Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Service Rules for Advanced Wireless Services in the 1915-1920 MHz, 1995-2000 MHz, 2020-2025 MHz and 2175-2180 MHz Bands	)	WT Docket No. 04-356
	)	
Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands	)	WT Docket No. 02-353

Reply Comment of Canyon Area Residents for the Environment (CARE)

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Reply Comment of Canyon Area Residents for the Environment (CARE)

I. Introduction and Summary

Canyon Area Residents for the Environment (CARE) hereby files its Reply Comment in the above-captioned proceeding pursuant to the Notice of Proposed Rulemaking ("NPRM"), WT Docket Nos. 04-356 and 02-353 , released September 24, 2004.

As noted in Par. 114 of NPRM, FCC's rules implementing The National Environmental Policy Act of 1969 (NEPA) "are intended to prevent human exposure to potentially unsafe levels of radiofrequency radiation."

Inherent in accelerating the deployment of wireless infrastructure is the accompanying proliferation of RF transmission sites and the proportional increase in RF radiation impacts as a permanent component of the "quality of the human environment" which requires scrutiny under NEPA. The scientific research record, upon which FCC's current RF radiation human exposure limits are currently based, stops at 1986. Nineteen years of research on this subject has accrued since then and by the time this proposed rule making is adopted, it is possible that more than 20 years of additional research will have been published. Due to an absence of funding in the United States today, most applicable research is coming from other countries. In the U.S. since

the mid-1990's several million wireless communications services subscribers has burgeoned to 174,569, 693 as of January 24, 2005.[1] CARE asserts that this fundamental change in the human environment in the United States warrants evaluation of the advances of the intervening 19 years of scientific study of potential adverse effects of human exposure to RF radiation. This evaluation should come sooner rather than later as more and more American citizens find that RF transmitting devices of all varieties have become permanent fixtures in their workplaces, schools, and residential neighborhoods. FCC's scheme to regulate human exposure to RF radiation must also keep pace with the increases in understanding in the field of bioelectromagnetics, and this proposed rule making does not reflect that obligation. NEPA requires that FCC examine the impact of RF interference to human cellular physiology, not just RF interference between wireless industry providers' electronic infrastructure.[2]

II. FEDERAL HEALTH AGENCY SPECIALISTS WHO ARE MEMBERS OF RFIAWG CONTINUE TO RAISE ISSUES WITH THE CURRENT FCC RF EXPOSURE LIMITS

On June 17, 1999, the National Institute of Occupational Safety and Health's (NIOSH) member of the federal Radiofrequency Interagency Work Group (RFIAWG), W. Gregory Lotz, sent a letter to Richard Tell, then Chairman of SCC28[3] (SC4) Risk Assessment Work Group of the Institute of Electrical and Electronics Engineers (IEEE), spelling out fourteen issues with the current IEEE/ICES human RF exposure standards.[4] RFIAWG is comprised of RF radiation specialists from the federal health agencies with responsibility for formulation of human RF radiation exposure limits. At present, IEEE/ICES is the body to which FCC looks for guidance in setting RF exposure limits.

The fourteen issues of concern spelled out by RFIAWG are:

1. Biological basis for local SAR (specific absorption rate of RF radiation) limit.
2. Selection of an adverse effect level.
3. Acute and chronic exposure.
4. One tier vs. two tier guidelines.
5. Controlled vs. uncontrolled (definitions of exposure environments/exposed persons).

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[1] See: www.wow-com.com web site of the Cellular Telecommunications and Internet Association.
[2] See Addendum 1: Studies reporting biological effects of radiofrequency radiation (RFR) at low intensities. Compiled by Henry C. Lai, PhD, Research Professor of Bioengineering, University of Washington, Jan. 21, 2005.
[3] This committee has since been renamed the International Committee on Electromagnetic Safety (ICES).
[4] See Addendum 2: June 19, 1999 letter and list of the 1999 RFIAWG members.

6. Uncertainty factors.
7. Intensity or frequency modulated (pulsed or frequency modulated) RF radiation.
8. Time averaging.
9. Lack of peak (or ceiling) limits for induced and contact currents.
10. Criteria for preventing hazards caused by transient discharges.
11. Limits for exposure at microwave frequencies.
12. Replication/Validation (of published peer-reviewed scientific studies).
13. Important health effects literature areas.
14. Compatibility of RFR guidelines.

On July 16, 2003, Norbert Hankin, Chairman of RFIAWG and specialist at the Radiation Protection Division of the Environmental Protection Agency (EPA) sent a letter[5] to C.K. Chou of Motorola, current Chairman of IEEE/ICES SC4, in response to ICES's proposal for a meeting with RFIAWG to respond to the June 1999 letter. Dr. Chou proposed to give RFIAWG an update of the revision ICES is proposing for its RF exposure standards. Mr. Hankin requested:

> *. . . responses to the 14 issues raised by the RFIAWG in the June 17, 1999 letter to Richard Tell . . . The RFIAWG is particularly interested in how these 14 issues are to be treated in the revision process. In addition, the RFIAWG is submitting the following additional issues for the ICES consideration and response:*
>
> - ***Issue: Exclusion of the pinna (external ear to be considered as a extremity).***
> *. . . If thermal effects would be the basis for the ICES standard, then the thermophysiology of the pinna and the skin, bone, and other head tissues adjacent to the pinna should be* ***discussed for all body sizes exposed.*** (Emphasis added.)
>
> - ***Issue: Rationale for relaxation of current limits.***
> *Federal agencies, as well as the general public and the public health community, are very concerned about a relaxation of exposure guidelines that may result in increased exposure in the future. A rationale should be presented for relaxation of standards. The rationale should include a clear explanation of the impact of the exposure that may result, i.e., the description of the exposures and the effects on critical tissues and organs. An explanation should be given as to why the current standard should be relaxed.* ***The issue of safety factors should also be addressed as part of the rationale for relaxation of current limits.*** (Emphasis added.)
>
> - ***Issue: sensitivity of different tissues.***
> *A clear explanation on how the revision has taken into account sensitivity of different tissues to temperature.* ***Effects of acute and chronic exposure to elevated temperature should be adequately covered. We consider it appropriate to include as a part of the revised standard a description of the risk analysis that was done.*** (Emphasis added.)
>
> *We ask that the RFIAWG be provided with a copy of the ICES response to all of the issues raised by the RFIAWG in advance of a meeting so that the Work Group members have sufficient time to study them and prepare for the meeting.*

[5] See Addendum 3: July 16, 2003 letter and list of the 2003 RFIAWG members.

III. BECAUSE RFIAWG's 17 ISSUES ADDRESS RF RADIATION EXPOSURE IMPACTS ON THE QUALITY OF THE HUMAN ENVIRONMENT AS NEPA REQUIRES, FCC MUST GIVE THEM WEIGHT

At present, Congress has directed that FCC bear the greatest responsibility of any federal agency to assure that its RF radiation safety rules prevent potential harm to the human environment in compliance with NEPA requirements. In May 1992, EPA issued *Guidelines for Exposure Assessment* [FRL-4129-5][6] to establish a broad framework for exposure assessments under NEPA by describing:

> *. . . the general concepts of exposure assessment including definitions and associated units, and by providing guidance on the planning and conducting of an exposure assessment.* ***Guidance is also provided on presenting the results of the exposure assessment and characterizing uncertainty.*** *Although these Guidelines focus on exposures of humans to chemical substances, much of the guidance contained herein also pertains to assessing wildlife exposure to chemicals, or* ***human exposures to*** *biological, noise, or* ***radiological agents****.* ***Since these latter four areas present unique challenges, assessments on these topics must consider additional factors beyond the scope of these Guidelines. pp. 1-2.*** (Emphasis added.)

Elements of risk/exposure assessment addressed in EPA's *Guidelines* include consideration of the size of the populations exposed, and the magnitude, frequency and duration of exposure, as well as evaluation of the nature of the exposed populations, i.e.:

- Individuals at high risk who are either more susceptible to adverse effects of an environmental agent than others in the population - such as children or the elderly - or who are highly exposed individuals, or both.
- Populations at higher risk due to the way the risk burden in distributed among various segments of the subject population. The segments (or subgroups) could be divided by geographic location, age, sex, ethnic background, lifestyle, economic factors, or other demographic variables, or groups of persons with a typical sensitivity or susceptibility, such as asthmatics.
- A multidisciplinary approach that encompasses the expertise of a variety of scientists.
- Non-linear dose-response models that may consider thresholds, windows, or other discontinuities.
- A special case of subpopulation for children for exposures that take place during childhood.
- Responsibility to present not just numbers but also a clear and explicit explanation of the implications and limitations of their analyses. Uncertainty characterization helps carry out this responsibility. The reward for analyzing uncertainties is knowing that the results have integrity or that significant gaps exist in available information that can make decision-making a tenuous process.
- Each measure or estimate of exposure will have its associated uncertainty which should be addressed both qualitatively and quantitatively.

[6] See: http://oaspub.epa.gov/eims/eimscomm.getfile?p_download_id=4544

IV. IEEE'S ICES SEEKS RFIAWG INPUT WHILE FCC MINIMIZES RFIAWG CONTRIBUTION TO RF RADIATION POLICY DEVELOPMENT

Four years after RFIAWG's letter laid out its 14 issues of concern regarding IEEE/ICES's human RF exposure standards, current ICES Chairman Chou made a request to meet with RFIAWG. The purpose was to provide an update of the revision to the RF exposure standards on which ICES is now working. RFIAWG Chairman Hankin's July 16, 2003 letter in response indicates that despite the intervening four years and the fact that ICES now desires to make its case regarding proposed revisions to the C95.1-199 standard, ICES has not answered the original 14 questions and RFIAWG expects those questions to be addressed before revisions can be discussed.

At the same time, FCC dismissed a Petition for Inquiry that was based on RFIAWG's 14 issues by minimizing the activities of RFIAWG.[7] In its dismissal, FCC stated:

> *We agree that in this letter, knowledgeable individuals appropriately identified issues of potential interest in setting RF exposure guidelines. These ideas had been solicited by another working group of experts convened to consider just such matters, the IEEE Risk Assessment Working Group. It is telling, however, that the letter specifically noted that it did not reflect the views of the respective agencies by which the individual IWG members are employed.*

Is the public to believe that FCC views RFIAWG's activities as merely an academic exercise that has no bearing on U.S. RF radiation policy development? The individual members of RFIAWG were chosen by their respective agencies for their RF-health expertise and, therefore, the importance of this working group cannot be dismissed out of hand. Currently two of the RFIAWG members work for FCC's Office of Engineering and Technology; and the IEEE's ICES seeks RFIWAG's perspective on its proposed revision to RF radiation exposure standards. In addition, RFIAWG's approach to RF policy development follows EPA's *Guidelines* for risk assessment by addressing the impacts on the quality of the human environment brought about by the ever-increasing exposure to ambient levels of RF radiation. The current FCC's proposal for RF rule making cannot arbitrarily leave out this most important consideration and the issues raised by RFIAWG.

[7] The EMR Network petition for rule making to revise FCC's RF exposure guidelines was dismissed in 2001. Letter from Bruce A. Franca, Acting Chief of the Commission's Office of Engineering and Technology, to James R. Hobson, EMR Network, December 11, 2001. FCC Order 03-191, a dismissal of the petition for reconsideration of the Franca dismissal, was released on August 14, 2003

To be in compliance with NEPA requirements, the current FCC rule making proceeding must examine RF interference with living human cellular physiology with as close a scrutiny as is being applied by wireless industry providers to RF interference with the operations of their electronic infrastructure for Advanced Wireless Services.

V. CONCLUSION

Human exposure to ambient levels of RF radiation is a question of public health policy, not merely one of engineering feasibility. If FCC is to comply with NEPA requirements, it must find a way to answer these important public health questions from a public health perspective. The current FCC NPRM examining Service Rules for Advanced Wireless Services does not reflect that NEPA responsibility.

For the reasons presented above, CARE proposes that the FCC postpone the implementation of its proposed rules relating to increasing the broadband spectrum available for advanced wireless services until the completion and thorough review of the research and studies recommended above and the preparation of an EIS in full compliance with the National Environmental Policy Act.

Respectfully submitted,

Canyon Area Residents for the Environment

(electronic filing)

Dated: January 24, 2005

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Addendum 1

1/21/05

Studies reporting biological effects of radiofrequency radiation (RFR) at low intensities
Compiled by Henry C. Lai, PhD, Research Professor of Bioengineering, University of Washington.

(1) Balode (1996)- blood cells from cows from a farm close and in front of a radar showed significantly higher level of severe genetic damage.

(2) Boscol et al. (2001)- RFR from radio transmission stations (0.005 mW/cm^2) affects immunological system in women.

(3) Chiang et al. (1989)- people who lived and worked near radio antennae and radar installations showed deficits in psychological and short-term memory tests**.**

(4) de Pomerai et al. (2000, 2002) reported an increase in a molecular stress response in cells after exposure to a RFR at a SAR of 0.001 W/kg. This stress response is a basic biological process that is present in almost all animals - including humans.

(5) de Pomerai et al. (2003) RFR damages proteins at 0.015-0.020 W/kg.

(6) D'Inzeo et al. (1988)- very low intensity RFR (0.002 – 0.004 mW/cm^2) affects the operation of acetylcholine-related ion-channels in cells. These channels play important roles in physiological and behavioral functions.

(7) Dolk et al. (1997)- a significant increase in adult leukemias was found in residence who lived near the Sutton Coldfield television (TV) and frequency modulation (FM) radio transmitter in England.

(8) Dutta et al. (1989) reported an increase in calcium efflux in cells after exposure to RFR at 0.005 W/kg. Calcium is an important component of normal cellular functions.

(9) Fesenko et al. (1999) reported a change in immunological functions in mice after exposure to RFR at a power density of 0.001 mW/cm^2.

(10) Hjollund et al. (1997)- sperm counts of Danish military personnel, who operated mobile ground-to-air missile units that use several RFR emitting radar systems (maximal mean exposure 0.01 mW/cm^2), were significantly low compared to references.

(11) Hocking et al. (1996)- an association was found between increased childhood leukemia incidence and mortality and proximity to TV towers.

(12) Ivaschuk et al. (1999)- short-term exposure to cellular phone RFR of very low SAR (26 mW/kg) affected a gene related to cancer.

(13) Kolodynski and Kolodynska (1996)- school Children lived in front of a radio station had less developed memory and attention, their reaction time was slower, and their neuromuscular apparatus endurance was decreased.

(14) Kwee et al. (2001)- 20 minutes of cell phone RFR exposure at 0.0021 W/kg increased stress protein in human cells.

(15) Lebedeva et al. (2000)- brain wave activation was observed in human subjects exposed to cellular phone RFR at 0.06 mW/cm^2.

(16) Magras and Xenos (1999) reported a decrease in reproductive function in mice exposed to RFR at power densities of 0.000168 - 0.001053 mW/cm^2.

(17) Mann et al. (1998)- a transient increase in blood cortisol was observed in human subjects exposed to cellular phone RFR at 0.02 mW/cm^2. Cortisol is a hormone involved in stress reaction.

(18) Marinelli et al. (2004)- exposure to 900-MHz RFR at 0.0035 W/kg affected cell's self-defense responses.

(19) Michelozzi et al. (1998)- leukemia mortality within 3.5 km (5,863 inhabitants) near a high power radio-transmitter in a peripheral area of Rome was higher than expected.

(20) Michelozzi et al. (2002)- childhood leukemia higher at a distance up to 6 km from a radio station.

(21) Navakatikian and Tomashevskaya (1994)- RFR at low intensities (0.01 - 0.1 mW/cm^2; 0.0027- 0.027 W/kg) induced behavioral and endocrine changes in rats. Decreases in blood concentrations of testosterone and insulin were reported.

(22) Novoselova et al. (1999)-low intensity RFR (0.001 mW/cm^2) affects functions of the immune system.

(23) Novoselova et al. (2004)- chronic exposure to RFR (0.001 mW/cm^2) decreased tumor growth rate and enhanced survival in mice.

(24) Park et al. (2004) - higher mortality rates for all cancers and leukemia in some age groups in the area near the AM radio broadcasting towers.

(25) Persson et al. (1997) - reported an increase in the permeability of the blood-brain barrier in mice exposed to RFR at 0.0004 - 0.008 W/kg. The blood-brain barrier envelops the brain and protects it from toxic substances.

(26) Phillips et al. (1998) - reported DNA damage in cells exposed to RFR at SAR of 0.0024 - 0.024 W/kg.

(27) Polonga-Moraru et al. (2002) - change in membrane of cells in the retina (eye) after exposure to RFR at 15 μW/cm^2.

(28) Pyrpasopoulou et al. (2004) - exposure to cell phone radiation during early gestation at SAR of 0.0005 W/kg (5 μW/cm^2) affected kidney development in rats.

(29) Salford et al. (2003)- nerve cell damage in brain of rats exposed for 2 hrs to GSM signal at 0.02 W/kg.

(30) Santini et al. (2002)- increase in complaint frequencies for tiredness, headache, sleep disturbance, discomfort, irritability, depression, loss of memory, dizziness, libido decrease, in people who lived within 300 m of mobile phone base stations.

(31) Sarimov et al. (2004)- GSM microwaves affect human lymphocyte chromatin similar to stress response at 0.0054 W/kg.

(32) Schwartz et al. (1990)- calcium movement in the heart affected by RFR at SAR of 0.00015 W/kg. Calcium is important in muscle contraction. Changes in calcium can affect heart functions.

(33) Somosy et al. (1991)- RFR at 0.024 W/kg caused molecular and structural changes in cells of mouse embryos.

(34) Stagg et al. (1997)- glioma cells exposed to cellular phone RFR at 0.0059 W/kg showed significant increases in thymidine incorporation, which may be an indication of an increase in cell division.

(35) Stark et al. (1997)- a two- to seven-fold increase of salivary melatonin concentration was observed in dairy cattle exposed to RFR from a radio transmitter antenna.

(36) Tattersall et al. (2001)- low-intensity RFR (0.0016 - 0.0044 W/kg) can modulate the function of a part of the brain called the hippocampus, in the absence of gross thermal effects. The changes in excitability may be consistent with reported behavioral effects of RFR, since the hippocampus is involved in learning and memory.

(37) Vangelova et al. (2002)- operators of satellite station exposed to low dose (0.1127 J/kg) of RFR over a 24-hr shift showed an increased excretion of stress hormones.

(38) Velizarov et al. (1999) - showed a decrease in cell proliferation (division) after exposure to RFR of 0.000021 - 0.0021 W/kg.

(39) Veyret et al. (1991)- low intensity RFR at SAR of 0.015 W/kg affects functions of the immune system.

(40) Wolke et al. (1996)- RFR at 0.001W/kg affects calcium concentration in heart muscle cells of guinea pigs.

Source of literature and abstracts:

(1) Balode, Z, Assessment of radio-frequency electromagnetic radiation by the micronucleus test in bovine peripheral erythrocytes. *Sci Total Environ* 180(1):81-85, 1996.

Previous bioindicative studies in the Skrunda Radio Location Station area have focused on the somatic influence of electromagnetic radiation on plants, but it is also important to study genetic effects. We have chosen cows as test animals for cytogenetical evaluation because they live in the same general exposure area as humans, are confined to specific locations and are chronically exposed to radiation. Blood samples were obtained from female Latvian Brown cows from a farm

close to and in front of the Skrunda Radar and from cows in a control area. A simplified alternative to the Schiff method of DNA staining for identification of micronuclei in peripheral erythrocytes was applied. Microscopically, micronuclei in peripheral blood erythrocytes were round in shape and exhibited a strong red colour. They are easily detectable as the only coloured bodies in the uncoloured erythrocytes. From each individual animal 2000 erythrocytes were examined at a magnification of x 1000 for the presence of micronuclei. The counting of micronuclei in peripheral erythrocytes gave low average incidences, 0.6 per 1000 in the exposed group and 0.1 per 1000 in the control, but statistically significant ($P < 0.01$) differences were found in the frequency distribution between the control and exposed groups.

(2) Boscol P, Di Sciascio MB, D'Ostilio S, Del Signore A, Reale M, Conti P, Bavazzano P, Paganelli R, Di Gioacchino M. Effects of electromagnetic fields produced by radiotelevision broadcasting stations on the immune system of women. *Sci Total Environ* 273(1-3):1-10, 2001.

The object of this study was to investigate the immune system of 19 women with a mean age of 35 years, for at least 2 years (mean = 13 years) exposed to electromagnetic fields (ELMFs) induced by radiotelevision broadcasting stations in their residential area. In September 1999, the ELMFs (with range 500 KHz-3 GHz) in the balconies of the homes of the women were (mean +/- S.D.) 4.3 +/- 1.4 V/m. Forty-seven women of similar age, smoking habits and atopy composed the control group, with a nearby resident ELMF exposure of < 1.8 V/m. Blood lead and urinary trans-trans muconic acid (a metabolite of benzene), markers of exposure to urban traffic, were higher in the control women. The ELMF exposed group showed a statistically significant reduction of blood NK CD16+-CD56+, cytotoxic CD3(-)-CD8+, B and NK activated CD3(-)-HLA-DR+ and CD3(-)-CD25+ lymphocytes. 'In vitro' production of IL-2 and interferon-gamma (INF-gamma) by peripheral blood mononuclear cells (PBMC) of the ELMF exposed group, incubated either with or without phytohaemoagglutinin (PHA), was significantly lower; the 'in vitro' production of IL-2 was significantly correlated with blood CD16+-CD56+ lymphocytes. The stimulation index (S.I.) of blastogenesis (ratio between cell proliferation with and without PHA) of PBMC of ELMF exposed women was lower than that of the control subjects. The S.I. of blastogenesis of the ELMF exposed group (but not blood NK lymphocytes and the 'in vitro' production of IL-2 and INF-gamma by PBMC) was significantly correlated with the ELMF levels. Blood lead and urinary trans-trans muconic acid were barely correlated with immune parameters: the urinary metabolite of benzene of the control group was only correlated with CD16+-CD56+ cells indicating a slight effect of traffic on the immune system. In conclusion, this study demonstrates that high frequency ELMFs reduce cytotoxic activity in the peripheral blood of women without a dose-response effect.

(3) Chiang H, Yao GD, Fang QS, Wang KQ, Lu DZ, Zhou YK, Health effects of environmental electromagnetic fields. *J. Bioelectricity* 8:127-131, 1989.

We investigated the effects of exposure to environmental electromagnetic fields (EMFs) in 1170 subjects. Neutrophil phagocytosis was enhanced in the low-intensity exposure groups, but reduced significantly at relatively higher intensities. Visual reaction time was prolonged and the scores of short-term memory tests were lower in some high-intensity exposure groups. EMFs may affect the central nervous and immune systems in man.

(4) de Pomerai D, Daniells C, David H, Allan J, Duce I, Mutwakil M, Thomas D, Sewell P, Tattersall J, Jones D, Candido P, Non-thermal heat-shock response to microwaves, *Nature* 405:417-418, 2000.

Nematode worms (C. elegans) exposed overnight to 750-MHz microwaves at a SAR of 0.001 W/kg showed an increased in heat shock proteins (HSPs). (Heat shock proteins are induced in most organisms by adverse conditions (such as heat or toxins) that cause damage to cellular proteins, acting as molecular chaperones to rescue damaged proteins). The authors give several arguments that the microwave-induced effect on HSPs is non-thermal and suggest that 'current exposure limits for microwave equipment may need to be reconsidered.'

de Pomerai DI, Dawe A, Djerbib L, Allan, Brunt G, Daniells C. Growth and maturation of the nematode *Caenorhabditis elegans* following exposure to weak microwave fields. *Enzyme Microbial Tech* 30:73-79, 2002.

Prolonged exposure to weak microwave fields (750–1000 MHz, 0.5 W) at 25°C induces a heat-shock response in transgenic *C. elegans* strains carrying *hsp16* reporter genes [1]. A comparable response to heat alone requires a substantially higher temperature of 28°C, suggesting that microwave heating of worms or of the system as a whole might provide a sufficient explanation, although this can be ruled out by indirect arguments [1]. Here we investigate two further biological consequences of prolonged microwave exposure at 25°C in synchronised cultures of wild-type worm larvae, namely alterations in (i) growth rate (GR) and (ii) the proportion of worms later maturing into egg-bearing adults (MP). Both of these parameters are significantly increased following microwave exposure (GR by 8–11%, and MP by 28–40%), whereas both are significantly decreased (GR by 10% and MP almost abolished) after mild heat treatment at 28°C for the same period. It follows that the biological consequences of microwave exposure are opposite to, and therefore incompatible with, those attributable to mild heating. This evidence does not in itself necessitate a non-thermal mechanism, but does eliminate explanations that invoke the bulk heating of tissues by microwaves. This latter, however, remains the sole basis for current regulations governing microwave exposure.

(5) de Pomerai DI, Smith B, Dawe A, North K, Smith T, Archer DB, Duce IR, Jones D, Candido EP. Microwave radiation can alter protein conformation without bulk heating. *FEBS Lett* 22;543(1-3):93-97, 2003.

Exposure to microwave radiation enhances the aggregation of bovine serum albumin in vitro in a time- and temperature-dependent manner. Microwave radiation also promotes amyloid fibril formation by bovine insulin at 60 degrees C. These alterations in protein conformation are not accompanied by measurable temperature changes, consistent with estimates from field modelling of the specific absorbed radiation (15-20 mW kg(-1)). Limited denaturation of cellular proteins could explain our previous observation that modest heat-shock responses are induced by microwave exposure in Caenorhabditis elegans. We also show that heat-shock responses both to heat and microwaves are suppressed after RNA interference ablating heat-shock factor function.

(6) D'Inzeo G, Bernardi P, Eusebi F, Grassi F, Tamburello C, Zani BM, Microwave effects on acetylcholine-induced channels in cultured chick myotubes. *Bioelectromagnetics* 9(4):363-372, 1988.

The behavior of cultured myotubes from chick embryos exposed to microwaves has been experimentally analyzed. Recordings of acetylcholine-induced currents have been obtained via patch-clamp techniques using both cell-attached (single-channel current recording) and whole-cell (total current recording) configurations. During the exposure to low-power microwaves the frequency of the ACh-activated single channel openings decreased, while the ACh-induced total current

showed a faster falling phase. Channel open time and conductance were not affected by microwave irradiation. It is concluded that the exposure to microwaves increases the rate of desensitization and decreases the channel opening probability. The nonthermal origin and the molecular interaction mechanisms governing these electromagnetic-induced effects are discussed.

(7) Dolk H, Shaddick G, Walls P, Grundy C, Thakrar B, Kleinschmidt I, Elliott P, Cancer incidence near radio and television transmitters in Great Britain. I. Sutton Coldfield transmitter. *Am J Epidemiol* 145(1):1-9, 1997.

A small area study of cancer incidence in 1974-1986 was carried out to investigate an unconfirmed report of a "cluster" of leukemias and lymphomas near the Sutton Coldfield television (TV) and frequency modulation (FM) radio transmitter in the West Midlands, England. The study used a national database of postcoded cancer registrations, and population and socioeconomic data from the 1981 census. Selected cancers were hematopoietic and lymphatic, brain, skin, eye, male breast, female breast, lung, colorectal, stomach, prostate, and bladder. Expected numbers of cancers in small areas were calculated by indirect standardization, with stratification for a small area socioeconomic index. The study area was defined as a 10 km radius circle around the transmitter, within which 10 bands of increasing distance from the transmitter were defined as a basis for testing for a decline in risk with distance, and an inner area was arbitrarily defined for descriptive purposes as a 2 km radius circle. The risk of adult leukemia within 2 km was 1.83 (95% confidence interval 1.22-2.74), and there was a significant decline in risk with distance from the transmitter (p = 0.001). These findings appeared to be consistent over the periods 1974-1980, 1981-1986, and were probably largely independent of the initially reported cluster, which appeared to concern mainly a later period. In the context of variability of leukemia risk across census wards in the West Midlands as a whole, the Sutton Coldfield findings were unusual. A significant decline in risk with distance was also found for skin cancer, possibly related to residual socioeconomic confounding, and for bladder cancer. Study of other radio and TV transmitters in Great Britain is required to put the present results in wider context. No causal implications can be made from a single cluster investigation of this kind.

(8) Dutta SK, Ghosh B, Blackman CF, Radiofrequency radiation-induced calcium ion efflux enhancement from human and other neuroblastoma cells in culture. *Bioelectromagnetics* 1989;10(2):197-202

To test the generality of radiofrequency radiation-induced changes in 45Ca2+ efflux from avian and feline brain tissues, human neuroblastoma cells were exposed to electromagnetic radiation at 147 MHz, amplitude-modulated (AM) at 16 Hz, at specific absorption rates (SAR) of 0.1, 0.05, 0.01, 0.005, 0.001, and 0.0005 W/kg. Significant 45Ca2+ efflux was obtained at SAR values of 0.05 and 0.005 W/kg. Enhanced efflux at 0.05 W/kg peaked at the 13-16 Hz and at the 57.5-60 Hz modulation ranges. A Chinese hamster-mouse hybrid neuroblastoma was also shown to exhibit enhanced radiation-induced 45Ca2+ efflux at an SAR of 0.05 W/kg, using 147 MHz, AM at 16 Hz. These results confirm that amplitude-modulated radiofrequency radiation can induce responses in cells of nervous tissue origin from widely different animal species, including humans. The results are also consistent with the reports of similar findings in avian and feline brain tissues and indicate the general nature of the phenomenon.

(9) Fesenko, EE, Makar, VR, Novoselova, EG, Sadovnikov, VB, Microwaves and cellular immunity. I. Effect of whole body microwave irradiation on tumor necrosis factor production in mouse cells. *Bioelectrochem Bioenerg* 49(1):29-35, 1999.

Whole body microwave sinusoidal irradiation of male NMRI mice with 8.15-18 GHz (1 Hz within) at a power density of 1 microW/cm2 caused a significant enhancement of TNF production in peritoneal macrophages and splenic T lymphocytes. Microwave radiation affected T cells, facilitating their capacity to proliferate in response to mitogenic stimulation. The exposure duration necessary for the stimulation of cellular immunity ranged from 5 h to 3 days. Chronic irradiation of mice for 7 days produced the decreasing of TNF production in peritoneal macrophages. The exposure of mice for 24 h increased the TNF production and immune proliferative response, and these stimulatory effects persisted over 3 days after the termination of exposure. Microwave treatment increased the endogenously produced TNF more effectively than did lipopolysaccharide, one of the most potential stimuli of synthesis of this cytokine. The role of microwaves as a factor interfering with the process of cell immunity is discussed.

(10) Hjollund NH, Bonde JP, Skotte J, Semen analysis of personnel operating military radar equipment. *Reprod Toxicol* 11(6):897, 1997.

This is a preliminary survey of semen quality among Danish military personnel operating mobile ground-to-air missile units that use several microwave emitting radar systems. The maximal mean exposure was estimated to be 0.01 mW/cm2. The median sperm density of the military personnel was significantly low compared to the references. The difference is either due to chance, uncontrolled bias, or nonthermal effects of transitory microwaves.

(11) Hocking B, Gordon IR, Grain HL, Hatfield GE, Cancer incidence and mortality and proximity to TV towers. *Med J Aust* 165(11-12):601-605, 1996.

(Published erratum appears in *Med J Aust* 166(2):80, 1997.)
OBJECTIVE: To determine whether there is an increased cancer incidence and mortality in populations exposed to radiofrequency radiations from TV towers. DESIGN: An ecological study comparing cancer incidence and mortality, 1972-1990, in nine municipalities, three of which surround the TV towers and six of which are further away from the towers. (TV radiofrequency radiation decreases with the square of the distance from the source.) Cancer incidence and mortality data were obtained from the then Commonwealth Department of Human Services and Health. Data on frequency, power, and period of broadcasting for the three TV towers were obtained from the Commonwealth Department of Communications and the Arts. The calculated power density of the radiofrequency radiation in the exposed area ranged from 8.0 microW/cm2 near the towers to 0.2 microW/cm2 at a radius of 4km and 0.02 microW/cm2 at 12 km. SETTING: Northern Sydney, where three TV towers have been broadcasting since 1956. OUTCOME MEASURES: Rate ratios for leukaemia and brain tumour incidence and mortality, comparing the inner with the outer areas. RESULTS: For all ages, the rate ratio for total leukaemia incidence was 1.24 (95% confidence interval [CI], 1.09-1.40). Among children, the rate ratio for leukaemia incidence was 1.58 (95% CI, 1.07-2.34) and for mortality it was 2.32 (95% CI, 1.35-4.01). The rate ratio for childhood lymphatic leukaemia (the most common type) was 1.55 (95% CI, 1.00-2.41) for incidence and 2.74 (95% CI, 1.42-5.27) for mortality. Brain cancer incidence and mortality were not increased. CONCLUSION: We found an association between increased childhood leukaemia incidence and mortality and proximity to TV towers.

(12) Ivaschuk OI, Jones RA, Ishida-Jones T, Haggren W, Adey WR, Phillips JL, Exposure of nerve growth factor-treated PC12 rat pheochromocytoma cells to a modulated radiofrequency field at 836.55 MHz: effects on c-jun and c-fos expression. *Bioelectromagnetics* 18(3):223-229, 1997.

Rat PC12 pheochromocytoma cells have been treated with nerve growth factor And then exposed to athermal levels of a packet-modulated radiofrequency field At 836.55 MHz. This signal was produced by a prototype time-domain multiple-access (TDMA) transmitter that conforms to the North American digital cellular telephone standard. Three slot average power densities were used: 0.09, 0.9, and 9 mW/cm2. Exposures were for 20, 40, and 60 min and included an intermittent exposure regimen (20 min on/20 min off), resulting in total incubation times of 20, 60, and 100 min, respectively. Concurrent controls were sham exposed. After extracting total cellular RNA, Northern blot analysis was used to assess the expression of the immediate early genes, c-fos and c-jun, in all cell populations. No change in c-fos transcript levels were detected after 20 min exposure at each field intensity (20 min was the only time period at which c-fos message could be detected consistently). Transcript levels for c-jun were altered only after 20 min exposure to 9 mW/cm2 (average 38% decrease).

(13) Kolodynski AA, Kolodynska VV, Motor and psychological functions of school children living in the area of the Skrunda Radio Location Station in Latvia*. Sci Total Environ* 180(1):87-93, 1996.

This paper presents the results of experiments on school children living in the area of the Skrunda Radio Location Station (RLS) in Latvia. Motor function, memory and attention significantly differed between the exposed and control groups. Children living in front of the RLS had less developed memory and attention, their reaction time was slower and their neuromuscular apparatus endurance was decreased.

(14) Kwee S, Raskmark P, Velizarov P. Changes in cellular proteins due to environmental non-ionizing radiation. I. Heat-shock proteins. *Electro- and Magnetobiology* 20: 141-152, 2001.

This paper describes the effect of weak microwave fields on the amounts of heat-shock proteins in cell cultures at various temperatures. The field was generated by signal simulation of the Global System for Mobile communications (GSM) of 960 Mhz, used in portable phones. Transformed human epithelial amnion (AMA) cells, growing on glass coverslips, were exposed in a transverse electromagnetic (TEM) cell to a microwave field, generating a specific absorption rate (SAR) of 2.1 $mW.kg^{-1}$ in the cells. Exposure temperatures were 35, 37, and 40 ± 0.1°C, respectively, and the exposure time was 20 min. The heat-shock proteins Hsp-70 and Hsp-27 were detected by immuno-fluorescence. Higher amounts of Hsp-70 were present in the cells exposed at 35 and 37°C than in the sham-exposed cells. These effects can be considered to be athermal, since the field strength was much lower than the safety standard for absence of heat generation by microwave fields. There was no significant response in the case of Hsp-27.

(15) Lebedeva NN, Sulimov AV, Sulimova OP, Kotrovskaya TI, Gailus T, Cellular phone electromagnetic field effects on bioelectric activity of human brain. *Crit Rev Biomed Eng* 28(1-2):323-337, 2000.

24 volunteers participated in the experiments. The investigation of EEG reactions to cellular phone (EMF frequency 902.4 MHz and intensity 0.06 mW/cm2) was conducted. Two experiments were performed with each subject--cellular phone exposure and Placebo Duration of the experiment was 60 min: 15 min--background; 15 min--EMF exposure or Placebo; 30 min—after exposure. EEG was recorded in 16 standard leads with "eyes open" and "eyes closed". Special software with non-linear dynamics was developed for EEG analyses. One parameter, multichannel (global) correlation dimension, was calculated. The changes of these parameters can be evidence of brain functional state changes. As a result of EEG record processing, a significant increase of global correlation dimension during the exposure and after exposure period was discovered, more pronounced in the case of "eyes closed". That can be viewed as the manifestation of cortex activation under phone EMF exposure.

(16) Magras, IN, Xenos, TD, RF radiation-induced changes in the prenatal development of mice. *Bioelectromagnetics* 18(6):455-461, 1997.

The possible effects of radiofrequency (RF) radiation on prenatal development has been investigated in mice. This study consisted of RF level measurements and in vivo experiments at several places around an "antenna park." At these locations RF power densities between 168 nW/cm2 and 1053 nW/cm2 were measured. Twelve pairs of mice, divided in two groups, were placed in locations of different power densities and were repeatedly mated five times. One hundred eighteen newborns were collected. They were measured, weighed, and examined macro- and microscopically. A progressive decrease in the number of newborns per dam was observed, which ended in irreversible infertility. The prenatal development of the newborns, however, evaluated by the crown-rump length, the body weight, and the number of the lumbar, sacral, and coccygeal vertebrae, was improved.

(17) Mann, K, Wagner, P, Brunn, G, Hassan, F, Hiemke, C, Roschke, J, Effects of pulsed high-frequency electromagnetic fields on the neuroendocrine system. *Neuroendocrinology* 67(2):139-144, 1998.

The influence of pulsed high-frequency electromagnetic fields emitted from a circularly polarized antenna on the neuroendocrine system in healthy humans was investigated (900 MHz electromagnetic field, pulsed with 217 Hz, average power density 0.02 mW/cm2). Nocturnal hormone profiles of growth hormone (GH), cortisol, luteinizing hormone (LH) and melatonin were determined under polysomnographic control. An alteration in the hypothalamo-pituitary-adrenal axis activity was found with a slight, transient elevation in the cortisol serum level immediately after onset of field exposure which persisted for 1 h. For GH, LH and melatonin, no significant effects were found under exposure to the field compared to the placebo condition, regarding both total hormone production during the entire night and dynamic characteristics of the secretion pattern. Also the evaluation of the sleep EEG data revealed no significant alterations under field exposure, although there was a trend to an REM suppressive effect. The results indicate that weak high-frequency electromagnetic fields have no effects on nocturnal hormone secretion except for a slight elevation in cortisol production which is transient, pointing to an adaptation of the organism to the stimulus.

(18) Marinelli F, La Sala D, Cicciotti G, Cattini L, Trimarchi C, Putti S, Zamparelli A, Giuliani L, Tomassetti G, Cinti C. Exposure to 900 MHz electromagnetic field induces an unbalance between pro-apoptotic and pro-survival signals in T-lymphoblastoid leukemia CCRF-CEM cells. *J Cell Physiol.* 198(2):324-332, 2004.

It has been recently established that low-frequency electromagnetic field (EMFs) exposure induces biological changes and could be associated with increased incidence of cancer, while

the issue remains unresolved as to whether high-frequency EMFs can have hazardous effect on health. Epidemiological studies on association between childhood cancers, particularly leukemia and brain cancer, and exposure to low- and high-frequency EMF suggested an etiological role of EMFs in inducing adverse health effects. To investigate whether exposure to high-frequency EMFs could affect in vitro cell survival, we cultured acute T-lymphoblastoid leukemia cells (CCRF-CEM) in the presence of unmodulated 900 MHz EMF, generated by a transverse electromagnetic (TEM) cell, at various exposure times. We evaluated the effects of high-frequency EMF on cell growth rate and apoptosis induction, by cell viability (MTT) test, FACS analysis and DNA ladder, and we investigated pro-apoptotic and pro-survival signaling pathways possibly involved as a function of exposure time by Western blot analysis. At short exposure times (2-12 h), unmodulated 900 MHz EMF induced DNA breaks and early activation of both p53-dependent and -independent apoptotic pathways while longer continuous exposure (24-48 h) determined silencing of pro-apoptotic signals and activation of genes involved in both intracellular (Bcl-2) and extracellular (Ras and Akt1) pro-survival signaling. Overall our results indicate that exposure to 900 MHz continuous wave, after inducing an early self-defense response triggered by DNA damage, could confer to the survivor CCRF-CEM cells a further advantage to survive and proliferate.

(19) Michelozzi P, Ancona C, Fusco D, Forastiere F, Perucci CA, Risk of leukemia and residence near a radio transmitter in Italy. *Epidemiology* 9 (Suppl) 354p, 1998.

We conducted a small area study to investigate a cluster of leukemia near a high power radio-transmitter in a peripheral area of Rome. The leukemia mortality within 3.5 km (5,863 inhabitants) was higher than expected (SMR=2.5, 95% confident interval 1.07-4.83); the excess was due to a significant higher mortality among men (7 cases observed, SMR=3.5). The results of the Stone's test, after adjusting for socio-economic confounding, showed a significant decline in risk with distance from the transmitter only among men (p=0.005), whereas the p-value for both sexes was p=0.07.

(20) Michelozzi P, Capon A, Kirchmayer U, Forastiere F, Biggeri A, Barca A, Perucci CA. Adult and childhood leukemia near a high-power radio station in Rome, Italy. *Am J Epidemiol* 155(12):1096-1103, 2002.

Some recent epidemiologic studies suggest an association between lymphatic and hematopoietic cancers and residential exposure to high-frequency electromagnetic fields (100 kHz to 300 GHz) generated by radio and television transmitters. Vatican Radio is a very powerful station located in a northern suburb of Rome, Italy. In the 10-km area around the station, with 49,656 residents (in 1991), leukemia mortality among adults (aged >14 years; 40 cases) in 1987-1998 and childhood leukemia incidence (eight cases) in 1987-1999 were evaluated. The risk of childhood leukemia was higher than expected for the distance up to 6 km from the radio station (standardized incidence rate = 2.2, 95% confidence interval: 1.0, 4.1), and there was a significant decline in risk with increasing distance both for male mortality (p = 0.03) and for childhood leukemia (p = 0.036). The study has limitations because of the small number of cases and the lack of exposure data. Although the study adds evidence of an excess of leukemia in a population living near high-power radio transmitters, no causal implication can be drawn. There is still insufficient scientific knowledge, and new epidemiologic studies are needed to clarify a possible leukemogenic effect of residential exposure to radio frequency radiation.

(21) Navakatikian MA, Tomashevskaya LA, Phasic behavioral and endocrine effects of microwaves of nonthermal intensity. In "Biological Effects of Electric and Magnetic Fields, Volume 1," D.O. Carpenter (ed) Academic Press, San Diego, CA, 1994, pp.333-342.

Microwaves at nonthermal levels are able to induce behavioral and endocrine changes at low power densities (0.01-0.1 mW/cm2). Our studies have demonstrated several phases of inhibition and activation. We suggest that inhibition of behavior by microwaves has many mechanisms depending on the strength and duration of exposure, and most inhibitory effects from direct actions on the nervous system. Activation, on the other hand, is correlated well with decreases in serum concentrations of testosterone and insulin. CW microwaves, however, have no influence on the secretion of insulin.

(22) Novoselova, EG, Fesenko, EE, Makar, VR, Sadovnikov, VB, Microwaves and cellular immunity. II. Immunostimulating effects of microwaves and naturally occurring antioxidant nutrients. *Bioelectrochem Bioenerg* 49(1):37-41, 1999.

The effect of 8.15-18 GHz (1 Hz within) microwave radiation at a power density of 1 microW/cm2 on the tumor necrosis factor (TNF) production and immune response was tested. A single 5 h whole-body exposure induced a significant increase in TNF production in peritoneal macrophages and splenic T cells. The mitogenic response in T lymphocytes increased after microwave exposure. The activation of cellular immunity was observed within 3 days after exposure. The diet containing lipid-soluble nutrients (beta-carotene, alpha-tocopherol and ubiquinone Q9) increased the activity of macrophages and T cells from irradiated mice. These results demonstrate that irradiation with low-power density microwaves stimulates the immune potential of macrophages and T cells, and the antioxidant treatment enhances the effect of microwaves, in particular at later terms, when the effect of irradiation is reduced.

(23) Novoselova EG, Ogay VB, Sorokina OV, Glushkova OV, Sinotova OA, Fesenko EE. The production of tumor necrosis factor in cells of tumor-bearing mice after total-body microwave irradiation and antioxidant diet. Electromag. Biol. Med. 23:167-180, 2004.

The effects of repeated treatment with weak microwaves (MW) (8.15–18 GHz, 1 μW/cm^2, 1.5 h daily) and diet with antioxidants (AO) (β-carotene, α-tocopherol, and ubiquinone Q_9) on production of tumor necrosis factor (TNF) in macrophages and T lymphocytes of healthy and tumor-bearing mice (TBM) were studied. Tumor size and mortality of TBM were also followed. Microwave radiation and antioxidant diet stimulated production of TNF in cells from healthy mice. At early stages, tumor growth induced TNF production in mouse cells; however, this effect decreased as tumors grew. In TBM exposed to MW, TNF production was higher than in unirradiated TBM. Oppositely, AO diet induced TNF production in healthy mice but did not affect TNF secretion in TBM. Accordingly, prolonged treatment of TBM to MW, but not to AO diet, decreased tumor growth rate and increased overall animal longevity. These results suggest that diminished tumor growth rate due to extremely low-level MW exposure of mice carrying tumors, at least in part, was caused by enhancement in TNF production and accumulation of plasma TNF.

(24) Park SK, Ha M, Im H-J. Ecological study on residences in the vicinity of AM radio broadcasting towers and cancer death: preliminary observations in Korea. *International Archives of Occupational and Environmental Health* 77(6):387-394, 2004.

Objectives Public health concern about the health effects of radio-frequency electromagnetic fields (RF-EMFs) has increased with the increase in public exposure. This study was to evaluate some health effect of RF exposure by the AM radio broadcasting towers in Korea.

Methods We calculated cancer mortality rates using Korean death certificates over the period of 1994–1995 and population census data in ten RF-exposed areas, defined as regions that included AM radio broadcasting towers of over 100 kW, and in control areas, defined as regions without a radio broadcasting tower inside and at least 2 km away from the towers.

Results All cancers-mortality was significantly higher in the exposed areas [direct standardized mortality rate ratio (MRR) =1.29, 95%CI=1.12–1.49]. When grouped by each exposed area and by electrical power, MRRs for two sites of 100 kW, one site of 250 kW and one site of 500 kW, for all subjects, and for one site of 100 kW and two sites of 250 kW, for male subjects, showed statistically significant increases without increasing trends according to the groups of electric power. Leukemia mortality was higher in exposed areas (MRR=1.70, 95% CI=0.84–3.45), especially among young adults aged under 30 years (0–14 years age group, MRR=2.29, 95% CI=1.05–5.98; 15–29 age group, MRR=2.44, 95% CI=1.07–5.24) .

Conclusions We observed higher mortality rates for all cancers and leukemia in some age groups in the area near the AM radio broadcasting towers. Although these findings do not prove a causal link between cancer and RF exposure from AM radio broadcasting towers, it does suggest that further analytical studies on this topic are needed in Korea.

(25) Persson BRR, Salford LG, Brun A, Blood-brain barrier permeability in rats exposed to electromagnetic fields used in wireless communication. *Wireless Network* 3:455-461, 1997.

Biological effects of radio frequency electromagnetic fields (EMF) on the blood-brain barrier (BBB) have been studied in Fischer 344 rats of both sexes. The rats were not anesthetised during the exposure. The brains were perfused with saline for 3-4 minutes, and thereafter perfusion fixed with 4% formaldehyde for 5-6 minutes. Whole coronal sections of the brains were dehydrated and embedded in paraffin and sectioned at 5 micrometers. Albumin and fibinogen were demonstrated immunochemically and classified as normal versus pathological leakage. In the present investigation we exposed male and female Fischer 344 rats in a Transverse Electromagnetic Transmission line camber to microwaves of 915 MHz as continuous wave (CW) and pulse-modulated with different pulse power and at various time intervals. The CW-pulse power varied from 0.001 W to 10 W and the exposure time from 2 min to 960 min. In each experiment we exposed 4-6 rats with 2-4 controls randomly placed in excited and non-excited TEM cells, respectively. We have in total investigated 630 exposed rats at various modulation frequencies and 372 controls. The frequency of pathological rats is significantly increased ($P < 0.0001$) from 62/372 (ratio 0.17 $\pm$ 0.02) for control rats to 244/630 (ratio: 0.39 $\pm$ 0.043) in all exposed rats. Grouping the exposed animals according to the level or specific absorption energy (J/kg) give significant difference in all levels above 1.5 J/kg. The exposure was 915 MHz microwaves either pulse modulated (PW) at 217 Hz with 0.57 ms pulse width, at 50 Hz with 6.6 ms pulse width or continuous wave (CW). The frequency of pathological rats (0.17) among controls in the various groups is not significantly different. The frequency of pathological rats was 170/480 (0.35 $\pm$ 0.03) among rats exposed to pulse modulated (PW) and 74/149 (0.50 $\pm$ 0.07) among rats exposed to continuous wave exposure (CW). These results are both highly significantly different to their corresponding controls ($p < 0.0001$) and the frequency

of pathological rats after exposure to pulsed radiation (PW) is significantly less ($p < 0.002$) than after exposure to continuous wave radiation (CW).

(26) Phillips, J.L., Ivaschuk, O., Ishida-Jones, T., Jones, R.A., Campbell-Beachler, M. and Haggren, W. DNA damage in Molt-4 T- lymphoblastoid cells exposed to cellular telephone radiofrequency fields in vitro. *Bioelectrochem. Bioenerg.* 45:103-110, 1998.

Molt-4 T-lymphoblastoid cells have been exposed to pulsed signals at cellular telephone frequencies of 813.5625 MHz (iDEN signal) and 836.55 MHz (TDMA signal). These studies were performed at low SAR (average = 2.4 and 24 microwatt/g for iDEN and 2.6 and 26 microwatt/g for TDMA) in studies designed to look for athermal RF effects. The alkaline comet, or single cell gel electrophoresis, assay was employed to measure DNA single-strand breaks in cell cultures exposed to the radiofrequency (RF) signal as compared to concurrent sham-exposed cultures. Tail moment and comet extent were calculated as indicators of DNA damage. Statistical differences in the distribution of values for tail moment and comet extent between exposed and control cell cultures were evaluated with the Kolmogorov-Smirnoff distribution test. Data points for all experiments of each exposure condition were pooled and analyzed as single groups. It was found that: 1) exposure of cells to the iDEN signal at an SAR of 2.4 microwatt/g for 2 h or 21 h significantly decreased DNA damage; 2) exposure of cells to the TDMA signal at an SAR of 2.6 microwatt/g for 2 h and 21 h significantly decreased DNA damage; 3) exposure of cells to the iDEN signal at an SAR of 24 microwatt/g for 2 h and 21 h significantly increased DNA damage; 4) exposure of cells to the TDMA signal at an SAR of 26 microwatt/g for 2 h significantly decreased DNA damage. The data indicate a need to study the effects of exposure to RF signals on direct DNA damage and on the rate at which DNA damage is repaired.

(27) Pologea-Moraru R, Kovacs E, Iliescu KR, Calota V, Sajin G. The effects of low level microwaves on the fluidity of photoreceptor cell membrane. *Bioelectrochemistry* 56(1-2):223-225, 2002.

Due to the extensive use of electromagnetic fields in everyday life, more information is required for the detection of mechanisms of interaction and the possible side effects of electromagnetic radiation on the structure and function of the organism.In this paper, we study the effects of low-power microwaves (2.45 GHz) on the membrane fluidity of rod photoreceptor cells. The retina is expected to be very sensitive to microwave irradiation due to the polar character of the photoreceptor cells [Biochim. Biophys. Acta 1273 (1995) 217] as well as to its high water content [Stud. Biophys. 81 (1981) 39].

(28) Pyrpasopoulou A, Kotoula V, Cheva A, Hytiroglou P, Nikolakaki E, Magras IN, Xenos TD, Tsiboukis TD, Karkavelas G. Bone morphogenetic protein expression in newborn rat kidneys after prenatal exposure to radiofrequency radiation. *Bioelectromagnetics* 25(3):216-227, 2004.

Effects of nonthermal radiofrequency radiation (RFR) of the global system of mobile communication (GSM) cellular phones have been as yet mostly studied at the molecular level in the context of cellular stress and proliferation, as well as neurotransmitter production and localization. In this study, a simulation model was designed for the exposure of pregnant rats to pulsed GSM-like RFR (9.4 GHz), based on the different resonant frequencies of man and rat. The power density applied was 5 microW/cm2, in order to avoid thermal electromagnetic effects as much as possible. Pregnant rats were exposed to RFR during days 1-3 postcoitum (p.c.) (embryogenesis, pre-implantation) and days 4-7 p.c. (early organogenesis, peri-implantation). Relative expression and localization of bone morphogenetic proteins (BMP) and their receptors

(BMPR), members of a molecular family currently considered as major endocrine and autocrine morphogens and known to be involved in renal development, were investigated in newborn kidneys from RFR exposed and sham irradiated (control) rats. Semi-quantitative duplex RT-PCR for BMP-4, -7, BMPR-IA, -IB, and -II showed increased BMP-4 and BMPR-IA, and decreased BMPR-II relative expression in newborn kidneys. These changes were statistically significant for BMP-4, BMPR-IA, and -II after exposure on days 1-3 p.c. (P <.001 each), and for BMP-4 and BMPR-IA after exposure on days 4-7 p.c. (P <.001 and P =.005, respectively). Immunohistochemistry and in situ hybridization (ISH) showed aberrant expression and localization of these molecules at the histological level. Our findings suggest that GSM-like RFR interferes with gene expression during early gestation and results in aberrations of BMP expression in the newborn. These molecular changes do not appear to affect renal organogenesis and may reflect a delay in the development of this organ. The differences of relative BMP expression after different time periods of exposure indicate the importance of timing for GSM-like RFR effects on embryonic development.

(29) Salford LG, Brun AR, Eberhardt JL, Malmgren L, Persson BRR, Nerve cell damage in mammalian brain after exposure to microwaves from GSM mobile phones. *Environ Health Persp* Online January 29, 2003.

The possible risks of radio-frequency electromagnetic fields for the human body is a growing concern for the society. We have earlier shown that weak pulsed microwaves give rise to a significant leakage of albumin through the blood-brain barrier (BBB). Now we have investigated whether a pathological leakage over the BBB might be combined with damage to the neurons. Three groups of each 8 rats were exposed for 2 hours to GSM mobile phone electromagnetic fields of different strengths. We found, and present here for the first time, highly significant (p< 0.002) evidence for neuronal damage in both the cortex, the hippocampus and the basal ganglia in the brains of exposed rats.

(30) Santini R, Santini P, Danze JM, Le Ruz P, Seigne M.Study of the health of people living in the vicinity of mobile phone base stations: I. Influence of distance and sex. *Pathol Biol* (Paris) 50(6):369-373, 2002.

[Article in French]
A survey study using questionnaire was conducted in 530 people (270 men, 260 women) living or not in vicinity of cellular phone base stations, on 18 Non Specific Health Symptoms. Comparisons of complaints frequencies (CHI-SQUARE test with Yates correction) in relation with distance from base station and sex, show significant (p < 0.05) increase as compared to people living > 300 m or not exposed to base station, till 300 m for tiredness, 200 m for headache, sleep disturbance, discomfort, etc. 100 m for irritability, depression, loss of memory, dizziness, libido decrease, etc. Women significantly more often than men (p < 0.05) complained of headache, nausea, loss of appetite, sleep disturbance, depression, discomfort and visual perturbations. This first study on symptoms experienced by people living in vicinity of base stations shows that, in view of radioprotection, minimal distance of people from cellular phone base stations should not be < 300 m.

(31) Sarimov R, Malmgren L.O.G., Markova, E., Persson, B.R.R.. Belyaev, I.Y. Nonthermal GSM microwaves affect chromatin conformation in human lymphocytes

similar to heat shock. *IEEE Trans Plasma Sci* 32:1600-1608, 2004.

Here we investigated whether microwaves (MWs) of Global System for Mobile Communication (GSM) induce changes in chromatin conformation in human lymphocytes. Effects of MWs were studied at different frequencies in the range of 895-915 MHz in experiments with lymphocytes from seven healthy persons. Exposure was performed in transverse electromagnetic transmission line cell (TEM-cell) using a GSM test-mobile phone. All standard modulations included 2 W output power in the pulses, specific absorbed rate (SAR) being 5.4 mW/kg. Changes in chromatin conformation, which are indicative of stress response and genotoxic effects, were measured by the method of anomalous viscosity time dependencies (AVTD). Heat shock and treatment with the genotoxic agent camptothecin, were used as positive controls. 30-min exposure to MWs at 900 and 905 MHz resulted in statistically significant condensation of chromatin in lymphocytes from 1 of 3 tested donors. This condensation was similar to effects of heat shock within the temperature window of 40/spl deg/C-44/spl deg/C. Analysis of pooled data from all donors showed statistically significant effect of 30-min exposure to MWs. Stronger effects of MWs was found following 1-h exposure. In replicated experiments, cells from four out of five donors responded to 905 MHz. Responses to 915 MHz were observed in cells from 1 out of 5 donors, $p<0.002$. Dependent on donor, condensation, 3 donors, or decondensation, 1 donor, of chromatin was found in response to 1-h exposure. Analysis of pooled data from all donors showed statistically significant effect of 1-h exposure to MWs. In cells from one donor, this effect was frequency-dependent ($p<0.01$). Effects of MWs correlated statistically significantly with effects of heat shock and initial state of chromatin before exposure. MWs at 895 and 915 MHz affected chromatin conformation in transformed lymphocytes. The conclusion-GSM microwaves under specific conditions of exposure affected human lymphocytes similar to stress response. The data suggested that the MW effects differ at various GSM frequencies and vary between donors.

(32) Schwartz JL, House DE, Mealing GA, Exposure of frog hearts to CW or amplitude-modulated VHF fields: selective efflux of calcium ions at 16 Hz. *Bioelectromagnetics* 11(4):349-358, 1990.

Isolated frog hearts were exposed for 30-min periods in a Crawford cell to a 240-MHz electromagnetic field, either continuous-wave or sinusoidally modulated at 0.5 or 16 Hz. Radiolabeled with calcium (45Ca), the hearts were observed for movement of Ca2+ at calculated SARs of 0.15, 0.24, 0.30, 0.36, 1.50, or 3.00 mW/kg. Neither CW radiation nor radiation at 0.5 Hz, which is close to the beating frequency of the frog's heart, affected movement of calcium ions. When the VHF field was modulated at 16 Hz, a field-intensity-dependent change in the efflux of calcium ions was observed. Relative to control values, ionic effluxes increased by about 18% at 0.3 mW/kg (P less than .01) and by 21% at 0.15 mW/kg (P less than .05), but movement of ions did not change significantly at other rates of energy deposition. These data indicate that the intact myocardium of the frog, akin to brain tissue of neonatal chicken, exhibits movement of calcium ions in response to a weak VHF field that is modulated at 16 Hz.

(33) Somosy Z, Thuroczy G, Kubasova T, Kovacs J, Szabo LD, Effects of modulated and continuous microwave irradiation on the morphology and cell surface negative charge of 3T3 fibroblasts. *Scanning Microsc* 5(4):1145-1155, 1991.

Mouse embryo 3T3 cells were irradiated with 2450 MHz continuous and low frequency (16 Hz) square modulated waves of absorbed energy ranging from 0.0024 to 2.4 mW/g. The low frequency modulated microwave irradiation yielded more morphological cell changes than did the continuous microwave fields of the same intensity. The amount of free negative charges (cationized ferritin binding) on cell surfaces decreased following irradiation by modulated waves but remained unchanged under the effect of a continuous field of the same dose. Modulated waves of 0.024 mW/g dose increased the ruffling activity of the cells, and caused ultrastructural alteration in the cytoplasm. Similar effects were experienced by continuous waves at higher (0.24 and 2.4 mW/g) doses.

(34) Stagg RB, Thomas WJ, Jones RA, Adey WR, DNA synthesis and cell proliferation in C6 glioma and primary glial cells exposed to a 836.55 MHz modulated radiofrequency field. *Bioelectromagnetics* 18(3):230-236, 1997.

We have tested the hypothesis that modulated radiofrequency (RF) fields may act as a tumor-promoting agent by altering DNA synthesis, leading to increased cell proliferation. In vitro tissue cultures of transformed and normal rat glial cells were exposed to an 836.55 MHz, packet-modulated RF field at three power densities: 0.09, 0.9, and 9 mW/cm2, resulting in specific absorption rates (SARs) ranging from 0.15 to 59 muW/g. TEM-mode transmission-line cells were powered by a prototype time-domain multiple-access (TDMA) transmitter that conforms to the North American digital cellular telephone standard. One sham and one energized TEM cell were placed in standard incubators maintained at 37 degrees C and 5% CO2. DNA synthesis experiments at **0.59-59 muW/g** SAR were performed on log-phase and serum-starved semiquiescent cultures after 24 h exposure. Cell growth at 0.15-15 muW/g SAR was determined by cell counts of log-phase cultures on days 0, 1, 5, 7, 9, 12, and 14 of a 2 week protocol. Results from the DNA synthesis assays differed for the two cell types. Sham-exposed and RF-exposed cultures of primary rat glial cells showed no significant differences for either log-phase or serum-starved condition. ***C6 glioma cells exposed to RF at 5.9 muW/g SAR (0.9 mW/cm2) exhibited small (20-40%) significant increases in 38% of [3H]thymidine incorporation experiments.*** Growth curves of sham and RF-exposed cultures showed no differences in either normal or transformed glial cells at any of the power densities tested. Cell doubling times of C6 glioma cells [sham (21.9 +/- 1.4 h) vs. field (22.7 +/- 3.2 h)] also demonstrated no significant differences that could be attributed to altered DNA synthesis rates. Under these conditions, this modulated RF field did not increase cell proliferation of normal or transformed cultures of glial origin.

(35) Stark KD, Krebs T, Altpeter E, Manz B, Griot C, Abelin T, Absence of chronic effect of exposure to short-wave radio broadcast signal on salivary melatonin concentrations in dairy cattle. *J Pineal Res* 22(4):171-176, 1997.

A pilot study was conducted to investigate the influence of electromagnetic fields in the short-wave range (3-30 MHz) radio transmitter signals on salivary melatonin concentration in dairy cattle. The hypothesis to be tested was whether EMF exposure would lower salivary melatonin concentrations, and whether removal of the EMF source would be followed by higher concentration levels. For this pilot study, a controlled intervention trial was designed. Two commercial dairy herds at two farms were compared, one located at a distance of 500 m (exposed), the other at a distance of 4,000 m (unexposed) from the transmitter. At each farm, five cows were monitored with respect to their salivary melatonin concentrations over a period of ten consecutive days. Saliva samples were collected at two-hour intervals during the dark phase of the night. As an additional intervention, the short-wave transmitter was switched off during three of the ten days (off phase). The

samples were analyzed using a radioimmunoassay. The average nightly field strength readings were 21-fold
greater on the exposed farm (1.59 mA/m) than on the control farm (0.076 mA/m).
The mean values of the two initial nights did not show a statistically significant difference between exposed and unexposed cows. Therefore, a chronic melatonin reduction effect seemed unlikely. ***However, on the first night of re-exposure after the transmitter had been off for three days, the difference in salivary melatonin concentration between the two farms (3.89 pg/ml, CI: 2.04, 7.41) was statistically significant, indicating a two- to seven-fold increase of melatonin concentration. Thus, a delayed acute effect of EMF on melatonin concentration cannot completely be excluded.*** However, results should be interpreted with caution and further trials are required in order to confirm the results.

(36) Tattersall JE, Scott IR, Wood SJ, Nettell JJ, Bevir MK, Wang Z, Somasiri NP, Chen X. Effects of low intensity radiofrequency electromagnetic fields on electrical activity in rat hippocampal slices. *Brain Res* 904(1):43-53, 2001.

Slices of rat hippocampus were exposed to 700 MHz continuous wave radiofrequency (RF) fields (25.2-71.0 V m(-1), 5-15 min exposure) in a stripline waveguide. At low field intensities, the predominant effect on the electrically evoked field potential in CA1 was a potentiation of the amplitude of the population spike by up to 20%, but higher intensity fields could produce either increases or decreases of up to 120 and 80%, respectively, in the amplitude of the population spike. To eliminate the possibility of RF-induced artefacts due to the metal stimulating electrode, the effect of RF exposure on spontaneous epileptiform activity induced in CA3 by 4-aminopyridine (50-100 &mgr;M) was investigated. Exposure to RF fields (50.0 V m(-1)) reduced or abolished epileptiform bursting in 36% of slices tested. The maximum field intensity used in these experiments, 71.0 V m(-1), was calculated to produce a specific absorption rate (SAR) of between 0.0016 and 0.0044 W kg(-1) in the slices. Measurements with a Luxtron fibreoptic probe confirmed that there was no detectable temperature change (+/-0.1 degrees C) during a 15 min exposure to this field intensity. Furthermore, imposed temperature changes of up to 1 degrees C failed to mimic the effects of RF exposure. These results suggest that low-intensity RF fields can modulate the excitability of hippocampal tissue in vitro in the absence of gross thermal effects. The changes in excitability may be consistent with reported behavioural effects of RF fields.

(37) Vangelova K, Israel M, Mihaylov S. The effect of low level radiofrequency electromagnetic radiation on the excretion rates of stress hormones in operators during 24-hour shifts. *Cent Eur J Public Health* 10(1-2):24-28, 2002.

The aim of the study was to investigate the effect of long term exposure to low level radiofrequency (RF) electromagnetic (EM) radiation on the excretion rates of stress hormones in satellite station operators during 24-hour shifts. Twelve male operators at a satellite station for TV communications and space research were studied during 24-hour shifts. Dosimetric evaluation of the exposure was carried out and showed low level exposure with specific absorption of 0.1127 J.kg-1. A control group of 12 unexposed male operators with similar job task and the same shift system were studied, too. The 11-oxycorticosteroids (11-OCS), adrenaline and noradrenaline were followed by spectrofluorimetric methods on 3-hour intervals during the 24-hour shifts. The data were analyzed by tests for interindividual analysis, Cosinor analysis and analysis of variance (ANOVA). Significant increase in the 24-hour excretion of 11-OCS and disorders in its circadian rhythm, manifested by increase in the mesor, decrease in the amplitude and shift in the acrophase were found in the exposed operators. The changes in the

excretion rates of the catecholamines were significant and showed greater variability of both variables. The long term effect of the exposure to low-level RF EM radiation evoked pronounced stress reaction with changes in the circadian rhythm of 11-OCS and increased variability of catecholamines secretion. The possible health hazards associated with observed alteration in the stress system need to be clarified by identification of their significance and prognostic relevance.

(38) Velizarov, S, Raskmark, P, Kwee, S, The effects of radiofrequency fields on cell proliferation are non-thermal. *Bioelectrochem Bioenerg* 48(1):177-180, 1999.

The number of reports on the effects induced by radiofrequency (RF) electromagnetic fields and microwave (MW) radiation in various cellular systems is still increasing. Until now no satisfactory mechanism has been proposed to explain the biological effects of these fields. One of the current theories is that heat generation by RF/MW is the cause, in spite of the fact that a great number of studies under isothermal conditions have reported significant cellular changes after exposure to RF/MW. Therefore, this study was undertaken to investigate which effect MW radiation from these fields in combination with a significant change of temperature could have on cell proliferation. The experiments were performed on the same cell line, and with the same exposure system as in a previous work [S. Kwee, P. Raskmark, Changes in cell proliferation due to environmental non-ionizing radiation: 2. Microwave radiation, Bioelectrochem. Bioenerg., 44 (1998), pp. 251-255]. The field was generated by signal simulation of the Global System for Mobile communications (GSM) of 960 MHz. Cell cultures, growing in microtiter plates, were exposed in a specially constructed chamber, a Transverse Electromagnetic (TEM) cell. The Specific Absorption Rate (SAR) value for each cell well was calculated for this exposure system. However, in this study the cells were exposed to the field at a higher or lower temperature than the temperature in the field-free incubator i.e., the temperature in the TEM cell was either 39 or 35 +/- 0.1 degrees C. The corresponding sham experiments were performed under exactly the same experimental conditions. The results showed that there was a significant change in cell proliferation in the exposed cells in comparison to the non-exposed (control) cells at both temperatures. On the other hand, no significant change in proliferation rate was found in the sham-exposed cells at both temperatures. This shows that biological effects due to RF/MW cannot be attributed only to a change of temperature. Since the RF/MW induced changes were of the same order of magnitude at both temperatures and also comparable to our previous results under isothermal conditions at 37 degrees C, cellular stress caused by electromagnetic fields could initiate the changes in cell cycle reaction rates. It is widely accepted that certain classes of heat-shock proteins are involved in these stress reactions.

(39) Veyret B, Bouthet C, Deschaux P, de Seze R, Geffard M, Joussot-Dubien J, le Diraison M, Moreau JM, Caristan A, Antibody responses of mice exposed to low-power microwaves under combined, pulse-and-amplitude modulation. *Bioelectromagnetics* 12(1):47-56, 1991.

Irradiation by pulsed microwaves (9.4 GHz, 1 microsecond pulses at 1,000/s), both with and without concurrent amplitude modulation (AM) by a sinusoid at discrete frequencies between 14 and 41 MHz, was assessed for effects on the immune system of Balb/C mice. The mice were immunized either by sheep red blood cells (SRBC) or by glutaric-anhydride conjugated bovine serum albumin (GA-BSA), then exposed to the microwaves at a low rms power density (30 microW/cm2; whole-body-averaged SAR approximately 0.015 W/kg). Sham exposure or microwave irradiation took place during each of five contiguous days, 10 h/day. The antibody response was evaluated by the plaque-forming cell assay (SRBC experiment) or by the titration

of IgM and IgG antibodies (GA-BSA experiment). In the absence of AM, the pulsed field did not greatly alter immune responsiveness. In contrast, exposure to the field under the combined-modulation condition resulted in significant, AM-frequency-dependent augmentation or weakening of immune responses.

(40) Wolke S, Neibig U, Elsner R, Gollnick F, Meyer R, Calcium homeostasis of isolated heart muscle cells exposed to pulsed high-frequency electromagnetic fields. *Bioelectromagnetics* 17(2):144-153, 1996.

The intracellular calcium concentration ([Ca(2+)]i) of isolated ventricular cardiac myocytes of the guinea pig was measured during the application of pulsed high-frequency electromagnetic fields. The high-frequency fields were applied in a transverse electromagnetic cell designed to allow microscopic observation of the myocytes during the presence of the high-frequency fields. The [Ca(2+)]i was measured as fura-2 fluorescence by means of digital image analysis. Both the carrier frequency and the square-wave pulse-modulation pattern were varied during the experiments (carrier frequencies: 900, 1,300, and 1,800 MHz pulse modulated at 217Hz with 14 percent duty cycle; pulsation pattern at 900 MHz: continuous wave, 16 Hz, and 50 Hz modulation with 50 percent duty cycle and 30 kHz modulation with 80 percent duty cycle). The mean specific absorption rate (SAR) values in the solution were within one order of magnitude of **1 mW/kg**. They varied depending on the applied carrier frequency and pulse pattern. The experiments were designed in three phases: 500 s of sham exposure, followed by 500 s of field exposure, then chemical stimulation without field. The chemical stimulation (K+ -depolarization) indicated the viability of the cells. The K+ depolarization yielded a significant increase in [Ca(2+)]i. Significant differences between sham exposure and high-frequency field exposure were not found except when a very small but statistically significant difference was detected in the case of 900 MHz/50 Hz. However, this small difference was not regarded as a relevant effect of the exposure.

DEPARTMENT OF HEALTH AND HUMAN SERVICES **Public Health Service**

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June 17, 1999

Mr. Richard Tell
Chair, IEEE SCC28 (SC4)
Risk Assessment Work Group
Richard Tell Associates, Inc.
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Dear Mr. Tell:

The members of the Radiofrequency Interagency Work Group (RFIAWG) have identified certain issues that we believe need to be addressed to provide a strong and credible rationale to support RF exposure guidelines. I am writing on behalf of the RFIAWG members to share these ideas with you and other members of the IEEE SCC28, Subcommittee 4 Risk Assessment Work Group. Our input is in response to previous requests for greater participation on our part in the SCC28 deliberations on RF guidelines. The issues, and related comments and questions relevant to the revision of the IEEE RF guidelines, are given in the enclosure. No particular priority is ascribed to the order in which the issues are listed.

The views expressed in this correspondence are those of the members of the Radiofrequency Interagency Work Group and do not represent the official policy or position of the respective agencies.

The members of the RFIAWG appreciate your consideration of our comments and welcome further dialog on these issues. Feel free to contact me or any member of the RFIAWG directly. A list of the members of the RFIAWG is enclosed, with contact information for your use.

Sincerely yours,

W. Gregory Lotz, Ph.D.
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RF Guideline Issues

Identified by members of the federal RF Interagency Work Group, June 1999

Issue: Biological basis for local SAR limit

The C95.1 partial body (local) exposure limits are based on an assumed ratio of peak to whole body SAR; that is, they are dosimetrically, rather than biologically based. Instead of applying a dosimetric factor to the whole body SAR to obtain the local limits, an effort should be made to base local SAR limits on the differential sensitivity of tissues to electric fields and temperature increases. For example, it seems intuitive that the local limits for the brain and bone marrow should be lower than those for muscle, fat and fascia; this is not the case with the current limits which implicitly assume that all tissues are equally sensitive (except for eye and testicle). If no other data are available, differential tissue sensitivity to ionizing radiation should be considered.

If it is deemed necessary to incorporate dosimetric factors into the resulting tissue-specific SAR limits these should be based on up-to-date dosimetric methods such as finite-difference time-domain calculations utilizing MRI data and tissue-specific dielectric constants. For certain exposure conditions FDTD techniques and MRI data may allow better simulation of peak SAR values. Consideration should be given to the practical tissue volume for averaging SAR and whether this volume is relevant to potential effects on sensitive tissues and organs.

Issue: Selection of an adverse effect level

Should the thermal basis for exposure limits be reconsidered, or can the basis for an unacceptable/adverse effect still be defined in the same manner used for the 1991 IEEE guidelines? Since the adverse effect level for the 1991 guidelines was based on acute exposures, does the same approach apply for effects caused by chronic exposure to RF radiation, including exposures having a range of carrier frequencies, modulation characteristics, peak intensities, exposure duration, etc., that does not elevate tissue temperature on a macroscopic scale?

Selection criteria that could be considered in determining unacceptable/adverse effects include:

a) adverse effects on bodily functions/systems
b) minimal physiological consequences
c) measurable physiological effects, but no known consequences

If the adverse effect level is based on thermal effects in laboratory animals, the literature on human studies (relating dose rate to temperature elevation and temperature elevation to a physiological effect) should be used to determine if the human data could reduce uncertainties in determination of a safety factor.

Issue: Acute and chronic exposures

There is a need to discuss and differentiate the criteria for guidelines for acute and chronic exposure conditions. The past approach of basing the exposure limits on acute effects data with an extrapolation to unlimited chronic exposure durations is problematic. There is an extensive data base on acute effects with animal data, human data (e.g. MRI information), and modeling to address thermal insult and associated adverse effects for acute exposure (e.g., less than one day). For lower level ("non-thermal"), chronic exposures, the effects of concern may be very different from those for acute exposure (e.g., epigenetic effects, tumor development, neurologic symptoms). It is possible that the IEEE RF radiation guidelines development process may conclude that the data for these chronic effects exist but are inconsistent, and therefore not useable for guideline development. If the chronic exposure data are not helpful in determining a recommended exposure level, then a separate rationale for extrapolating the results of acute exposure data may be needed. In either case (chronic effects data that are useful or not useful), a clear rationale needs to be developed to support the exposure guideline for chronic as well as acute exposure.

Issue: One tier vs two tier guidelines:

A one tier guideline must incorporate all exposure conditions and subject possibilities (e.g., acute or chronic exposure, healthy workers, chronically ill members of the general public, etc.). A two tier guideline, as now exists, has the potential to provide higher limits for a specific, defined population (e.g., healthy workers), and exposure conditions subject to controls, while providing a second limit that addresses greater uncertainties in the data available (about chronic exposure effects, about variations in the health of the subject population, etc.). A greater safety factor would have to be incorporated to deal with greater uncertainty in the scientific data available. Thus, a two-tier guideline offers more flexibility in dealing with scientific uncertainty, while a one-tier guideline would force a more conservative limit to cover all circumstances including the scientific uncertainties that exist.

Issue: Controlled vs. uncontrolled (applicability of two IEEE exposure tiers)

The current "controlled" and "uncontrolled" definitions are problematic, at least in the civilian sector, particularly since there are no procedures defined in the document to implement the "controlled" condition. The new guidelines should offer direction for the range of controls to be implemented and the training required for those who knowingly will be exposed (e.g. workers), along the lines of the existing ANSI laser safety standards. This essential element needs to be included for whatever limits are defined, be they one-tier or two-tier.

For example, the OSHA position is that the "uncontrolled" level is strictly an "action" level

which indicates that there is a sufficiently high exposure (compared to the vast majority of locations) to merit an assessment to determine what controls and training are necessary to ensure persons are not exposed above the "controlled" limit. Many similar "action" levels are part of OSHA and public health standards. Should this interpretation be incorporated into the IEEE standard as a means to determine the need to implement a safety plan? [The laser standard has a multi-tiered (Class I, II, III, IV) standard which similarly requires additional controls for more powerful lasers to limit the likelihood of an excess exposure, even though the health effect threshold is the same.]

On the other hand, if it is determined that certain populations (due to their health status or age) are more susceptible to RF exposures, then a multi-tiered standard, applicable only to those specific populations, may be considered.

The ANSI/IEEE standard establishes two exposure tiers for controlled and uncontrolled environments. The following statement is made in the rationale (Section 6, page 23): "The important distinction is not the population type, but the nature of the exposure environment." If that is the case, consideration should be given to providing a better explanation as to why persons in uncontrolled environments need to be protected to a greater extent than persons in controlled environments. An uncontrolled environment can become a controlled environment by simply restricting access (e.g., erecting fences) and by making individuals aware of their potential for exposure. After such actions are taken, this means that the persons who previously could only be exposed at the more restrictive uncontrolled levels could now be exposed inside the restricted area (e.g., inside the fence) at controlled levels.

What biologically-based factor changed for these people? Since the ostensible public health reason for providing greater protection for one group of persons has historically been based on biological considerations or comparable factors, it is not clear why the sentence quoted above is valid.

Issue: Uncertainty factors

The uncertainties in the data used to develop the guideline should be addressed. An accepted practice in establishing human exposure levels for agents that produce undesirable effects is the application of factors representing each area of uncertainty inherent in the available data that was used to identify the unacceptable effect level. Standard areas of uncertainty used in deriving acceptable human dose for agents that may produce adverse (but non-cancer) effects include

(1) extrapolation of acute effects data to chronic exposure conditions,
(2) uncertainty in extrapolating animal data to humans in prolonged exposure situations,
(3) variation in the susceptibility (response/sensitivity) among individuals,
(4) incomplete data bases,
(5) uncertainty in the selection of the effects basis, inability of any single study to

adequately address all possible adverse outcomes.
If guidelines are intended to address nonthermal chronic exposures to intensity modulated RF radiation, then how could uncertainty factors be used; how would this use differ from the historical use of uncertainty factors in establishing RF radiation guidelines to limit exposure to acute or sub-chronic RF radiation to prevent heat-related effects?

There is a need to provide a clear rationale for the use of uncertainty factors.

Issue: Intensity or frequency modulated (pulsed or frequency modulated) RF radiation

Studies continue to be published describing biological responses to nonthermal ELF-modulated and pulse-modulated RF radiation exposures that are not produced by CW (unmodulated) RF radiation. These studies have resulted in concern that exposure guidelines based on thermal effects, and using information and concepts (time-averaged dosimetry, uncertainty factors) that mask any differences between intensity-modulated RF radiation exposure and CW exposure, do not directly address public exposures, and therefore may not adequately protect the public. The parameter used to describe dose/dose rate and used as the basis for exposure limits is time-averaged SAR; time-averaging erases the unique characteristics of an intensity-modulated RF radiation that may be responsible for producing an effect.

Are the results of research reporting biological effects caused by intensity-modulated, but not CW exposure to RF radiation sufficient to influence the development of RF exposure guidelines? If so, then how could this information be used in developing those guidelines? How could intensity modulation be incorporated into the concept of dose to retain unique characteristics that may be responsible for a relationship between exposure and the resulting effects?

Issue: Time averaging

Time averaging of exposures is essential in dealing with variable or intermittent exposure, e.g., that arising from being in a fixed location of a rotating antenna, or from moving through a fixed RF field. The 0.1 h approach historically used should be reassessed, but may serve this purpose adequately. Time averaging for other features of RF exposure is not necessarily desirable, however, and should be reevaluated specifically as it deals with modulation of the signal, contact and induced current limits, and prolonged, or chronic exposure. These specific conditions are discussed in a little more detail elsewhere.

If prolonged and chronic exposures are considered to be important, then there should be a reconsideration of the time-averaging practices that are incorporated into existing exposure guidelines and used primarily to control exposure and energy deposition rates in acute/subchronic exposure situations.

Issue: Lack of peak (or ceiling) limits for induced and contact current

A recent change in the IEEE guidelines allows for 6 minute, rather than 1 second, time-weighted-averaging for induced current limits. This change increases the concern about the lack of a peak limit for induced and contact currents. Will the limits for localized exposure address this issue, i.e., for tissue along the current path?

Issue: Criteria for preventing hazards caused by transient discharges

The existing IEEE recommendation states that there were insufficient data to establish measurable criteria to prevent RF hazards caused by transient discharges. If specific quantitative criteria are still not available, can qualitative requirements be included in the standard to control this hazard (e.g., metal objects will be sufficiently insulated and/or grounded, and/or persons will utilize sufficient insulating protection, such as gloves, to prevent undesirable transient discharge.)?

ISSUE: Limits for exposure at microwave frequencies

Concerns have been expressed over the relaxation of limits for continuous exposures at microwave frequencies above 1500 MHz. The rationale provided in the current guideline (Section 6.8) references the fact that penetration depths at frequencies above 30 GHz are similar to those at visible and near infrared wavelengths and that the literature for skin burn thresholds for optical radiation "is expected to be applicable." The rationale then implies that the MPE limits at these high frequencies are consistent with the MPE limits specified in ANSI Z136.1-1986 for 300 GHz exposures. This is apparently the rationale for "ramping up" to the MPE limits for ***continuous*** exposure of 10 mW/cm^2 at frequencies above 3 GHz (controlled) or 15 GHz (uncontrolled). The rationale should be given as to why this ramp function has been established at relatively low microwave frequencies (i.e., 1500 MHz and above), rather than being implemented at higher frequencies that are truly quasi-optical. For example, one option could be two ramp functions, one beginning at 300 MHz, based on whole- or partial-body dosimetry considerations, and another at higher frequencies (say 30-100 GHz) to enable consistency with the laser standard. Such a revision should help reduce concern that the standard is not restrictive enough for continuous exposures at lower microwave frequencies where new wireless applications for consumers could make this an issue in the future.

Issue: Replication/Validation

Published peer-reviewed studies that have been independently replicated/validated should be

used to establish the adverse effects level from which exposure guidelines are derived. The definition of "replicated/validated" should not be so restrictive to disallow the use of a set of reports that are scientifically valid but are not an exact replication/validation of specific experimental procedures and results.

Peer-reviewed, published studies that may not be considered to be replicated/validated, but are well done and show potentially important health impacts provide important information regarding uncertainties in the data base used to set the adverse effect level (e.g., incomplete data base).

Issue: Important Health Effects Literature Areas:

Documentation should be provided that the literature review process included a comprehensive review of the following three areas:

1) long-term, low-level exposure studies (because of their importance to environmental and chronic occupational RFR exposure);
2) neurological/behavioral effects (because of their importance in defining the adverse effect level in existing RFR guidelines); and
3) micronucleus assay studies (because of their relevance to carcinogenesis).

Issue: Compatibility of RFR guidelines

Compatibility of national and international RFR guidelines remains a concern. It is important for the IEEE Committee to address this issue by identifying and discussing similarities and differences in a revised IEEE guideline and other RFR guidelines.
Compatibility/noncompatibility issues could be discussed in the revised IEEE guideline or as a companion document distributed at the time the revised IEEE guideline is released to the public.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUL 16 2003

OFFICE OF
AIR AND RADIATION

C. K. Chou, Ph.D.
Co-Chairman, International Committee on Electromagnetic
Safety (ICES), Subcommittee-4
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Dear Dr. Chou:

This letter is in response to your proposal of a meeting with the federal Radiofrequency Interagency Work Group (RFIAWG) that would provide an opportunity for the IEEE ICES SC4 to give the Work Group an update of the revision of the C95.1-1999 standard.

We look forward to your presentation regarding the items listed in your proposed agenda, i.e., approaches of standard setting, literature review, rationale, basic restrictions and reference levels, and responses to the 14 issues raised by the RFIAWG in the June 17,1999, letter to Richard Tell.

The RFIAWG is particularly interested in how these 14 issues are to be treated in the revision process. In addition, the RFIAWG is submitting the following additional issues for the ICES consideration and response.

Issue: Exclusion of pinna

If the pinna is to be considered an extremity and subjected to exposure limit of 20 W/Kg over 10 g of tissue, then a clear rationale for treating the pinna as an extremity should be presented. This rationale should include biological properties of the pinna that qualifies it for this exclusion. If thermal effects would be the basis for the ICES standard, then the thermophysiology of the pinna and the skin, bone and other head tissues adjacent to the pinna should be discussed for all body sizes exposed.

Issue: Rationale for relaxation of current limits

Federal agencies, as well as the general public and the public health community, are very concerned about a relaxation of exposure guidelines that may result in increased exposure in the future. A rationale should be presented for relaxation of standards. The rationale should include a clear explanation of the impact of the exposures that may

result, i.e., the description of the exposures and the effects on critical tissues and organs. An explanation should be given as to why the current standard should be relaxed. The issue of safety factors should be also be addressed as part of the rationale for relaxation of current limits.

Issue: Sensitivity of different tissues

A clear explanation on how the revision has taken into account sensitivity of different tissues to temperature. Effects of acute and chronic exposure to elevated temperature should be adequately covered. We consider it appropriate to include as a part of the revised standard a description of the risk analysis that was done.

We ask that the RFIAWG be provided with a copy of the ICES response to all of the issues raised by the RFIAWG in advance of a meeting so that the Work Group members have sufficient time to study them and prepare for the meeting. We also request that you provide any other materials that you feel would be of value to the Work Group in preparing for a meeting.

Please be aware that comments and opinions that may be expressed by the RFIAWG participants are their personal comments and opinions and have not been reviewed and/or approved by their management or their agencies.

Sincerely,

Norbert N. Hankin
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