

AD-A149 347

GENETIC EFFECTS OF MICROWAVE EXPOSURE ON MAMMALIAN
CELLS IN VITRO VOLUME 2. (U) TEXAS UNIV HEALTH SCIENCE
CENTER AT SAN ANTONIO DEPT OF RADIO. M L MELTZ ET AL.
OCT 84 USAFSAM-TR-84-24-VOL-2 F/G 6/18

1/1

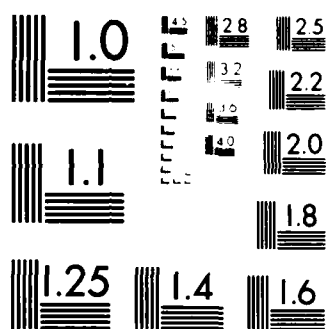
UNCLASSIFIED

NL

END

FILED

10/10



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

13

GENETIC EFFECTS OF MICROWAVE EXPOSURE ON MAMMALIAN CELLS IN VITRO: VOLUME II

Martin L. Meltz, Ph.D.

Clifton R. Harris, Ph.D.

Kathleen A. Walker, B.S.

University of Texas Health Science Center
7703 Floyd Curl Drive
San Antonio, Texas 78284

October 1984

Annual Report for Period 1 July 1981 - 30 September 1982

DTIC
ELECTE
S JAN 2 1985 D
D

Approved for public release; distribution is unlimited.

Prepared for
USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, TX 78235-5000



DTIC FILE COPY

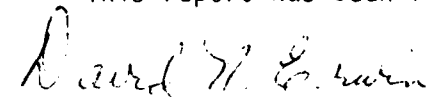
NOTICES

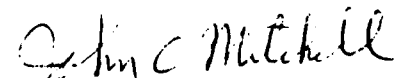
This annual report was submitted by the University of Texas Health Science Center, San Antonio, Texas, under contract F33615-80-C-0607, job order 7757-01-80, with the USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas. Dr. David N. Erwin (USAFSAM/RZP) was the Laboratory Project Scientist-in-Charge.

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication, or otherwise in any manner construed, as licensing the holder, or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.


DAVID N. ERWIN, Ph.D.
Project Scientist


JOHN C. MITCHELL, B.S.
Supervisor



ROYCE MOSER, Jr.
Colonel, USAF, MC
Commander

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

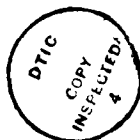
AD-A149347

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified			1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE				
4. PERFORMING ORGANIZATION REPORT NUMBER S/			5. MONITORING ORGANIZATION REPORT NUMBER S/ USAFSAM-TR-84-24	
6a. NAME OF PERFORMING ORGANIZATION University of Texas Health Science Center, Dept. of Radiology		6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION USAF School of Aerospace Medicine (RZP)	
6c. ADDRESS (City, State and ZIP Code) Division of Radiation Oncology 7703 Floyd Curl Drive San Antonio, Texas 78284			7b. ADDRESS (City, State and ZIP Code) Aerospace Medical Division (AFSC) Brooks Air Force Base, Texas 78235-5000	
8a. NAME OF FUNDING SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F33615-80-C-0607	
8c. ADDRESS (City, State and ZIP Code)			10. SOURCE OF FUNDING NOS	
			PROGRAM ELEMENT NO 62202F	TASK NO. 7757
			WORK UNIT NO. 01	80
11. TITLE (Include Security Classification) GENETIC EFFECTS OF MICROWAVE EXPOSURE ON MAMMALIAN CELLS IN VITRO: VOLUME II				
12. PERSONAL AUTHOR(S) Meltz, Martin L.; Harris, Clifton R.; and Walker, Kathleen A.				
13a. TYPE OF REPORT Annual Report		13b. TIME COVERED FROM 7/1/81 TO 9/30/82		14. DATE OF REPORT (Yr., Mo., Day) 1984 October
15. PAGE COUNT 91				
16. SUPPLEMENTARY NOTATION Appendix A and Appendix B of this report are available as separate documents, USAFSAM-TR-84-24-APP-A and USAFSAM-TR-84-24-APP-B, through the Defense Technical Information Center (DTIC), Cameron Station, Alexandria VA 22304-6145.				
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB GR	Cell growth; cell viability; Chinese Hamster Ovary; chromosome aberrations; DNA repair; human fibroblasts; radiofrequency radiation; RFR; and sister chromatid exchange	
06	18			
19. ABSTRACT (Continue on reverse if necessary and identify by block number) This work is a continuation of studies designed to answer the question of whether radiofrequency radiation (RFR) at lower power levels (no greater than 10 mW/cm ²), where measurable heating in the exposure system cannot be detected, causes any transient or permanent alteration in a series of subtle biochemical processes elicited in the DNA of mammalian cells. The specific process(es) being studied are: the effects of RFR on repair synthesis in normal human fibroblasts after ultraviolet light damage of the DNA; and the possible induction by RFR of sister chromatid exchanges or chromosome aberrations in Chinese Hamster Ovary cells. Additional information obtained in the latter studies includes any effects on cell viability (by cloning efficiency) or on cell growth (increase in cell number).				
20. DISTRIBUTION AVAILABILITY OF ABSTRACT UNCLASSIFIED UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS ☐			21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED	
22a. NAME OF RESPONSIBLE INDIVIDUAL David W. Erwin, Ph.D.			22b. TELEPHONE NUMBER (Include Area Code) (512) 536-3582	22c. OFFICE SYMBOL USAFSAM/RZP

BLANK PAGE

Accession For	DTIS	GRATI	☒	☐
	DTIC	TAB	☐	☐
	Unannounced			
	Justification			
By	Distribution/			
	Availability Codes			
	Avail and/or			
	Special			
st				



CONTENTS

	<u>Page</u>
INTRODUCTION.....	5
DNA Repair Studies.....	5
CHO Studies.....	6
METHODS AND MATERIALS.....	9
RFR Exposure Facilities and Parameters.....	9
Specific Absorption Rate Measurements for DNA Repair Studies.....	9
Signal Quality Control for DNA Repair Studies.....	10
Exposure Facility for CHO Experiments.....	10
CHO Cell Exposure Geometry.....	14
Signal Quality Control for CHO Studies.....	14
SAR Measurements for CHO Studies.....	15
Cell Lines.....	15
MRC-5 Cells	15
CHO Cells.....	15
Procedures for DNA Repair Studies.....	15
General Experimental Protocol for CHO Studies.....	15
Clonal Survival.....	16
Growth Kinetics.....	16
General Morphology.....	16
Sister Chromatid Exchange and Chromosome Aberration Analysis.....	16
RESULTS OF THE DNA REPAIR STUDIES.....	18
SAR Determinations for DNA Repair Studies.....	18
Signal Quality Control for DNA Repair Studies.....	18
Results of Investigation of a Possibly More Rapid Procedure for Isolating Parental Repair Replicated DNA.....	18
Results of RFR on Semi-Conservative DNA Synthesis.....	19
Summary of RFR Exposure Effects on UV-induced DNA Repair Synthesis.....	19
RESULTS OF THE CHO STUDIES.....	24
SAR Measurements for CHO Experiments.....	24
Signal Quality Control for CHO Studies.....	27
Clonal Survival.....	28
Growth Kinetics.....	28
Cellular Morphology.....	28
Sister Chromatid Exchange.....	28
Chromosome Aberrations.....	33
DISCUSSION.....	33
REFERENCES.....	34
APPENDIX A. Cytogenetics and Growth Kinetics Data, 850 MHz (Available in Microfiche).....	88
APPENDIX B. Cytogenetics and Growth Kinetics Data, 1.2 GHz (Available in Microfiche).....	88

CONTENTS (Cont'd)

Figures

<u>Figure No.</u>	<u>Page</u>
1. The mechanism of sister chromatid differentiation.....	6
2. Diagrammatic appearance of chromosomes with three sister chromatid exchanges.....	7
3. Corrected SAR values at different locations in a square petri dish containing cell culture medium (350 MHz).....	11
4. Corrected SAR values at different locations in a square petri dish containing cell culture medium (850 MHz).....	11
5. Representative spectra for 850-MHz pulsed wave.....	12
6. Representative spectra for 1.2-GHz pulsed wave.....	13
7. The microwave exposure facility (block diagram).....	14
8. UV-induced DNA repair synthesis during 1.2-GHz RFR exposure at 37°C..	20
9. UV-induced DNA repair synthesis during 350-MHz RFR exposure at 37°C..	22
10. UV-induced DNA repair synthesis during 850-MHz RFR exposure at 37°C..	23
11. Power-density map, 850 MHz, 350 W.....	24
12. Power-density map, 1.2 GHz, 380 W.....	25
13. SAR map, 850 MHz, 38 mW/cm ²	25
14. SAR map, 1.2 GHz, 15 mW/cm ²	26
15. Typical SAR experiment data.....	26
16. Spectrum analysis of 850-MHz signal.....	27
17. Spectrum analysis of 1.2-GHz signal.....	27
18. CHO growth kinetics data: A. 850 MHz, 37°C; and B. 850 MHz, 39°C....	29
19. CHO growth kinetics data: A. 1.2 GHz, 37°C; and B. 1.2 GHz, 39°C....	30
20. Phase-contrast micrographs of CHO cells, 3 hr after exposure to 850-MHz fields, 37°C: A. Control; and B. Exposed.....	31
21. Phase-contrast micrographs of CHO cells, 3 hr after exposure to 1.2-GHz fields, 37°C: A. Control; and B. Exposed.....	32
22. CHO chromosomes for SCE analysis.....	33

CONTENTS (Cont'd)

Tables

Table No.	Page
1. DNA repair study: 1.2-GHz continuous-wave radiation - 37°C.....	36
2. DNA repair study: 1.2 GHz pulse-wave radiation - 37°C.....	39
3. DNA repair study: 350-MHz continuous-wave radiation - 37°C.....	42
4. DNA repair study: 350-MHz pulse-wave radiation - 37°C.....	45
5. Smith and Hanawalt technique comparison.....	48
6. Effect of RFR (10 mW/cm ²) on semi-conservative DNA synthesis.....	49
7. DNA repair study: 850 MHz continuous-wave radiation - 37°C.....	51
8. DNA repair study: 850-MHz pulse-wave radiation - 37°C.....	54
9. DNA repair study: 1.2-GHz pulse-wave radiation - 37°C.....	57
10. DNA repair study: 850-MHz continuous-wave radiation--37°C.....	60
11. DNA repair study: 850-MHz pulse-wave radiation - 39°C.....	63
12. DNA repair study: 1.2-GHz pulse-wave radiation - 37°C.....	66
13. DNA repair study: 1.2-GHz pulse-wave radiation - 39°C.....	69
14. DNA repair study: 350-MHz pulse-wave radiation - 37°C.....	72
15. DNA repair study: 350-MHz pulse-wave radiation - 39°C.....	74
16. DNA repair study: 850-MHz pulse-wave radiation - 39°C.....	77
17. Clonal survival data, CHO cells, 850 MHz and 1.2 GHz, 37°C and 39°C..	80
18. Summary of growth kinetics, CHO cells, 850 MHz and 1.2 GHz, 37°C and 39°C.....	80
19. Sister chromatid exchange frequency, CHO cells, 850 MHz, 37°C and 39°C.....	81
20. Sister chromatid exchange frequency, CHO cells, 1.2 GHz, 37°C and 39°C.....	82
21. Exposure parameters for studies of effects of RFR on UV-induced DNA repair synthesis in MRC-5 cells.....	84

BLANK PAGE

GENETIC EFFECTS OF MICROWAVE EXPOSURE ON MAMMALIAN CELLS IN VITRO: VOLUME II

INTRODUCTION

This work is a continuation of studies designed to answer the question of whether radiofrequency radiation (RFR) at lower power levels (no greater than 10 mW/cm²), where measurable heating in the exposure system cannot be detected, causes any transient or permanent alteration in a series of subtle biochemical processes elicited in the DNA of mammalian cells. The specific processes being studied are: the effects of RFR on the repair synthesis process in normal human fibroblasts after ultraviolet light (UV) damage of the DNA; and the possible induction by RFR of sister chromatid exchanges (SCE) or chromosome aberrations in Chinese Hamster Ovary (CHO) cells. Additional information obtained in the latter studies includes any effects on cell viability (by cloning efficiency) or on cell growth (increase in cell number).

DNA Repair Studies

In Volume I of this series (for the period February 1, 1980, to June 30, 1981), data were presented for DNA repair studies involving various exposure conditions (5); and, for the convenience of the reader, the respective tables incorporating these data have also been included in this Report (Volume II). Here, the table numbers are as follows:

Table 1. DNA repair study: 1.2-GHz continuous-wave radiation, 37°C;

Table 2. DNA repair study: 1.2-GHz pulse-wave radiation, 37°C;

Table 3. DNA repair study: 350-MHz continuous-wave radiation, 37°C; and

Table 4. DNA repair study: 350-MHz pulse-wave radiation, 37°C.

In conjunction with the continuation of this project, we investigated a possibly more rapid procedure for isolating parental repair replicated DNA (Table 5). We also examined whether RFR at 10 mW/cm² had an effect on semi-conservative DNA synthesis (Table 6).

Because a question arose as to whether or not the 1.2-GHz data in Table 2 were really the result of a pulse-wave exposure, the experiment was repeated (Table 9). As described in the "Results" section, other experiments have also been repeated for Volume II of this series, when review of all the available data indicated that some effect of RFR on repair synthesis--albeit transient in nature--might be occurring.

EDITOR'S NOTE: In this Report, BrUdR and BrdU are used interchangeably to represent bromodeoxyuridine. For the convenience of the reader, all tables have been grouped at the close of this publication.

In addition, the experiments were extended to an RFR exposure where the incubation medium was maintained at 39°C, rather than the normal 37°C. This temperature (39°C) was shown not to affect UV-induced repair synthesis by itself (Fig. 4), but was considered to represent a biological system already under "thermal stress" prior to RFR exposure. The data for DNA repair synthesis studies included in this Report are presented in Tables 7-16.

CHO Studies

As just indicated, the genetic studies were expanded to include analysis for any RFR induction of SCEs or chromosome aberrations in CHO cells. These experiments were performed with pulse wave exposures, and at both 37°C and 39°C.

For the cytotoxicity of athermal levels of RFR irradiation to be assessed, a battery of endpoints were studied in cultured hamster fibroblasts (CHO) after exposure to 850 MHz and 1.2-GHz pulsed-wave fields at 10 mW/cm². This power density induced no significant increase in the temperature of the culture medium which bathed the cells.

The cellular parameters chosen for these studies were: clonal survival, growth kinetics, morphology, chromosome aberration, and SCE frequencies. All of these endpoints are sensitive indicators of cellular perturbations, with SCE induction probably being the most sensitive (1). The mechanism of SCE induction is unknown; substantial evidence exists, however, that these lesions are related to some disturbance in the cell's normal synthesis of DNA. Therefore, these studies relate well to the examination of RFR effects on UV-induced DNA repair replication.

SCEs were originally observed by Taylor (2), using tritiated thymidine prelabeling and subsequent autoradiography of the chromosomes. An SCE represents a homologous exchange between sister chromatids. These exchanges are most conveniently visualized by using one of the many methods for sister chromatid differentiation (SCE). Most SCE methodologies are based on staining of chromosomes by certain dyes, which are quenched when 5-bromodeoxyuridine (BrdU) has been incorporated into the DNA. Growing cells in BrdU-containing medium for two generations results in the differential BrdU-labeling pattern of chromatids (Fig. 1).

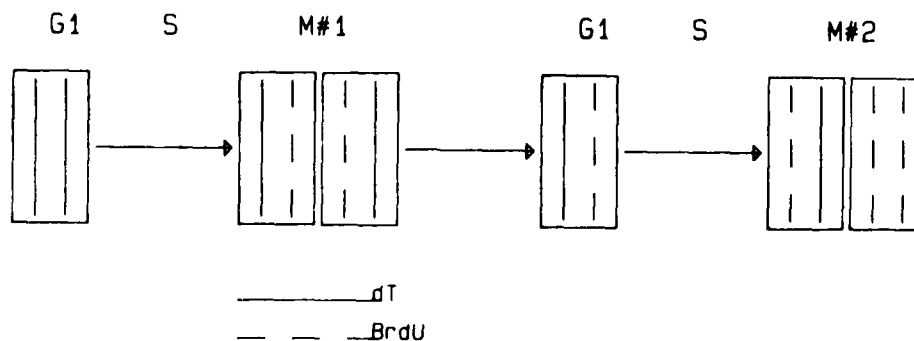


Figure 1. The mechanism of sister chromatid differentiation. (dT = thymidine; and BrdU = bromodeoxyuridine)

The more heavily BrdU-labeled chromatids quench staining more, and therefore, result in a more lightly stained chromatid relative to the sister chromatid. If no SCEs are present, then the chromosome will contain one intensely stained and one lightly stained chromatid--the "harlequin" staining pattern. When SCEs occur, however, they appear as alternating light and dark regions along the long axis of a chromatid, with the sister chromatid having the converse pattern (Fig. 2).



Figure 2. Diagrammatic appearance of chromosomes with three sister chromatid exchanges.

The studies reported herein represent an effort to determine whether or not various cellular processes are affected by exposure of cultured hamster fibroblasts to athermal levels of RFR (850 MHz and 1.2 GHz).

The data for this report are available, in Appendixes A and B, as indicated here:

Raw Data, 850 MHz

The number designations in the following lists refer to page(s) in Appendix A on which data are given.

<u>Experi- ment No.</u>	<u>SCE</u>	<u>Chromo- some No.</u>	<u>Chromosome aberration</u>	<u>Growth kinetics</u>	<u>Surviving fraction</u>
1	A1-A4	A1-A4	A5	A6	A7
2	A8-A11	A8-A11	--	--	A12
3	A13-A16	A13-A16	A17	--	A18
4	A19-A22	A19-A22	A23	A24	A25
5	A26-A29	A26-A29	--	--	A30
6	A31-A34	A31-A34	A35	--	A36

Raw Data, 1.2 GHz

The number designations in the following lists refer to page(s) in Appendix B on which data are given.

<u>Experi- ment No.</u>	<u>SCE</u>	<u>Chromo- some No.</u>	<u>Chromosome aberration</u>	<u>Growth kinetics</u>	<u>Surviving fraction</u>
1	B1-B6	B1-B6	B7	B8	--
2	B9-B14	B9-B14	--	--	B15
3	B16-B21	B16-B21	B22	--	B23
4	B24-B29	B24-B29	--	--	B30
5	B31-B36	B31-B36	B37	B38	--
6	B39-B44	B39-B44	--	--	B45
7	B46-B51	B46-B51	B52	--	B53
8	B54-B59	B54-B59	--	--	B60

METHODS AND MATERIALS

RFR Exposure Facilities and Parameters

All RFR exposures (see footnote) were conducted, at the USAF School of Aerospace Medicine (USAFSAM), in the anechoic chambers or Narda Model 8801 Transverse Electromagnetic Mode (TEM) Transmission Cell. The exposure geometry for DNA repair experiments, using MRC-5 human diploid fibroblasts, has been described in the "Introduction" in Volume I (5); that for the CHO cells is described in the following section of this report (Volume II).

Specific Absorption Rate Measurements for DNA Repair Studies

Specific absorption rate (SAR) measurements were made for the DNA repair studies with the assistance of the technical staff at USAFSAM. The following procedure was employed:

In preparation for the SAR determination, media was prepared to have the same ingredients and molarities as the exposure media, except that "cold" thymidine (TdR) was used in place of ^3H TdR. The media consists of complete Basal Minimal Essential Medium (BME) with Hanks' Salts, $5 \times 10^{-3}\text{M}$ hydroxyurea (HU), $5 \times 10^{-6}\text{M}$ BrUdR, 10^{-6}M 5-fluorodeoxyuridine (FUDR), and $2.7 \times 10^{-7}\text{M}$ TdR. For each SAR we used 80 ml of media in a square dish with a lid with numerous holes.

The SAR determinations were done in anechoic chamber No. 1 at a chamber temperature of 37°C . Four Vitek probes were used--three for media temperatures, and one for room temperature. They were interfaced to a Hewlett Packard 9830A Computer for printout. The 3 media Viteks were moved to various positions in the dish so that the complete field could be determined (viewed from top of dish); e.g.,



NOTE: The exposure parameters for all of our DNA repair experiments, since the beginning of the project, are listed in Table 21.

Temperature measurements were taken at 10-sec intervals during the stabilization period, the 1-min exposure period, and the cool-down period. Three 1-min exposures were done at each Vitek configuration. These temperatures were entered into an SAR computer program with a correction factor to determine the SARs at the actual exposure power level of 10 mW/cm².

For 350 MHz, an MCL generator (No.15022) and MCL amplifier (No.10110) were used. Transmitter output power was 1226 W, continuous wave (CW), as compared with the 32 W used for the exposure of 10 mW/cm²; a correction factor was used to determine the values in Figure 3. The dish was placed in the TEM chamber (Narda 8801) with the circulating fan off.

For 850 MHz, an MCL generator No.15022 with MCL amplifier No.10110 was used. Dosimetry was done at a transmitter output power of 575-W CW, to give a power density of 20 mW/cm². Actual SAR exposure output was 600-W CW. A correction factor was used to give the values for a 10 mW/cm² exposure (Fig. 4). The square dish with media was placed in a Plexiglas water bath with noncirculating water. Distance from the horn was 1.1 m. Because of the buffer effect of the water bath, more cooling and heating of the media occurred during the stabilization and cool-down periods. The respective data for 350 and 850 MHz are presented in Figures 3 and 4.

Signal Quality Control for DNA Repair Studies

In addition to the stringent control of physical factors (e.g., temperature during exposures), we have begun documenting the quality of the signal being transmitted. This aim is accomplished by analyzing and stroking the signal spectrum with a Hewlett Packard 8566A spectrum analyzer interfaced to a Hewlett Packard 8566B computer with a 9872C eight-pen vector plotter. These data are collected when the transmitter is reconfigured for a new frequency, and during each exposure run to confirm reproducibility.

Figures 5 and 6 show representative spectra for 850 MHz and 1.2 GHz, respectively. Detailed parameters of the signals are presented in the legends.

Exposure Facility for CHO Experiments

Exposures to far-field RFR at 350 MHz and 1.2 GHz were performed in anechoic chamber No.2 (Fig. 7) in Building 1187, Radiofrequency Radiation Research Laboratory, Brooks Air Force Base. The chamber temperature was maintained externally by forced air heating; the deviation in air temperature was approximately $\pm 0.3^{\circ}\text{C}$.

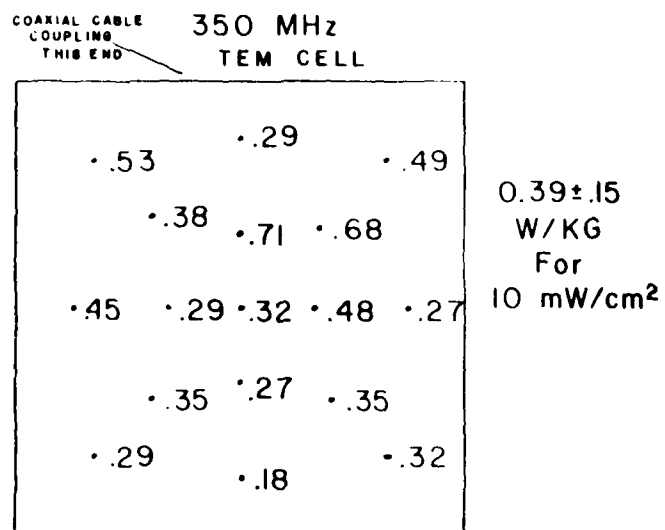
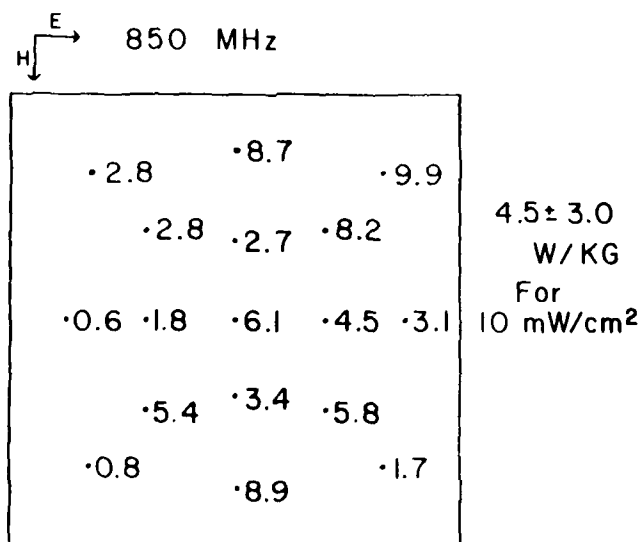


Figure 3. Corrected SAR values at different locations in a square petri dish containing cell culture medium (350 MHz).



Door

Figure 4. Corrected SAR values at different locations in a square petri dish containing cell culture medium (850 MHz).

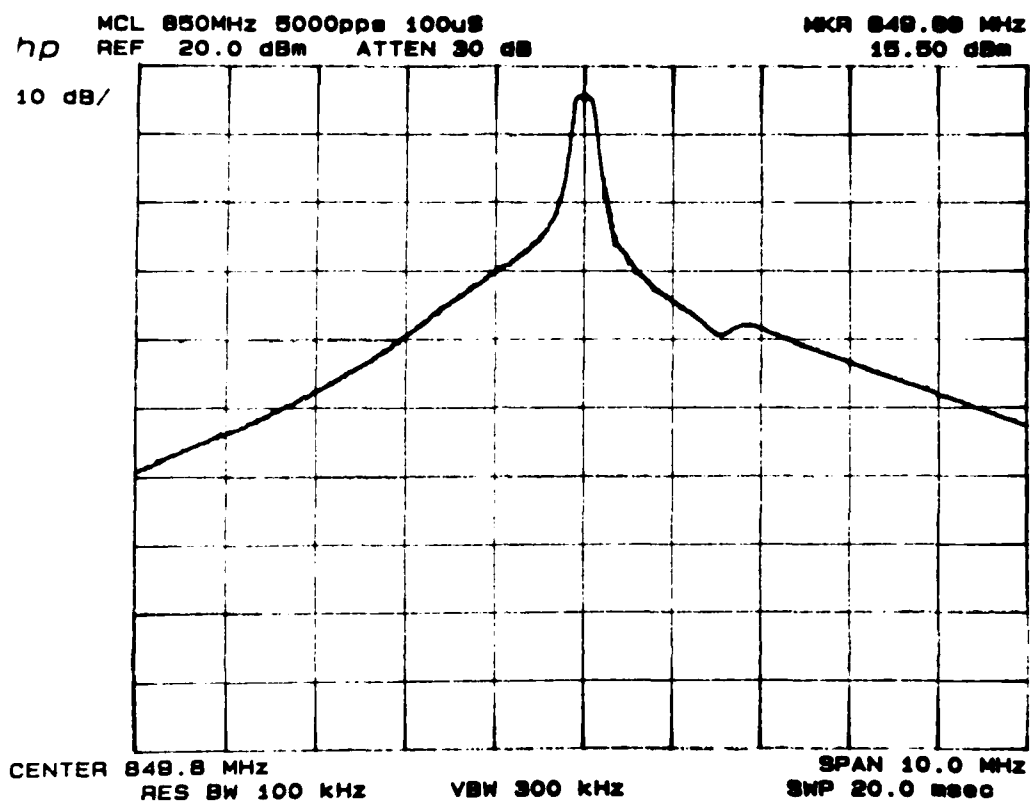


Figure 5. Representative spectra for 850-MHz pulsed wave (5000 pulses/sec, 100- μ sec pulse width, MCL transmitter).

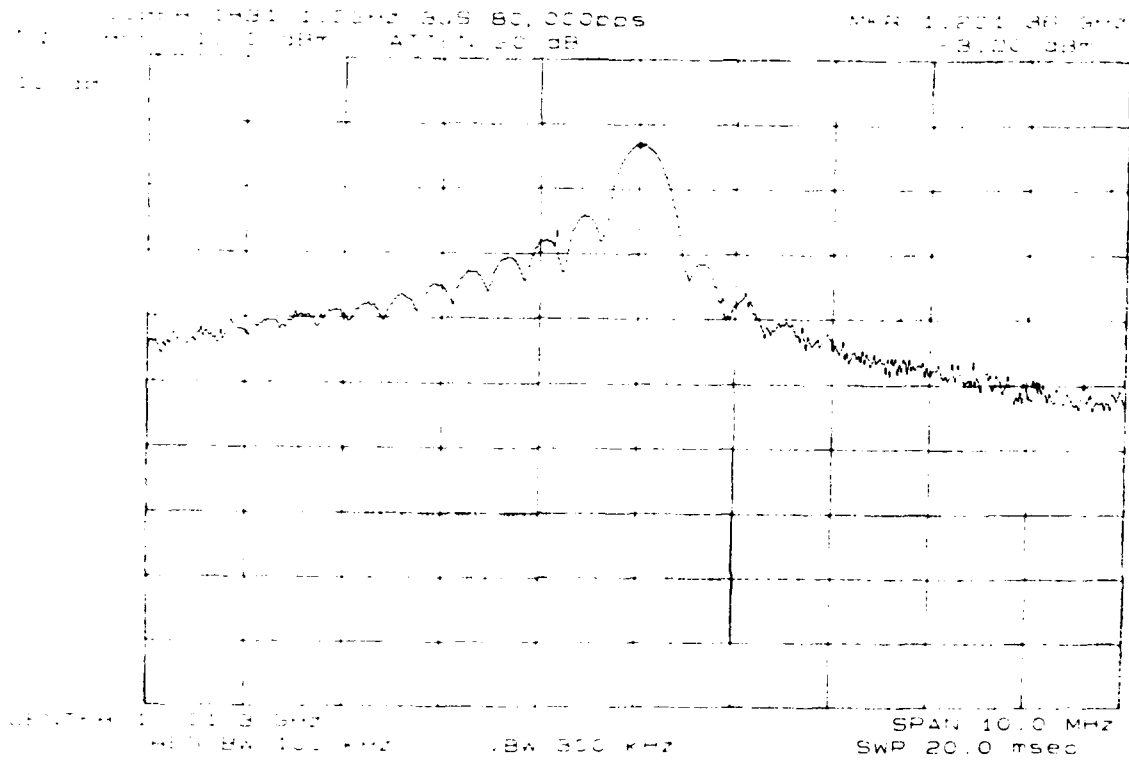


Figure 6. Representative spectra for 1.2-GHz pulsed wave (80,000 pulses/sec, 3- μ sec pulse width, Cober Model 1831 transmitter).

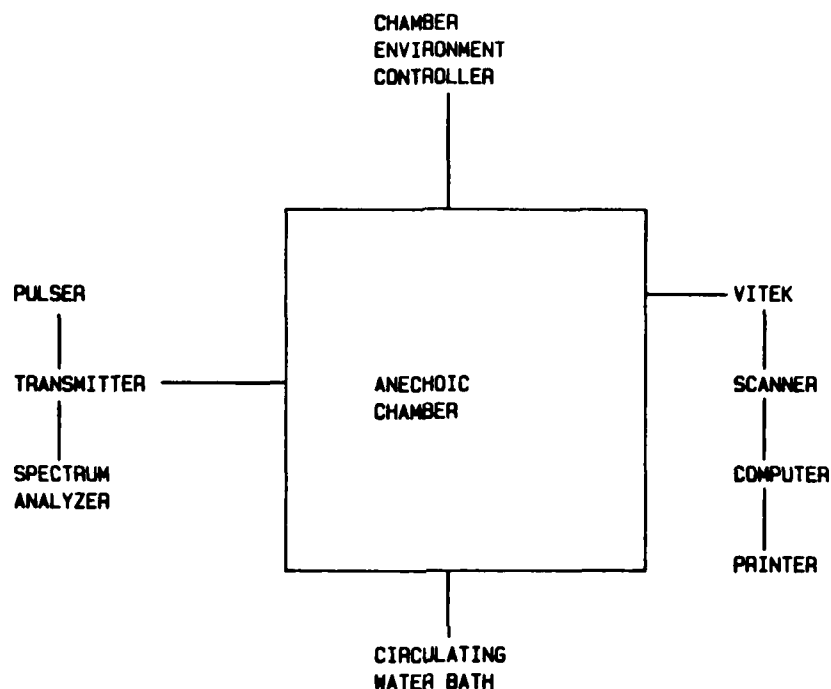


Figure 7. The microwave exposure facility(block diagram).

CHO Cell Exposure Geometry

The CHO cells to be exposed to RFR were contained in T-25 flasks, attached in a 3x3 array to the underside of a sheet of RF-transparent foam. The flask-foam assemblies were floated in water baths connected to a large volume water circulator outside of the anechoic chamber. The experimental water bath was situated in the center of the far field, approximately 1.5 m from the horn. The control water bath was placed out of the field and was shielded by RF opaque material.

Signal Quality Control for CHO Studies

The output frequency of the transmitters was analyzed with a Hewlett Packard spectrum analyzer. Power levels were measured in the far field with Narda probes, a minimum of five points being measured within the area to contain the experimental samples.

SAR Measurements for CHO Studies

The SAR measurement was performed throughout the exposure facility by placing Vitek temperature probes in different positions of each T-25 flask containing 20 ml of growth medium. Maximum transmitter power was imparted on the system, and the temperature rise was measured as a function of time; the power was then removed and the cooling rate was determined. From these data, SARs were estimated by the method of Lozano (3).

Cell Lines

MRC-5 Cells--The MRC-5 normal human diploid fibroblast cell line used in these investigations is an "aging" cell line. It was obtained from the American Type Culture Collection (ATCC), and was kept frozen under liquid nitrogen (in sterile ampoules) until experiments were to be performed. The cells were used only at relatively early passage numbers (before passage 35). Once thawed, the cells were maintained in the biohazard tissue culture laboratories of the Department of Radiology, The University of Texas Health Science Center at San Antonio (UTHSCSA), in BME with Hanks' Salts. HEPES at 25 mM was added to maintain the pH in an air atmosphere. The concentration of fetal calf serum was 10%; antibiotics were added.

CHO Cells--Chinese hamster ovary fibroblasts (originally obtained from Dr. Abraham Hsie, Oak Ridge National Laboratories) were used in all of the described studies. The cells were maintained in exponential growth phase by serial passage by trypsinization, with a split ratio of 1:500 every four days. The medium used was Ham's F12, supplemented with: 10% heat-inactivated (56°C, 30 min) fetal calf serum; 1.8 mM glutamine; 90 units/ml penicillin; and 90 µg/ml streptomycin. Cultures were maintained at 37°C with a humidified atmosphere of 5% carbon dioxide - 95% air.

Cell cultures were routinely monitored for normal morphology and microbial contamination by observation with phase-contrast microscopy. Mycoplasma screening was performed by the fluorescent Hoechst 33258 method.

Procedures for DNA Repair Studies

Fully described in Volume I (5) are the: Cell Culture Procedures for UV and RFR exposures; Repair Replication Protocol; Temperature-Effect Studies; DNA Isolation Procedures; Alkali Cesium Chloride-Cesium Sulfate Density Gradient Procedure; and DNA Concentration Determination--The Hinegardner Technique.

General Experimental Protocol for CHO Studies

Approximately 18 hr preexposure, experimental and control cultures were prepared. An exponential maintenance culture of CHO was harvested by a 15 min treatment with trypsin (0.05% in Earle's balanced salt solution, Ca^{2+} and Mg^{2+} free) at ambient temperature. The culture was passed into the prescribed number of T-25 flasks at a split ratio of 1:32, the total amount of medium being 20 ml. The flasks were placed in an incubator and maintained overnight at 37°C in a humidified atmosphere of 5% CO_2 in air.

Immediately before departure for the transmitter facility, the cultures were tightly wrapped in heavy-duty aluminum foil. This package was transported via automobile; the transport time averaged approximately 30 min. That this method of transfer did not significantly affect any of the cytotoxicity parameters measured was evident when transported cultures were compared with cultures left in the laboratory at UTHSCSA.

Upon arrival at the RFR laboratory, the T-25 flasks were mounted in the holders and placed in the water baths which were pre-equilibrated to either 37° or 39°C. After the cultures had reached experimental temperature, the 3-hr exposure commenced.

After treatment, the cultures were exposed to chemicals when necessary; all were wrapped in heavy-duty aluminum foil and transported to UTHSCSA, where they were returned to a humidified environment of 5% carbon dioxide - 95% air at 37°C.

Clonal Survival

Two hundred cells were plated into three T-25 flasks, 18 hr before RFR exposure. After exposure, the cultures were allowed to proliferate for 4 days. The medium was decanted and the colonies were fixed with methanol:acetic acid (3:1); and colonies were stained with 1% aqueous trypan blue. Colonies were counted with the aid of a dissecting microscope; the lower limit for a clone was 50 cells. Correction was made for multiplicity, and all groups were normalized to their control.

Growth Kinetics

Cells, one flask per time point, were released by trypsinization (as already described) at various times after RFR exposure. Cell numbers per flask were enumerated with an electronic particle counter (Model ZB-1, Coulter Electronics). A total of three counts were made on each sample.

General Morphology

Morphological examination of CHO cultures was performed by phase-contrast microscopy (Olympus Model IMT Inverted Microscope) of living cultures at various times for 72 hr after experimental treatment. Photomicrographs were recorded on Technical Pan 35-mm film (Kodak).

Sister Chromatid Exchange and Chromosome Aberration Analysis

Cells were prepared according to General Experimental Protocol (1:32 dilution of an exponentially grown culture). Immediately after RFR exposure, 100 µl of a solution of 5-bromo-2'-deoxyuridine (2×10^{-4} M in complete culture medium) was added to the existing 20 ml of medium in each flask, thus yielding a final concentration of 10^{-6} M BrdU. From this point forward, the cultured cells were kept wrapped in heavy-duty aluminum foil to prevent

exposure to light; only brief exposures to gold-filtered fluorescent lighting was allowed during required culture manipulations. Cultures were returned to UTHSCSA, and were incubated under standard conditions for 19.5 hr.

To arrest cells in metaphase, 100 μ l of colcemid (4×10^{-5} M in complete culture medium) was added to each culture to give a final concentration of 2×10^{-7} M. Standard incubation was allowed to continue for 2.5 hr. The total elapsed time after administration of BrdU was 22 hr, equivalent to two generation times.

Cells were harvested by trypsinization (as described earlier), and were transferred to 15-ml centrifuge tubes. The cells were then pelleted by centrifugation at 80 g for 15 min, and the pellets were resuspended in 10 ml of 0.075M KCl which had been prewarmed to 37°C. Incubation in KCl at 37°C was allowed to proceed for 12 min, and was followed by pelleting at 800 g for 15 min. This pellet was resuspended in 10 ml of methanol:acetic acid (3:1), and allowed to fix for 30 min. The pre-fixed cells were centrifuged at 800 g for 15 min; the pellet was resuspended in 10 ml of fresh methanol:acetic acid (3:1) and refrigerated (4°C) for 24 hr.

The fixed cells were pelleted at 800 g for 15 min, and approximately 9.5 ml of the supernatant was discarded. The pellet was resuspended in the remaining 0.5 ml of fixative. Cells were spread on clean, dry slides by depositing 1 drop of suspension from a height of approximately 12 in. The slides, precleaned in acid-dichromate cleaning solution for a minimum of 24 hr, had undergone exhaustive washing in deionized water and air-drying in a dust-free environment. Slides were air-dried and stored in dust-free storage boxes.

SCE analysis was performed by the fluorescence method of Goto et al. (4). Slides were stained for 5 min in 0.175% acridine orange (C.I. No. 46005) in 0.067 M phosphate buffer (PB), pH 6.8. The slides were then washed in running distilled water for 10 min, and soaked in PB for 10 min; a 22 x 40-mm cover slip was then mounted with a drop of PB.

Slides were observed with a Zeiss Model 18 microscope, equipped with an epifluorescence attachment for blue excitation. When an appropriate metaphase plate was located, the exciter filter was removed in order to allow "burning in" of sister chromatid differentiation. Upon differentiation, the exciter filter was replaced, and the chromosome number and sister chromatid exchanges per cell were scored.

Upon completion of SCE analysis the cover slips were floated off of the slides; these were then stained with a 1:20 dilution of Giemsa stain stock solution in PB for 15 min. The slides were washed in three changes of distilled water, 5 min for each change. After air-drying, 22 x 40 cover slips were mounted with Permount resin.

Chromosome aberration analysis was performed by scoring the frequency of dicentric chromosomes in a total of 500 metaphases.

RESULTS OF THE DNA REPAIR STUDIES

SAR Determinations for DNA Repair Studies

The distribution of values (determined as already described in "Methods") are indicated: in Figure 3, for 350-MHz exposure in the Narda TEM cell; and, in Figure 4, for 850-MHz exposure in the anechoic chamber. The average value for the 350-MHz exposure is $0.39 \pm .15$ W/kg, with individual values ranging from 0.18 to 0.71 W/kg. For the 850-MHz exposure, the average value is 4.5 ± 3.0 W/kg, with individual values ranging from 0.6 to 9.9 W/kg.

Signal Quality Control for DNA Repair Studies

These determinations are presented in Figures 5 and 6 for 850 MHz pulse-wave (PW) radiation and 1.2-GHz PW radiation, respectively.

Results of Investigation of a Possibly More Rapid Procedure for Isolating Parental Repair Replicated DNA

Investigated in this research was a previously published technique for isolating DNA, by density gradient centrifugation, almost directly from labeled cells (6). If this technique were to prove successful, it could reduce the time necessary to perform a complete assay (currently requiring 1 week for DNA isolation) and two 36-hr density gradient centrifugations.

The results are summarized in Table 5. Included in the experimental data are results obtained when a separate portion of the same UV-irradiated and repair labeled cell population was processed using our standard isolation procedure, and the first of the two alkaline density gradient centrifugation steps was typically performed.

In this attempt, at least, an increasing extent of repair incorporation with increasing UV dose was not detected by the Smith and Hanawalt method, although a dose dependence was evident after only one gradient and pooling in the standard method.

Because the yield ($\mu\text{g DNA}/.1 \text{ ml}$) appears to be greater for the Smith and Hanawalt procedure after one gradient, a second alkali gradient added to that procedure might eliminate incorporated radioactivity overlap which we detected in the fractionation profile (continuous O.D. and filter spotting of small aliquots from each fractionation tube). Thereby the UV-induced DNA repair would be allowed to become evident, while still reducing the total assay time. Because a second gradient would be necessary, our decision was not to change techniques at this point in the project.

Results of RFR (10 mW/cm²) on Semi-Conservative DNA Synthesis

In conjunction with many of the DNA repair studies described herein, a preliminary study was performed to investigate the effect of RFR radiation on semi-conservative DNA synthesis. In either the presence or absence of an RF field at 10 mW/cm², MRC-5 cells were allowed to incorporate the DNA precursor ³H-TdR for 1 hr. The DNA was isolated as in the repair studies, and then subjected to one neutral pH density gradient centrifugation. The dpm/μg were determined (Table 6). For all of the PW data--350 MHz (37°C), 350 MHz (39°C), 850 MHz (39°C), and 1.2 GHz (39°C)--the RFR at 10 mW/cm² had no effect on precursor incorporation.

For the CW RFR exposure, at 350 MHz (37°C) and 850 MHz (37°C), the 10 mW/cm² RFR exposure appeared to result in an increase in incorporation. Because the specific activity of the isolated DNA (dpm/μg) in these two early experiments (Table 6) is so low as compared with that in the more recent PW experiments, drawing a conclusion from the data must be delayed until additional experiments are performed.

Summary of RFR Exposure Effects on UV-Induced DNA Repair Synthesis in MRC-5 Cells

1.2-GHz CW, 37°C--The results for the CW exposure at 37°C for this frequency (Table 7) are plotted graphically in Figure 8, upper panel. No significant effect on incorporated repair radioactivity is evident at either 1 or 10 mW/cm² of 1.2-GHz CW exposure.

1.2-GHz PW, 37°C--The original experiment (Table 2) was probably not a PW exposure. The experiment was therefore repeated; the data are presented in Table 9, and are plotted in Figure 8, middle panel (Expt. 1). As can be seen in Figure 8, for both the 1 mW/cm² and 10 mW/cm² power densities, a "lag" of the repair label incorporation at the 2-hr time point was apparent for the RFR-exposed cells as compared with that for the control cells. The "lag" had disappeared within 3 hr.

To confirm whether or not this observation was reproducible, an additional repeat experiment has been performed at both 1 and 10 mW/cm² (Table 12). The results are plotted in the lower panel (Expt. 2) of Figure 8. The original observation is clearly absent; the conclusion is that RFR--at 1.2-GHz PW, 37°C, 1 and 10 mW/cm² average power densities--has no effect on DNA repair synthesis.

1.2-GHz PW, 39°C--These experiments have been performed to determine whether incubation of the cells in medium at 39°C during the RFR exposure period, in effect producing a non-RFR induced "thermal stress," resulted in any RFR effect not previously observed at 37°C for 1 and 10 mW/cm² average power densities (Table 13). With the generator on, but no RFR being transmitted, incubation of UV-irradiated cells at 39°C in the exposure position does not result in an increase in incorporated repair label above that in the control position (Table 13, Part A). Surprisingly, for 1 mW/cm² PW RFR, 39°C (Table 13, Part D), and to a lesser extent for 10 mW/cm² PW RFR, 39°C (Table 13, Part E), the incorporated repair radioactivity in the exposed cells was consistently higher than in the control cells. This observation should be confirmed.

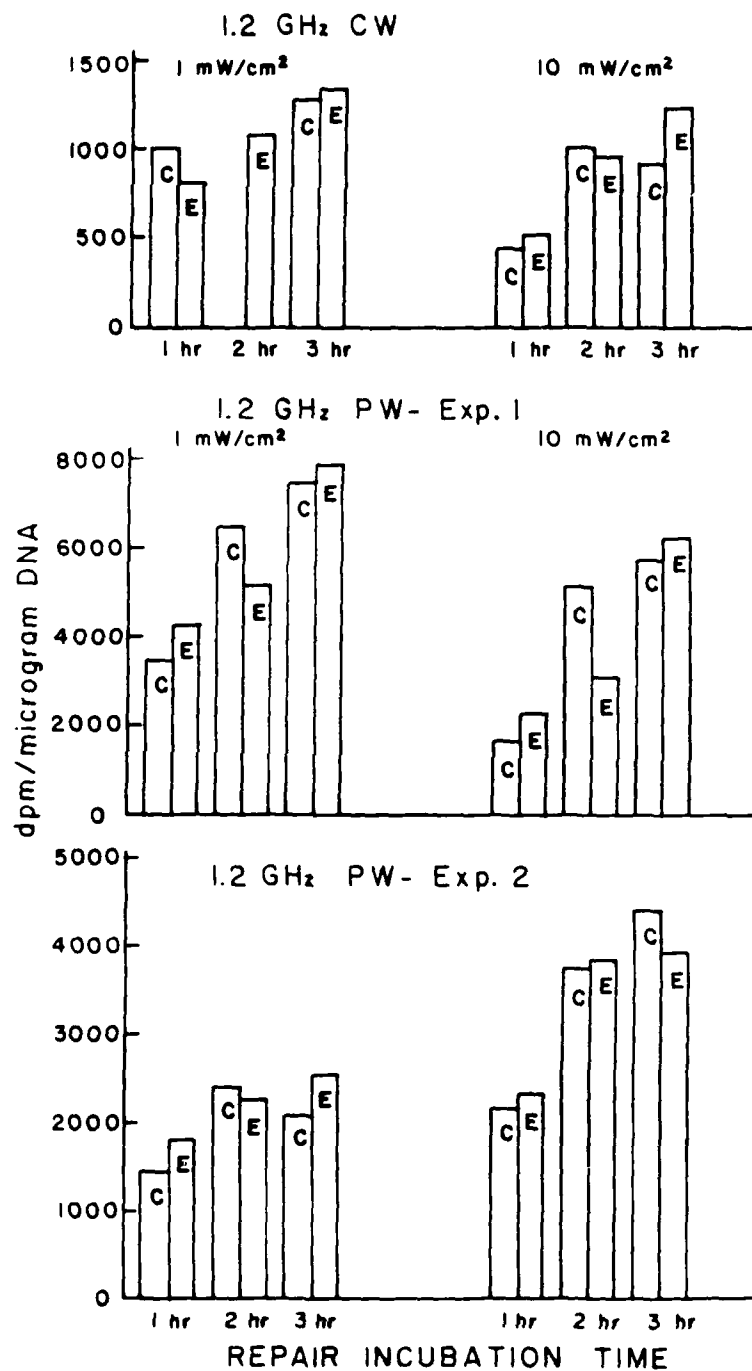


Figure 3. UV-induced DNA repair synthesis during 1.2 GHz RFR exposure at 37°C.

350-MHz CW, 37°C--The results for the CW exposure at 37°C for this frequency (Table 3) are plotted graphically in Figure 9, upper panel. No evidence exists of any effect of 350-MHz CW exposure at either 1 or 10 mW/cm².

350-MHz PW, 37°C--The data for 350-MHz PW exposure have been presented in Table 4. At 10 mW/cm², no RFR effect was observed (Fig. 9, lower right panel). For the 1 mW/cm² exposure, the initial data were unsatisfactory (3-hr values less than 2-hr values), and the experiment was repeated. As can be seen, 1 mW/cm² of 350-MHz PW RFR also has no significant effect on DNA repair synthesis (Table 13; and Fig. 9, lower left panel).

350-MHz PW, 39°C--The results of these experiments are shown in Table 15. The exposures in this experiment were 5 and 10 mW/cm², instead of the usual 1 and 10 mW/cm² average power densities. At both 5 and 10 mW/cm², an absence of any effect of 350-MHz PW exposure with incubation at 39°C was noted.

850-MHz CW, 37°C--The original data for this experiment appear in Table 7. Analysis of these data indicated that they were internally inconsistent and not acceptable.

The experiment has therefore been repeated; the data are presented in Table 10, and plotted in Figure 10, upper panel. No indication was noted of any effect of CW exposure at this frequency on DNA repair synthesis.

850-MHz PW, 37°C--The data for this experiment appear in Table 8, and in Figure 10, lower panel. No indication was noted of any effect of PW exposure at this frequency on DNA repair synthesis.

850-MHz PW, 39°C--The results of these experiments are shown in Tables 11 and 16. The data in Table 11, Part D, do not indicate any effect of 1 mW/cm² PW RFR at 850 MHz on the DNA repair process at 39°C. At 10 mW/cm² in this experiment, however, we noted a continuing inhibitory action on UV-induced DNA repair synthesis, as observed at 2 and 3 hr of incubation.

To confirm this observation, the experiment was repeated. The data are given for both 1 and 10 mW/cm² in Table 16. The results do not confirm the previous observation; an 850-MHz PW exposure, at 1 or 10 mW/cm² average power density, does not interfere with the DNA repair process in cells incubated at 39°C.

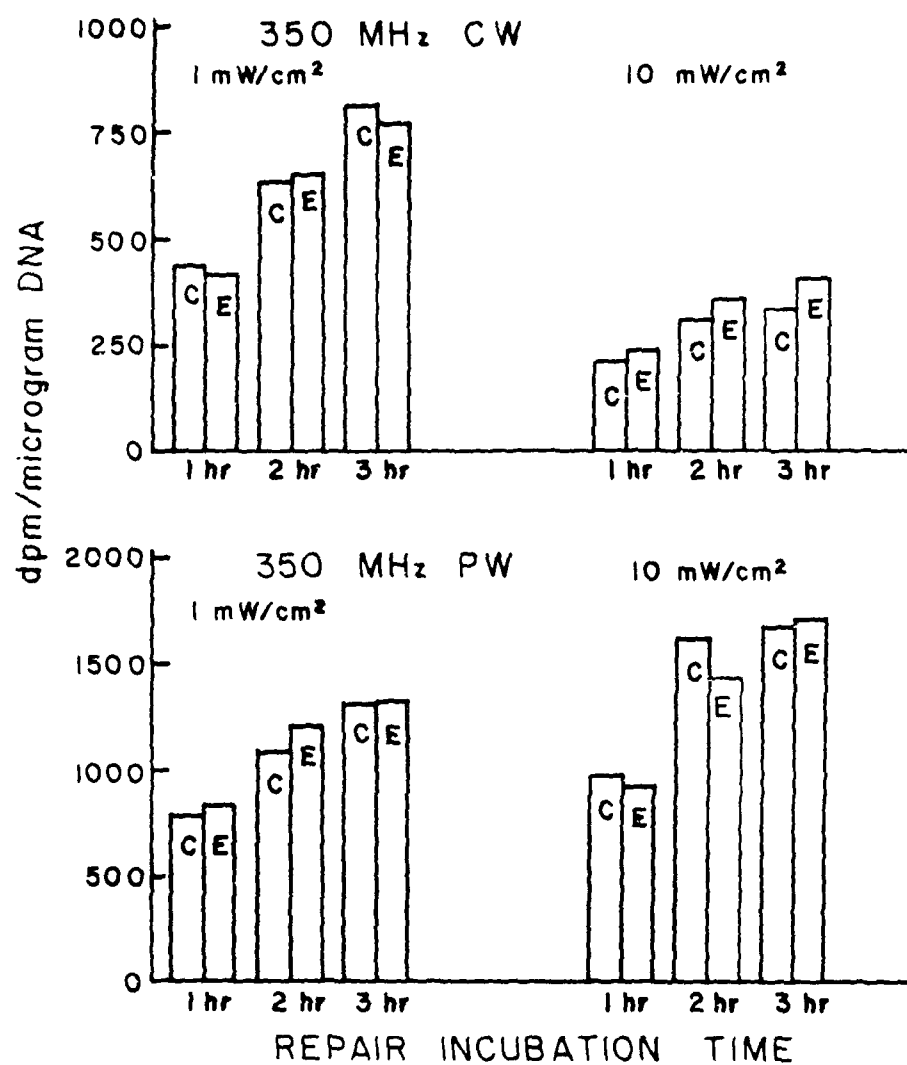


Figure 9. UV-induced DNA repair synthesis during 350-MHz RFR exposure at 37°C.

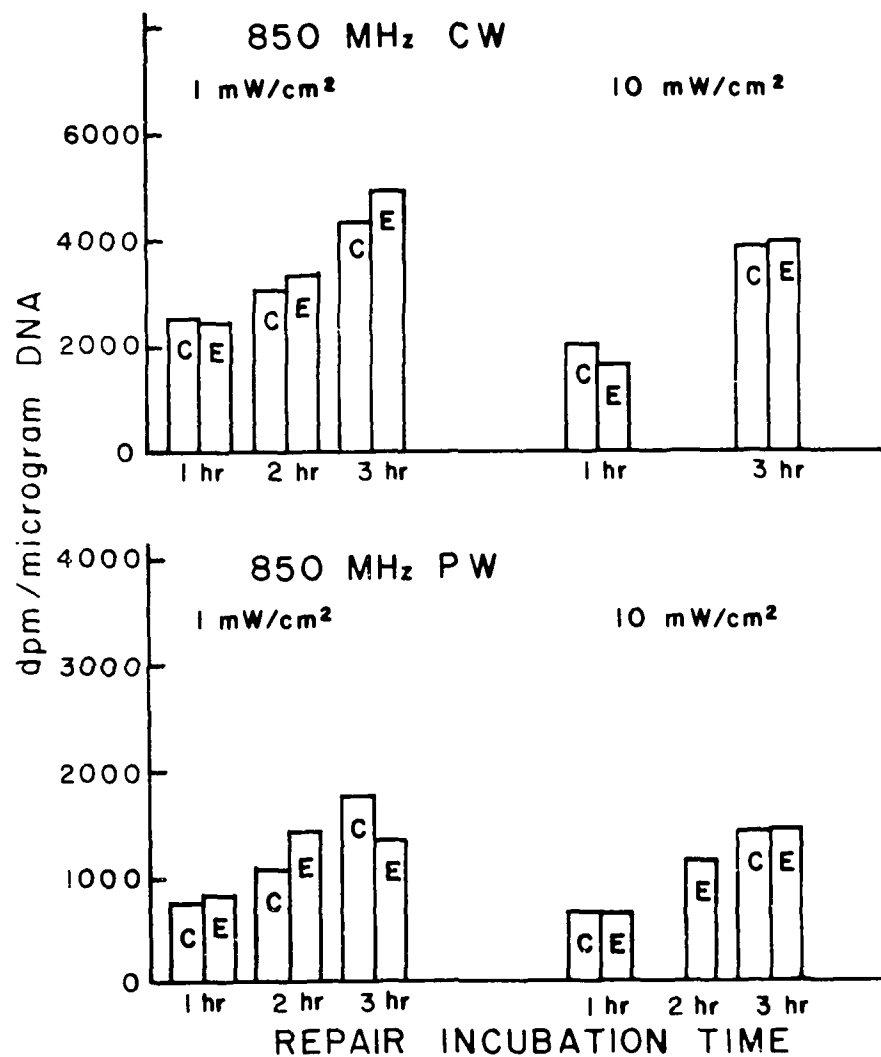


Figure 10. UV-induced DNA repair synthesis during 850-MHz RFR exposure at 37°C.

RESULTS OF THE CHO STUDIES

SAR Measurements for CHO Experiments

The exposure fields have been mapped in terms of power density (mW/cm^2) and are presented in Figures 11 and 12. Specific absorption rate (W/kg) distributions were determined at various locations in the culture medium (Figs. 13 and 14). The data in Figure 15 are from a typical SAR experiment; the heating-cooling kinetic data were further treated to yield average SAR values.

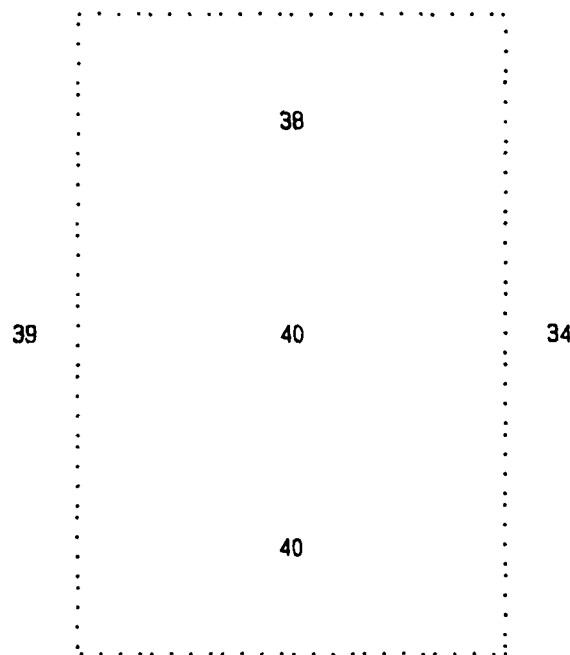
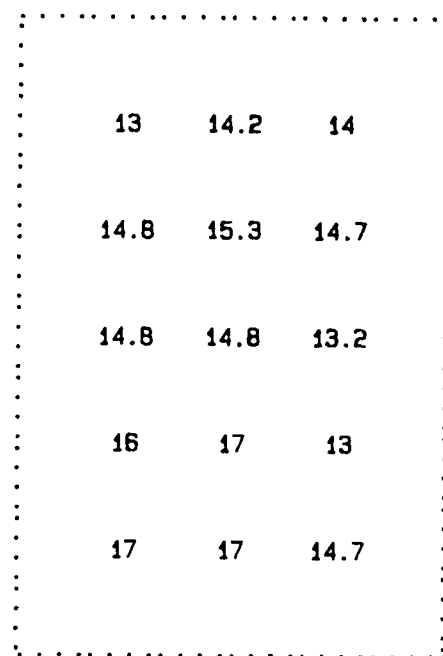
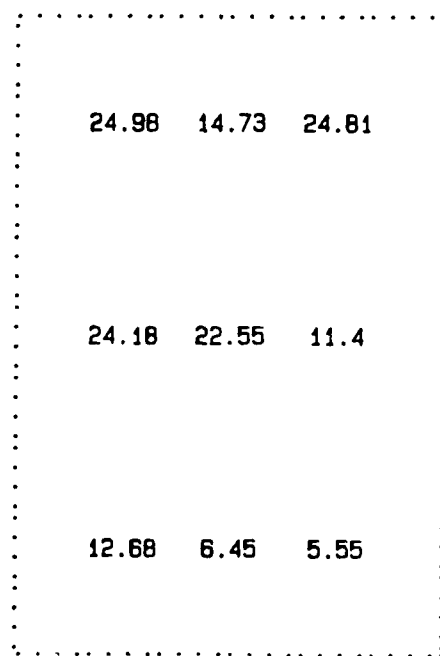


Figure 11. Power-density map, 350 MHz, 350 W.
(dotted line = water-bath outline)



(mW/cm)

Figure 12. Power-density map, 1.2 GHz, 380 W.
(dotted line = water-bath outline)



(W/kg)

Figure 13. SAR map, 850 MHz, 38 mW/cm².
(dotted line = water-bath outline)

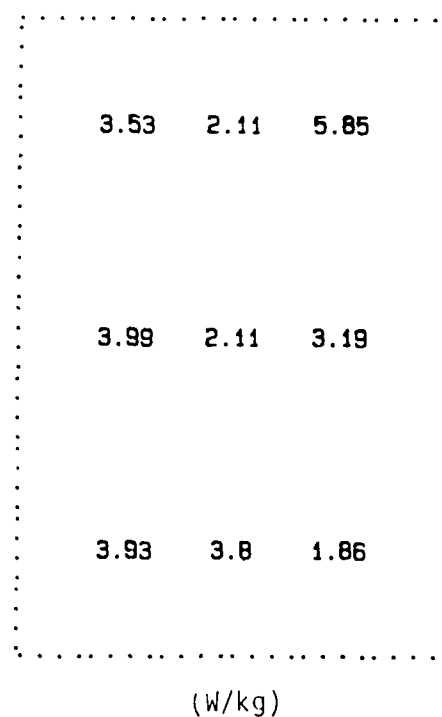


Figure 14. SAR map, 1.2 GHz, 15 mW/cm².
(dotted line = water-bath outline)

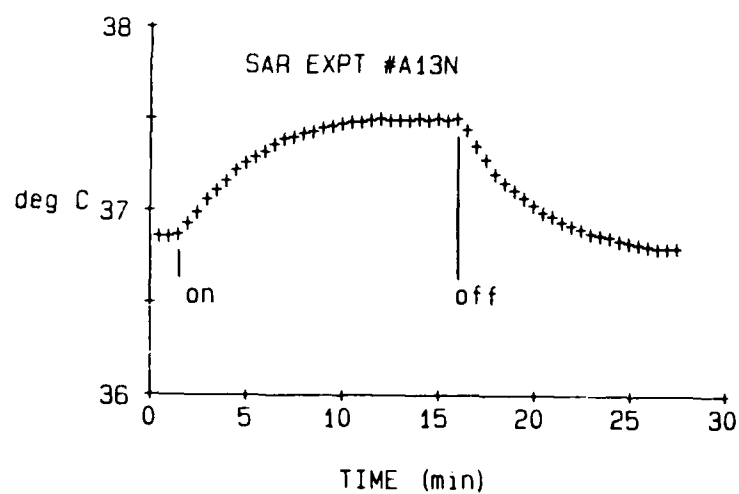


Figure 15. Typical SAR experiment data. (on = magnetron current on;
off = magnetron current off)

Power densities were reasonably uniform in the far field for both 350 MHz and 1.2 GHz. The specific absorption rates were fairly similar throughout the 1.2-GHz field; however, some variations in the 350-MHz field were significant.

Signal Quality Control for CHO Studies

A major quality control procedure was spectral analysis of the transmitter output. Figures 16 and 17 are representative spectra for 350 MHz and 1.2 GHz, respectively.

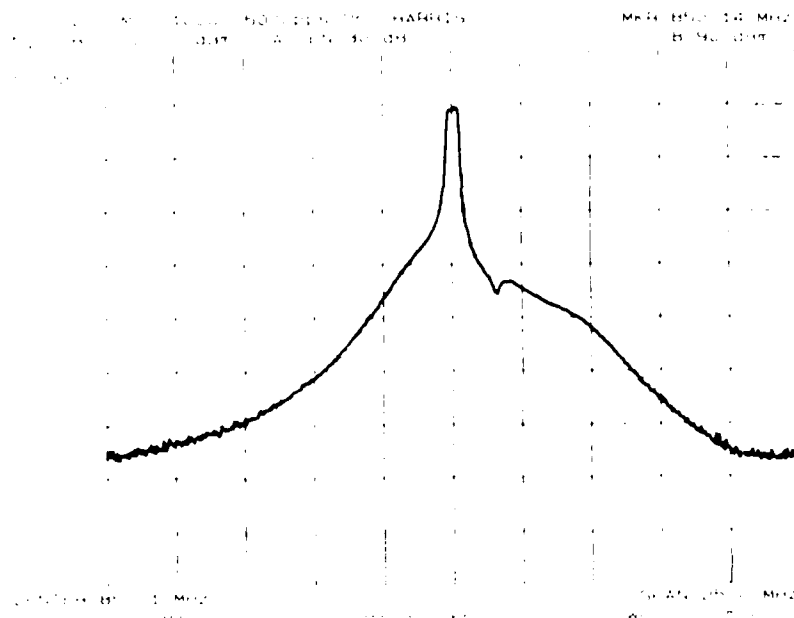


Figure 16. Spectrum analysis of 350-MHz signal.

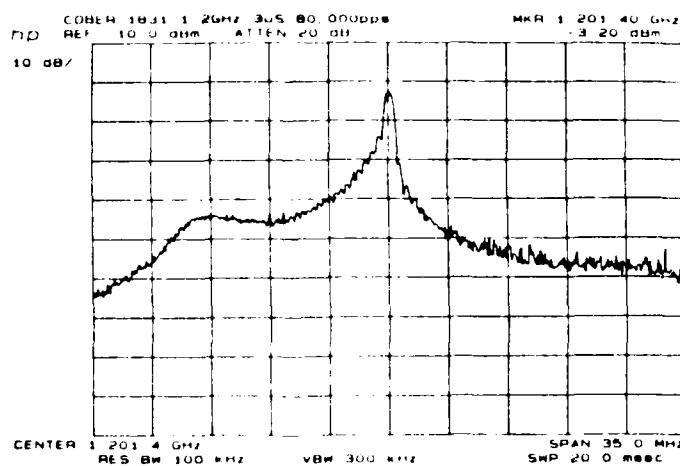


Figure 17. Spectrum analysis of 1.2-GHz signal.

Clonal Survival

No differences in clonal survival were detected between cultures left undisturbed at the UTHSCSA laboratory and those transported to the RFR laboratory. Clonal survival values were the calculated quotient of the number of colonies in each exposed flask and of the mean number of colonies in control flasks. The mean of the clonal survival values is defined as the surviving fraction (SF). These data for 850 MHz and 1.2 GHz are summarized in Table 17. No decline in cell survival was observed under the exposure conditions utilized.

Growth Kinetics

Representative data from four growth kinetics experiments are shown in Figures 18 and 19. The semilogarithmic transforms of the data are linear and fit the equation $C = C_0 e^{\lambda t}$, where: C = number of cells at time t ; C_0 = initial cell number; and λ = growth constant. The data for the series of growth kinetics are summarized in Table 13. No differences were detected among the groups; and all had a doubling time of 11 hr, characteristic of CHO cells.

Cellular Morphology

CHO cells grown in monolayer culture exhibit a typical fibroblastic morphology with no outstanding features. The population is homogeneous; however, occasional large multinucleated cells do arise. These unusual cells appear to be reproductively terminal, and therefore do not affect the parameters studied.

Representative phase-contrast photomicrographs of CHO cells at various times after microwave exposure are presented in Figures 20 and 21. None of the experimental treatments caused any demonstrable morphological alterations. Possible morphological changes investigated were: general cell shape and size; membrane blebbing; micronucleation; and granulation and vesiculation of the cytoplasm.

Sister Chromatid Exchange

In each experiment, two or three exposed and control flasks were devoted to SCE analysis. Two slides were analyzed from each flask, fifty metaphases being scored for chromosome number and SCEs per cell. Not included in the scores were metaphases which had obviously had chromosomes lost during preparation, were incompletely spread, or were obviously polyploid. The modal chromosome number was 19.

The SCE frequency data for all experiments are contained in Table 19 for 850-MHz PW, and in Table 20 for 1.2-GHz PW; the means (± 1 standard deviation) for each slide are tabulated. Statistical analysis of differences among means was performed by the two-tailed t statistic method. Differences between exposed and control means were not significant ($P < .01$).

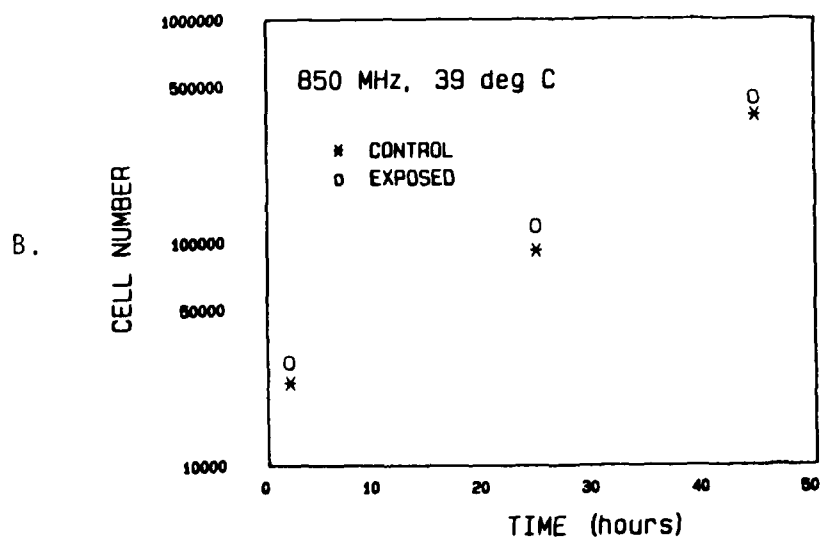
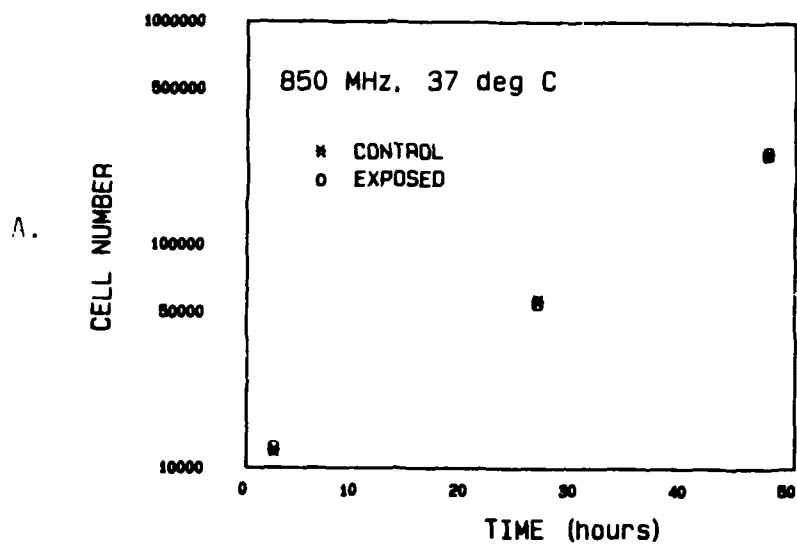


Figure 18. CHO growth kinetics data: A. 850 MHz, 37°C; and B. 850 MHz, 39°C.

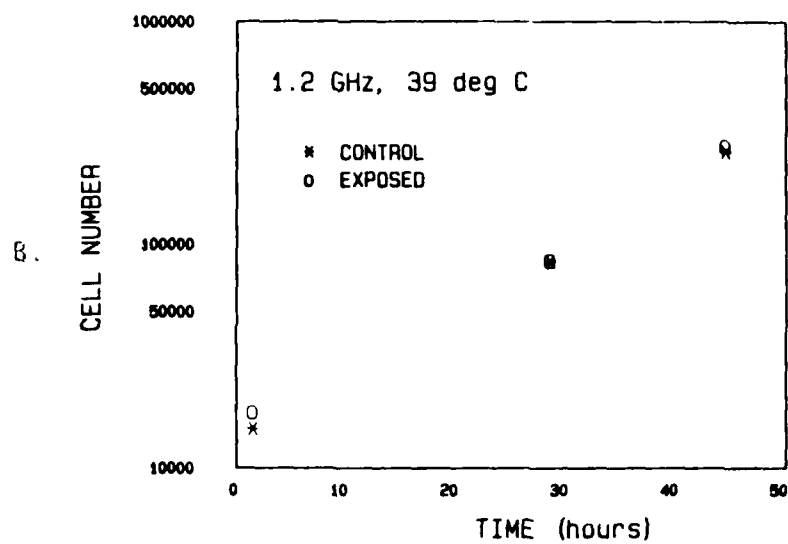
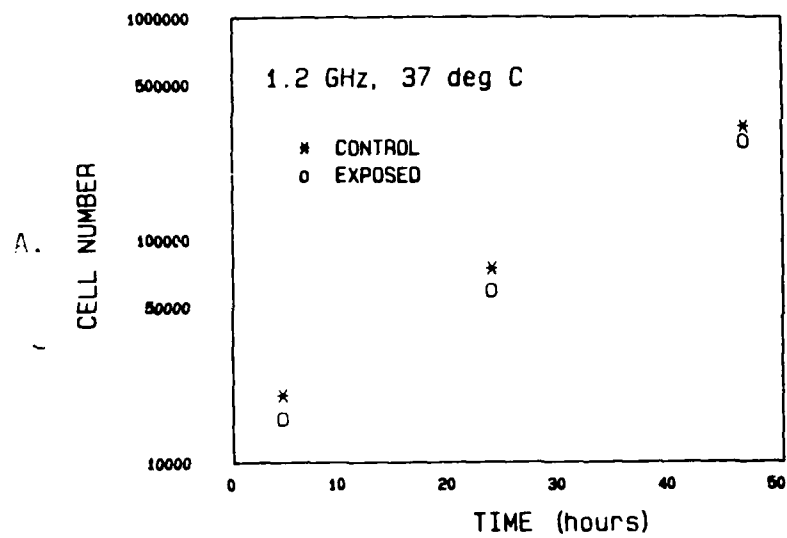


Figure 19. CHO growth kinetics data: A. 1.2 GHz, 37°C; and B. 1.2 GHz, 39°C.

A.



B.



Figure 20. Phase-contrast micrographs of CHO cells, 3 hr after exposure to 350-MHz fields, 37°C: A. Control; and B. Exposed.

A.



B.

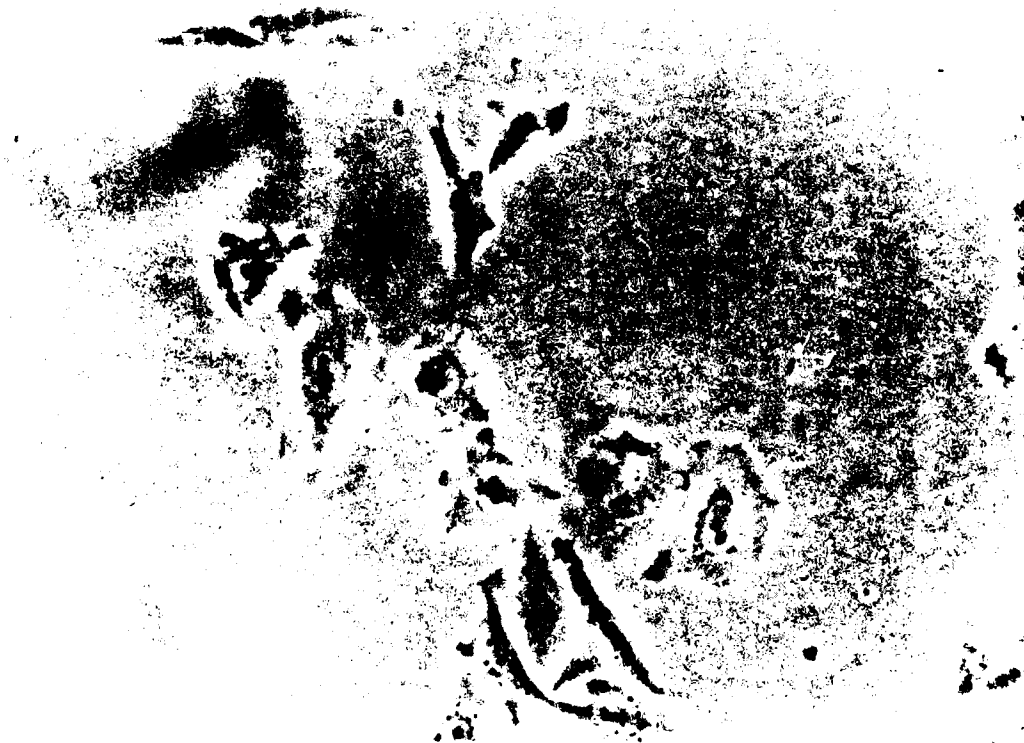


Figure 21. Phase-contrast micrographs of CHO cells, 3 hr after exposure to 1.2-GHz fields, 37°C: A. Control; and B. Exposed.

A typical metaphase for SCE analysis is presented in Figure 22. The photomicrographic quality is poor because of high-intensity red-background fluorescence which tends to create a "haze." However, the observer has a very sharp image for scoring.



Figure 22. CHO chromosomes for SCE analysis.

Chromosome Aberrations

Under no experimental conditions were any dicentric chromosomes detected. Previous experience discloses that the number of cells scored (500) is sufficient to observe any meaningful increase in the frequency of dicentrics in cultured Chinese hamster fibroblasts.

DISCUSSION

According to the results of these studies, RFR exposure under the described conditions produced no effects on cultured Chinese hamster fibroblasts. The endpoints chosen for these studies encompass a wide variety of potential biological effects. We conclude, therefore, that short-term PW exposure at 850 MHz and 1.2 GHz at an average power density of 10 mW/cm^2 elicits no deleterious cellular effects.

Continuation of these studies at different frequencies and at higher power levels could lead to interesting results. In addition, studies at other frequencies are indicated in order for potential occupational hazards of such exposures to be ascertained.

REFERENCES

1. Latt, S. A., Allen, J., Bloom, S. E., Carrano, A., Falke, E., Kram, D., Schneider, E., Schrenck, R., Tice, R., Whitfield, B., Wolff, S., "Sister Chromatid Exchanges: A report of the Gene-Tox Program." Mutation Res, Vol. 87, pp. 17-52, 1981.
2. Taylor, J. H., "Sister Chromatid Exchanges in Tritium Labelled Chromosomes." Genetics, Vol. 43, pp. 515-529, 1953.
3. Lozano, L. Abstract. Fourth Annual Scientific Session, Bioelectromagnetics Society, Los Angeles, Calif., June 1982.
4. Goto, K., Maeda, S., Kano, Y., Sugiyama, T., "Factors Involved in Differential Giemsa-staining of Sister Chromatids, Chromosoma, Vol. 66, pp. 351-363, 1978.
5. Meltz, M. L., Walker, K.A., Genetic Effects of Microwave Exposure on Mammalian Cells In Vitro: Volume I. USAFSAM-TR-84-22, 1984.
6. Smith, C. A., Hanawalt, P. C., "Repair Replication In Human Cells. Simplified Determination Utilizing Hydroxyurea." Biochim Biophys Acta, Vol. 432: pp. 336-347, 1976.

T A B L E S 1 - 21

EDITORIAL NOTE: Throughout the series of tables in the Report, the following abbreviations are frequently used--

R/S ratio	= <i>diagrams ratio, liquid scintillation counter</i>
Bkg	= <i>background</i>
hpm	= <i>disintegration(s) per minute</i>
EFF	= <i>percent efficiency</i>
TE	= <i>transverse electric mode</i>

TABLE 1. DNA REPAIR STUDY: 10000 CONTINUOUS-WAVE RADIATION -- 37°C

[Table is in column 1.2]

Incubation time (hr)	cpm 1 ml	Avg.	-8kg	R/A ratio	Avg.	%Eff	cpm 1 ml	μg DNA 1 ml	cpm μg DNA
A. UV-induced repair replication in anechoic chamber with generator on, in Exposure vs. Control Position. The cells were <u>not</u> exposed to RFR.									
1. Control Position 1	377 280	329	305	.381 .379	.380	36.5	836	1.18	708
2. Exposure Position 1	191 201	196	172	.400 .405	.403	38.0	453	0.64	708
3. Control Position 3	506 496	501	477	.369 .381	.375	36.0	1,325	0.96	1,380
4. Exposure Position 3	284 391	338	314	.399 .374	.387	37.0	849	0.63	1,348
B. Background level of radioactivity incorporated into DNA of cells without UV exposure in anechoic chamber with generator on, in Exposure vs. Control Position. The cells were <u>not</u> exposed to RFR.									
1. Control Position 3	117 143	130	98	.410 .401	.406	40.0	245	0.94	261
2. Exposure Position 3	84 79	82	50	.457 .435	.446	42.5	118	0.56	211

(Continued on next page)

Refer to Table 1 in the preceding issue of "Health Progress."

TABLE 1 (Cont'd.)

	Incubation time (hr)	cpm .1 ml	Avg.	-Bkg	B/A ratio	Avg.	%Eff	dpm .1 ml	$\mu\text{g DNA}$.1 ml	dpm $\mu\text{g DNA}$
C. Assay for induction of repair synthesis by 1.2-GHz continuous-wave radiation in non-UV irradiated cells.										
1. Control	3	151 149	150	118	.413 .405	.409	40.0	295	0.70	421
2. RFR (10 mW/cm ²)	3	176 170	173	141	.400 .378	.389	38.7	364	0.82	444
D. Effect of 1.2-GHz continuous-wave radiation at 1 mW/cm ² on UV-induced DNA repair.										
1. Control	1	42 42	42	10	.500 .536	.518	45.2	22	0.02 ^f	1,100
2. 1 mW/cm ²	1	222 227	225	193	.384 .400	.392	39.0	495	0.61	811
3. Control	2	107 114	111	79	.429 .403	.416	40.5	195	0.92	212 ^g
4. 1 mW/cm ²	2	240 207	224	192	.376 .407	.392	39.0	492	0.45	1,093
5. Control	3	297 229	298	266	.390 .379	.385	38.5	691	0.54	1,280
6. 1 mW/cm ²	3	194 177	186	154	.388 .414	.401	39.5	390	0.29 ^b	1,345

^aContinued on next page.

TABLE 1 (Cont'd.)

TABLE 1 (Cont'd.)

TABLE 1 (Cont'd.)

	Incubation time (hr)	cpm .1 ml	Avg.	-Bkg	B/A ratio	Avg.	%Eff	dpm .1 ml	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$
E. Effect of 1.2-GHz continuous-wave radiation at 10 mW/cm ² on UV-induced DNA repair.										
1. Control	1	302 195	249	225	.387 .400	.394	37.5	600	1.34	448
2. 10 mW/cm ²	1	141 160	151	127	.407 .425	.416	39.0	326	0.64	509
3. Control	2	291 396	344	320	.396 .374	.385	37.0	865	0.86	1,006
4. 10 mW/cm ²	2	304 289	297	273	.376 .363	.370	35.8	763	0.8	954
5. Control	3	238 205	222	198	.375 .404	.390	37.2	532	0.58	917
6. 10 mW/cm ²	3	70 80	75	51	.471 .437	.454	41.2	124	0.1 ¹	1,240

TABLE 2. DNA REPAIR STUDY: 1,2-DHAPOL-INDUCED MUTAGENESIS -- 37°C

[Table continued on page 14]

Incubation time (hr)	cpm .1 ml	Avg.	-Bkg	B/A ratio	Avg.	%Eff	dpm .1 ml	µg DNA .1 ml	dpm µg DNA
A. UV-induced repair replication in anechoic chamber with generator <u>on</u> , in Exposure vs. Control Position. The cells were <u>not</u> exposed to RFR.									
1. Control Position 1	94 107	101	77	.376 .424	.400	39	197	0.7	281
2. Exposure Position 1	69 69	69	45	.485 .478	.482	44	102	0.3	340
3. Control Position 3	120 118	119	95	.425 .423	.424	41	232	0.4	580
4. Exposure Position 3	139 138	139	115	.402 .398	.400	39	295	0.51	578
B. Background level of radioactivity incorporated into DNA of cells without UV exposure in a choice chamber with generator <u>on</u> , in Exposure vs. Control Position. The cells were <u>not</u> exposed to RFR.									
1. Control Position 3	37 40	39	15	.555 .589	.572	47	32	0.4	80
2. Exposure Position 3	43 40	42	18	.547 .525	.536	45	40	0.45	89

Continued on page 14 in the following part of "Bioscience"

	Incubation time (hr)	cpm -1 ml	Avg.	-Bkg	B/A ratio	Avg.	%Eff	dpm -1 ml	µg DNA .1 ml	dpm µg DNA
C. Assay for induction of repair synthesis by 1.2 GHz pulse-wave radiation in non-UV irradiated cells.										
1. Control	3	51 53	52	28	.480 .509	.495	43	65	0.95	68
2. RFR (10 mW/cm ²)	3	33 32	33	9	.545 .593	.569	47	19	0.4	48
D. Effect of 1.2-GHz pulse-wave radiation at 1 mW/cm ² on UV-induced DNA repair.										
1. Control	1	57 57	57	33	.491 .446	.469	43	77	0.2	385
2. 1 mW/cm ²	1	73 73	73	49	.438 .424	.431	41	120	0.28	429
3. Control	2	97 93	95	71	.453 .467	.460	43	165	0.26	635
4. 1 mW/cm ²	2	126 132	129	105	.396 .416	.406	40	263	0.42	626
5. Control	3	64 57	61	37	.492 .456	.474	44	84	0.05	1,680
6. 1 mW/cm ²	3	167 149	158	134	.389 .422	.406	40	335	0.45	744

(Continued on next page)

TABLE 2 (Cont'd.)

	Incubation time (hr)	cpm .1 ml	Avg.	-Bkg	B/A ratio	Avg.	%Eff	dpm .1 ml	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	dpm $\frac{\mu\text{g DNA}}{\mu\text{g DNA}}$
E. Effect of 1.2-GHz pulse-wave radiation at 10 mW/cm ² on UV-induced DNA repair.										
1. Control	1	81 81	81	57	.450 .456	.453	40	143	0.5	286
2. 10 mW/cm ²	1	38 43	41	17	.540 .604	.572	47	36	0.15	240
3. Control	2	85 85	85	61	.452 .470	.461	41	149	0.35	426
4. 10 mW/cm ²	2	119 114	117	93	.386 .424	.405	38	245	0.33	742
5. Control	3	105 107	106	82	.419 .452	.436	39	210	0.38	553
6. 10 mW/cm ²	3	146 151	149	125	.413 .400	.407	38	329	0.6	548

TABLE 3. DNA REPAIR STUDY: 350-MHz CONTINUOUS-WAVE RADIATION -- 37°C

[Table 7 in Volume I ^a]

	Incubation time (hr)	cpm .1 ml	Avg.	-Bkg	B/A ratio	Avg.	%Eff	dpm .1 ml	µg DNA .1 ml	dpm µg DNA
A. UV-induced repair replication in TEM Chamber with generator <u>on</u> , vs. in Sham Chamber. The cells were <u>not</u> exposed to RFR.										
1. Sham Chamber	3	385 469	427	402	.309 .321	.315	32	1,256	2.1	598
2. Generator <u>on</u> , TEM Chamber	3	311 306	309	284	.327 .333	.330	33	861	1.35	638
B. Background level of radioactivity incorporated into DNA of cells without UV exposure in TEM Chamber with generator <u>on</u> , vs. in Sham Chamber. The cells were <u>not</u> exposed to RFR.										
1. Sham Chamber	3	57 57	57	33	.491 .491	.491	43	77	1.3	59
2. Generator <u>on</u> , TEM Chamber	3	48 45	47	22	.416 .477	.447	40	55	0.63	87

(Cont'd. on next page)

^a Refer to Item 6 in the preceding list of "References."

TABLE 3 (Cont'd.)

	Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	Avg.	-Bkg	B/A ratio	Avg.	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$
C. Assay for induction of repair synthesis by 350 MHz continuous-wave radiation in non-UV irradiated cells.										
1. Control	3	42 46	44	19	.476 .422	.449	40	48	0.63	76
2. RFR (10 mW/cm ²)	3	55 51	53	28	.454 .400	.427	39	72	1.0	72
D. Effect of 350-MHz continuous-wave radiation at 1 mW/cm ² on UV-induced DNA repair.										
1. Control	1	155 146	151	126	.367 .372	.370	36	350	0.8	438
2. 1 mW/cm ² on	1	116 119	118	93	.387 .372	.380	36	258	0.62	417
3. Control	2	183 167	175	150	.362 .359	.361	35	429	0.68	631
4. 1 mW/cm ²	2	117 118	118	93	.370 .364	.367	35	266	0.41	649
5. Control	3	135 135	135	110	.377 .370	.374	36	306	0.38	805
6. 1 mW/cm ²	3	210 210	210	185	.352 .347	.350	35	529	0.69	767

(Cont'd. on next page)

TABLE 3 (Cont'd.)

	Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	Avg.	-Bkg	B/A ratio	Avg.	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$
E. Effect of 350-MHz continuous-wave radiation at 10 mW/cm ² on UV-induced DNA repair.										
1. Control	1	89 91	90	66	.443 .422	.433	40	165	0.78	212
2. 10 mW/cm ²	1	118 123	121	97	.389 .389	.389	37	262	1.1	238
3. Control	2	128 118	123	99	.433 .358	.396	38	261	0.85	307
4. 10 mW/cm ²	2	119 120	120	96	.403 .420	.412	39	246	0.7	351
5. Control	3	77 80	79	55	.467 .417	.442	40	138	0.42	329
6. 10 mW/cm ²	3	170 165	168	144	.382 .378	.380	37	389	0.95	409

TABLE 1. DNA REPAIR STUDY: 300-MHZ POLYMERASE CHAIN REACTION -- 37°C

[Table continues on Volume I-2]

	Incubation time (hr)	cpm 1 ml	Avg.	-Bkg	B/A ratio	Avg.	%Eff	dpm 1 ml	µg DNA 1 ml	dpm µg DNA
A. UV-induced repair replication in TEM Chamber with generator <u>on</u> , vs. in Sham Chamber. The cells were <u>not</u> exposed to RFR.										
1. Sham Chamber	1	878 862	870	847	.386 .380	.383	37	2,289	1.7	1,347
2. Generator <u>on</u> , TEM Chamber	1	632 653	643	620	.386 .372	.379	37	1,676	1.25	1,341
3. Sham Chamber	3	1,331 1,356	1,344	1,320	.368 .371	.370	36	3,667	1.78	2,060
4. Generator <u>on</u> , TEM Chamber	3	1,278 1,269	1,274	1,250	.374 .379	.377	36	3,472	1.45	2,395
B. Background level of radioactivity incorporated into DNA of cells without UV exposure in TEM Chamber with generator <u>on</u> , vs. in Sham Chamber. The cells were <u>not</u> exposed to RFR.										
1. Sham Chamber	3	356 357	357	334	.433 .435	.434	38	879	1.48	594
2. Generator <u>on</u> , TEM Chamber	3	154 150	152	129	.409 .402	.406	37	349	1.24	281

(Continued on next page)

Table 1. DNA REPAIR STUDY: 300-MHZ POLYMERASE CHAIN REACTION -- 37°C

TABLE 3 (cont'd.)

	Incubation time (hr)	cpm .1 ml	Avg.	-Bkg	B/A ratio	Avg.	%Eff	dpm .1 ml	µg DNA .1 ml	dpm µg DNA
C. Assay for induction of repair synthesis by 350-MHz pulse-wave radiation in non-UV irradiated cells.										
1. Control	3	54 56	55	32	.500 .490	.495	42	76	0	---
2. RFR (10 mW/cm ²)	3	239 239	239	216	.424 .447	.436	39	554	0.8	692
D. Effect of 350-MHz pulse-wave radiation at 1 mW/cm ² on UV-induced DNA repair.										
1. Control	1	121 112	117	94	.475 .446	.461	40	235	0.25	940
2. 1 mW/cm ²	1	535 543	539	516	.433 .421	.427	38	1,358	0.7	1,940
3. Control	2	631 620	626	603	.428 .418	.423	38	1,587	0.75	2,116
4. 1 mW/cm ²	2	712 722	717	694	.428 .421	.425	38	1,826	0.75	2,435
5. Control	3	350 347	349	326	.417 .426	.422	38	858	0.5	1,716
6. 1 mW/cm ²	3	333 523	428	405	.349 .340	.345	33	1,227	0.7	1,753

Efficiency on basis of 100%

TABLE 4 (Cont'd.)

	Incubation time (hr)	cpm .1 ml	Avg.	-Bkg	B/A ratio	Avg.	%Eff	dpm .1 ml	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$
E. Effect of 350-MHz pulse-wave radiation at 10 mW/cm ² on UV-induced DNA repair.										
1. Control	1	483 457	470	447	.376 .396	.386	37	1,208	1.24	974
2. 10 mW/cm ²	1	567 570	569	545	.382 .377	.380	37	1,473	1.58	932
3. Control	2	693 754	724	700	.372 .359	.366	36	1,944	1.2	1,620
4. 10 mW/cm ² ^a	2	535 523	529	506	.376 .372	.374	36	1,406	0.98	1,434
5. Control	3	910 922	916	893	.365 .369	.367	36	2,481	1.48	1,676
6. 10 mW/cm ²	3	910 893	902	878	.369 .367	.368	36	2,439	1.43	1,706

^a These data are from a continuous-wave exposure, not a pulse-wave exposure.

TABLE 5. SMITH AND HANAWALT (6)^a TECHNIQUE COMPARISON

Sample	cpm .1 ml	Avg	-8kg (30 cpm)	B/A ratio	Avg	%Eff	dpm .1 ml	µg DNA .1 ml	dpm µg DNA
<u>Smith and Hanawalt</u>									
0-sec UV	1,534 1,531	1,533	1,503	.431 .416	.424	34	4,421	1.0	4,421
8-sec UV	1,961 2,187	2,074	2,044	.420 .439	.430	35	5,840	1.6	3,650
15-sec UV	2,333 2,160	2,247	2,217	.432 .425	.429	35	6,334	1.9	3,334
25-sec UV	1,569 1,394	1,482	1,452	.407 .393	.400	33	4,400	1.6	2,750
<u>Old Method - 1 gradient</u>									
0-sec UV	303 279	291	261	.508 .494	.501	39	669	0.38	1,761
8-sec UV	612 612	612	582	.487 .477	.482	38	1,532	0.4	3,829
15-sec UV	557 549	553	523	.491 .478	.485	38	1,376	0.3	4,588
25-sec UV	505 236	505	475	.432	.432	35	1,443	0.3	4,810

^a Refer to item 6 in the preceding list of "References."

^b The replicate cpm was less than half of the indicated value. Its use in the average would have resulted in a 3-hr dpm/µg being less than the 2-hr value and, therefore, was not used in the computation shown.

TABLE 1. EFFECT OF RFR (10 mW/cm²) ON SEMI-QUANTITATIVE DNA SYNTHESIS

Expt	Time	Avg	Stdg	B/A ratio	Avg	Stdg	µm	µg DNA	µm	µg DNA
							mm	mm	mm	mm
350-MHz CW (37°C):										
1-hr control										
		9,152	9,129	.335	.336	34	25,047	1.2	5,593	
		3,347		.336						
1-hr 10 mW/cm ²										
		15,113	15,089	.331	.335	34	44,379	4.7	9,442	
		14,255		.338						
350-MHz CW (37°C):										
1-hr control										
		59,027	59,628	.359	.361	35	170,300	2.1	81,095	
		59,169		.362						
1-hr 10 mW/cm ²										
		53,630	51,289	.335	.339	34	150,779	1.55	91,331	
		48,947		.342						
250-MHz CW (37°C):										
1-hr control										
		3,624	3,567	.431	.433	356	9,935	2.8	3,548	
		3,509		.435						
1-hr 10 mW/cm ²										
		5,372	5,348	.357	.353	30	19,393	3.4	5,704	
		5,323		.349						

Values are means ± SD

* Experimental data from different experiments are shown in parentheses.

TABLE 1 (continued)

Sample	cpm .1 ml	Avg	-3kg	B/A ratio	Avg	%Eff	dpm .1 ml	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$
<u>350-MHz PW (39°C):</u>									
1-hr control	31,611 29,549	30,558	30,536	.415 .414	.415	36	34,383	2.42	35,076
1-hr 10 mW/cm ²	30,705 30,944	30,825	30,903	.413 .410	.412	36	85,563	2.26	37,360
<u>850-MHz PW (39°C):</u>									
1-hr control	17,133 16,706	16,920	16,897	.471 .470	.471	34	49,697	1.7	29,234
1-hr 10 mW/cm ²	20,150 19,905	20,028	20,005	.470 .474	.472	34	58,837	1.9	30,367
<u>1.2-GHz PW (39°C):</u>									
1-hr control	15,726 15,144	15,435	15,409	.459 .455	.457	34	45,321	1.1	41,201
1-hr 10 mW/cm ²	17,105 17,716	17,411	17,385	.432 .430	.431	32	54,327	1.4	39,305

TABLE 7. DNA REPAIR STUDY: ^{32}P -MMP CONTINUOUS-WAVE IRRADIATION--1980

	Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-8kg (30 cpm)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	$\frac{\text{Avg dpm}}{\mu\text{g DNA}}$
A. UV-induced repair replication in an anechoic chamber with the generator on, culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.									
1. Control Position	1	211 218	181 188	.466 .458	38 37	476 508	2.3	207 221	214
2. Exposure Position	1	390 343	360 313	.438 .438	36 36	1000 869	4.3	233 202	218
3. Control Position	3	457 454	427 424	.459 .454	37 37	1154 1146	2.6	444 441	443
4. Exposure Position	3	496 492	466 462	.449 .444	37 36	1259 1283	3.0	420 428	424
B. Background level of radioactivity incorporated into DNA of cells without UV exposure in an anechoic chamber with the generator on, culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.									
1. Control Position	3	60 59	30 29	.474 .525	38 42	79 69	1.5	53 46	50
2. Exposure Position	3	90 94	60 64	.500 .478	40 39	150 164	2.4	63 68	66

TABLE 1 (Continued)

	Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-Bkg (30 cpm)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	$\frac{\text{Avg dpm}}{\mu\text{g DNA}}$
C. Assay for the induction of repair synthesis by 850-MHz continuous wave radiation in non-UV-irradiated cells									
1. Control	3	54 51	24 21	.500 .529	40 42	60 50	1.4 36	43 36	40
2. RFR (10 mW/cm ²)	3	43 143	13 113	.558 .440	43 36	30 314	0.05 6280	600 6280	3440
D. Effect of 850-MHz continuous-wave radiation at 1 mW/cm ² on UV-induced DNA repair									
1. Control	1	214 225	184 195	.455 .473	37 38	497 513	1.5	331 342	337
2. 1 mW/cm ²	1	202 196	172 166	.465 .448	38 37	453 449	1.7	266 264	265
3. Control	2	148 162	118 132	.476 .459	38 37	311 357	0.7	444 510	477
4. 1 mW/cm ²	2	293 188	263 158	.320 .382	29 32	939 494	1.2	783 412	598
5. Control	3	222 232	192 202	.457 .441	37 36	519 561	0.9	577 623	600
6. 1 mW/cm ²	3	251 389	221 359	.384 .347	32 30	691 1197	1.5	461 798	630

(Continued on next page)

TABLE 7 (Cont'd.)

		Incubation time (hr)	cpm .1 ml	-Bkg (30 cpm)	B/A ratio	%Eff	dpm .1 ml	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	Avg dpm $\frac{\mu\text{g DNA}}$
E. Effect of 850-MHz continuous-wave radiation at 10 mW/cm ² on UV-Induced DNA repair										
1. Control	1	187 168	157 138	.326 .389	28 33	561 418	0.9	623 464	544	
2. 10 mW/cm ²	1	140 225	110 195	.438 .400	36 33	306 591	1.4	219 422	321	
3. Control	2	159 148	129 118	.481 .469	39 38	331 311	0.8	414 389	402	
4. 10 mW/cm ²	2	130 116	100 86	.418 .469	35 38	286 226	0.7	409 323	366	
5. Control	3	36 36	6 6	.542 .583	43 45	14 13	No Yield	---	---	
6. 10 mW/cm ²	3	175 180	145 150	.459 .494	37 40	392 375	0.9	436 417	427	

TABLE 1. DNA REPAIR STUDY: 10-MHz POLAR WAVE RADIATION, 1970

	Incubation time (hr)	cpm .1 ml	-Bkg (30 cpm)	B/A ratio	%Eff	dpm .1 ml	μg DNA .1 ml	dpm μg DNA	Avg dpm μg DNA
A. UV-induced repair replication in an anechoic chamber with the generator on, culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.									
1. Control Position	1	199	169	.457	37	457	0.7	653	662 ²
		199	169	.442	36	469		670	
2. Exposure Position	1	251	221	.428	35	631	0.9	701	714 ¹
		265	235	.439	36	653		726	
3. Control Position	3	315	285	.324	28	1018	0.8	1273	1106
		270	240	.382	32	750		938	
4. Exposure Position	3	736	706	.429	35	2017	1.2	1681	1673
		729	699	.429	35	1997		1664	
B. Background level of radioactivity incorporated into DNA of cells without UV exposure in an anechoic chamber with the generator <u>on</u> , culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.									
1. Control Position	3	127	97	.492	40	243	0.9	270	285
		130	100	.457	37	270		300	
2. Exposure Position	3	99	69	.438	36	192	0.8	240	223
		96	66	.494	40	165		206	

(Cont'd. on next page)

¹ The cells were held at 40°C for the last 10 min of the labeling period.

TABLE 1 (Cont'd.)

	Incubation time (hr)	cpm .1 ml	-Bkg (30 cpm)	B/A ratio	%Eff	dpm .1 ml	μg DNA .1 ml	dpm μg DNA	Avg dpm μg DNA
C. Assay for the induction of repair synthesis by 850-MHz pulse-wave radiation in non-UV-irradiated cells									
1. Control	3	38 43	8 13	.552 .581	43 45	19 29	0.2	95 145	120
2. RFR (10 mW/cm ²)	3	57 58	27 28	.517 .517	41 41	66 68	0.3	220 227	224
D. Effect of 850-MHz pulse-wave radiation at 1 mW/cm ² on UV-induced DNA repair									
1. Control	1	369 469	339 439	.319 .287	28 25	1211 1756	2.0	606 878	742
2. 1 mW/cm ²	1	531 499	501 469	.412 .436	34 36	1474 1303	1.7	867 766	817
3. Control	2	267 268	237 238	.439 .460	36 38	658 626	0.6	1097 1043	1070
4. 1 mW/cm ²	2	702 728	672 698	.413 .419	34 35	1976 1994	1.4	1411 1424	1418
5. Control	3	1061 872	1031 842	.424 .417	35 35	2946 2406	1.5	1964 1604	1784
6. 1 mW/cm ²	3	839 795	809 765	.366 .366	31 31	2610 2468	1.9	1374 1299	1337

(Cont'd. on next page)

TABLE 1 (Cont'd.)

	Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-Bkg (30 cpm)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	Avg dpm $\mu\text{g DNA}$
E. Effect of 850-MHz pulse-wave radiation at 10 mW/cm ² on UV-induced DNA repair									
1. Control	1	478 496	448 466	.426 .421	35 35	1280 1331	1.9	674 701	688
2. 10 mW/cm ²	1	494 534	464 504	.365 .371	31 31	1497 1626	2.3	651 707	679
3. Control	2	166 ^b 148 ^b	136 ^b 118 ^b	.460 .455	38 37	358 ^b 319 ^b	0.9	159 141	150
4. 10 mW/cm ²	2	108 128	78 98	.500 .445	40 36	195 272	0.2	975 1360	1168
5. Control	3	624 631	594 601	.431 .424	35 35	1697 1717	1.2	1414 1431	1423
6. 10 mW/cm ²	3	1259 1271	1229 1241	.433 .426	36 35	3414 3546	2.4	1423 1478	1451

^b These values are for 0.26 ml, not 0.1 ml.

TABLE 3. DNA REPAIR STUDY: 1.1-GHZ PULSE-WAVE RADIATION--37°C

	Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-8kg (30 cpm)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	$\frac{\text{Avg dpm}}{\mu\text{g DNA}}$
A. UV-induced repair replication in an anechoic chamber with the generator on, culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.									
1. Control Position	1	727 662	697 632	.433 .461	32 34	2178 1859	1.15	1894 1617	1756
2. Exposure Position	1	sample lost							
3. Control Position	3	152 159	122 129	.506 .534	37 39	330 331	0.1	3297 3310	3304
4. Exposure Position	3	1835 1922	1805 1892	.450 .450	33 33	5470 5733	1.75	3126 3276	3201
B. Background level of radioactivity incorporated into DNA of cells without UV exposure in an anechoic chamber with the generator on, culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.									
1. Control Position	3	225 222	195 192	.482 .488	35 36	557 533	1.9	293 281	287
2. Exposure Position	3	212 208	182 178	.481 .478	35 35	520 509	1.85	281 275	278

(CONT'D. ON NEXT PAGE)

TABLE 9 (Cont'd.)

	Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-Bkg (30 cpm)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	Avg dpm $\mu\text{g DNA}$
C. Assay for the induction of repair synthesis by 1.2-GHz pulse-wave radiation in non-UV irradiated cells									
1. Control	3	534 523	504 493	.487 .484	36 36	1400 1369	1.1	1273 1245	1259
2. RFR (10 mW/cm ²)	3	215 243	185 213	.353 .359	27 27	685 789	0.85	806 928	867
D. Effect of 1.2-GHz pulse-wave radiation at 1 mW/cm ² on UV-induced DNA repair									
1. Control	1	443 436	413 406	.555 .547	40 39	1033 1041	0.3	3443 3470	3457
2. 1 mW/cm ²	1	838 870	808 840	.540 .525	39 38	2072 2211	0.5	4144 4422	4283
3. Control	2	266 255	236 225	.554 .533	40 39	590 577	0.09	6556 6411	6484
4. 1 mW/cm ²	2	985 994	955 964	.495 .519	36 38	2653 2537	0.5	5306 5074	5190
5. Control	3	1058 1043	1028 1013	.533 .535	39 39	2636 2597	0.35	7531 7420	7476
6. 1 mW/cm ²	3	1259 1232	1229 1202	.532 .529	39 38	3151 3163	0.4	7878 7908	7893

(Cont'd. on next page)

TABLE 3 (Cont'd.)

	Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-8kg (30 :pm)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	$\frac{\text{Avg dpm}}{\mu\text{g DNA}}$
E. Effect of 1.2-GHz pulse-wave radiation at 10 mW/cm ² on UV-induced DNA repair									
1. Control	1	213 218	183 188	.504 .518	37 38	495 495	0.3 0.3	1650 1650	1650
2. 10 mW/cm ²	1	701 716	671 686	.470 .474	35 35	1917 1960	0.85 0.85	2255 2306	2281
3. Control	2	1347 1344	1317 1314	.537 .532	39 39	3377 3369	0.65 0.65	5195 5183	5189
4. 10 mW/cm ²	2	821 849	791 819	.520 .503	38 37	2082 2214	0.7 0.7	2974 3163	3069
5. Control	3	1413 1316	1383 1286	.531 .529	39 38	3546 3384	0.6 0.6	5910 5640	5775
6. 10 mW/cm ²	3	1699 1755	1669 1725	.533 .531	39 39	4279 4423	0.7 0.7	6113 6319	6216

TABLE 10. DNA REPAIR STUDY: 60-60-MHz CONTINUOUS-WAVE RADIATION--37°C

	Incubation time (hr)	cpm .1 ml	-8kg (23 cpm)	B/A ratio	%Eff	dpm .1 ml	µg DNA .1 ml	dpm µg DNA	Avg dpm µg DNA
A. UV induced repair replication in an anechoic chamber with the generator on, culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.									
1. Control Position	1	313 307	290 284	0.500 0.496	35 35	829 811	0.3	2762 2703	2733
2. Exposure Position	1	517 505	494 482	0.497 0.489	35 34	1411 1418	0.5	2822 2836	2829
3. Control Position	3	493 476	470 453	0.481 0.496	33 35	1424 1294	0.3	4747 4313	4530
4. Exposure Position	3	1268 1267	1245 1244	0.481 0.486	33 34	3773 3659	0.6	6288 6098	6193
B. Background level of radioactivity incorporated into DNA of cells without UV exposure in an anechoic chamber with the generator on, culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.									
1. Control Position	3	120 121	97 98	0.544 0.550	37 38	262 258	1.3	202 198	200
2. Exposure Position	3	123 127	100 104	0.560 0.547	38 37	263 281	1.0	263 281	272

(Cont'd. on next page)

		Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-Rkg (23 cpm)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	Avg dpm $\mu\text{g DNA}$
C. Assay for the induction of repair synthesis by 850 MHz continuous wave radiation in non-UV-irradiated cells										
1. Control	3	121 132	98 109	0.541 0.526	37 36	265 303	1.0	265 303	284	
2. RFR (10 mW/cm ²)	3	121 121	98 98	0.550 0.512	38 35	258 280	0.9	287 311	299	
D. Effect of 850-MHz continuous-wave radiation at 1 mW/cm ² on UV-induced DNA repair										
1. Control	1	895 892	872 869	0.490 0.492	34 34	2565 2556	1.0	2565 2556	2561	
2. 1 mW/cm ²	1	1065 1030	1042 1007	0.497 0.496	35 35	2977 2877	1.2	2481 2398	2440	
3. Control	2	641 628	618 605	0.486 0.478	34 33	1818 1833	0.6	3030 3055	3043	
4. 1 mW/cm ²	2	1286 1254	1263 1231	0.486 0.480	34 34	3715 3621	1.1	3377 3292	3335	
5. Control	3	1497 1464	1474 1441	0.479 0.470	34 33	4335 4367	1.0	4335 4367	4351	
6. 1 mW/cm ²	3	1693 1705	1670 1682	0.484 0.486	34 34	4912 4947	1.0	4912 4947	4930	

(Cont'd. on next page)

TABLE 10 (Cont'd.)

	Incubation time (hr)	cpm .1 ml	-Bkg (23 cpm)	B/A ratio	%Eff	dpm .1 ml	$\mu\text{g DNA}$.1 ml	dpm $\mu\text{g DNA}$	Avg dpm $\mu\text{g DNA}$
E. Effect of 850-MHz continuous-wave radiation at 10 mW/cm ² on UV-induced DNA repair									
1. Control	1	1319 1272	1296 1249	0.492 0.496	34 35	3812 3569	1.8	2118 1983	2051
2. 10 mW/cm ²	1	743 540	720 517	0.439 0.480	31 34	2323 1521	1.2 ^a (1.0) ^b	1936(2323) 1268(1521)	1602 (1922)
3. Control	Samples lost due to water bath overflow during exposure								
4. 10 mW/cm ²	Samples lost due to water bath overflow during exposure								
5. Control	3	1633 1582	1610 1559	0.493 0.486	34 34	4735 4585	1.2	3946 3821	3884
6. 10 mW/cm ²	3	1367 1374	1344 1351	0.491 0.489	34 34	3953 3974	1.0	3953 3974	3964

^a Value from an Hingeneher replicate. The byproduct was 0.1 m² and gave a mean of four readings.

^b The values in parentheses are the average of both replicates, it was calculated using the same.

Incubation time (hr)	cpm .1 ml	-Bkg (23 cpm)	B/A ratio	%Eff	dpm .1 ml	µg DNA .1 ml	dpm µg DNA	Avg dpm µg DNA
-------------------------	--------------	------------------	--------------	------	--------------	-----------------	---------------	-------------------

A. UV induced repair replication in an anechoic chamber with the generator on, culture dishes in the exposure vs. control position. The cells were not exposed to radiofrequency radiation.

1. Control Position	1	1176 1161	1153 1138	.477 .484	34 35	3391 3251	1.2 1.2	2826 2709	2768
2. Exposure Position	1	1204 1166	1181 1143	.485 .482	35 35	3374 3266	1.3 1.3	2595 2512	2554
3. Control Position	3	1663 1668	1640 1645	.484 .482	35 35	4686 4700	1.3 1.3	3605 3615	3610
4. Exposure Position	3	1834 1860	1811 1837	.479 .479	35 35	5174 5249	1.3 1.3	3980 4038	4009

B. Background level of radioactivity incorporated into DNA of cells without UV exposure in an anechoic chamber with the generator on, culture dishes in the exposure vs. control position. The cells were not exposed to radiofrequency radiation.

1. Control Position	3	73 80	50 57	.589 .575	41 40	122 143	0.3 0.3	407 477	442
2. Exposure Position	3	176 170	153 147	.511 .497	37 36	414 408	1.0 1.0	414 408	411

TABLE 11 (Cont'd.)

	Incubation time (hr)	cpm .1 ml	-Bkg (23 cpm)	B/A ratio	%Eff	dpm .1 ml	$\mu\text{g DNA}$.1 ml	dpm $\mu\text{g DNA}$	Avg dpm $\mu\text{g DNA}$
C. Assay for the induction of repair synthesis by 850-MHz pulse-wave radiation (39°C) in non-UV-irradiated cells									
1. Control	3	177 174	154 151	.519 .522	37 37	416 408	0.5	832 816	824
2. RFR (10 mW/cm ²)	3	181 173	158 150	.502 .497	36 36	439 417	0.6	732 695	714
D. Effect of 850-MHz pulse-wave radiation (39°C) at 1 mW/cm ² on UV-induced DNA repair									
1. Control	1	1727 1684	1704 1661	.503 .495	36 36	4733 4614	1.7	2784 2714	2749
2. 1 mW/cm ²	1	1746 1736	1723 1717	.497 .498	36 36	4786 4758	1.9	2519 2504	2512
3. Control	3	2575 2440	2552 2417	.491 .491	35 35	7291 6906	1.2	6076 5755	5916
4. 1 mW/cm ²	3	2997 2935	2974 2912	.492 .489	35 35	8497 8320	1.4	6069 5943	6006

(Cont'd. on next page)

		Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-Bkg (23 cpm)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	$\frac{\text{Avg dpm}}{\mu\text{g DNA}}$
E. Effect of 850-MHz pulse-wave radiation (39°C) at 10 mW/cm ² on UV-induced DNA repair										
1. Control	1		1065 1014	1042 991	.492 .486	35 35	2977 2831	0.7	4253 4044	4149
2. 10 mW/cm ²	1		1570 1605	1547 1582	.489 .495	35 36	4420 4394	1.1	4018 3995	4007
3. Control	2		894 820	871 797	.501 .495	36 36	2419 2214	0.3	8063 7380	7722
4. 10 mW/cm ²	2		1547 1588	1524 1565	.495 .495	36 36	4233 4347	0.7	6047 6210	6129
5. Control	3		1269 1280	1246 1257	.498 .489	36 35	3461 3591	0.4	8653 8978	8816
6. 10 mW/cm ²	3		1781 1786	1758 1763	.506 .498	36 36	4883 4897	0.7	6976 6996	6986

TABLE 12. DNA REPAIR STUDY: 1.2-GHz PULSE-WAVE RADIATION--40°C

	Incubation time (hr)	cpm .1 ml	-Bkg (27 cpm)	B/A ratio	%Eff	dpm .1 ml	µg DNA .1 ml	dpm µg DNA	Avg dpm µg DNA
B. Background level of radioactivity incorporated into DNA of cells without UV exposure in an anechoic chamber with the generator on, culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.									
1. Control Position	3	127 129	100 102	.535 .534	38 38	263 268	0.7 0.7	376 383	380
2. Exposure Position	3	135 138	101 111	.570 .557	40 40	270 278	0.9 0.9	300 309	305
C. Assay for the induction of repair synthesis by 1.2-GHz pulse-wave radiation in non-UV-irradiated cells									
1. Control	3	147 145	120 118	.462 .493	40 41	300 288	0.7 0.7	429 411	420
2. RFR (10 mW/cm ²)	3	169 168	142 141	.458 .461	39 40	364 353	0.9 0.9	404 392	398

Continued on next page

TABLE 12 (Cont'd.)

	Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-Bkg (cpm)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	$\frac{\text{Avg dpm}}{\mu\text{g DNA}}$
D. Effect of 1.2-GHz pulse-wave radiation at 1 mW/cm ² on UV-induced DNA repair									
1. Control	1	991 985	964 958	.416 .396	37 36	2605 2661	1.8	1447 1478	1463
2. 1 mW/cm ²	1	1846 1822	1819 1795	.426 .421	37 37	4916 4851	2.7	1821 1797	1809
3. Control	3	1718 1762	1691 1735	.421 .434	37 38	4570 4566	1.9	2405 2403	2404
4. 1 mW/cm ²	3	1066 1011	1039 984	.420 .417	37 37	2808 2659	1.2	2340 2216	2278
5. Control	3	835 709	808 682	.404 .387	36 35	2244 1949	1.0	2244 1949	2097
6. 1 mW/cm ²	3	1455 1460	1428 1433	.377 .376	35 35	4080 4094	1.6	2550 2559	2555

continued on next page

TABLE 10 (Cont'd.)

		Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-Bkg ($\frac{\text{cpm}}{.1 \text{ ml}}$)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	Avg dpm $\mu\text{g DNA}$
t. Effect of 1.2-GHz pulse-wave radiation at 10 mW/cm ² on UV-induced DNA repair										
1. Control	1		615 638	588 611	.530 .556	38 40	1547 1528	0.7 ^a	2210 2183	2197 ^b
2. 10 mW/cm ²	1		1224 1164	1197 1137	.538 .535	39 38	3069 2992	1.3	2361 2302	2332
3. Control	2		1052 1066	1025 1039	.549 .543	39 39	2628 2664	0.7	3754 3806	3780
4. 10 mW/cm ²	2		1108 1082	1081 1055	.556 .548	40 39	2703 2705	0.7	3861 3864	3863
5. Control	3		1238 1194	1211 1167	.536 .540	38 39	3187 2992	0.7	4553 4274	4414
6. 19 mW/cm ²	3		1390 1367	1363 1340	.535 .521	38 38	3587 3526	0.9	3986 3918	3952

^a Calculated from the value of the DNA polymerase I activity (0.7 and 1.5 $\mu\text{g}/0.1 \text{ ml}$)
^b The average of 1.18 to 3.1 ml gives a final value of 1.00 $\mu\text{g}/0.1 \text{ ml}$.

TABLE NO. 1. DNA REPAIR (1969): 1.1-202 FOLLE-HAVE RADIATION--35°C

Incubation Time (hr)	cpm .1 ml	-EKG (24 cps)	B/A ratio	%Eff	dpm .1 ml	μg DNA .1 ml	dpm μg DNA	Avg dpm μg DNA
a. γ induced repair replication in an anechoic chamber with the generator <u>ON</u> , culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.								
1. Control Position	2759 2848	2735 2824	.424 .432	36 37	7597 7632	1.4	5426 4351	5439
2. Exposure Position	2302 2367	2778 2843	.429 .440	37 37	7508 7684	1.4	5363 5489	5426
3. Control Position	3697 3698	3673 3674	.426 .432	37 37	9927 9930	1.0	9927 9930	9929
4. Exposure Position	4439 4389	4415 4365	.424 .431	36 37	12,264 11,797	1.4	8760 8426	8593
b. Background level of radioactivity incorporated into DNA of cells without UV exposure in an anechoic chamber with the generator <u>ON</u> , culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.								
1. Control Position	494 505	470 481	.497 .502	37 37	1270 1300	1.1	1155 1182	1169
2. Exposure Position	796 796	772 772	.483 .488	36 36	2144 2144	1.2	1787 1787	1787

(Cont'd. on next page)

TABLE 15 (cont'd.)

	Incubation time (hr)	cpm .1 ml	-Bkg (24 cpm)	B/A ratio	%Eff	dpm .1 ml	µg DNA .1 ml	dpm µg DNA	Avg dpm µg DNA
C. Assay for the induction of repair synthesis by 1.2-GHz pulse-wave radiation in non-UV-irradiated cells (9 mW/cm ²)									
1. Control	3	681 678	657 654	.496 .505	37 37	1776 1768	0.4	4440 4420	4430
2. RFR (9 mW/cm ²)	3	928 965	904 941	.501 .487	37 36	2443 2614	0.7	3490 3734	3612
D. Effect of 1.2-GHz pulse-wave radiation at 1 mW/cm ² on UV-induced DNA repair									
1. Control	1	1440 1436	1416 1412	.433 .447	37 38	3827 3716	0.4	9568 9290	9429
2. 1 mW/cm ²	1	1312 1283	1288 1259	.432 .436	37 37	3481 3403	0.3	11,603 11,343	11,473
3. Control	2	845 876	821 852	.444 .444	37 37	2219 2303	0.2	11,095 11,515	11,305
4. 1 mW/cm ²	2	2638 2658	2614 2634	.437 .434	37 37	7065 7119	0.5	14,130 14,238	14,184
5. Control	3	1136 1137	1112 1113	.433 .441	37 37	3005 3008	0.2	15,025 15,040	15,033
6. 1 mW/cm ²	3	2048 1996	2024 1972	.439 .435	37 37	5470 5330	0.3	18,233 17,767	18,000

(Cont'd. on next page)

^a Both exposed dish and control dish were incubated for 70 min with the radioactive label present before the 3-hr RFR exposure started.

TABLE 13 (Cont'd.)

	Incubation time (hr)	cpm .1 ml	-Rkg (24 pm)	B/A ratio	%Eff	dpm .1 ml	ug DNA .1 ml	dpm ug DNA	Avg dpm ug DNA
E. Effect of 1.2-GHz pulse-wave radiation at 10 mW/cm ² on UV-induced DNA repair									
1. Control	1	1912 1825	1888 1801	.484 .471	36 35	5244 5146	1.1	4767 4678	4723
2. 10 mW/cm ²	1	2252 2221	2228 2197	.486 .486	36 36	6189 6103	1.2	5158 5086	5122
3. Control	2	3106 3149	3082 3125	.482 .477	36 35	8561 8929	1.3	6585 6868	6727
4. 10 mW/cm ²	2	3611 3661	3587 3637	.488 .489	36 36	9964 10,103	1.3	7665 7772	7719
5. Control	3	3203 3172	3179 3148	.453 .456	34 34	9350 9259	1.3	7192 7122	7157
6. 10 mW/cm ²	3	3566 3639	3542 3615	.476 .473	35 35	10,120 10,329	1.2	8433 8608	8521

TABLE 14. Induction of repair synthesis by 350 MHz pulse-wave radiation in non-UV-irradiated cells

	Incubation time (hr)	cpm .1 ml	-Bkg (23 cpm)	B/A ratio	%Eff	dpm 1 ml	μg DNA .1 ml	dpm μg DNA	Avg dpm μg DNA
B. Background level of radioactivity incorporated into DNA of cells without UV exposure in an anechoic chamber with the generator on, culture dishes in the exposure vs. control position. The cells were not exposed to radiofrequency radiation.									
1. Control Position	3	130 136	107 113	.600 .600	42 42	255 269	1.25 1.25	204 215	210
2. Exposure Position	3	132 138	109 115	.537 .543	38 39	287 295	1.3 1.3	221 227	224
C. Assay for the induction of repair synthesis by 350 MHz pulse-wave radiation in non-UV-irradiated cells									
1. Control	3	159 170	136 147	.553 .544	39 39	349 377	1.4 1.4	249 269	259
2. RFR (10 mW/cm ²)	3	175 169	152 146	.563 .556	40 40	380 365	1.3 1.3	292 281	287

Continued on next page

TABLE 10 (Cont'd.)

	Incubation time (hr)	cpm .1 ml	-Bkg (23 cpm)	B/A ratio	%Eff	dpm .1 ml	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	Avg dpm $\frac{\mu\text{g DNA}}$
D. Effect of 350-MHz pulse-wave radiation at 1 mW/cm ² or UV-induced DNA repair									
1. Control	1	689 679	666 656	.519 .517	37 37	1800 1773	2.3	783 771	777
2. 1 mW/cm ²	1	765 768	742 745	.530 .539	38 40	1953 1863	2.3	849 810	830
3. Control	2	637 638	614 615	.525 .524	38 38	1616 1618	1.5	1077 1079	1078
4. 1 mW/cm ²	2	839 720	816 697	.513 .506	37 37	2205 1884	1.7	1297 1108	1203
5. Control	3	895 879	872 856	.506 .499	37 36	2357 2378	1.8	1309 1321	1315
6. 1 mW/cm ²	3	260 261	237 238	.501 .494	36 36	658 661	0.5	1316 1322	1319

TABLE 15. DNA REPAIR STUDY: 250-MHZ PULSE-WAVE RADIATION--29°C
(5 and 10 mW/cm²)

Incubation time (hr)		cpm .1 ml	-Bkg (cpm)	B/A ratio	%Eff	dpm .1 ml	µg DNA .1 ml	dpm µg DNA	Avg dpm µg DNA
A. UV-induced repair replication in an anechoic chamber with the generator <u>on</u> , culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.									
1. Control Position	1	995 1020	973 998	.396 .386	34 33	2862 3024	.52	5504 5815	5660
2. Exposure Position	1	943 979	921 957	.383 .397	33 34	2791 2815	.50	5582 5630	5606
3. Control Position	3	990 1193	968 1171	.381 .407	33 35	2933 3346	.28	10,475 11,950	11,213
4. Exposure Position	3	2389 2234	2367 2212	.413 .408	35 35	6763 6320	.62	10,908 10,194	10,551
B. Background level of radioactivity incorporated into DNA of cells without UV exposure in an anechoic chamber with the generator <u>on</u> , culture dishes in the exposure vs. control position. The cells were <u>not</u> exposed to radiofrequency radiation.									
1. Control Position	3	135 140	113 118	.474 .467	39 39	290 303	.40	725 758	742
2. Exposure Position	3	210 227	188 205	.459 .446	38 38	495 539	.55	900 980	940

TABLE 15. CONT.

	Incubation time (hr)	cpm .1 ml	-Bkg (cpm)	B/A ratio	%Eff	dpm .1 ml	µg DNA .1 ml	dpm µg DNA	Avg dpm µg DNA
C. Assay for the induction of repair synthesis by 350-MHz pulse-wave radiation in non-UV-irradiated cells (5 mW/cm ²)									
1. Control	3	114 118	92 96	.464 .432	38 37	242 259	.30	807 863	835
2. RFR (5 mW/cm ²)	3	184 184	162 162	.475 .448	39 38	415 426	.55	755 775	765
D. Effect of 350-MHz pulse-wave radiation at 5 mW/cm ² on UV-induced DNA repair									
1. Control	1	871 870	849 849	.421 .417	36 36	2358 2356	.64	3684 3681	3683
2. 5 mW/cm ²	1	1509 1505	1487 1483	.438 .431	37 37	4019 4008	1.14	3525 3516	3521
3. Control	2	1072 1174	1050 1152	.424 .439	36 37	2917 3114	.60	4862 5190	5026
4. 5 mW/cm ²	2	1058 1056	1036 1034	.418 .417	36 36	2878 2872	.60	4797 4787	4792
5. Control	3	1583 1610	1561 1588	.425 .427	36 37	4336 4292	.70	6194 6131	6163
6. 5 mW/cm ²	3	2274 2074	2252 2052	.410 .417	36 36	6256 5700	.95	6585 6000	6293

Continued on next page

TABLE 10 (Continued)

	Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-Bkg (22 cpm)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	Avg dpm $\mu\text{g DNA}$
E. Effect of 350-MHz pulse-wave radiation at 10 mW/cm ² on UV-induced DNA repair									
1. Control	1	798 836	776 814	.382 .395	33 34	2352 2394	.92	2557 2602	2580
2. 10 mW/cm ²	1	1367 1548	1345 1526	.365 .387	32 33	4203 4624	1.84	2284 2513	2399
3. Control	2	1114 1224	1092 1202	.393 .401	34 34	3212 3535	.84	3824 4208	4016
4. 10 mW/cm ²	2	974 1008	952 986	.401 .386	34 33	2800 2988	.68	4118 4394	4256
5. Control	3	1701 1577	1679 1555	.410 .389	35 34	4797 4574	.90	5330 5082	5206
6. 10 mW/cm ²	3	1943 1801	1921 1779	.414 .400	35 34	5489 5232	.91	6032 5749	5891

TABLE 10. (Continued)

	Incubation time (hr)	$\frac{\text{cpm}}{.1 \text{ ml}}$	-Bkg (21 cpm)	B/A ratio	%Eff	$\frac{\text{dpm}}{.1 \text{ ml}}$	$\frac{\mu\text{g DNA}}{.1 \text{ ml}}$	$\frac{\text{dpm}}{\mu\text{g DNA}}$	Avg dpm $\frac{\text{dpm}}{\mu\text{g DNA}}$
D. Effect of 350-MHz pulse wave radiation at 1 mW/cm ² on UV-induced DNA repair									
1. Control	1	948 926	927 905	.460 .464	39 39	2377 2321	1.6 1.6	1486 1451	1469
2. 1 mW/cm ²	1	809 798	788 777	.461 .460	39 39	2021 1992	1.3 1.3	1555 1532	1544
3. Control	2	979 990	958 969	.447 .447	38 38	2521 2550	.85 1.0	2966 3000	2983
4. 1 mW/cm ²	2	154 117	133 96	.467 .491	39 41	341 234	0.15 0.15	2273 1560	1917
5. Control	3	1215 1219	1194 1198	.452 .458	38 39	3111 3072	1.0 1.0	3142 3072	3107
6. 1 mW/cm ²	3	1886 1946	1865 1925	.449 .450	38 38	4908 5066	1.6 1.6	3068 3166	3117

TABLE 1

		Incubation time (hr)	cpm .1 ml	-Bkg (cpm)	B/A ratio	%Eff	dpm .1 ml	µg DNA .1 ml	dpm µg DNA	Avg dpm µg DNA
E. Effect of 850 MHz pulse-wave radiation at 10 mW/cm ² on UV-induced DNA repair										
1. Control	1		290 370	269 349	.397 .382	35 34	769 1026	0.9	854 1140	997
2. 10 mW/cm ²	1		626 648	605 627	.400 .409	35 36	1729 1742	1.4	2535 1244	1240
3. Control	2		512 549	491 528	.322 .342	30 31	1637 1703	1.0	1637 1703	1570
4. 10 mW/cm ²	2		502 509	481 488	.395 .388	35 34	1374 1435	0.7	1963 2050	2007
5. Control	3		739 758	718 737	.367 .372	33 33	2176 2233	1.1	1978 2030	2004
6. 10 mW/cm ²	3		809 780	788 759	.383 .371	34 33	2318 2300	1.2	1932 1917	1925

TABLE 11. CLONAL SURVIVAL DATA, CHO CELLS, 810 MHz and 1.2 GHz, 37°C and 39°C

<u>FREQUENCY</u>	<u>TEMP. (deg C)</u>	<u>SF</u>
0.85	37	1.02
		0.99
		1.01
	39	1.00
		1.03
		0.98
1.2	37	0.99
		1.02
		1.01
	39	1.02
		1.01
		1.01

TABLE 12. SUMMARY OF GROWTH KINETICS, CHO CELLS, 810 MHz and 1.2 GHz, 37°C and 39°C

FREQUENCY	TEMP. (deg C)	LAMBDA	
		CONTROL	EXPOSED
0.85	37	0.063	0.062
	39	0.064	0.063
1.2	37	0.063	0.064
	39	0.063	0.063

TABLE 19. SISTER CHROMATID EXCHANGE (SCE) LEAKAGE FROM CELLS, 400 M², 1000 M², 10000 M²

EXPT. #	FREQUENCY (GHz)	TEMP. (deg C)	SCE/CELL (1 SD)	SCE/CELL (1 SD)
1	.85	37	10.74 (1.575)	8.98 (2.47)
			10.58 (.928)	10.3 (1.432)
			10.5 (.735)	10.58 (.731)
			10.46 (1.474)	10.62 (1.784)
2	.85	37	10.48 (1.488)	10.46 (.676)
			10.66 (.772)	10.58 (.758)
			10.6 (1.088)	10.72 (1.213)
			10.44 (.76)	10.44 (1.28)
3	.85	37	10.24 (1.021)	10.42 (.642)
			10.62 (.845)	10.02 (1.27)
			10.94 (2.316)	10.38 (.753)
			10.42 (.758)	10.38 (.878)
4	.85	39	10.34 (1.437)	10.44 (2.349)
			10.44 (.76)	10.54 (1.446)
			10.46 (1.501)	10.46 (1.129)
			10.54 (.734)	11.1 (1.607)
5	.85	39	10.54 (1.164)	10.38 (.945)
			10.48 (.809)	10.36 (1.711)
			10.52 (1.329)	10.5 (1.298)
			10.54 (.788)	10.46 (.994)
6	.85	39	10.44 (1.716)	10.54 (1.446)
			10.54 (.762)	10.58 (1.357)
			10.46 (2.111)	10.24 (1.437)
			10.6 (.571)	10.74 (.965)

TABLE 20. SISTER CHROMATID EXCHANGE FREQUENCY, CHO CELLS, 1.2 GHz, 37°C and 39°C

EXPT. #	FREQUENCY (GHz)	TEMP. (deg C)	SCE/CELL CONTROL (1 SD)	SCE/CELL EXPOSED (1 SD)
1	1.2	37	10.64 (1.102)	10.56 (.893)
			10.84 (1.785)	10.76 (1.744)
			10.4 (.881)	10.62 (1.141)
			10.5 (.707)	10.38 (1.978)
			10.44 (.861)	10.18 (.962)
			10.58 (1.214)	10.62 (1.413)
2	1.2	37	10.64 (.875)	10.08 (1.259)
			10.46 (.613)	10.66 (1.768)
			10.48 (.909)	10.44 (1.327)
			10.4 (.857)	10.58 (.673)
			10.56 (1.296)	10.5 (1.129)
			100.72 (.73)	10.42 (1.052)
3	1.2	37	10.66 (1.062)	10.3 (1.074)
			10.22 (1.788)	10.32 (.899)
			10.82 (1.395)	10.84 (1.808)
			10.38 (.897)	10.68 (1.203)
			10.54 (.706)	10.5 (.544)
			10.56 (.541)	11.04 (1.734)
4	1.2	37	10.54 (.894)	10.54 (1.232)
			10.36 (.898)	10.88 (.784)
			10.74 (1.259)	10.6 (.321)
			10.34 (.557)	10.82 (2.174)
			10.56 (.883)	10.44 (.704)
			10.34 (1.042)	10.74 (2.078)

(Cont'd. on next page)

TABLE 20 (Cont'd.)

EXPT. #	FREQUENCY (GHz)	TEMP. (deg C)	SCE/CELL CONTROL (1 SD)	SCE/CELL EXPOSED (1 SD)
5	1.2	39	10.92 (1.482)	10.22 (1.055)
			10.72 (1.891)	10.64 (.875)
			10.42 (1.052)	11.08 (2.239)
			10.44 (.541)	10.32 (1.382)
			10.92 (1.322)	10.4 (1.069)
6	1.2	39	10.38 (1.086)	11.06 (2.411)
			10.48 (2.206)	10.36 (2.048)
			10.28 (.858)	10.5 (.735)
			10.12 (1.674)	10.58 (1.739)
			10.4 (.99)	10.74 (.828)
7	1.2	39	10.64 (.631)	10.5 (1.741)
			10.44 (1.053)	10.4 (.804)
			10.7 (1.542)	10.48 (.831)
			10.48 (.677)	10.7 (1.819)
			10.5 (.614)	10.5 (.614)
8	1.2	39	10.42 (1.162)	10.5 (.678)
			10.7 (1.189)	10.62 (1.413)
			10.28 (.607)	10.54 (.762)
			10.74 (1.175)	10.44 (1.358)
			10.52 (1.432)	10.28 (1.98)
			10.38 (.067)	10.22 (2.141)
			10.22 (1.112)	10.58 (.785)
			10.32 (.587)	10.54 (.862)
			10.76 (1.384)	10.3 (.763)

DATE OF EXPOSURE	12/17/80	12/16/80	1/22/81	1/20/81	2/26/81	2/24/81	3/26/81	3/24/81
FREQUENCY	1.2 GHz	1.2 GHz	1.2 GHz	1.2 GHz	350 MHz	350 MHz	350 MHz	350 MHz
MODE	CW	CW	PW	PW	CW	CW	PW	PW
AVERAGE POWER DENSITY (mW/cm ²)	1	10	1	10	1	10	1*	10**
CHAMBER	No. 1	No. 1	No. 1	No. 1	No. 1	No. 1	No. 1	No. 1
GENERATOR	Cober 1831	Cober 1831	Cober 1831	Cober 1831	MCL15122	MCL 15022	MCL 15022	MCL 15022
AMPLIFIER (if used)	----	----	----	----	----	----	MCL 10110	MCL 10110
TRANSITION DIMENSIONS (cm)	+ horn 34 x 46	+ horn 34 x 46	8.25x16.5	8.25x16.5	TEM Narda 8801	TEM Narda 8801	TEM Narda 8801	TEM Narda 8801
DISTANCE FROM TRANSITION (m)	1.0 (near field)	1.0 (near field)	1.5	1.5	TEM Narda 8801	TEM Narda 8801	TEM Narda 8801	TEM Narda 8801
DISTANCE FROM FLOOR (m)	0.85	0.85	0.85	0.85	TEM Narda 8801	TEM Narda 8801	TEM Narda 8801	TEM Narda 8801
TRANSMITTER OUTPUT POWER (W) (Average/Peak)	Not Recorded	Not Recorded	Not Recorded	Not Recorded	1.5	15	1.5/30	15/300
IF PULSED MODE:	--	----						
PULSES PER SECOND	--		5000	5000			5000	5000
PULSE WIDTH (μ sec)	--		10	10			10	10
PEAK POWER DENSITY (mW/cm ²) (AVERAGE D.F.)	--		20	200			20	200
DUTY FACTOR (PPS x Pulse width)	----		.05 Redone because of false parameters	.05			.05	.05

Because of settings, could possibly have been Avg. Power Den. of *0.5 **5.0

(Cont'd. on next page)

DF = duty factor
PPS = pulses per second

DATE OF EXPOSURE	8/13/81	8/11/81	9/11/81	9/9/81	11/19/81	11/17/81	1/21/82	1/19/82
FREQUENCY	850 MHZ	850 MHZ	850 MHZ	850 MHZ	1.2 GHZ	1.2 GHZ	850 MHZ	850 MHZ
MODE	CW	CW	PW	PW	PW	PW	CW	CW
AVERAGE POWER DENSITY (mW/cm ²)	1	10	1	10	1	10	1	10
CHAMBER	No. 1	No. 1	No. 1	No. 1	No. 1	No. 1	No. 1	No. 1
GENERATOR	MCL 15022	MCL 15022	MCL 15022	MCL 15022	Cober 1831	Cober 1831	MCL 15022	MCL 15022
AMPLIFIER (if used)	MCL 10110	MCL 10110	MCL 10110	MCL 10110	----	----	MCL 10110	MCL 10110
TRANSITION DIMENSIONS (cm)	17x33.5	17x33.5	17x33.5	17x33.5	8.25x16.5	8.25x16.5	17x33.5	17x33.5
DISTANCE FROM TRANSITION (m)	1.38	1.38	1.38	1.38	1.5	1.5	1.38	1.38
DISTANCE FROM FLOOR (m)	0.85	0.85	0.85	0.85	0.75	0.75	0.85	0.85
TRANSMITTER OUTPUT POWER (W) (Average/Peak)	35	350	26/520	250/500	30/125	380/1583	28	280
IF PULSED MODE:								
PULSES PER SECOND	--		5000	5000	80,000	80,000		
PULSE WIDTH (μ sec)	--		10	100	3	3		
PEAK POWER DENSITY (mW/cm ²) (AVERAGE D.F.)	--		20	20	4.2	41.7		
DUTY FACTOR (PPS .. Pulse width)			.05	.5	.24	.24		

Redone because of low 3H uptake

(Cont'd. on next page)

TABLE 10 (Cont'd)

DATE OF EXPOSURE	3/2/82	3/4/82	4/27/82	4/22/82	4/30/82	6/15/82	6/11/82	7/29/82
FREQUENCY	850 MHz	850 MHz	1.2 GHz	1.2 GHz	350 MHz	850 MHz	850 MHz	1.2 GHz
MODE	PW 39°	PW 39°	PW	PW	PW	PW 39°	PW 39°	PW 39°
AVERAGE POWER DENSITY (mW/cm ²)	1	10	1	10	1	1	10	1
CHAMBER	No. 1	No. 1	No. 2	No. 2	No. 1	No. 2	No. 2	No. 2
GENERATOR	MCL 15022	MCL 15022	Cober 1831	Cober 1831	MCL 15022	MCL 15022	MCL 15022	Cober 1831
AMPLIFIER (if used)	----	MCL 10110	----	----	MCL 10110	MCL 10110	MCL 10110	----
TRANSITION DIMENSIONS (cm)	17x33.5	17x33.5	8.25x16.5	8.25x16.5	TEM Narda 8801	17x33.5.5	17x33.5	8.25x16.5
DISTANCE FROM TRANSITION (m)	1.38	1.38	1.5	1.5	TEM Narda 8801	1.38	1.38	1.38
DISTANCE FROM FLOOR (m)	0.85	0.85	1.08	1.08	TEM Narda 8801	1.08	1.08	1.08
TRANSMITTER OUTPUT POWER (W) (Average/Peak)	23/46	300/600	33/138	280/1167	4.6/92	22/44	147/294	44/183
IF PULSED MODE:								
PULSES PER SECOND	5000	5000	80,000	80,000	5000	5000	5000	80,000
PULSE WIDTH (μ sec)	100	100	3	30	10	100	100	3
PEAK POWER DENSITY (mW/cm ²) (AVERAGE D.F.)	2	20	4.2	41.7	20	2	20	4.2
DUTY FACTOR (PPS X Pulse width)	.5	.5	0.24	0.24	0.05	.5	.5	0.24

(Cont'd. on next page)

TABLE 21 (Cont'd.)

DATE OF EXPOSURE	7/27/82	9/10/82	9/8/82
FREQUENCY	1.2 GHz	350 MHz	350 MHz
MODE	PW 39°	PW 39°	PW 39°
AVERAGE POWER DENSITY (mW/cm ²)	10	10	5
CHAMBER	No. 2	No. 1	No. 1
GENERATOR	Cober 1326	MCL 15022	MCL 15022
AMPLIFIER (if used)	----	MCL 10110	MCL 10110
TRANSITION DIMENSIONS (cm)	8.25x16.5	TEM Narda 8801	TEM Narda 8801
DISTANCE FROM TRANSITION (m)	1.38	TEM Narda 8801	TEM Narda 8801
DISTANCE FROM FLOOR (m)	1.08	TEM Narda 8801	TEM Narda 8801
TRANSMITTER OUTPUT POWER (W) (Average/Peak)	413/1721	32/640	16/320
IF PULSED MODE:			
PULSES PER SECOND	80,000	5000	5000
PULSE WIDTH (μ sec)	3	10	10
PEAK POWER DENSITY (mW/cm ²) (AVERAGE D.F.)	42	20	200
DUTY FACTOR (PPS x Pulse width)	0.24	.05	.05

APPENDIX A: CYTOGENETICS AND GROWTH KINETICS DATA, 850 MHz

APPENDIX B: CYTOGENETICS AND GROWTH KINETICS DATA, 1.2 GHz

(For: USAFSAM-TR-84-24: GENETIC EFFECTS OF MICROWAVE EXPOSURE
ON MAMMALIAN CELLS IN VITRO: VOLUME II,
by Martin L. Meltz, Ph.D.; Clifton R. Harris, Ph.D.; and
Kathleen A. Walker, B.S.)

RE: How to Order Appendix A (USAFSAM-TR-84-24-APP-A)
How to Order Appendix B (USAFSAM-TR-84-24-APP-B)

In order for comprehensive information on this
research to be accessible, microfiche have been made of these
Appendixes. The microfiche are available through:

DEFENSE TECHNICAL INFORMATION CENTER (DTIC)
Cameron Station
Alexandria VA 22304-6145

END

FILMED

2-85

DTIC