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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) The biological effects of microwave radiation on testicular tissue of 56-65 days old Swiss male mice were studied at 1.7 and 3.0 GHz. The power density and time of exposure varied. At 1.7 GHz and a power density of 10 mW/cm ² for 100 minute exposure, severe changes in morphology were observed. The study indicates that non-ionizing radiation at 1.7 GHz and a power density of 50 nW/cm ² for 30-40 minutes exposure alters spermatogenesis.		

Biological Effects of Microwave Radiation on the Testes
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by:

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Microwave radiation has been reported to produce adverse effects in a variety of biological systems. Most significant are the microwave induced lenticular changes causing cataracts in eyes of humans ^{1,2} rabbits and dogs. ^{3,5} ^{Testes?} The effects of microwaves on the testes is indicated in several studies. ^{6,9} The purpose of this study was to determine the effect of microwaves at 1.7 and 3.0 GHz on testicular tissue of Swiss Mice.

Swiss male mice (Charles River Breeding Labs., Mass.), ranging from 56-65 days old, with an average weight of 35 grams, were anesthetized and irradiated in an anechoic chamber.^a The continuous pulse was produced by a generator HP8690B oscillator with a plug in-head. The output of the oscillator was amplified by a Varian 4K5SL-1 Klystron with a peak output power of 2500 watts. Each animal was laid supine on a platform, at a distance of 4 ft., in front of the wave guide. Care was taken to align both testes at an equal distance from the source of radiation. The time of exposure and power densities varied (Table 1). The testes of 8 normal sham-irradiated (anesthetized) males were employed as histological controls. Histological results are shown in Figure 1.

^aWalter Reed Army Medical Center, Washington, D.C.

Following the irradiation, the animals were sacrificed immediately, the testes were removed, fixed in 10% formalin, alcohol and xylene and embedded in parafin. Sections were then appropriately prepared for light microscope observation using conventional iron-hematoxylin and eosin stain. Slides were made using rotary microtome.

Physical manifestations of the microwave exposure were monitored on a closed circuit television. "After the first 5 minutes at 1.7 GHz, and 200 mW/cm² the animals were probably aware of the stimulus as evidenced by muscle spasms, tremors, tail erections with eventual arousal of the mice from anesthesia." After 20 minute exposure at 1.7 GHz and power density of 200 mW/cm² burns up to first degree were detected. Because the animals started moving around, the beam directly exposed some other parts of the body also. Edema and rise in scrotal temperature were observed at all power densities, however, these effects were not quantified. *I agree!*

Gross post-mortem findings in this experiment indicated diffuse hemorrhages in the subcutaneous tissue which appeared "cooked". The skin around the scrotal appeared greenish-gray and hair dropped off on touch. There were also damages to major organs, the liver and spleen were discolored and there were hemorrhages in the gastroenteric tract.

On histological examination the seminiferous tubules appeared extremely tortuous and in section of the testes each tubule was cut at more than one place, circular and oval profiles were predominant.

At 1.7 GHz, (10 mW/cm^2) there was little or no damage to testes, except when the time of exposure was increased to 100 minutes, then severe changes in morphology were observed (Figure 2). The number of cells in the seminiferous tubules were reduced and, the tubules showed sloughing of degenerating germinal cells into the lumen while the lumen appeared as a coagulated mass of fused spermatids, probably caused by hypothermia. Sertoli and interstitial cells remained intact.

When the power density was increased to 50 mW/cm^2 , (1.7 GHz) and the exposure time varied between 30-40 minutes, the lumens were empty with complete disintegration of spermatids, sertoli cells and the delicate connective tissue which surrounds the seminiferous tubules with vacant spaces between the seminiferous tubules.

Ref? → At the 3.0 GHz level the damage appeared insignificant although the lumens showed a small degree of disintegration of nuclear material. Other investigators 6,7,8,12 have reported that exposure of the scrotal area, at various frequencies, for the power density of $10-15 \text{ mW/cm}^2$ has resulted in varying degree of testicular damage such as edema, fibrosis and coagulation necrosis of seminiferous tubules in humans and animals.

This study indicates that nonionizing radiation at 1.7 GHz, 50 mW/cm² for 30-40 minute exposure altered spermiogenesis, however, in depth studies should be conducted using the Dominant Lethal test. At 3.00 GHz, 50 mW/cm² and 20 minutes exposure the injuries were minimal.

ZUSAMMENFASSUNG:

Die biologischen Effekte der Mikrowellen - Bestrahlung auf die Hodengewebe einiger 56 bis 65 alten Schweizer männlicher Mäuse wurden bei 1.7 und 3.0 GHz untersucht. Die Energiestärke und die Dauer der Bestrahlungen waren verschieden. Bei 1.7 GHz und einer Energiestärke von 10 mW/cm² während einer 100 Minuten langen Bestrahlung wurden einige Veränderungen in der Morphologie beobachtet. Die Zahl der Zellen in den samentragenden Röhren wurde vermindert; die Röhren zeigten eine Ablösung degenerierter Keimzellen im Lumen, währenddessen der Lumen als eine flockige Masse geschmolzener Samenzellen erschien. Sertoli- und zwischenräumliche Zellen blieben unversehrt. Die Untersuchung ergab, dass eine nichtionisierende Bestrahlung bei 1.7 GHz und einer Energiestärke von 50 mW/cm² während 30 bis 40 Minuten die Samenbildung verändert.

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TABLE 1.

Frequency, power density and exposure time of irradiated animals.

Frequency (GHz)	Power Density mW/cm ²	Exposure (Min.)
3.0	10	20
1.7	200	20
1.7	50	10
1.7	50	15
1.7	50	30
1.7	50	40
1.7	10	10
1.7	10	40
1.7	10	100

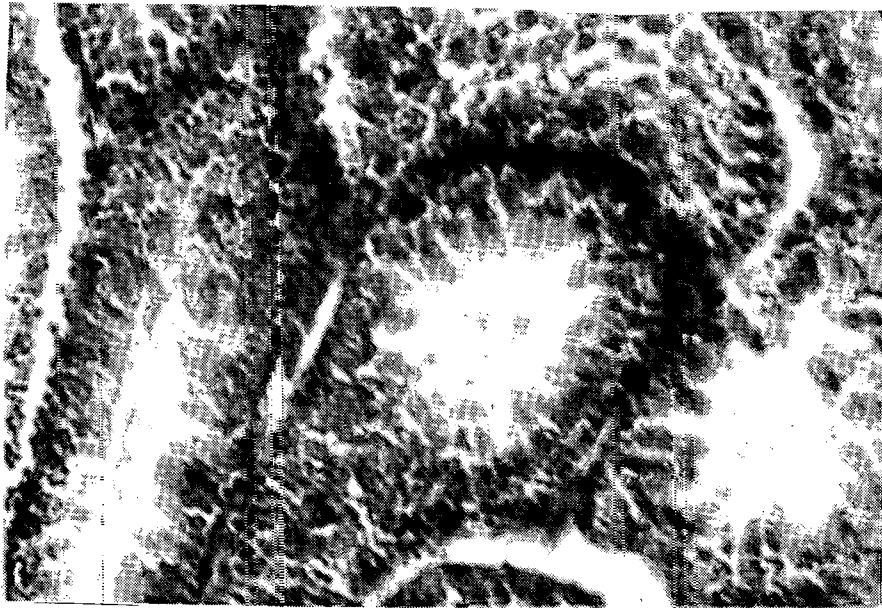


FIGURE 1. Normal Mice Testes (100x)



FIGURE 2. Irradiated Mice Testes
(1.7 GHz 10 mW/cm² for
100 minute exposure. 100x)