Science and Human Behavior. The Free Press, New York, New York, 461 pp.

Smialowicz, R.J. 1976. The Effect of Microwaves (2450 MHz) on Lymphocyte Blast Transformation *In Vitro*. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 472-483.

Smialowicz, R.J., J.B. Kinn, and J.A. Elder. 1979a. Perinatal Exposure of Rats to 2450-MHz CW Microwave Radiation: Effects on Lymphocytes. Radio Sci., 14(6S):147-153.

Smialowicz, R.J., M.M. Riddle, P.L. Brugnolotti, J.M. Sperrazza, and J.B. Kinn. 1979b. Evaluation of Lymphocyte Function in Mice Exposed to 2450 MHz (CW) Microwaves. In: Electromagnetic Fields in Biological Systems, S.S. Stuchly, ed. The International Microwave Power Institute, Edmonton, Canada. pp. 122-152.

Smialowicz, R.J., J.S. Ali, E. Berman, S.J. Bursian, J.B. Kinn, C.G. Liddle, L.W. Reiter, and C.M. Weil. 1981a. Chronic Exposure of Rats to 100-MHz (CW) Radiofrequency Radiation: Assessment of Biological Effects. Radiat. Res., 86:488-505.

Smialowicz, R.J., M.M. Riddle, P.L. Brugnolotti, R.R. Rogers, and K.L. Compton. 1981b. Detection of Microwave Heating in 5-Hydroxytryptamine-

Induced Hypothermic Mice. Radiat. Res., 88:108-117.

Smialowicz, R.J., P.L. Brugnolotti, and M.M. Riddle. 1981c. Complement Receptor Positive Spleen Cells in Microwave (2450-MHz) Irradiated Mice. J. Microwave Power, 16:73-77.

Smialowicz, R.J., C.M. Weil, J.B. Kinn, and J.A. Elder. 1982. Exposure of Rats to 425-MHz (CW) Radiofrequency Radiation: Effects on Lymphocytes. J. Microwave Power, 17:211-221.

Smialowicz, R.J., R.R. Rogers, R.J. Garner, M.M. Riddle, R.W. Luebke, and D.G. Rowe. 1983. Microwaves (2450-MHz) Suppress Murine Natural Killer Cell Activity. Bioelectromagnetics, 4:371-381.

Smith, J.B., R.P. Knowlton, and S.S. Agarwal. 1978. Human Lymphocyte Responses are Enhanced by Culture at 40°C. J. Immunol., 121:691-694.

Smith, P.E., and E.W. James. 1964. Human Responses to Heat Stress. Arch. Environ. Health, 9:332-342.

Smolyanskaya, A.Z., and R.L. Vilenskaya. 1973. Effects of Millimeter-Band Electromagnetic Radiation on the Functional Activity of Certain Genetic Elements of Bacterial Cells. Usp Fiz. Nauk, 110:571-572. (Trans. in Soviet Physics Uspekhi, 16(4):571-572, 1974.)

Snyder, S.H. 1971. The Effect of Microwave Irradiation on the Turnover Rate of Serotonin and Norepinephrine and the Effect of Monoamine Metabolizing Enzymes. Final Report, Contract No. DADA 17-69-C-9144, U.S. Army Medical Research and Development Command, Washington, D.C. (NTIS AD-729 161). 26 pp.

Sommer, H.C., and H.E. von Gierke. 1964. Hearing Sensations in Electric Fields. Aerospace Med., 35:834-839.

Spalding, J.F., R.W. Freyman, and L.M. Holland. 1971. Effects of 800-MHz Electromagnetic Radiation on Body Weight, Activity, Hematopoiesis and Life Span in Mice. Health Phys., 20:421-424.

Spiegel, R.J., D.M. Deffenbaugh, and J.E. Mann. 1979. Modeling Heat Transfer in Man Exposed to an Electromagnetic Field. Final Tech. Report No. 14-9239, Southwest Research Institute, San Antonio, Texas. 106 pp.

Spiegel, R.J., D.M. Deffenbaugh, and J.E. Mann. 1980a. A Thermal Model of the Human Body Exposed to an Electromagnetic Field. Bioelectromagnetics, 1(3):253-270.

Spiegel, R.J., W.E. Oakey, and E.L. Bronaugh. 1980b. A Variable-Volume Cavity Electromagnetic Near-Field Simulator. IEEE Trans. Electromagnetic Compatibility, EMC-22(4):289-297.

Stavinoha, W.B., A. Modak, M.A. Medina, and A.E. Gass. 1975. Growth and Development of Neonatal Mice Exposed to High-Frequency Electromagnetic Fields (NTIS AD-A022 765). 12 pp.

Stern, S., L. Margolin, B. Weiss, S. Lu, and S.M. Michaelson. 1979. Microwaves: Effect on Thermoregulatory Behavior in Rats. Science, 206:1198-1201.

Stitt, J.T. 1979. Fever Versus Hyperthermia. Fed. Proc., 38:39-43.

Stodolnik-Baranska, W. 1967. Lymphoblastoid Transformation of Lymphoctyes *In Vitro* after Microwave Irradiation. Nature, 214:102-103.

Stolwijk, J.A.J. 1969. Expansion of a Mathematical Model of Thermoregulation to Include High Metabolic Rates. NASA CR-102192 (NTIS N70-19831), Washington, D.C. 120 pp.

Stolwijk, J.A.J. 1971. A Mathematical Model of Physiological Temperature Regulation in Man. NASA CR-1855 (NTIS N71-33401), Washington, D.C. 76 pp.

Stolwijk, J.A.J. 1980. Mathematical Methods of Thermal Regulation. Ann. N.Y. Acad. Sci., 33:309-325.

Stolwijk, J.A.J., and D.J. Cunningham. 1968. Expansion of a Mathematical Model of Thermoregulation to Include High Metabolic Rates. NASA CR-92443 (NTIS N69-16568), Washington, DC. 133 pp.

Stolwijk, J.A.J., and J.D. Hardy. 1966. Temperature Regulation in Man — A Theoretical Study. Pflugers Arch., 291:129-162.

Stolwijk, J.A.J., and J.D. Hardy. 1977. Control of Body Temperature. In: Handbook of Physiology - Reactions to Environmental Agents, Douglas H. K. Lee, ed. Williams and Wilkins, Baltimore, Maryland. Ch. 4, pp. 45-68.

Stratton, J.A. 1941. Electromagnetic Theory. McGraw-Hill, New York, New York. pp. 414-420.

Stricker, E.M., and F.R. Hainsworth. 1971. Evaporative Cooling in the Rat: Interaction with Heat Loss from the Tail. Q.J. Exp. Physiol., 56:231-241.

Stuchly, M.A., and S.S. Stuchly. 1980. Dielectric Properties of Biological Substances - Tabulated. J. Microwave Power, 15(1):19-26.

Sugano, Y. 1981. Seasonal Changes in Heat Balance of Dogs Acclimatized to Outdoor Climate. Jap. J. Physiol., 31:465-475.

Sulek, K., C.J. Schlagel, W. Wiktor-Jedrzecjzak, H.S. Ho, W.M. Leach, A. Ahmed, J.N. Woody. 1980. Biologic Effects of Microwave Exposure. I. Threshold Conditions for the Induction of the Increase in Complement Receptor Positive ($CR^+$)

Mouse Spleen Cells Following Exposure to 2450-MHz Microwaves. Radiat. Res., 83:127-137.

Susskind, C. 1962. Nonthermal Effects of Microwave Radiation. Report RADC-TDR-62-624, Annual Scientific Report (1961-62) on Contract No. NONR-222(92) and Final Report on Contract AF41(657)-114, University of California, Electronics Research Laboratory, Berkeley, California. 25 pp.

Susskind, C. 1975. Correspondence on D.R. Justesen's "Prescriptive Grammar for the Radiobiology of Nonionizing Radiation." J. Microwave Power, 10(4):357.

Sutton, C.H., and F.B. Carroll. 1979. Effects of Microwave-Induced Hyperthermia on the Blood-Brain Barrier of the Rat. Radio Sci., 14:329-334.

Swicord, M.L. 1971. Microwave Measurements and New Types of Detectors for Evaluation of Health Hazards. BRH/DEP Publication No. 71-1. U.S. Department of Health, Education and Welfare, Public Health Service, Rockville, Maryland. 33 pp.

Switzer, W.G., and D.S. Mitchell. 1977. Long-Term Effects of 2.45-GHz Radiation on the Ultrastructure of the Cerebral Cortex and on Hematologic Profiles of Rats. Radio Sci., 12:287-293.

Szmigielski, S. 1975. Effect of 10-cm (3 GHz) Electromagnetic Radiation (Microwaves) on Granulocytes *In Vitro*. Ann. N.Y. Acad. Sci., 247:275-281.

Szmigielski, S., J. Jeljaszewicz, and M. Wiranowska. 1975. Acute Staphylococcal Infections in Rabbits Irradiated with 3-GHz Microwaves. Ann. N.Y. Acad. Sci., 247:305-311.

Szmigielski, S., M. Kobus, and M. Janiak. 1976. Enhanced Cytotoxic Effect of Hyperthermia (43°C) on Colcemide-Treated Normal and $SV_{40}$-Transformed Cells Grown *In Vitro*. Z. Geschwulstkrankh., 47:396-399.

Szmigielski, S., G. Pulverer, W. Hryniewicz, and M. Janiak. 1977. Inhibition of Tumor Growth in Mice by Microwave Hyperthermia, Streptolysin S and Colcemide. Radio Sci., 12(6S):185-189.

Szmigielski, S., M. Janiak, W. Hryniewicz, J. Jeljaszewicz, and G. Pulverer. 1978. Local Microwave Hyperthermia (43°C) and Stimulation of the Macrophage and T-Lymphocyte Systems in Treatment of Guérin Epithelioma in Rats. Z. Krebsforsch., 91:35-48.

Szmigielski, S., A. Szydzinski, A. Pietraszek, and M. Bielec. 1980. Acceleration of Cancer Development in Mice by Long-Term Exposition to 2450-MHz Microwave Fields. In: URSI International Symposium Proceedings, Ondes Electromagnetiques et Biologie, A.J. Berteaud and B. Servantie, eds. Paris, France. pp. 165-169.

Szmigielski, S., A. Szymdzinski, A. Pietraszek, M. Bielec, M. Janiak, and J.K. Wrembel. 1982. Accelerated Development of Spontaneous and Benzopyrene-Induced Skin Cancer in Mice Exposed to 2450-MHz Microwave Radiation. Bioelectromagnetics, 3:179-191.

Taber, C.W. 1953. Taber's Vocabulary of Medical Terms. F.A. Davis Company, Philadelphia.

Takashima, S. 1963. Dielectric Dispersion of DNA. J. Mol. Biol., 7:455-467.

Takashima, S., and A. Minikata. 1975. Dielectric Behavior of Biological Macromolecules. Digest of Literature on Dielectrics, 37:602-653 (NAS, Washington, D.C.).

Takashima, S., B. Onaral, and H.P. Schwan. 1979. Effects of Modulated RF Energy on the EEG of Mammalian Brains. Radiat. Environ. Biophys., 16:15-27.

Taylor, C.R. 1977. Exercise and Environmental Heat Loads: Different Mechanisms for Solving Different Problems? Inter. Rev. Physiol., Environ. Physiol. II, Vol. 14, D. Robertshaw, ed. University Park Press, Baltimore, Maryland. pp. 119-146.

Taylor, E.M., and B.T. Ashleman. 1974. Analysis of Central Nervous System Involvement in the Microwave Auditory Effect. Brain Res., 74:201-208.

Taylor, E.M., and B.T. Ashleman. 1975. Some Effects of Electromagnetic Radiation on the Brain and Spinal Cord of Cats. Ann. N.Y. Acad. Sci., 247:63-73.

Tell, R. 1972. Microwave Energy Absorption in Tissue. EPA Report PB 208-233, U.S. Environmental Protection Agency, Washington, D.C. 53 pp.

Tell, R.A., and F. Harlen. 1979. A Review of Selected Biological Effects and Dosimetric Data Useful for Development of Radiofrequency Safety Standards for Human Exposure. J. Microwave Power, 14:405-424.

Tennent, D.M. 1946. A Study of Water Losses Through the Skin in the Rat. Am. J. Physiol., 145:436-440.

Thauer, R. 1963. Circulatory Adjustments to Climatic Requirements. Handbook of Physiology, Vol. III. American Physiological Society, Washington, D.C. p. 1921.

Thomas, J.R., and G. Maitland. 1979. Microwave Radiation and Dextroamphetamine: Evidence of Combined Effects on Behavior of Rats. Radio Sci., 14:253-258.

Thomas, J.R., E.D. Finch, D.W. Fulk, and L.S. Burch. 1975. Effects of Low-Level Microwave Radiation on Behavioral Baselines. Ann. N.Y. Acad. Sci., 247:425-432.

Thomas, J.R., S.S. Yeandle, and L.S. Burch. 1976. Modification of Internal Discriminative Stimulus Control of Behavior by Low Levels of Pulsed Microwave Radiation. In: Biological Effects of Electromagnetic Waves, Vol. I., C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 201-214.

Thomas, J.R., L. S. Burch, and S.S. Yeandle. 1979. Microwave Radiation and Chlordiazepoxide: Synergistic Effects on Fixed-Interval Behavior. Science, 203:1357-1358.

Thomas, J.R., J. Schrot, and R.A. Banvard. 1980. Behavioral Effects of Chlorpromazine and Diazepam Combined with Low-Level Microwaves. Neurobehav. Toxicol., 2:131-135.

Thomson, R.A.E., S.M. Michaelson, and J.W. Howland. 1965. Modification of X-Irradiation Lethality in Mice by Microwaves (Radar). Radiat. Res., 24: 631-635.

Tinney, C.E., J.L. Lords, and C.H. Durney. 1976. Rate Effects in Isolated Turtle Hearts Induced by Microwave Irradiation. IEEE Trans. Microwave Theory Techniques, MTT-24:18-24.

Tolgskaya, M.S., and Z.V. Gordon. 1973. Pathological Effects of Radio Waves. (Trans. from Russian by B. Haigh.) LC Cat. Card 72-94825. Consultants Bureau, New York, New York. pp. 63-106.

Tyazhelov, V.V., S.I. Alekseyev, and P.A. Grigor'ev. 1979a. Change in the Conductivity of Phospholipid Membranes Modified by Alamethicin on Exposure to a High Frequency Electromagnetic Field. Biophysics, 23:750-751. (Trans. of Biofizika, 23:732-733, 1978.)

Tyazhelov, V.V., R.E. Tigranian, E.O. Khizhniak, and I.G. Akoev. 1979b. Some Peculiarities of Auditory Sensations Evoked by Pulsed Microwave Fields. Radio Sci., 14(6S):259-263.

Ubeda, A., J. Leal, M.A. Trillo, M.A. Jimenez, and J.M.R. Delgado. 1983. Pulse Shape of Magnetic Fields Influences Chick Embryogenesis. J. Anat., 137:513-536.

United States Senate Committee on Commerce, Science, and Transportation. 1979. Microwave Irradiation of the U.S. Embassy in Moscow. U.S. Government Printing Office, Washington, D.C. 26 pp.

Van Demark, N.L., and M.J. Free. 1970. Temperature Effects. In: The Testis, Vol. III, A.D. Johnson, W.R. Gomes, and N.L. Van Demark, eds. Academic Press, New York, New York, Chapter 7, pp. 233-312.

Varma, M.M., and E.A. Traboulay, Jr. 1976. Evaluation of Dominant Lethal Test and DNA Studies in Measuring Mutagenicity Caused by Non-Ionizing Radiation. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 386-396.

Varma, M.M., and E.A. Traboulay. 1977. Comparison of Native and Microwave Irradiated DNA. Experientia, 33:1649-1650.

Varma, M.M., E.L. Dage, and S.R. Joshi. 1976. Mutagenicity Induced by Non-Ionizing Radiation in Swiss Male Mice. In: Biological Effects of Electromagnetic Waves, Vol. I, C.C. Johnson and M.L. Shore, eds. HEW Publication (FDA) 77-8010, Rockville, Maryland. pp. 397-405.

Vendrik, A.J. H., and J.J. Vos. 1958. Comparison of the Stimulation of the Warmth Sense Organ by Microwave and Infrared. J. Appl. Physiol., 13:435-444.

Wachtel, H., R. Seaman, and W. Joines. 1975. Effects of Low-Intensity Microwaves on Isolated Neurons. Ann. N.Y. Acad. Sci., 247:46-62.

Wakim, K.G., J.W. Gersten, J.F. Herrick, E.C. Elins, and F.H. Krusen. 1948. The Effects of Diathermy on the Flow of Blood in the Extremities. Arch. Phys. Med., 29:583-593.

Wangemann, R.T., and S.F. Cleary. 1976. The *In Vivo* Effects of 2.45 GHz Microwave Radiation on Rabbit Serum Components and Sleeping Times. Radiat. Environ. Biophys., 13:89-103.

Ward, T.R., J.W. Allis, and J.A. Elder. 1975. Measure of Enzymatic Activity Coincident with 2450 MHz Microwave Exposure. J. Microwave Power, 10:315-320.

Weil, C.M. 1974. Propagation of Plane Waves Through Two Parallel Dielectric Sheets. IEEE Trans. Biomed. Eng., BME-21(2):165-168. (Addendum and Corrections, BME-24(1):78-80, 1977.)

Weil, C.M. 1975. Absorption Characteristics of Multilayered Sphere Models Exposed to UHF/Microwave Radiation. IEEE Trans. Biomed. Eng., BME-22(6):468-476.

Weil, C.M. 1977. Review of Exposure Techniques and Dosimetric Methods Employed in Microwave Bioeffects Research. Proceedings of IEEE Region III Conference (Southeastern), Williamsburg, Virginia. Cat. No. 77 CHO 1233-6 Region III. pp. 507-510.

Weil, C.M., W.T. Joines, and J.B. Kinn. 1981. Frequency Range of Large-Scale TEM Mode Rectangular Strip Lines. Microwave J., 24(11):93-100.

Werner, J. 1980. The Concept of Regulation for Human Body Temperature. J. Thermal Biol., 5:75-82.

Wever, R. 1973. Human Circadian Rhythms Under the Influence of Weak Electric Fields and the Different Aspects of These Studies. Int. J. Biometeorol., 17:227-232.

Wickersheim, K.A., and R.V. Alves. 1982. Fluoroptic Thermometry: A New RF-Immune Technology. Biomedical Thermology (Prog. Clin. Biol. Res., Vol. 107, M. Gauthrie and E. Albert, eds.). Alan R. Liss, New York, New York. pp. 547-554.

Wiktor-Jedrzejczak, W., A. Ahmed, P. Czerski, W.M. Leach, and K.W. Sell. 1977a. Immune Response of Mice at 2450-MHz Microwave Radiation: Overview of Immunology and Empirical Studies of Lymphoid Splenic Cells. Radio Sci., 12(6S):209-219.

Wiktor-Jedrzejczak, W., A. Ahmed, P. Czerski, W.M. Leach, and K.W. Sell. 1977b. Increase in the Frequency of Fc Receptor (FcR) Bearing Cells in The Mouse Spleen Following a Single Exposure of Mice to 2450 MHz Microwaves. Biomedicine, 27:250-252.

Wiktor-Jedrzejczak, W., A. Ahmed, K.W. Sell, P. Czerski, and W.M. Leach. 1977c. Microwaves Induce an Increase in the Frequency of Complement Receptor-Bearing Lymphoid Spleen Cells in Mice. J. Immunol., 118:1499-1502.

Williams, D.B., J.P. Monalen, W.J. Nicholson, and J.J. Aldrich. 1955. Biologic Effects Studies on Microwave Radiation. AMA Arch. Ophth., 54:863-874.

Wilson, B.S., J.M. Zook, W.T. Joines, and J.H. Casseday. 1980. Alterations in Activity at Auditory Nuclei of the Rat Induced by Exposure to Microwave Radiation: Autoradiographic Evidence Using [$^{14}$C]2-Deoxy-D-Glucose. Brain Res., 187: 291-306.

Wilson, J.G. 1973. Environment and Birth Defects. Academic Press, New York, New York. 305 pp.

Wissler, E.H. 1961. Steady-State Temperature Distribution in Man. J. Appl. Physiol., 16:734-740.

Wissler, E.H. 1964. A Mathematical Model of the Human Thermal System. Bull. Math. Biophys., 26:147-166.

Wyndham, C.H., and A.R. Atkins. 1960. An Approach to the Solution of the Human Biothermal Problem with the Aid of an Analog Computer. Proc. 3rd Int. Conf. Medical Electronics, London, England.

Yamaura, I., and S. Chichibu. 1967. Super-High Frequency Electric Field and Crustacean Ganglionic Discharges. Tohoku J. Exp. Med., 93:249-259.

Yang, H.K., C.A. Cain, J. Lockwood, and W.A. Tompkins. 1983. Effects of Microwave Exposure on the Hamster Immune System. I. Natural Killer Cell Activity. Bioelectromagnetics, 4:123-139.

Youmans, H.D., and H.S. Ho. 1975. Development of Dosimetry for RF and Microwave Radiation-I: Dosimetric Quantities for RF and Microwave Electromagnetic Fields. Health Phys., 29:313-316.

Zamenhof, S., and S. Greer. 1958. Heat as an Agent Producing High Frequency of Mutations and Unstable Genes in *Escherichia coli*. Nature, 182(4635):611-613.

Zaret, M.M. 1974. Selected Cases of Microwave Cataract in Man Associated with Concomitant Annotated Pathologies. In: Biologic Effects and Health Hazards of Microwave Radiation, P. Czerski, K. Ostrowski, M.L. Shore, C. Silverman, M.J. Suess, and B. Waldeskog, eds. Polish Medical Publishers, Warsaw, Poland. pp. 294-301.

Zaret, M.M. 1976. Electronic Smog as a Potentiating Factor in Cardiovascular Disease: A Hypothesis of Microwaves as an Etiology for Sudden Death from Heart Attack in North Karelia. Med. Res. Eng., 12:13-16.

Zaret, M.M. 1977. Microwave Radiation (R.O. Becker), Dr. Zaret's Reply. Letter to the Editor. N.Y. State J. Med., 77:2172-2174.

Zaret, M.M., and M. Eisenbud. 1961. Preliminary Results of Studies of the Lenticular Effects of Microwaves Among Exposed Personnel. In: Biological Effects of Microwave Radiation, Vol. I, Proceedings of the 4th Tri-Service Conference, M.F. Peyton, ed. Plenum Press, New York, New York. pp. 293-308.

Zaret, M.M., I.T. Kaplan, and A.M. Kay. 1970. Clinical Microwave Cataracts. In: Biological Effects and Health Implications of Microwave Radiation, S.F. Cleary, ed. HEW Publication BRH/DBE 70-2, Rockville, Maryland. pp. 82-84.

Zeman, G.H., R.L. Chaput, Z.R. Glazer, and L.C. Gershman. 1973. Gamma-Aminobutyric Acid Metabolism in Rats Following Microwave Exposure. J. Microwave Power, 8:213-216.

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