Biological Effects of Microwave Radiation on the Testes of Swiss Mice

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]. The effects of microwaves on the testes is indicated in several studies[6–11]. 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 g, were anesthetized and irradiated in an anechoic chamber (Walter Reed Army Medical Center, Washington, D.C.). 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. The testes of 8 normal sham-irradiated (anesthetized) males were employed as histological controls. Histological results are shown in Figure 1.

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

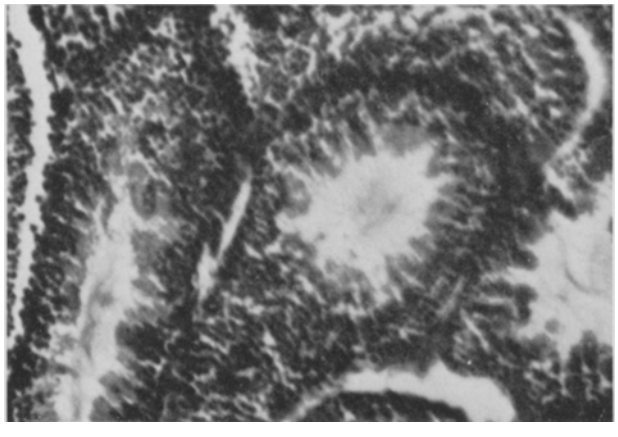

Fig. 1. Normal mice testes.

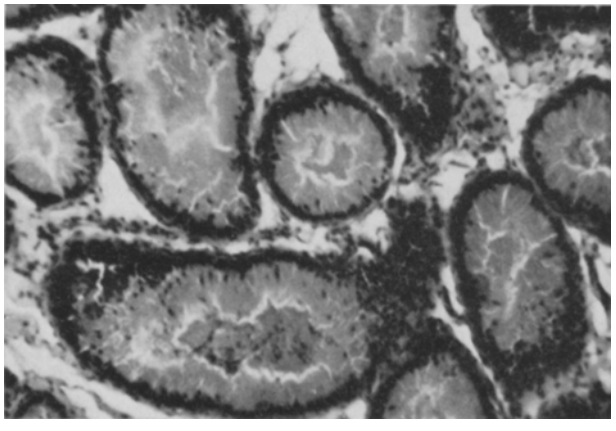

Fig. 2. Irradiated mice testes (1.7 GHz 10 mW/cm² for 100 min exposure.

Physical manifestations of the microwave exposure were monitored on a closed circuit television. After the first 5 min 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 min 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 denstities, however, these effects were not quantified.

Gross post-mortem findings in this experiment indicated diffuse hemmorrhages in the subcutaneous tissue which appeared 'cooked'. The skin around the scrotal appeared greenish-gray and hair dropped off on touch. There were also damage to major organs, the liver and spleen were discolored and there was hemmorrhages in the gastro-enteric 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/cm²) there was little or no damage to testes, except when the time of exposure was increased to 100 min, 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/cm², (1.7 GHz) and the exposure time varied between 30–40 min, the lumens were empty with complete disintegration of spermitids, sertoli cells and the delicate connective tissue which surrounds the seminiferous tubules with vacant spaces between the seminiferous tubules.

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

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frequencies, for the power density of 10–15 mW/cm² 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 min exposure altered spermiogenesis, however, in depth studies should be conducted using the Dominant Lethal Test. At 3.00 GHz, 50 mW/cm² and 20 min exposure the injuries were minimal.

Zusammenfassung. Nachweis histologischer Veränderungen am Hodengewebe 2 Monate alter Schweizer Mäuse nach Mikrowellenbestrahlung. Es ergab sich, dass eine nichtionisierende Bestrahlung bei 1,7 GHz und einer Intensität von 50 mW/cm² während 30–40 min die Samenbildung verändert.

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Studies on the Physiology of Hyacinth Bulbs VII. Root and Bulblet-Like Regenerations from the Ovary Wall of *Hyacinthus orientalis* L.

In horticultural practice, hyacinths are mostly propagated by 'scooping', where the basal plate of bulb is scooped out, or by 'scoring' (cross-cutting), where cuts are made across the base of bulb, each cut being deep enough to cross the basal plate and the growing point. Other methods of propagation of hyacinths are those by 'scaling' and by leaf cuttings[1].

Root and bulblet regeneration of few-month-old hyacinth bulbs[2] and of the perianth of flower buds[3] was found to be dependent on the levels of growth substances added to the MURASHIGE and SKOOG[4] (MS) medium under in vitro conditions. The best combination for bulblet initiation was 1 ppm of α-naphthaleneacetic acid (NAA) and 10 ppm of benzyladenine (BA). For callus formation and root differentiation, NAA was the only necessary hormone.

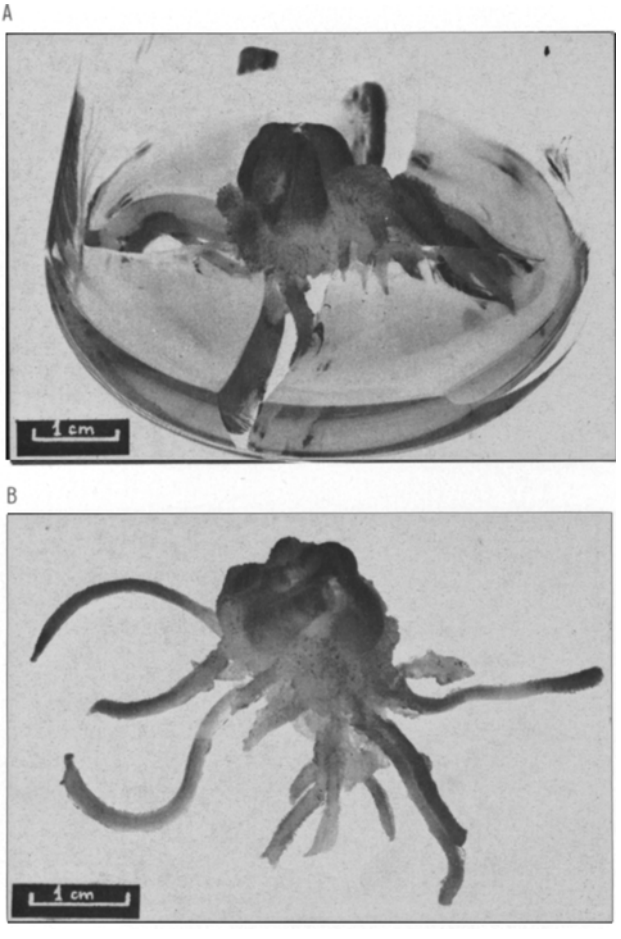

Fig. 1. A 65-(A) and 78-(B)-day-old, in vitro grown ovary of hyacinth on the MS medium containing 1 ppm of NAA: callus and roots formation from the ovary wall can be observed.

The aim of present experiments was to study hormonal regulation in the regeneration processes of excised ovaries of *Hyacinthus orientalis* L. The excised ovaries of hyacinth, cv. Lady Derby, were taken in the spring at the beginning of flowering (April 19, 1974), sterilized with 0.2% solution of mercury chloride for 0.5 h, washed several times with sterilized water. They were planted on MURASHIGE and SKOOG's medium[4] with 1 ppm concentration of auxin (NAA), 10 ppm of cytokinin (BA) or their mixtures. The experiments were conducted in the dark at 25 ± 2°C and 70% humidity. A minimum of 10 ovaries were used for each treatment and the experiments were performed twice.

The type of organ regeneration from the ovary wall of the hyacinth depended on the level of growth substances in the medium. In the MS medium containing 1 ppm of NAA, the ovaries continued their growth and developed into normal-looking capsules, and the callus tissue was found to develop from the wall at base of ovaries. In turn, the callus differentiated into roots (Figure 1). In the MS medium supplemented with 1 ppm of NAA and 10 ppm of BA, the ovaries continued their growth, and, from the ovary wall, the differentiation of small bulblet-like formations took place (Figure 2).

It was found earlier by MAJUMDAR[5] that excised ovaries of *Haworthia turgida* var. *pallidifolia* (Liliaceae), grown in vitro on White's medium containing 1 ppm of indole-3-acetic acid (IAA), 0.5 ppm of kinetin and 20% of coconut water, produced young plants and callus tissue from the ovary wall. The callus was capable of unlimited growth and also produced plantlets with leaves and roots.

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