A New Paradigm, the physical, biological and health effects of Radiofrequency/Microwave Radiation

Dr Neil Cherry

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Kufstein, Austria

Neil.Cherry@ecan.govt.nz

Human Sciences Department
P.O. Box 84
Lincoln University
Canterbury, New Zealand

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"Our frame of reference determines what we look at and how we look. And as a consequence, this determines what we find."

Burke J, *The Day the Universe Changed*, 1985.

Abstract:

Our preconceived views strongly influence our opinions and decisions. People almost universally view the human (mammal) body as a biological organ with biochemical processes controlling biological cells. This fails to recognize the vital role of biophysics with its electromagnetic signals carrying out vital functions in the brain, central nervous system, heart, motor neuron system and in all cells. Oscillating electromagnetic signals, produced by and interacting with ions, such as calcium ions, are active in all cells for cell-to-cell communication, gap junctions and voltage-gated ion channels. Phase locked loop detection systems are widespread in cells and especially neurons. The heart and brain are monitored using the ECG and EEG electromagnetic detection systems. Classical physics processes involve resonant absorption and interference with the natural EMR/EMF signals. This has been causally demonstrated with external ELF signals altering the ELF calcium ion oscillations in brain and heart tissue. Understanding and appreciating this biophysical science, opening your mind to the genotoxic evidence, and considering the epidemiological evidence, leads to a major paradigm shift. External EMR/EMF signals penetrate human bodies, resonantly interacting with cellular processes, altering cellular calcium ions, reducing melatonin and damaging DNA. Everyone has their whole body exposed to these genotoxic signals showing that EMR/EMF is a Ubiquitous Universal Genotoxic Carcinogen, that causes elevation of the rates of a wide range of cancer, cardiac, reproductive and neurological diseases and death in human populations. This paradigm is confirmed by multiple independent papers showing DNA damage and a body of epidemiological studies showing elevated sickness and death rates for all of these health effects in electrical workers and many also at residential exposure levels, many involving dose-response relationships pointing to a safe threshold of zero exposure, consistent with EMR/EMF being a genotoxic carcinogen.

Introduction:

A major shift in thinking occurs as we understand and accept that our bodies, brains, hearts and cells use electromagnetic signals as part of their normal and natural operations. The electromagnetic signalling of our brains is well understood through studies of the electroencephalogram (EEG). Thinking involves well organised and synchronized electromagnetic brain waves. Our heart beats regularly using an electric pulse that stimulates a cascade of calcium ions that flow through the heart muscle cells causing them to all contract together to produce a heart beat. A regular, synchronized heart-beat is one of the bases of

healthy living. The synchronization signal is external and electromagnetic. The shift in thinking proposed here is simply a move back to basic physics, biophysics, biochemistry and epidemiology.

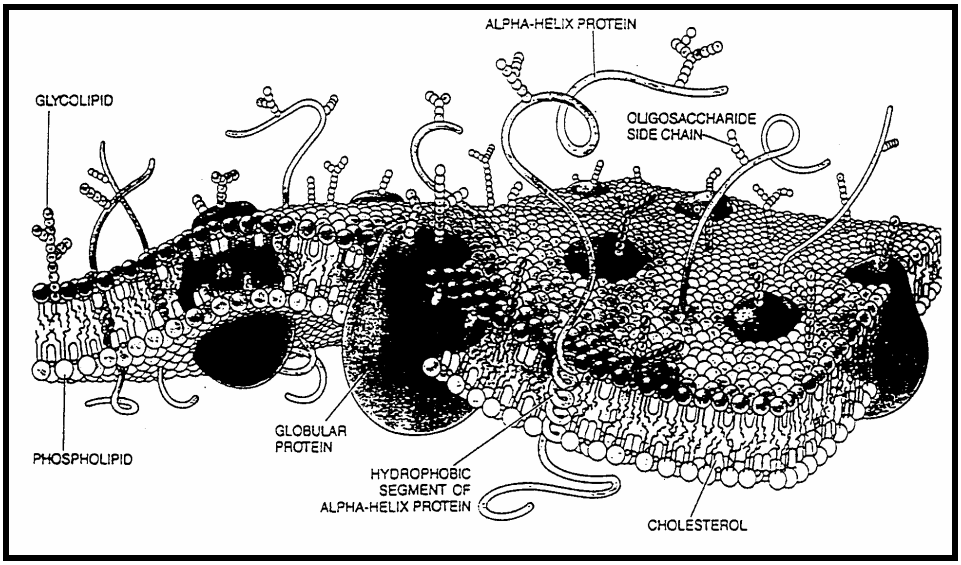

Figure 1: A schematic diagram of the cell membrane, showing the alpha helix of the signal transduction apparatus, with its "Y" shaped receptors on the alpha helix protein.

Our brains communicate with our glands, organs and cells using electric signals through the central nervous system, neurohormones, neurotransmitters and ions as first messengers that flow through our circulation system seeking a compatible receptor on cells. On finding the receptor, the positively charged first messenger is attracted to the negatively charged receptor, Figure 1.

On entering the receptor the signal is amplified to produce a cascade of second messenger molecules that alter that cells behaviour in some manner. The receptors are protein structures that pass through the cell membrane which has a voltage across it, called the membrane potential, with positive on the inside to the cell and negative charge on the outside. Two other protein structures in the cell membrane are important in this consideration. The voltage-gated ion channels act like transistors in controlling the flow of messenger ions into and out of the cell according to the voltage across the channel.

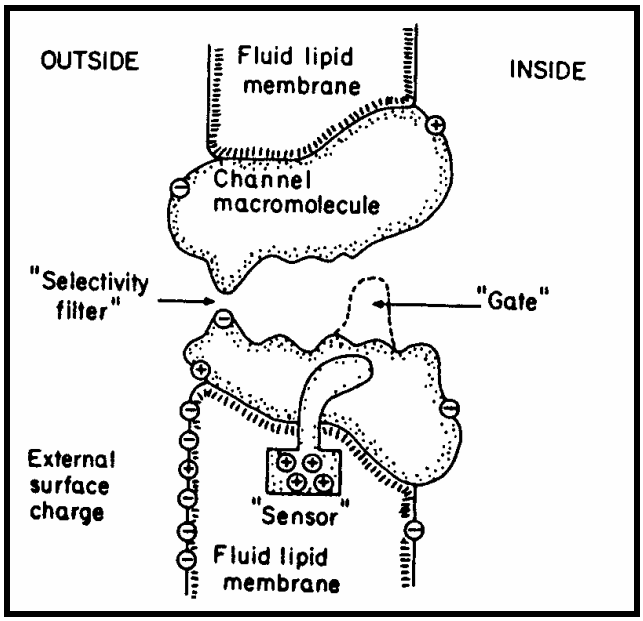

Figure 2: Voltage-gated ion channel within the cell membrane, acts like a transistor to control the ion current flow into and out of the cell, Catterall (1992).

Between many cells there is a six-sided protein structure called a gap-junction. This allows small molecules to flow from cell-to-cell as part of the cell-to-cell communication system. Interference with the inter-cellular communication system can cause cancer through the lack of detection and regulation of genetically damaged cells. Alternatively it can cause cell death.

A primary first and second messenger molecule is the calcium ion, Ca^{2+}. Ca^{2+} are ubiquitous, occurring throughout the body in all cells. Ca^{2+} ions are vital for brain activity. They regulate the neurotransmitters in neurons, regulate gap-junction opening and closing, affecting the efficiency of cell-to-cell communication. They have their own voltage-gated ion channels in cells. They are involved with hormone regulation, DNA synthesis, cell differentiation and proliferation, chromosome aberrations and cell-to-cell communication. When a cell is damaged and the cell has to "decide" whether of survive or commit suicide through programmed cell death, Apoptosis, then one of the primary factors that determines this decision is the intra-cellular Ca^{2+} concentration. Many chemical carcinogens, for example TPA, act by altering the Ca^{2+} concentration in cells.

The first well established non-thermal biological effect of EMR exposure was calcium ion efflux, Blackman 1990. Extremely low frequency modulated signals, up to about 500 Hz, are shown to significantly cause Ca^{2+} to inflow and outflow from cells, depending on the conditions. This occurs in a non-linear resonant fashion with "windows" of effect and no effect varying with carrier frequency, modulation frequency, signal intensity, ambient temperature and geomagnetic field strength and orientation.

Ca^{2+} research in the United States was originally stimulated by German and American experiments that showed that ELF modulated EMR signals caused human and animal reaction time and EEG changes. Bawin and Adey (1976) showed that this was caused by EMR induced alteration of cellular calcium ions in brains.

This means that it is scientifically plausible that in windows of exposure at non-thermal exposure levels the EMR induced Ca^{2+} changes in cells can alter brain activity, alter the hormone production, alter the DNA integrity and repair, enhance chromosome aberrations cause cancer and apoptosis.

All of these factors have been observed in cells, animals and people across a wide range of exposure situations, down to extremely low mean exposure levels, and across the whole range of carrier frequencies from ELF to radiofrequency and microwave signals.

Extremely low intensities are involved because of resonant absorption in oscillating systems. Resonant absorption occurs when a stimulus frequency is close to a natural frequency of oscillation or a harmonic. This is how radio and TV signal reception occurs, with shortwave signals, even on the other site of the world. Brains and cells have well organised, regular and synchronized oscillators involving cells like Ca^{2+}. Cell-to-cell communication involves encoders and decoders of AM and FM oscillating ion signals. FM signals are tuned into using phase-locked loop systems where there is a biochemical messenger stream whose intensity of proportional to the phase difference in the detector and transmitted signal. The feed-back loop tunes the oscillator into the incoming signal. Such circuits are used in FM radios and TVs. Our brains and cells have similarly efficient frequency tuned circuits.

The combination of the basic physics of resonant absorption and the biochemistry of cellular ion oscillators, brain EEG, cardiac ECG and cellular phase-locked loops are sufficient to confirm that EMR interacts with and interferes with natural body processes at extremely low induced field intensities when the frequencies match.

Calcium ion homeostasis alteration evidence:

Through replicating and extending the experiments of other laboratories, Dr Carl Blackman and his team at the U.S. Environmental Protection Agency have become the world leaders in calcium ion efflux research. That is why he was well qualified to review the research results and conclude, Blackman (1990) that

"Taken together, the evidence overwhelmingly indicates that electric and magnetic fields can alter normal calcium ion homeostasis and lead to changes in the response of biological systems to their environment".

The following diagrams summarize the calcium ion results.

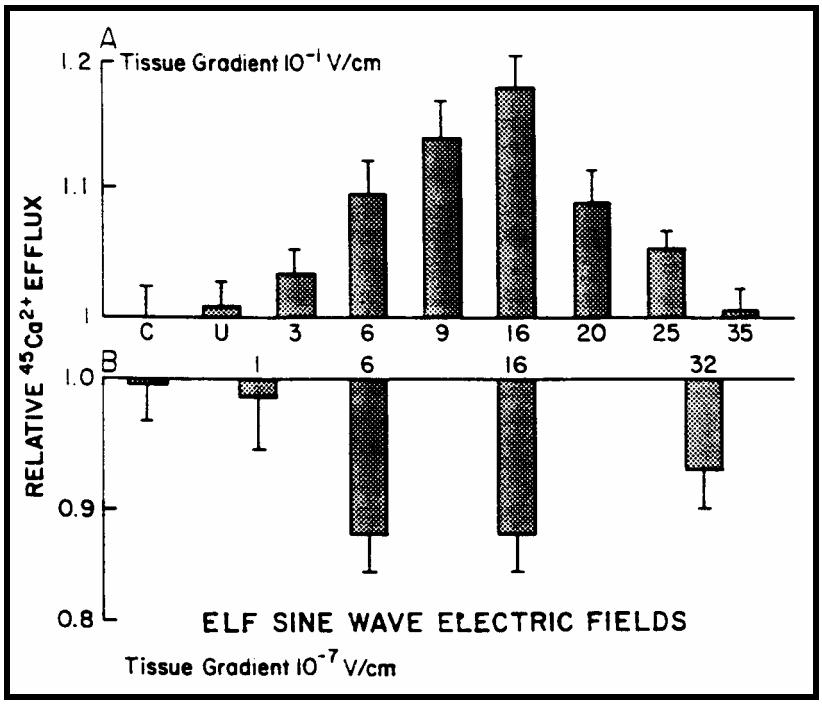

Figure 3: ELF induced calcium ion efflux in chick brain cells from (A) an ELF modulated 147 MHz signal and (B) an ELF signal, Bawin, Kaczmarek and Adey (1975).

Figure 3 is a classic result that illustrates several important scientific facts. Figure 3 shows,

(a) That the RF induced Ca^{2+} efflux which is associated with enhanced programmed cell death (Apoptosis).

(b) That the ELF signal induces Ca^{2+} influx, which is associated with the enhanced survival of damaged cells, i.e. it enhances cancer.

(c) That the RF signal (147 MHz) of the same external field strength as the ELF signal, 56 V/m, induces a million times higher tissue electric field gradient that the ELF signal on its own. This is support for the EMR Spectrum Principle.

(d) For both the RF and ELF signals there is an optimal response for a modulation frequency of about 16 Hz.

(e) The GSM cellphone signal has a pulse frequency of 217 Hz and a modulation frequency of 8.34 Hz. An 8.34 Hz signal is biologically active in brain cells as shown by Figure 3.

The wide range of biologically active modulation frequencies is shown in Figure 4.

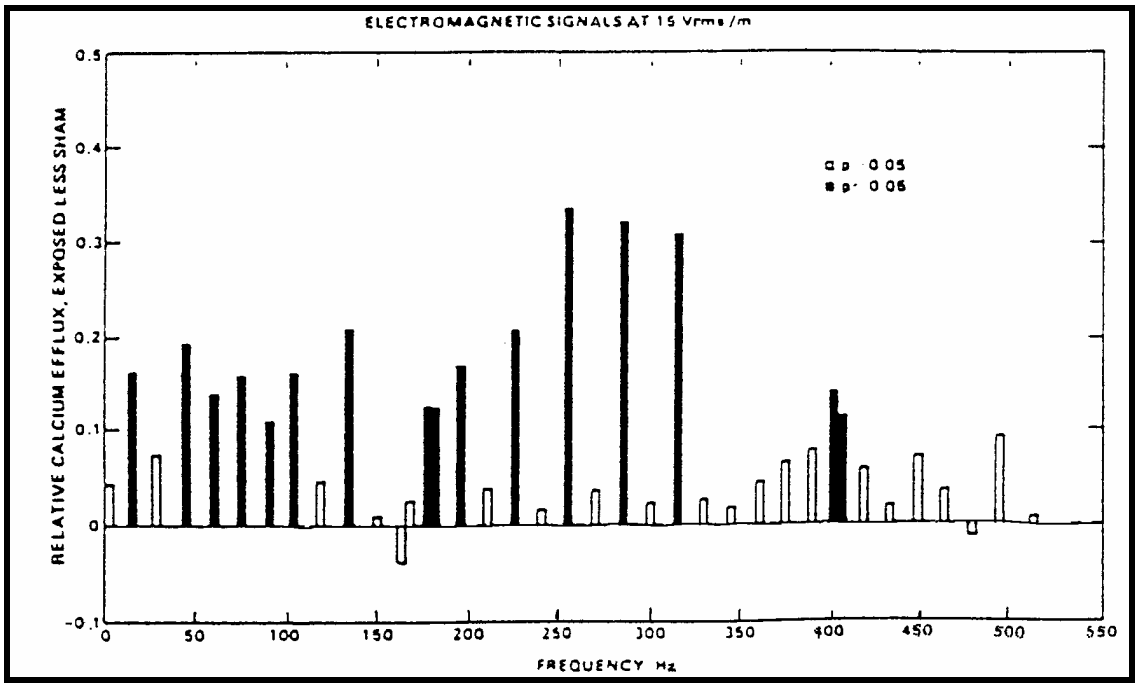

Figure 4: Effect of 15 Vrms/m electromagnetic fields on the efflux of calcium ions from chick brains as a function of modulation frequency, Blackman et al. (1988).

Figure 4 demonstrates the modulation frequency window effects with significant efflux windows separated by weak or no efflux windows. This is for a given field strength, 15 Vrms/m. The windows change with a range of parameters.

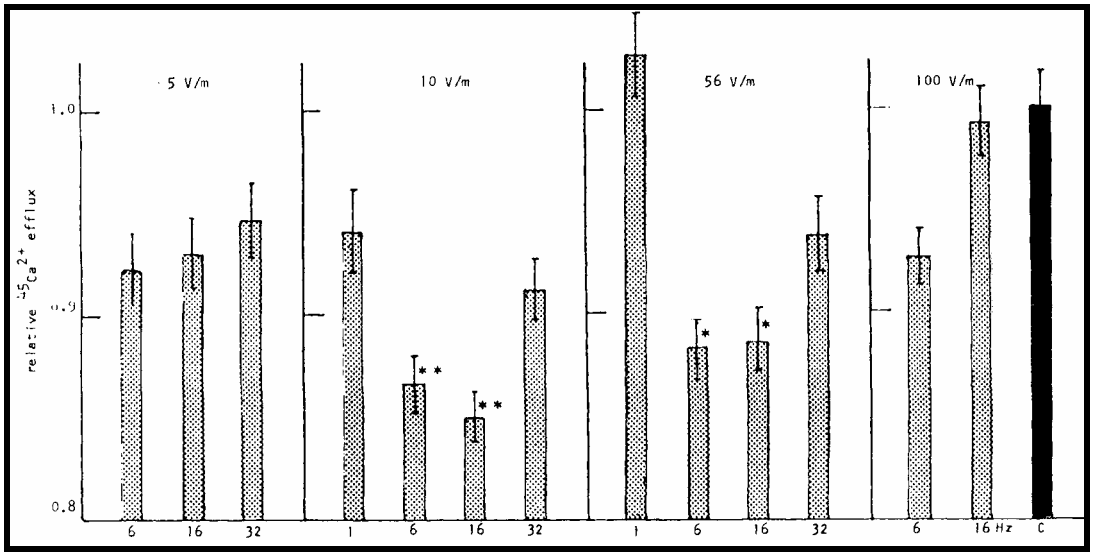

Figure 5: Effects of extremely low frequency fields on calcium ion efflux from chick forebrain. *,p<0.05; ** p<0.01 compared with control, Bawin and Adey (1976).

Figure 5 shows a range of field strengths and modulation frequencies. This shows the non-linear nature of this effect. The relative efflux is stronger at 10 and 56 V/m then at 5 and 100 V/m, especially for the 6 and 16 Hz signals.

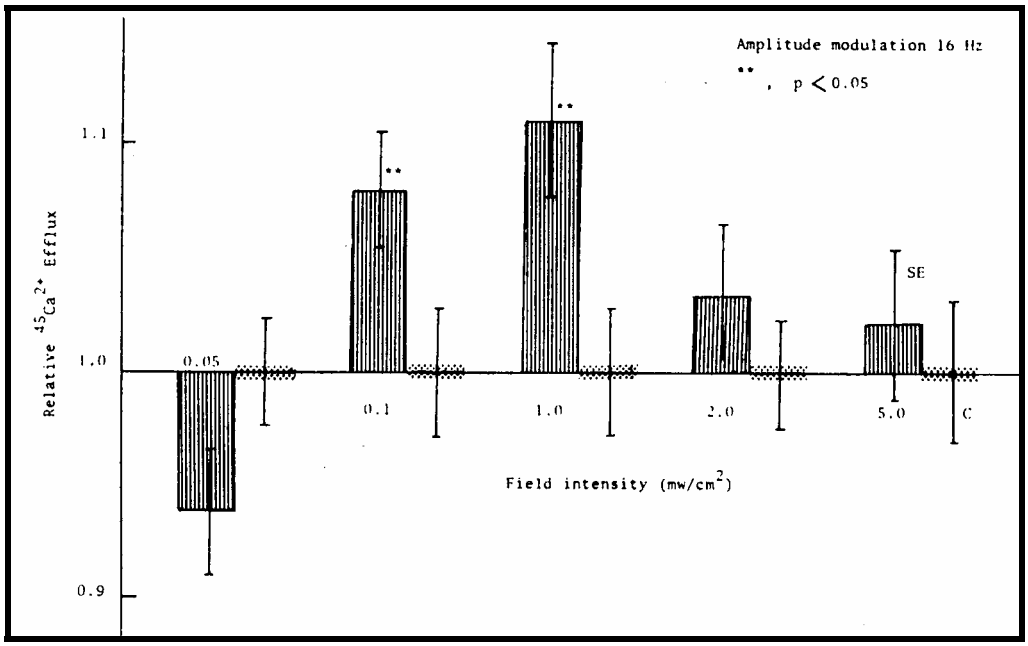

Figure 6: Effects of changing intensity of 450 MHz field, amplitude modulated at 16 Hz, on the efflux of calcium ions from chick cerebral hemispheres, Bawin, Sheppard and Adey (1978).

Figure 6 confirms the effect occurs at UHF frequencies, an also in a non-linear fashion with field intensity windows. Efflux occurs at 0.1 mW/cm^2 and above, and influx occurs at lower intensities under these circumstances.

EMR Spectrum Principle:

I have identified and defined what I term the "EMR Spectrum Principle". This is a new way of viewing electromagnetic radiation effects and fundamental to the new paradigm. The principle is that:

"The biological and epidemiological effects of electromagnetic radiation are quite consistent across the EMR spectrum from ELF to RF/MW, with the biological impact generally increasing with increased carrier frequency because of the declining dielectric constant."

The initial basis of this principle comes from the evidence in Figure 3 and the frequency dependence of the dielectric constant, Figure 7.

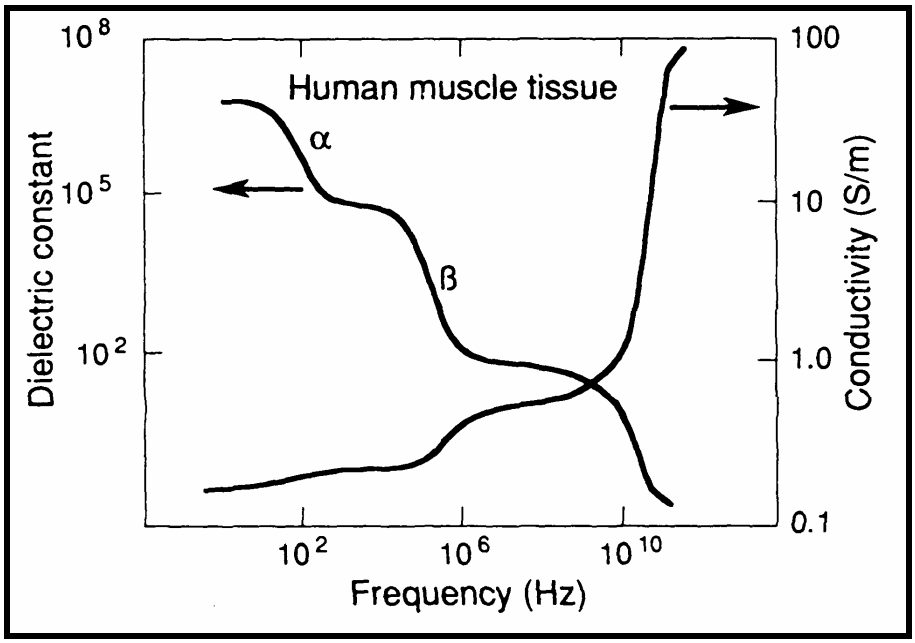

Figure 7: The dielectric constant and the conductivity for human muscle tissue as a function of the carrier frequency, From Schwan (1985) cited in WHO (1993).

Italian researchers, Vignati and Giuliani (1997) considered this information very important and used it to calculate the induced current variation for a unit field input over a range of carrier frequencies, Figure 8.

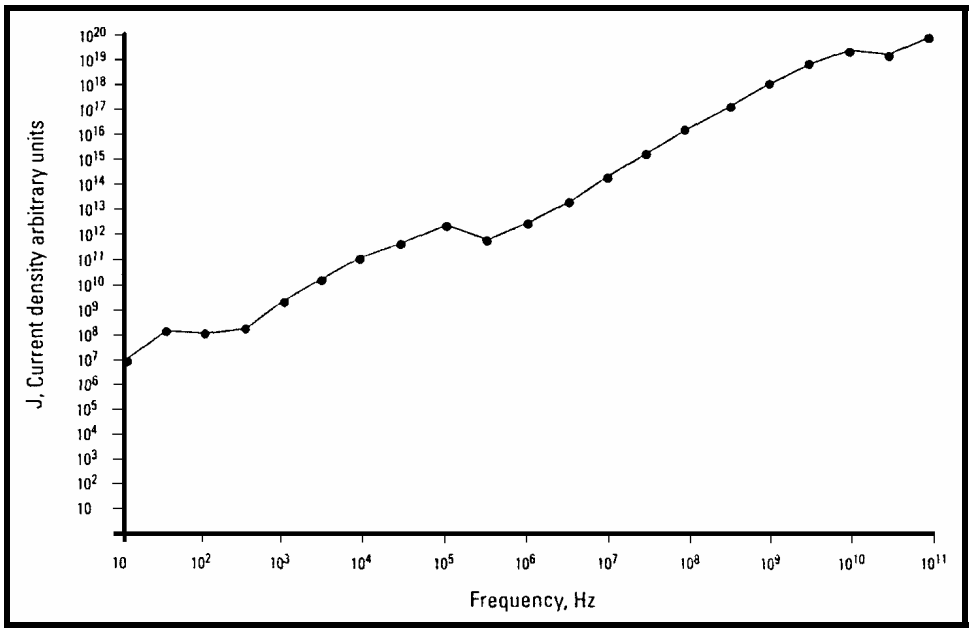

Figure 8: Capacitive current density in a toroid of human muscle tissue of unitary radius, to a unitary magnetic induction, Vignati and Giuliani (1997).

The EMR Spectrum Principle is confirmed by observations that across the spectrum from ELF to RF/MW, DNA strand breaks, chromosome aberrations and melatonin reduction also occur.

Independently epidemiological studies show that cancer, especially brain tumour and leukaemia, cardiac, neurological and reproductive effects have been observed in multiple studies and with dose-response relationships across the spectrum, with a threshold of no effect at zero mean chronic exposure for both ELF and RF/MW exposures for cardiac and neurological effect. But for cancer the RF/MW threshold is zero, but the ELF threshold is around 0.1μT, for childhood leukaemia in the vicinity of high voltage powerlines, Feychting et al. (1995),[RR = 1.0 for 0.1μT, RR = 2.0 (1.0-4.1) for ≥0.2μT and RR = 5.1 (2.1-12.6) for ≥0.5 μT.]

Gap Junctions:

Gap junctions are protein bridges between cells. They are fundamental to the cell-to-cell communication that is necessary to maintain healthy cells, Figure 9.

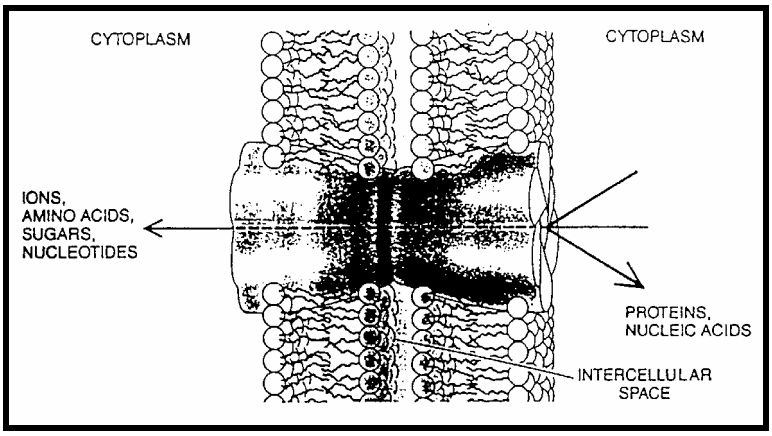

Figure 9: A Gap Junction structure, a six-element protein bridge that allows selective molecules to pass between cells as part of the cell-to-cell communication to coordinate cell regulation.

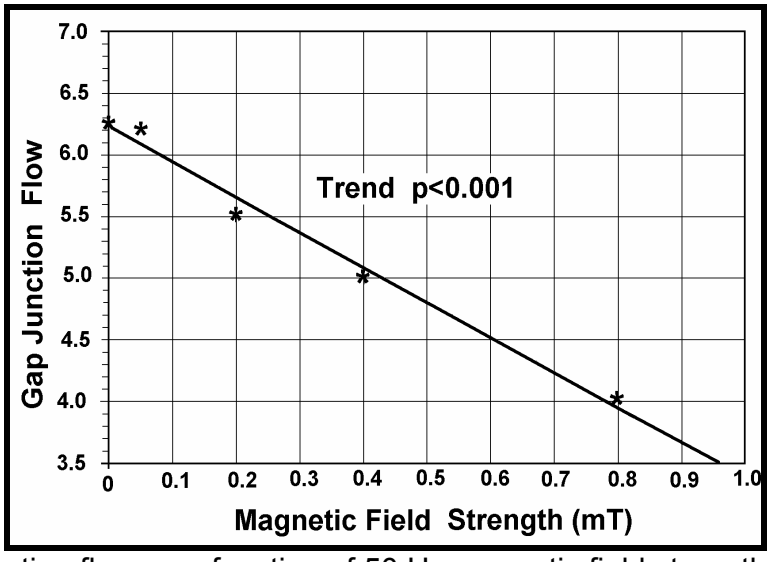

Figure 10: Gap junction flow as a function of 50 Hz magnetic field strength, Li et al. (1999).

Gap junction opening is regulated by calcium ions and pH, Alberts et al. (1994). Li et al. (1999) observed that when a 50 Hz magnetic field was combined with the application of the cancer promoter TPA then the gap junction flow was impaired in a significant dose-response manner as a function of the magnetic field exposure, Figure 8. Li at al. conclude that 50 Hz fields act similarly to the cancer promoter TPA, in closing the gap junction, and therefore 50 Hz fields may act as cancer promoters by doing this. Following the EMR Spectrum Principle, this is probably happening more strongly for RF/MW fields, just like calcium ion efflux in Figure 3.

Detection of Schumann Resonances for Neurological and Cardiac Synchronization:

Resonant absorption occurs when there is a frequency match. Figure 11 shows the typical human EEG spectrum and Figure 12 shows the Schumann Resonance Spectrum.

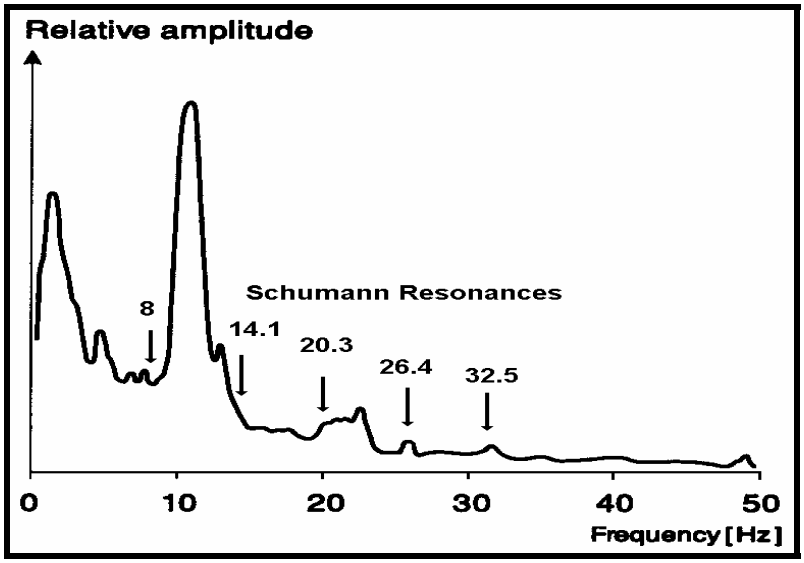

Figure 11: A typical EEG spectrum, with the Schumann Resonance peaks superimposed.

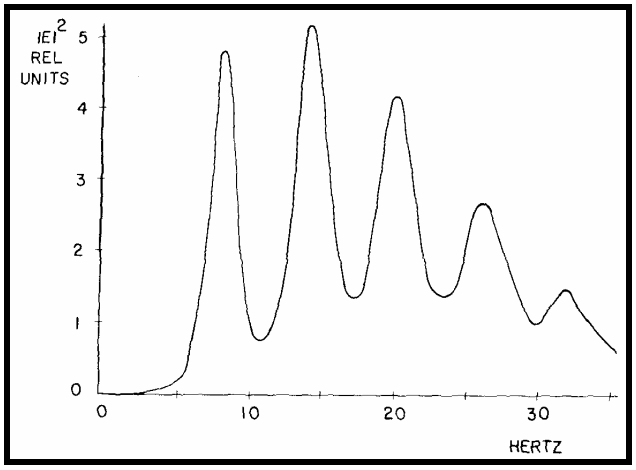

Figure 12: Daytime Schumann Resonance Spectrum, Polk (1982).

The frequency range of the Schumann Resonances and the human EEG overlap and some peaks coincide, showing the probability of resonant absorption and the likelihood of interaction. Both the high frequency peaks and the diurnal frequency shifts, high during the day and low at night, match between the two spectra.

It was proven, but not well known, that human brains detect, use and react to natural low frequency signals, the Schumann Resonances, König (1974). Konig (1974) reports on the results of an experiment carried out at the Munich Transport Exhibition of 1953, Figure 13. About 49,500 people were recorded in a visual reaction time experiment. Their reaction times were extremely highly correlated with the intensity of the Schumann Resonance signals.

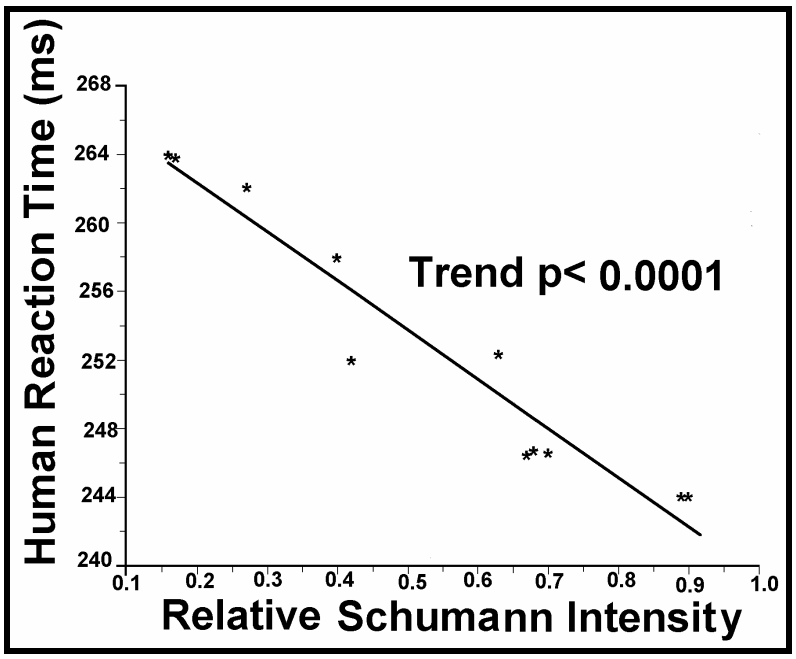

Figure 13: Human reaction times are causally correlated with natural variations in the Schumann Resonance Intensity, Konig (1974). The mean Schumann intensity (Relative Schumann Intensity =0.5) is 0.65mV/m or 0.1pW/cm^2. The range is 0.2 to 1.2 mV/m (0.01 to 0.4pW/cm^2).

The Schumann Resonances are global signals that radiate from tropical thunderstorms. They propagate around the world within the cavity created by the earth and the ionosphere. The intensity and spectrum of the Schumann Resonances vary markedly from day to night and with solar activity. At night both the EEG and the Schumann Resonances are dominated by very low frequencies (<5 Hz). With the coincidence of the frequency ranges, some of the high frequency peaks and the diurnal variation of the EEG and Schumann Resonances, it is biologically plausible that there is a resonant interaction between, and EEG reaction to the changing Schumann Resonance signals.

This biological plausibility is significantly strengthened by the observation that mammal brains contain and use phase-locked loop circuitry to detect and react to incoming ELF signals, Ahissar et al. (1997). Hence our brains contain a highly efficient, tuned FM receiver, Motluk (1997).

This result was confirmed by laboratory experiments that showed that 10 Hz signals significantly and consistently increase the reaction speed and 3 Hz signals slowed them down, Konig (1974). These results were independently confirmed by Hamer (1966, 1969). Hamer observed that human reaction times were significantly altered at exposure levels down to 4mV/m, 4.2pW/cm^2. This is approaching the level of the Schumann Resonance signal, which averages about 0.08mV/m, 0.1pW/cm^2.

These experiments give substantial proof that extremely small natural and artificial ELF signals interact significantly with human brains. The signal level of this interaction is 2,000,000,000 times below the ICNIRP ELF guideline. This guideline is based on avoiding acute shocks and not on avoiding proven neurological effects. The maintenance of the standard is obtained by ignoring or rejecting any and all evidence that contradicts it.

Independently Wever (1974), at the Max Planck Institute, showed that by shielding people from the Schumann Resonances the average day length in isolation experiments is significantly longer that simple sunlight isolation, $p<0.001$. More significantly 30 % of subjects in the Faraday Cage shielded room desynchronized, $p<0.001$. This was corrected at will by the observers applying a small 10 HZ signal, Figure 14.

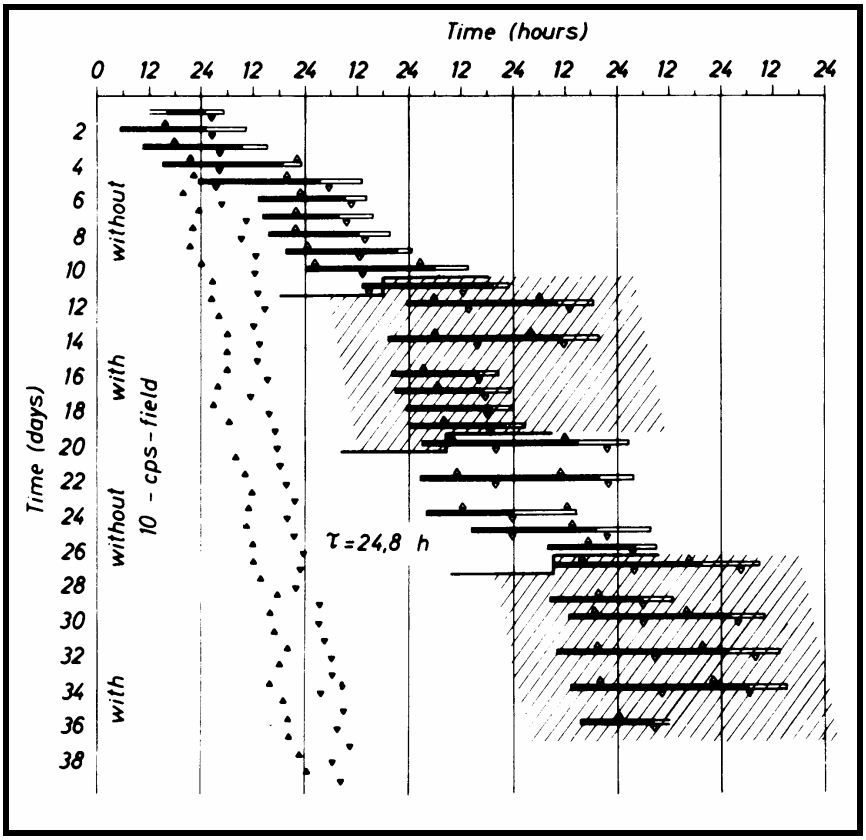

Figure 14: Free running circadian rhythm of a subject living under strict isolation from environmental time cues. The shaded period involve the secret application of 10 Hz pulsed signal with a peak-to-peak voltage of 2.5 V/m, corresponding to an rms voltage of 0.88V/m (S = 0.2μW/cm^2).

Wever concludes that these experiments provide strong proof that electromagnetic fields in the ELF range influence human circadian rhythms, and therefore human beings. Together Konig and Wever prove that human brains detect and react to the Schumann Resonance (SR) signal. This signal has a mean field strength of 0.08V/m, S = 0.1pW/cm^2.

This gives a very strong basis for this paradigm shift that recognizes the exquisite sensitivity of the human brain and its regulation and synchronization by these very weak naturally occurring, globally available, ELF signals. The paradigm shift is also based a classical public health approach setting standards based on epidemiology and strong evidence that electromagnetic fields and radiation is a genotoxic carcinogen.

Considering the SR signal, there is independent confirmation. In measuring the melatonin levels in electrical workers in the United States, Dr James Burch and his team at the Colorado State University, Fort Collins, found that ELF fields significantly reduce melatonin, as does cellphone use. Having removed the ELF and cellphone effects there was a residual variation in the data. This was dose-response related to Geomagnetic Activity, Figure 15.

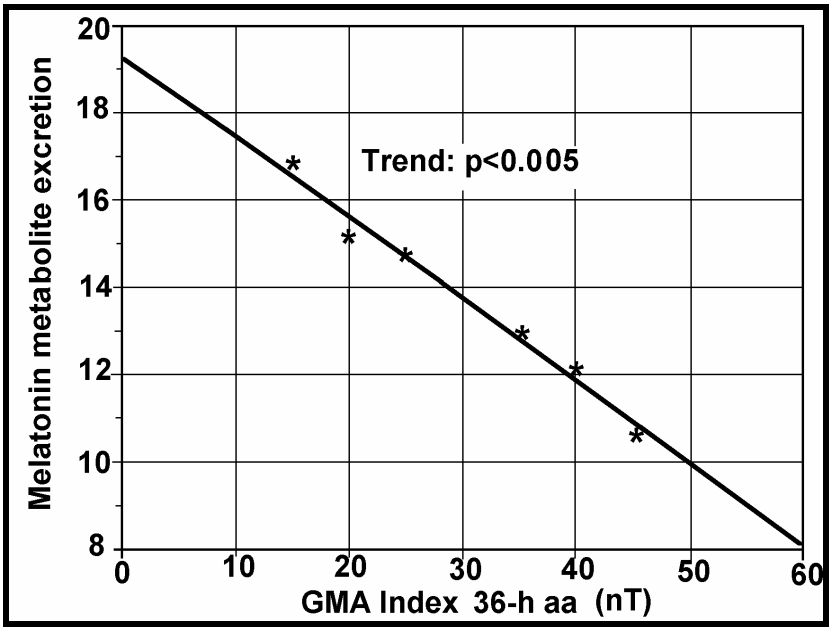

Figure 15: A dose-response reduction in human melatonin associated with increased geomagnetic activity, Burch et al. (1999).

An increase in GMA increases the nocturnal intensity of the Schumann Resonance signal that decreases the melatonin production in a causal manner (highly significant dose response). Hence our brain's ability to detect and respond to the exquisitely minute signal of the Schumann Resonances results in changes in GMA causing physiological changes in human beings through the reduction in melatonin. A reduction in melatonin is associated with a very wide range of illnesses and diseases, including cancer, neurological, cardiac and reproductive health effects.

Fifteen other studies show that EMR from ELF to RF/MW reduces melatonin in exposed human populations. This is proof of a causal effect between EMR exposure and a wide range of morbidity and mortality.

Evidence of RF/MW Genotoxicity:

Substances that damage cellular genetic material, such as DNA and chromosomes, are called “genotoxic”. Genotoxic substances cause cancer, reproductive health effects and neurological damage. Chromosome aberrations are visible through powerful microscopes. Chromosomes are formed from folded segments of DNA. Damage to chromosomes is therefore evidence of damage to DNA.

DNA is frequently damaged by natural processes, such as oxygen free radicals. Gey (1993) comments that free radicals may be involved in the etiology of cancer and cardiovascular diseases. In epidemiological studies poor plasma levels of antioxidants (free radical scavengers) are associated with increased relative risks of cancer and ischemic heart disease. Cells have elaborate DNA repair mechanisms because DNA stability is vital for species survival. Uncorrected DNA damage is mutation, Alberts et al. (1994). Alberts et al. outline many DNA repair mechanisms, including Repair Enzymes. They also outline the way apoptosis can digest and destroy damaged cells by internal "programming" of the process. The Immune System has B lymphocytes that produce antibody proteins to protect against 'foreign' cells, such as mutated cells. Natural Killer (NK) cells kill some types of tumours and some virus-infected cells, Alberts et al.

Enhanced DNA strand breakage leads to enhanced DNA repair. Hence enhanced DNA repair rates are also used as evidence of DNA damage, Meltz (1995).

Many studies have shown that radiofrequency/microwave (RF/MW) radiation and extremely low frequency (ELF) fields cause increased DNA strand breakage and chromosome aberrations. This has been shown in cell lines, human blood, animals and living human beings. This means that epidemiological studies of people exposed to electromagnetic radiation (EMR) are likely to show increased cancer, miscarriage and reproductive adverse effects. In fact many epidemiological studies have shown these effects, Goldsmith (1995, 1996, 1997, 1997a), Szmigielski (1991, 1996).

Two plausible biological mechanisms involving free radicals are involved in this effect. The first involves increased free radical activity and genetic damage as a response to exposure. The second involves increased free radical activity and genetic damage because of an induced reduction of a free radical scavenger, e.g. reduced melatonin, Reiter (1994). It is clear however, that both mechanisms have the same effect of damaging the DNA and chromosomes. Another established biological mechanism, EMR-induced alteration of cellular calcium ion homeostasis, Blackman (1990), is also involved in cell regulation, cell survival and apoptosis, DNA synthesis and melatonin regulation.

Direct measurements of Chromosome aberrations:

Direct evidence that EMR induces significant increases in chromosome damage, with significant dose response relationships, is evidence of a causal effect when replicated or extended by independent laboratories.

Chromosome damage from RF/MW exposure:

The first identified study that showed that pulsed RF radiation cause significant chromosome aberrations was Heller and Teixeira-Pinto (1959). Garlic roots were exposed to 27 MHz pulsed at 80 to 180 Hz. for 5 min and then they were examined 24 hrs later. The concluded that this RF signal mimicked the chromosomal aberration produced by ionizing radiation and c-mitotic substances. No increased temperature was observed.

Blood samples were taken from the staff of the U.S. Embassy in Moscow. They had been chronically exposed to a low intensity radar signal. Significant increases in chromosome damage was reported, Tonascia and Tonascia (1966) cited in Goldsmith (1997a).

Yao (1982) exposed rat kangaroo RH5 and RH16 cells to 2.45 GHz microwaves, maintaining the temperature at 37°C in the incubator. After 50 passages with microwave exposure there we 30 passages without. Significant chromosome aberrations were measured after 20 MW passages.

Garaj-Vrhovac et al. (1990) noted the differences and similarities between the mutagenicity of microwaves and VCM (vinyl chloride monomer). They studied a group of workers who were exposed to 10 to 50 $\mu W/cm^2$ of radar produced microwaves. Some were also exposed to about 5 ppm of VCM, a known carcinogen. Exposure to each of these substances (microwaves and VCM) produced highly significant ($p<0.01$ to $p<0.001$) increases in Chromatid breaks, Chromosome breaks, acentric and dicentric breaks in human lymphocytes from blood taken from exposed workers. The results were consistent across two assays, a micronucleus test and chromosome aberration assay.

Chromosome aberrations and micronuclei are significantly higher than the controls, ($p<0.05$, $p<0.001$, $p<0.0001$), for each of the exposure intensity. Garaj-Vrhovac, Horvat and Koren (1991) exposed Chinese hamster cells to 7.7 GHz microwave radiation to determine cell survival and chromosome damage. They assayed chromosome aberrations and micronuclei and found that microwaves increased these in a dose response manner, Figure 16, to levels that were highly significantly elevated ($p<0.02$ to $p<0.01$).

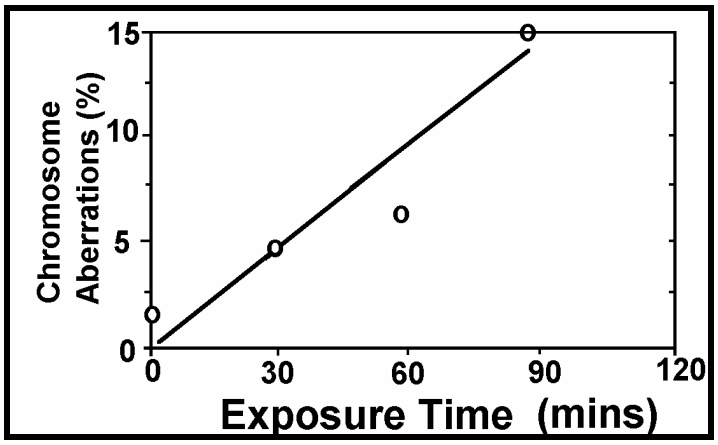

Figure 16: Chromosome aberrations in V79 Chinese hamster cells exposed to 7.7 GHz microwaves at 30 mW/cm^2, Garaj-Vrhovac, Horvat and Koren (1991).

An exposure level of 30 mW/cm^2 is usually able to slightly raise the temperature over an hour. This experiment was undertaken under isothermal conditions, with samples being kept within 0.4°C of 22°C. The consistency of the time exposure and the survival assay at non-thermal exposure levels, confirms that this is a non-thermal effect.

This is very strong evidence of genotoxic effects from RF/MW exposures. When chromosomes are damaged one of the primary protective measures is for the immune system natural killer cells to eliminate the damaged cells. Alternatively the cells can enter programmed cell suicide, apoptosis. Garaj-Vrhovac, Horvat and Koren (1991) measured the cell survival rates. They found that cell survival reduced and the cell death increased in a time dependent and exposure dose response manner, Figure 17.

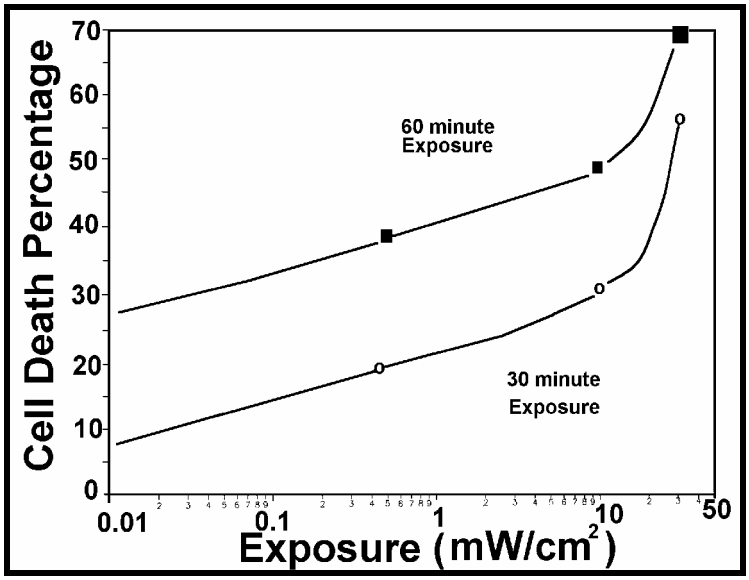

Figure 17: Cell death percentage of Chinese hamster cells exposed to 7.7 GHz microwaves (CW) for 30 minutes and 60 minutes in an isothermal exposure system, Garaj-Vrhovac, Horvat and Koren (1991).

Figure 17 shows that cell death varies with time and intensity of exposure, down to very low exposure levels. An apparent 'saturation' at high levels is also becoming evident. This is probably because of the lethal effect of high intensity microwaves. Since this is an isothermal experiment it raised important questions about the reasons for the cell death as acute genetic damage which is continuously related to microwave exposure down to non-thermal levels.

Note that the general public ICNIRP guideline for microwaves above 2 GHz is 1 mW/cm^2, and for workers is 5 mW/cm^2. Even at 100 times below the public exposure guideline a 60 minute exposure kills 28% of the cells and 30 minutes kills 8 % of the cells. Garaj-Vrhovac et al. (1992) exposed human lymphocytes and showed that microwave radiation produced a dose response increase in chromosome aberrations, Figure 18.

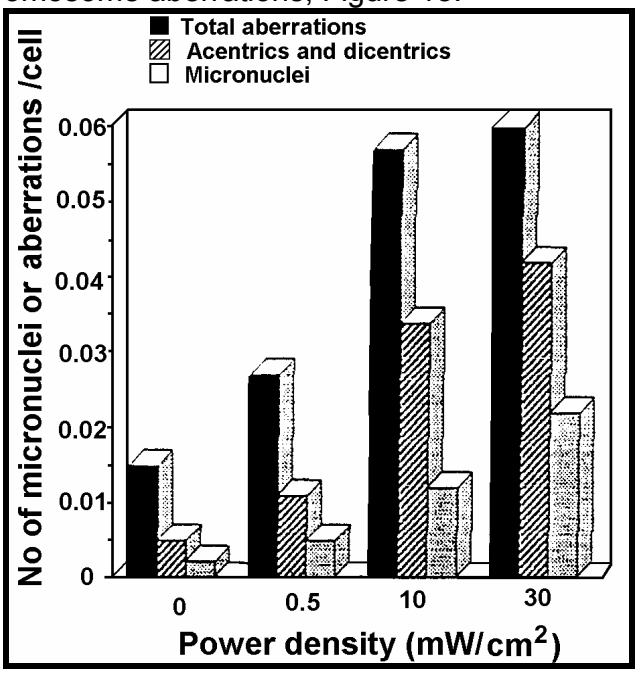

Figure 18: The relation of total chromosome aberrations. micronuclei formation and specific chromosome aberrations for each cell in human lymphocyte cultures in the dose of microwave radiation in vitro, Garaj-Vrhovac et al. (1992).

Having established that microwave exposure damaged chromosomes, this research group were asked to analyze blood samples from workers who had been exposed to pulsed microwaves generated by air traffic control radars while they were repairing them. Garag-Vrhovac and Fucic (1993) analysed the chromosome aberration (CA) in 6 technical staff who had experienced accidental exposure to the radar. The initial CA percentage ranged from 3% to 33%, all being significantly higher than unexposed people.

The repair rate over time was monitored. Figure 19 shows the man who had 33 % CA which was followed over 30 weeks following this exposure. The repair rate follows a significant linear rate (r=0.98), dropping from 33% to 3% over 30 weeks, 1 %/week.

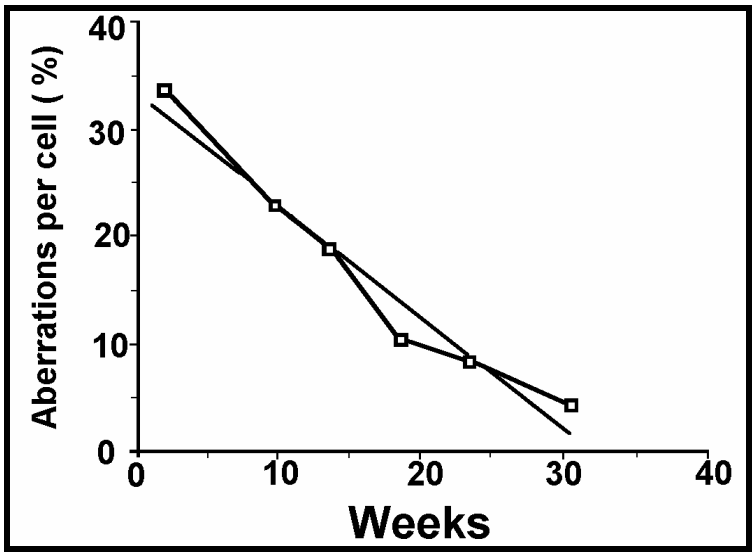

Figure 19: The time-dependent decrease in the number of chromosome aberrations for subjects with high numbers of chromosomal impairments, y = 0.318 - 0.010x, r=0.98. Garaj-Vrhovac and Fucic (1993).

Garaj-Vrhovac (1999) found that 12 workers occupationally exposed to microwave had significantly increased chromosome damage as well as disturbances in the distribution of cells over the first, second and third mitotic divisions.

Quite independently, Maes et al. (1993) found highly significant ($p<0.001$) increases is the frequency of chromosome aberrations (including dicentric and acentric fragments) and micronuclei in human blood exposed to 2.45 GHz microwaves to 30 to 120 minutes in vitro. The micronuclei assay showed a dose response with time, Figure 20.

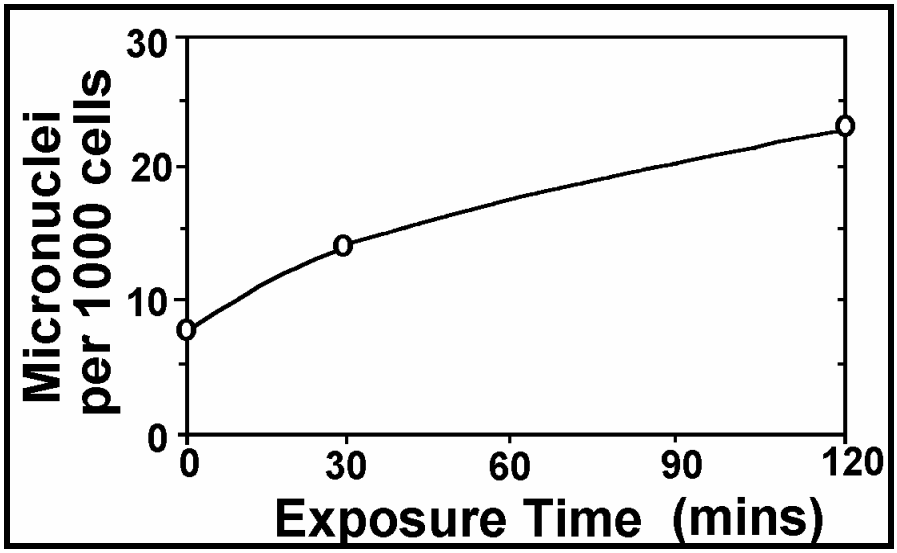

Figure 20: Micronuclei in microwave exposed human lymphocytes, the average of 4 donors, Maes et al. (1993). Exposure was to 75 W/kg, 2.45 GHz microwaves pulsed at 50 Hz, under controlled isothermal conditions

Timchenko and Ianchevskaia (1995), Balode (1996), Haider et al. (1994) and Vijayalaxmi et al. (1997) have reported significant chromosome aberrations from RF/MW exposures. In the Mar/Apr 1999 edition of Microwave News it is reported that Drs Tice, Hook and McRee showed chromosome damage from all cell phones tested, all being statistically significant and all but one highly significant with dose-response relationships up to a factor of three increase in chromosome aberrations, Tice, Hook and McRee (1999). They repeated the experiment and confirmed that the results were robust and not an artifact.

Vijayalaxmi et al. (1997) chronically exposed cancer prone mice to 2.45 GHz CW microwaves at an SAR of 1 W/kg for 20 hr/day, 7 days/week for 18 months. Their aim was to determine whether microwaves were genotoxic through determining if there was significant chromosome damage. They found highly significant increases in micronuclei in peripheral blood, from 8 per 2000 cells in sham exposed mice to 9 per 2000 cells microwave exposed mice, and increase of 12.5 %, $p<0.001$. There was a significant increase of 6.6%, $p<0.025$, of micronuclei in the bone marrow. They also observed a significant 41 % increase in tumours in the exposed mice compared to the sham exposed mice.

This was a totally unexpected result from this group. A great deal of effort was put into playing down the implications. They describe the increase in peripheral blood as a 0.05%, by dividing the increase of 1 by 2000. This is not a significant increase and this is not the right comparison. It is a deliberate attempt to disguise their true result that shows that microwaves are genotoxic.

Multiple independent studies, in 16 papers, show significant increases in chromosome aberrations from RF/MW exposure. Four studies show dose-response relationships. This is more than adequate to classify RF/MW radiation as genotoxic.

Chromosome damage from ELF exposure:

El Nahas and Oraby (1989) observed significant dose-response dependent micronuclei increase in 50 Hz exposed mice somatic cells. Elevated CA have been recorded in a number of workers in electrical occupations. In Sweden Nordenson et al. (1988) found significant CA in 400 kV-substation workers and with 50 Hz exposures to peripheral human lymphocytes, Nordenson et al. (1984) and human amniotic cells, Nordenson et al. (1994). Significant CA in human lymphocytes exposed to 50 Hz fields are also reported by Rosenthal and Obe (1989), Khalil and Qassem (1991), Garcia-Sagredo and Monteagudo (1991), Valjus et al. (1993) and Skyberg et al. (1993). Skyberg et al. collected their samples from high-voltage laboratory cable splicers and Valjus et al. from power linesmen.

Hence chromosome damage has been recorded from exposes across the EMR spectrum from ELF to RF/MW exposures, in plants, mammal and human cells, animals and human beings, and from many independent laboratories. This confirms that EMR does damage chromosomes and establishes EMR induced chromosome aberrations as a biological effect. For a neoplastic cell to survive it must have an altered genetic structure to store the damage and to hide this from the immune system so that NK cells do not kill the neoplasm transformed cells.

Chromosome Aberrations Conclusions:

Many studies, from independent laboratories, have shown that ELF, RF/MW and cell phone radiation, significantly increases chromosome aberrations in exposed cells, including cells taken from human beings who have been exposed to EMR in occupational situations. Even at very low intensity radar exposures that were experienced at the U.S. Embassy in Moscow, significant increases in chromosome damage was measured from human blood samples. This evidence shows conclusively that across the EMR spectrum, EMR is genotoxic. Hence it is carcinogenic and teratogenic.

Direct evidence of neoplasm in microwave exposed cells:

Balcer-Kubiczek and Harrison (1991) observed a significant dose response increase of neoplastic transformation in a standard cell set (C3H/10T1/2) from a 24 hr exposure to 2.45 GHz microwaves. The transformation was assayed after 8 weeks of exposure to a known cancer promoter chemical TPA, Figure 21. The method was confirmed with a positive control using X-rays. This also showed that 60Hz magnetic fields also significantly increased neoplastic transformation.

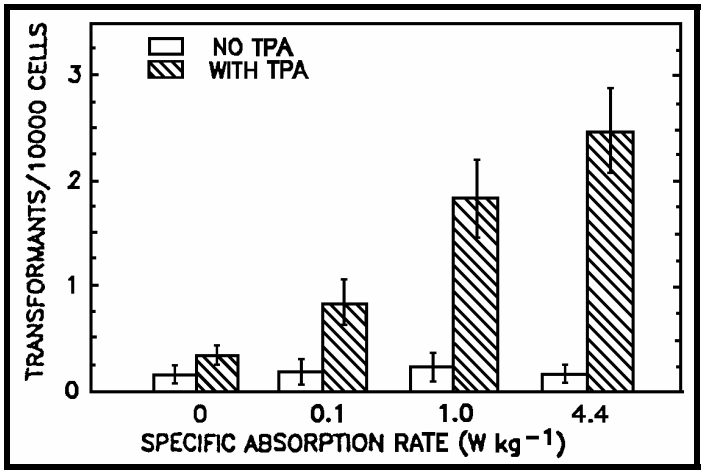

Figure 21: Dose-response relationship for induction of neoplastic transformation in C3H/10T1/2 cells by a 24h exposure to 2.45 GHz microwaves at the specific absorption rate (SAR) with and without TPA post-treatment for 8 weeks, Balcer-Kubiczek and Harrison (1991).

Direct evidence of DNA strand breakage:

Sarkar, Ali and Behari (1994) investigated the effect on DNA of exposures accepted a safe by the Non-ionizing Radiation Committee of IRPA (International Radiation Protection Association - the predecessor of ICNIRP).

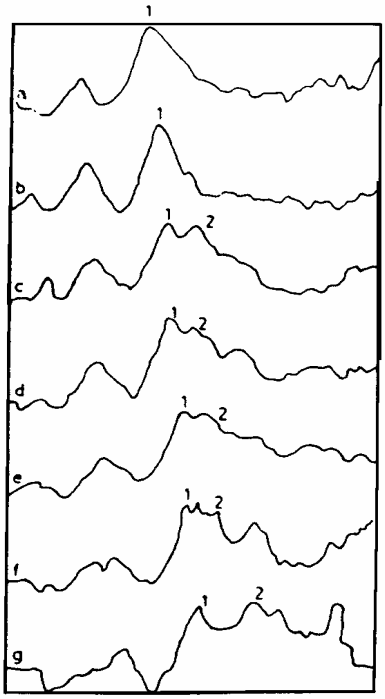

Figure 22: Densitometric analysis of the brain DNA, a and b are control DNA, c to g are DNA from exposed animals. Peak 1 is present in both control and exposed animals while peak 2 appears only in all of the exposed animals.

The exposure regime was a 2 hr exposure to 2.45 GHz CW microwaves at 1 mW/cm^2, SAR = 1.18 W/kg. They observed significant alterations in the DNA from rat brains and testis in the 7 to 8 kb region of the DNA in the hybridization profile and in a densitometric analysis, Figure 22.

The Comet Assay Method:

A very advanced assay of DNA strand breakage has been developed by Dr N.P. Singh at the University of Washington. This is called the microgel electrophoresis or Comet Assay, Singh et al. (1994). The Comet Assay involves migration of segments of DNA down an electric field gradient, Figure 23.

The modified microgel electrophoresis assay or Comet Assay for single DNA-strand breaks, involves extraction of a sample of tissue, washing it several times to remove blood, snipping the tissue with sharp scissors to reduce the sample sizes and further washing to remove blood. Single cell suspensions are mixed with agarose to make a microgel on a slide that is cooled to form a gel. Slides are immersed in an ice-cold lysing solution and then stored in the dark at 4 °C.

DNA is negatively charged. It is closely associated with positively charged bound protein and RNA. They help to fold the DNA. To release DNA from these bonds, one has to use Proteinase K to digest the bound proteins and RNAase A to digest the RNA. Hence in the morning the slides were treated with DNAase-free proteinase K for 2 hr at 37 °C to remove

the bound protein from the DNA. They were then places on the horizontal slab of an electrophoretic assembly. An electrophoresis buffer is added and the sample is left for 20 min to allow the DNA to unwind. The buffer includes antioxidants to counter the free radicals produced by electrophoresis.

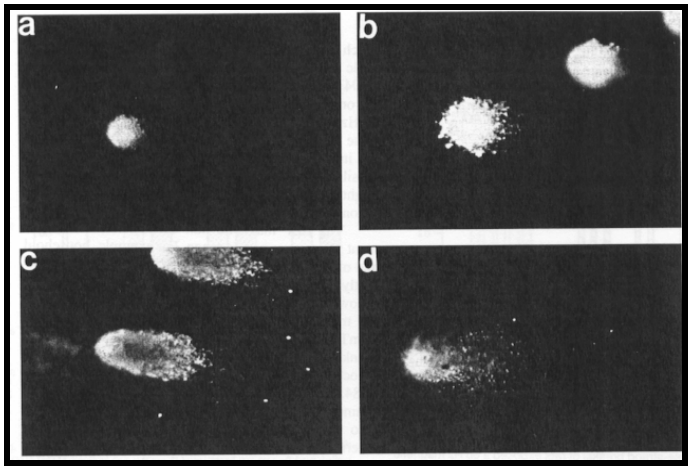

Figure 23: Photographs of double-strand break DNA migration pattern of individual brain cells from rats exposed to (a) bucking condition (0.1 mT), (b) magnetic fields of 0.1 mT, (c) 0.25 mT and (d) 0.5 mT, Lai and Singh (1997a). The “bucking mode” is the condition to reverse the field to cancel the magnetic fields with all else remaining constant.

The electrophoresis was then carried out for 60 minutes with 0.4 V/m, 250 mA. During this process the fluid in the assembly is re-circulated at the rate of about 100 ml/min. The negatively charged segments of DNA migrate down the electric field gradient, forming a comet-like tail, the mass of which is proportional to the amount of damaged DNA material and the electric field gradient and time of exposure.

For DNA double-strand breaks the microgel preparation is the same as above. Slides are then treated with ribonuclease A for 2 hr and then proteinase K for 2 hr. They are then placed in the neutral electrophoresis buffer (pH 9) for 20 mins and then electrophorezed for 1 hr at 0.4 V/cm. For both single- and double- strand assays the sample are stained with an intense florescent dye solution of YOYO-1 and then examined in a vertical florescent microscope.

The proteinase K treatment is vital. It removes the bound protein from the DNA strands. DNA and protein have the opposite charge and so for the electric field to cause migration, the protein must be removed. Four slides were prepared for each animal, two for single and two for double-strand assays. Fifty representative cells were scored off each slide, giving 100 cells scored for each of the single and double-strand DNA breaks. Frequency distributions for the 100 assayed cells are presented, Figure 19, and the comet tail moment calculated.

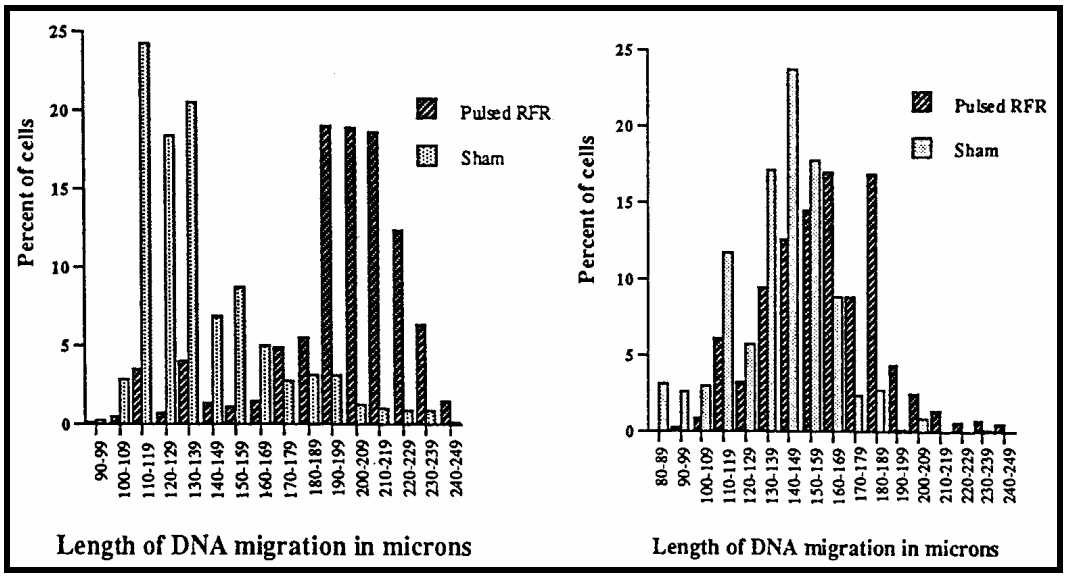

Figure 24: Single- and double-strand DNA breaks frequency distribution for percentage of cells of a given tail length from pulsed RFR and sham exposed brain cells, from 8 animals and 100 cells per animal, Lai and Singh (1996).

Figure 24 clearly shows significant increases in single- and double-strand DNA breaks from the pulsed microwave exposed animal brains compared with the sham exposed animals. The tail DNA fragments extend out to 250 microns. The Comet tails in the Malyapa et al. assay extend to less than 40 microns. This clearly documents how less sensitive their method is.

Motorola Funded Counter Research on DNA breakage:

Motorola funded Dr Joseph Roti Roti's group at Washington University, St Louis, to replicate the Lai/Singh DNA damage research and to extend it to cell phone frequencies. "Replication" requires the work to be very closely following the method and conditions of the earlier study. While both groups used 2.45 GHz microwaves for exposure, the follow up study used a cell line (C3H/10T1/2) compared to living rats, and they used a very different DNA damage assay based on Olive et al. (1992) not Singh et al. (1994). This follow up study used a much weaker fluorescent stain, an overall weaker electrophoresis field (0.6 V/cm for 25 mins c.f. 0.4 V/cm for 60 mins) and did not use proteinase K to separate the bound protein from the DNA strands. It is therefore understandable why they didn't observe DNA stand breakage from MW exposure.

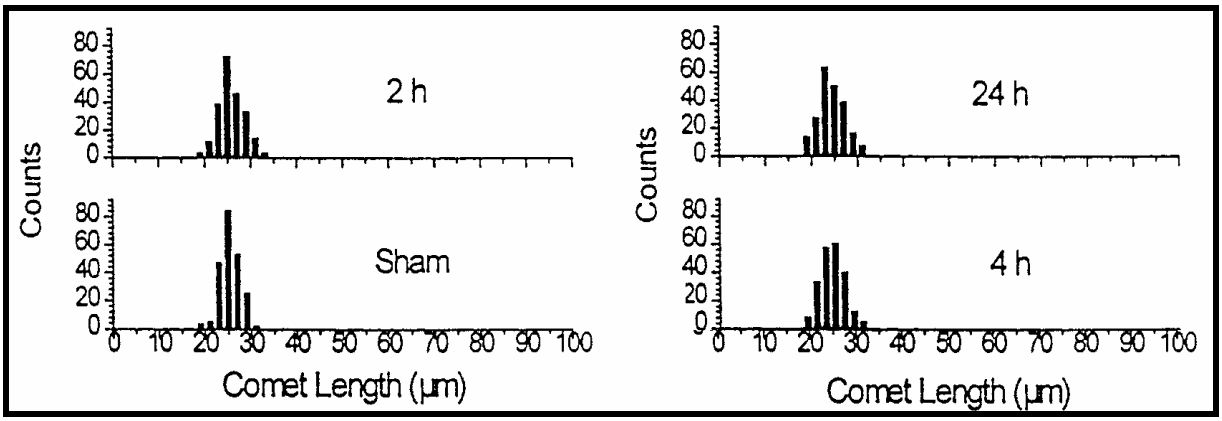

Figure 25: Frequency Distribution of Comet tail lengths for 2.45GHz exposed C3H10T1/2 cells, Malyapa et al. (1998), showing sham, 2 hr, 4 hr, and 24 hr exposure periods.

There is a clear difference between the sham exposed and the 2 hr exposed sample. By digitizing the distributions the difference between the number of comet tails less than or equal to 28μm compared with longer tails, is given in Table 1 and the time related results plotted in Figure 25a.

Table 1: The 2x2 table of results for DNA strand breakage after exposure of U87MG cells to 2.45 GHz microwaves, from Figure 14:

	Comet Length Class					
Time	≤28μm	>28μm	RR	95%CI	χ^2	p-value
Sham	196	29	1.00			
2hr	174	51	1.75	1.16 -2.76	7.34	0.0067
4 hr	206	20	0.06	0.40 -1.18	1.90	0.169
24 hr	197	25	0.87	0.53 -1.44	0.28	0.60

The time sequence of variations reveals a significant increase in DNA strand breakage after 2 hours and then the repair process kicks in and over compensates, Figure 25a.

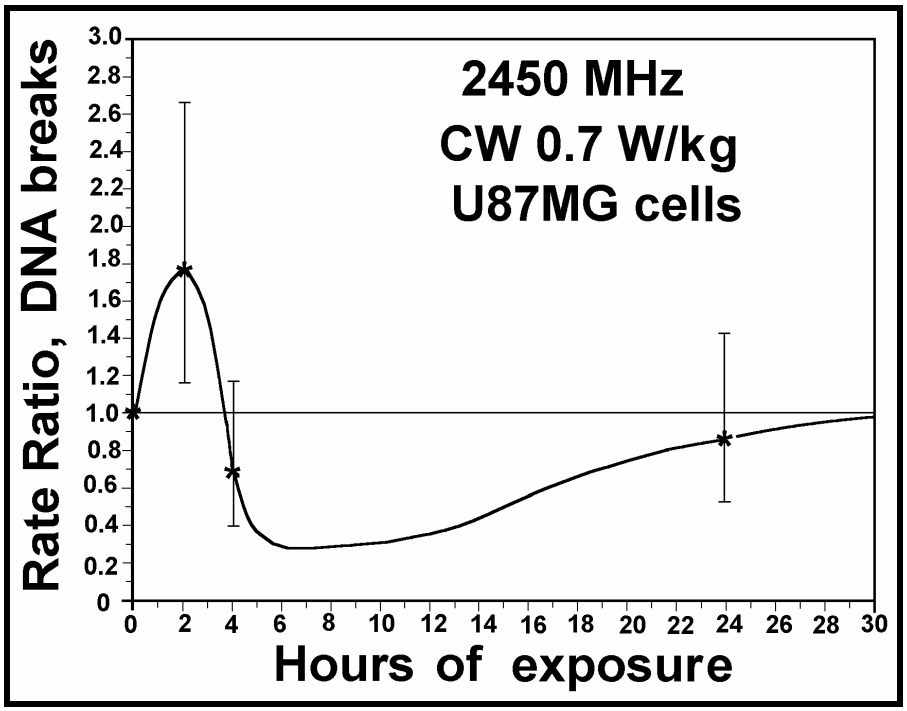

Figure 25a: The time sequence of DNA damage and enhanced repair for Figure 5 in Malyapa et al. (1997).

This confirms the Lai and Singh results rather than contradicting them. This shows significant DNA strand breakage after 2 hours. A repair mechanism kicks in to repair these human brain cells. The mistakes made in the repairs leads to mutations that result in enhanced cell death and cancer rates.

Differences between Lai and Singh and Malyapa et al.:

There are five primary differences between the Lai and Singh Comet Assay method derived from Singh at al. (1994) used at the University of Washington and the Comet assay method used at Washington University by Malyapa et al, derived from Olive et al. (1992).

The following factors make the Lai/Singh Assay more sensitive than that of Malyapa et al.:

1. Complete lysis using highly concentrated salt and two detergents.

2. The use of proteinase K to remove the positively charges bound protein from the negatively charged DNA stands so that the electrophoresis field produces more migration.

3. The use of antioxidants during electrophoresis.

4. Electrophoresis for a longer time to allow longer tails to form in the "Comet". Lai and Singh have 250 micron tails while Malyapa et al. have 40 micro tails.

5. The use of the YOYO-1 dye. YOYO-1 is 100-fold more sensitive when bound to DNA than propidium iodide.

Hence there are basic practical scientific reasons why Lai and Singh observe EMR-induced DNA strand breaks with RF/MW exposures, whereas Malyapa et al. don't. Two independent laboratories have shown that EMR, including cell phone radiation at extremely low intensities, causes DNA strand breaks. They are Verschaeve et al. (1994) and Phillips et al. (1998), who used the Lai/Singh method.

The Comet Assay and EMR effects:

Drs Lai and Singh have now shown that ELF and RF/MW radiation both cause single and double strand DNA breakage and are associated with free radical and reduced melatonin in living exposed rats. Lai and Singh (1995) observed a dose response increase in Single-strand DNA breakage in the rat's brain and hippocampus that increased significantly after 4 hours, Figure 26. The increases in DNA single-strand breakage after 4 hrs is highly significant, $p<0.001$ and they show a dose-response relationship.

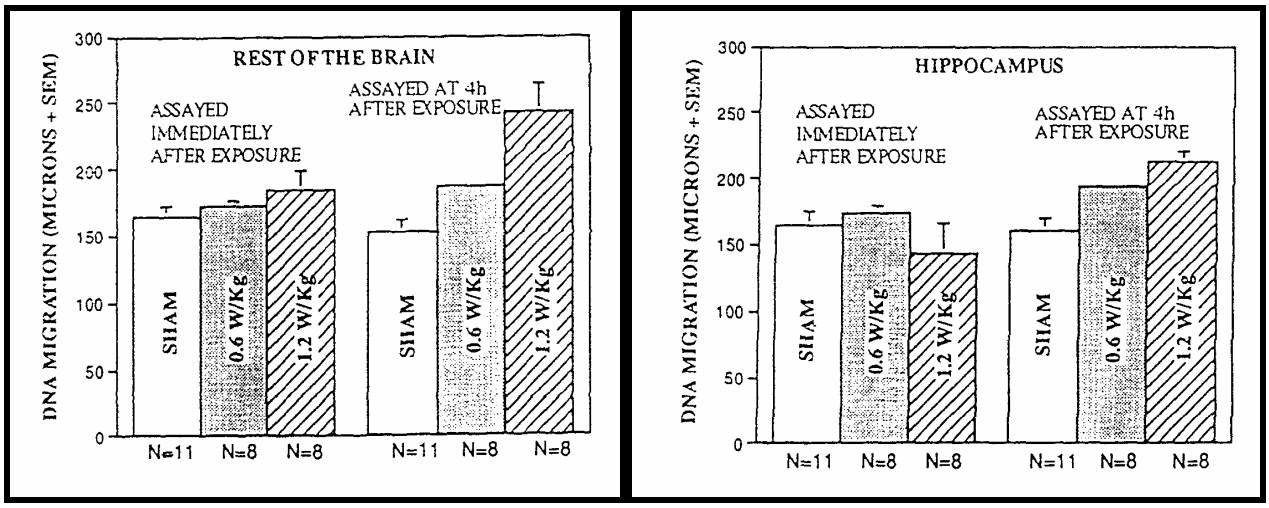

Figure 26: DNA single-strand breakage in cells from the rat brain and hippocampus, immediately after a 2 hr exposure to a whole body SAR of 0.6 and 1.2 W/kg to 2.45 GHz microwave radiation, pulsed at 500 pps. N is the number of rats studied. Lai and Singh (1995).

The assay method was extended to measure DNA double-strand breakage. Lai and Singh (1996) reported that both continuous wave (CW) and pulsed microwaves caused significant ($p<0.01$) increased single-strand DNA breakage, and double-strand breakage, CW, $p<0.05$) and pulsed, $p<0.01$), Figure 26.

This shows that both continuous and pulsed microwaves cause single and double DNA strand breakage, but pulsed microwaves cause more than continuous waves. Hence pulsed cell phone signals and radar signals are highly likely to cause DNA damage. This has been confirmed for radar and chromosome aberrations above and for cell phones by Phillips et al. (1998).

In the mean time Lai and Singh (1997) investigated the mechanism which is involved with this genotoxic effect of RF/MW radiation. They treated the microwave exposed rats with melatonin

and a spin-trap compound (PBN) to determine the role of free radicals. They showed that both melatonin and PBN eliminated the microwave induced DNA damage. Figure 28 shows the effect of melatonin for single- and double- strand DNA breaks and Figure 24 the same for PBN.

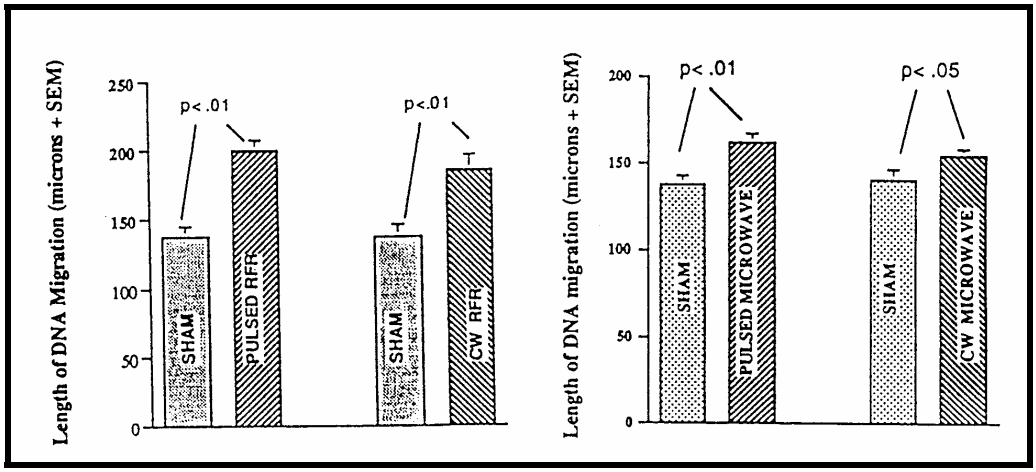

Figure 27: Single-strand (left) and double-strand (right) breaks in brain cells of rat after exposure to pulsed or continuous-wave RFR. Each bar represents data from 8 rats, Lai and Singh (1996).

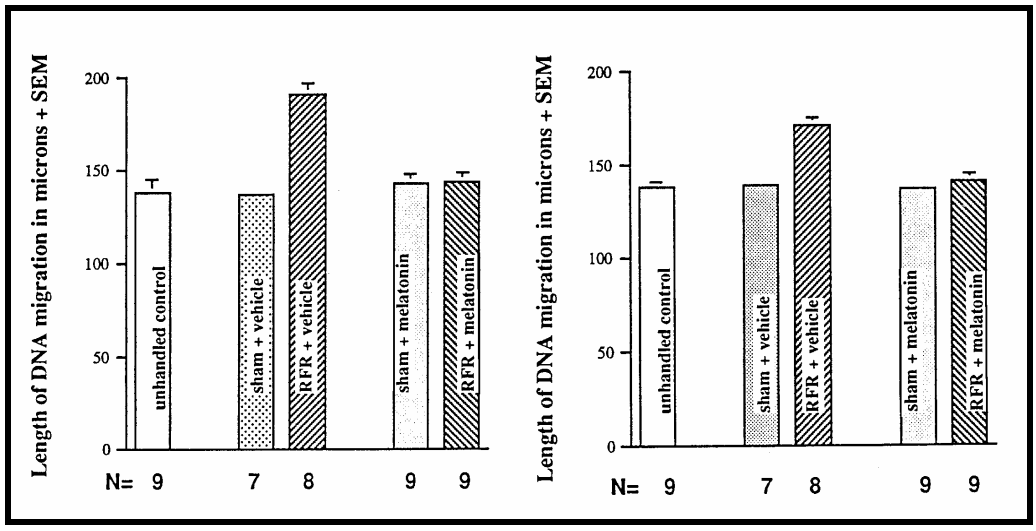

Figure 28: Effect of treatment with melatonin for RFR-induced increase in DNA single-strand (left) and double-strand (right) breaks in rats brain cells. Data was analysed using the one-way ANOVA, which showed a significant treatment effect ($p<0.001$) for both cases. "vehicle" involves injecting with the physiological saline without the active substance. Lai and Singh (1997)

Lai and Singh (1997) conclude that if free radicals are involved in the RFR-induced DNA strand breaks in brain cells, the results of their study could have an important implication of the health effects of RFR exposure. Involvement of free radicals in human diseases, such as cancer and atherosclerosis, have been suggested. Free radicals also play an important role in aging processes, Reiter, (1995). They also point out that both melatonin and PBN can have

other actions on cells in the brain that can decrease DNA damage. Therefore further support is necessary to interpret these results.

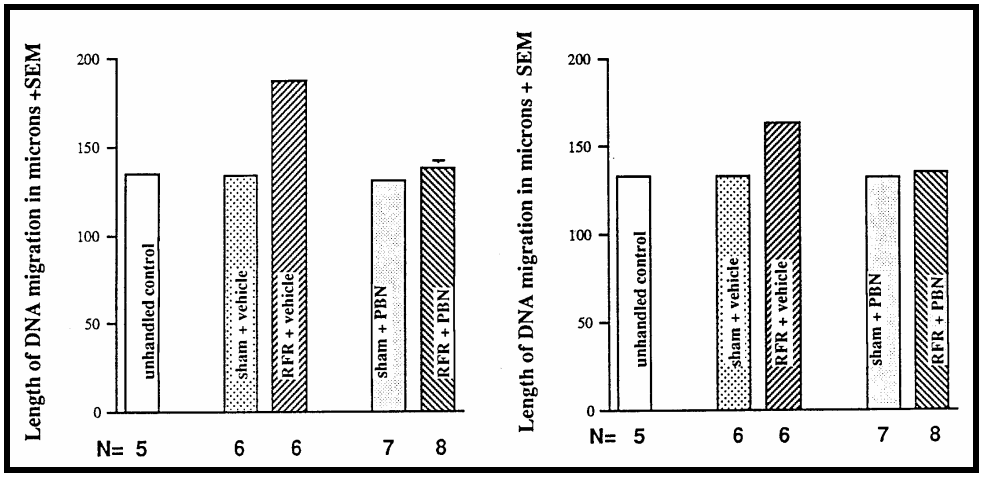

Figure 29: Effect of treatment with PBN for RFR-induced increase in DNA single-strand (left) and double-strand (right) breaks in rats brain cells. Data was analysed using the one-way ANOVA, which showed a significant treatment effect ($p<0.001$) for both cases. "vehicle" involves injecting with the physiological saline without the active substance. Lai and Singh (1997).

Phelan et al. (1992) exposed B-16 melanoma cell line to pulsed 2.45 GHz, 100 pps, 1hr exposure SAR = 0.2 W/kg. This resulted in changes of membrane ordering. Their data indicated that a significant, specific alteration of the cell-membrane ordering followed microwave exposure and that the alteration was due at least part, to the generation of oxygen radicals. Hence there is independent support for the generation of free radicals by microwaves, as well as the Lai/Singh evidence that PBN and Melatonin reduce the RFR induced DNA damage.

Two other laboratories have recorded RF/MW produced significant DNA stands breaks. Verschave et al. (1994), who used a GSM cell phone signal to expose human and rat peripheral blood lymphocytes, found significantly increased strand breaks at high, but non-thermal exposure levels. Phillips et al. (1998) exposed Molt-4 T-lymphoblastoid cells the a range of cell phone radiation in the SAR range 0.0024 W/kg to 0.026 W/kg for both iDEN and TDMA signals. Using the basic equations, these SARs at the 813-836 MHz range [SAR = $\sigma E^2/2\rho$, σ=1 S/m, ρ=940 kg/m^3, and S = $E^2/3.77$ μW/cm^2, E: the electric field gradient in V/m and S the exposure in μW/cm^2] result in 1.2 to 14.2μW/cm^2. A 2 hr exposure to these low levels of cell phone radiation significantly increased ($p<0.0001$) or decreased ($p<0.0001$) the DNA damage. Decreased DNA damage is evidence of increased repair that is evidence of damage, Meltz (1995). Significance at these levels is often taken as causal.

Hence RF/MW radiation has been confirmed to enhance DNA damage under RF/MW exposure from radar-like and cell phone exposures, including an exposure level which is 0.27% of the ICNIRP guideline.

ELF Exposure and DNA strand breakage:

Four independent laboratories have also published data on ELF induced DNA strand breaks confirming that ELF EMR damages DNA strands; Lai and Singh (1997a), Svedenstal et al. (1998), Phillips et al. (1998a), and Ahuja et al. (1997). Lai and Singh (1997a) also demonstrate the involvement of free radicals and the protective effect of melatonin. With the evidence above that EMR reduces melatonin this confirms that reduced melatonin causes higher concentrations of free radicals which produce more DNA strand breaks from EMR exposure from ELF to RF/MW frequencies. Increased DNA strand breaks will result in increased chromosome aberrations.

Multiple evidence from independent laboratories established that EMR from ELF to RF/MW causes DNA single- and double-strand breaks at very low, non-thermal exposure levels. This extends and confirms the genotoxic evidence from chromosome aberration studies.

EMR Altered Gene Activity

There is also evidence that EMR not only can damage chromosomes and DNA strands, but it is observed to alter cellular calcium ions and the activity levels of proto oncogenes (cancer genes).

Blackman (1990) concluded that there was overwhelming evidence that EMR can alter normal calcium ion homeostasis and lead to changes in the response of biological systems to their environment. On of these changes is altered gene transcription and expression. The lowest published exposure level associated with significant EMR-induced alteration of cellular calcium ions occur is reported by Schwartz et al. (1990). It was 0.00015 W/kg in a 30 min exposure to a 240 MHz signal modulated at 16 Hz. The medium was frog hearts. This is equivalent to an exposure level of about 0.06 $\mu W/cm^2$.

Calcium ion fluxes occur in “windows” of exposure parameter combinations. Two studies associate EMR exposure alteration of gene transcription with exposure windows. Litovitz et al. (1990) identified amplitude (intensity) windows, and Wei et al. (1990) frequency windows in the range 15 to 150 Hz. They observed a peak effect in c-myc gene transcription at 45 Hz. Liburdy et al. (1993) show that c-myc induction occurs in a direct sequence from calcium ion influx. Increased c-myc gene transcripts by 50/60 Hz fields has also been observed, Goodman et al. (1989, 1992) and Lin et al. (1994). Phillips et al. (1992, 1993) observed time-dependent changes in the transcription of c-fos, c-jun, c-myc and protein kinase C, from 60 Hz exposure and a linear reduction in ras p21 expression by a 72 Hz signal. 50/60 Hz signals altered c-jun and c-fos gene expression as observed by and Lagroye and Poncy (1998) and c-fos expression by Rao and Henderson (1996) and Campbell-Beachler et al. (1998). The ppSom gene is very important in human neurological disorders, and is regulated by calcium ions Capone, Choi and Vertifuille (1998).

Cell phone radiation (836.55 MHz) significantly altered c-jun transcript levels, Ivaschuk et al. (1997). Cell phone radiation significantly enhances the proto oncogene c-fos activity in C3H 10T 1/2 cells, from a 40 % ($p=0.04$) increase from a digital cell phone and a 2-fold increase ($p=0.001$) from an analogue cell phone, Goswami et al. (1999).

Hence proto oncogene activity is altered and enhanced in multiple independent experiments from ELF and RF/MW exposure, including cell phone radiation.

Immune system impairment by EMR

Impairment of the immune system is related to calcium ion efflux, Walleczek (1992) and to reduced melatonin, Reiter and Robinson (1995). Cossarizza et al. (1993) showed that ELF fields increased both the spontaneous and PHA and TPA- induced production of interleukin-1 and IL-6 in human peripheral blood. Rats exposed to microwaves showed a significant reduction in splenic activity of natural killer (NK) cells, Nakamura et al. (1997).

Dmoch and Moszczynski (1998) found that microwave exposed workers had decreased NK cells and a lower value of the T-helper/T-suppressor ratio was found. Moszczynski et al. (1999) observed increased IgG and IgA and decreased lymphocytes and T8 cells in TV signal exposed workers. Quan et al. (1992) showed that microwave heating of human breast milk highly significantly suppressed the specific immune system factors for E.Coli bacteria compared with conventional heating. Chronic, 25 year, exposure to an extremely low intensity ($<0.1\mu W/cm^2$) 156-162 MHz, 24.4 Hz pulse frequency, radar signal in Latvia produced significant alterations in the immune system factors of exposed villagers, Bruvere et al. (1998).

EMR Reduces Melatonin in Animals and People

DNA strand breaks, Chromosome Aberrations, impaired immune system competence and many other biological and health effects, are caused by reduced melatonin, Reiter and Robinson (1995). Light-at-night and electromagnetic radiation, are proven to reduce melatonin and hence pose significant adverse health effects.

The evidence for EMR reduction of melatonin is summarized here. Rosen, Barber and Lyle (1998) state that seven different laboratories have reported suppression of nighttime rise in pineal melatonin production in laboratory animals. They show that a 50 μT, 60 Hz field with a 0.06μT DC field, over 10 experiments, averages a 46% reduction in melatonin production from pinealocytes. Stark et al. (1997) observed a significant increase in salival melatonin in a group of 5 cows when the short-wave radio transmitter at Schwarzenberg, Switzerland, was turned off for three days, compared to 5 cows that had much lower RF exposure. Hence there are now nine independent observations of melatonin reduction in animals from ELF and RF exposure.

Fifteen studies from show that ELF and RF/MW exposure reduces melatonin and enhances serotonin in people. Evidence that EMR reduced melatonin in human beings commenced with Wang (1989) who found that workers who were more highly exposed to RF/MW had a dose-response increase in serotonin, and hence indicates a dose-response reduction in melatonin. Fourteen studies have observed significant EMR associated melatonin reduction in humans. They involve a wide range of exposure situations. This includes 16.7 Hz fields, Pfluger et al. (1996); 50/60 Hz fields, Wilson et al. (1990), Graham et al. (1994), Wood et al. (1998), Karasek et al. (1998), Burch et al. (1997, 1998, 1999a, 2000), Juutilainen et al. (2000) and Graham et al. (2000a); combination of 60 Hz fields and cell phone use, Burch et al.

(1997,1999a); VDTs ELF/RF exposures, Arnetz et al. (1996), and a combination of occupational 60Hz exposure and increased geomagnetic activity reduced melatonin is a dose-response manner, Burch et al. (1999b).

The fourteenth human melatonin reduction study is from 6.1-21.8 MHz SW RF exposure as reported during the shutting down process of the Schwarzenburg shortwave radio tower, Professor Theo Abelin (seminar and pers.comm.). Urinary melatonin levels were monitored prior to and following the closing down of the Schwarzenburg short wave radio transmitter. This showed a significant rise in melatonin after the signal was turned off.

Fifteen studies is sufficient to establish that EMR reduces melatonin in people from exposures across the EMR spectrum, and at extremely low mean exposure levels.

Genotoxicity Conclusions:

There is more than sufficient evidence of chromosome aberrations, DNA strand breakage altered oncogene activity and neoplastic transformation if cells to conclude that EMR across the spectrum from ELF to RF/MW is genotoxic. This is independently confirmed by the established biological mechanisms of calcium ion efflux and melatonin reduction.

His is also totally independent of over a hundred occupational groups showing elevated cancer from EMR exposure, scores showing significantly to extremely significantly elevated cancer incidence and mortality, and dozens of dose response relationships.

Epidemiological Evidence:

I strongly advocate that human health protection standards should be based on human health studies. Professor Abraham Lilienfeld expresses this as "The proper study of man is man."

The principles of applying epidemiological evidence is set out in Hill (1965). Sir Austin Bradford Hill was one of the eminent epidemiologists of the 20th Century. As a matter of principle I follow his approach.

Strength of evidence for public health has a classical hierarchy that has dose-response relationship at the top and biological mechanism at the bottom, Hill (1965). This is seen by considering Sir Austin Bradford Hill's descriptions of his 'view points' from which the question of cause and effect is being considered. Of dose-response he says:

"The simple dose-response curve admits of a simple explanation and obviously puts the case in a clearer light", i.e. cause and effect.

Sir Austin considers many other forms of evidence from which cause and effect can be decided in the absence of a dose-response. These include strength of association and consistency, although he points out that the lack of strength and apparent inconsistency, is not necessarily arguments against cause and effect. Of biological mechanism, or plausibility, he states:

"It will be helpful if the causation we suspect is biologically plausible. But this is a feature I am convinced we cannot demand. What is biologically plausible depends upon the biological knowledge of the day."

Thus biological plausibility has a low status and dose-response has a very high status.

When epidemiological evidence is available it should be used to set public health standards, where possible, using the dose-response relationships. In the absence of these, the level of lowest observed effect, with a safety margin to allow for uncertainly, the vulnerable, the size of the population at risk, are appropriate.

Dose response relationships for epidemiological studies of cancer are likely to be linear because of the cumulative cell damage/repair/mistake mechanism. At very high levels approaching lethal levels the curve become asymptotic. At very low levels, around the optimum homeostatic levels, curves can become "⊂" shaped. Thus, with the great sensitivity of the brain the neurological effects at extremely low exposure levels might be curved.

Cardiac Electrical Sensitivity:

Hearts are obviously bioelectrical organs. The electrocardiogram (ECG) is a fundamental monitoring tool of cardiologists in diagnosing the state of the heart muscle. The heart-beat occurs as a series of regular electrical pulses Each electric pulse initiates a cascade of calcium ions to flood the heart muscle and cause it to contract. Interference with this regular electrical pulse leads to heart disease and heart attack of the Arrhythmic kind. We would therefore expect electromagnetic radiation to cause arrhythmia and heart attack.

Epidemiological dose-response relationships from RF/MW exposures:

Dose-response relationships are shown here because they are very strong evidence of cause and effect and they give guidance as to the exposure levels involved. It should be noted however, that many other studies show significant increases in all of the cancer, cardiac, neurological and reproductive effects reported here. All occur at long-term mean exposure levels more than 100 times below the ICNIRP guideline, and residential studies involve mean exposures more than 1000 times lower than the public exposure guideline.

The guidance given by Sir Austin Bradford Hill, Hill (1965) shows that even a consistent non-significant relationship can be assessed as a causal effect. When a dose response relationship is obtained then it is very strong evidence of a causal effect.

"Classic" RF/MW studies:

Two U.S. radar exposure studies are classically quoted as showing no effects. This is not true to the data contained in Lilienfeld et al. (1978) and Robinette et al. (1980). Both show significantly elevated mortality and morbidity for a range of diseases, including cancer, cardiac

and neurological diseases. Some symptoms also occur with significant dose-response relationships.

Lilienfeld et al. (1978) report on the health effects of staff and dependents exposed to low level radar signals during tours of duty at the U.S. Embassy in Moscow.

Dose-response relationships as a function of years of exposure to these radar signals are shown in Table 1 Hence this study suggests that chronic exposure to extremely low intensity RF/MW radiation from radar produces a wide range of illnesses in a dose-response manner.

Table 1: Sickness rates increased in Moscow with years of service: (Table 6.18)

	Under 2 yrs	2-3 years	4 + years	p-value for trend
Number of people	316	455	45	
Person-years	3709	5570	568	
Male Conditions (%)				
Present Health Summary	5.4	9.7	16.2	0.05
Arthritis/rheumatism	4.3	6.5	8.8	0.02
Back Pain	4.0	7.7	11.8	0.04
Ear problems	3.8	5.6	14.7	0.02
Vascular system	0.8	2.7	11.8	0.004
Skin & Lymphatic	9.4	12.2	28.0	0.02
Female Conditions (%)				
Vaginal discharge	4.2	13.8	17.5	0.04

The sickness rates increased independent of the age of arrival and faster than the influence of aging.

Table 2: Neurological Symptoms per 1000 p-y, Male employees: (Table 6.31)

	Moscow	Comparison	RR	p-value
Depression	1.3	0.73	1.78	0.004
Migraine	1.8	0.97	1.86	
Lassitude	1.2	0.78	1.54	
Irritability	1.3	0.66	1.97	0.009
Nervous Disorders	1.5	0.64	2.34	
Difficulty in Concentrating	1.4	0.52	2.96	0.001
Memory Loss	1.6	0.50	3.20	0.008
Dizziness	1.2	0.85	1.41	
Finger Tremor	1.3	0.71	1.83	
Insomnia	1.1	0.90	1.22	
Neurosis	1.3	0.76	1.71	

Table 2 shows that chronic low level radar exposure increases a wide range of neurological symptoms with some critical symptoms being significantly elevated. These symptoms are

consistent with the "Microwave Syndrome" of the "Radiofrequency Radiation Sickness", Johnson-Liakouris (1998). Mild et al. (1998) identified significant dose-response relationships for the following symptoms from the use of mobile phones: Memory Loss, Difficulty in Concentrating, Headache, Fatigue. Hence it is now shown and known that RF/MW exposure from extremely low but chronic exposure over many years, occupational exposure and cell phone use all produces significant and consistent neurological symptoms. The Risk Ratios were quite large but they were not quite significant because of the very small sample numbers.

Table 3 summarizes the childhood diseases that were elevated. The sample size is very small, limiting the ability to reach statistical significance.

Table 3: Congenital Malformations of children after the first tour:

Conditions	Moscow SMBR	Comparison SMBR	RR	Number of children
Leukaemia and cancer	1.2	0.84	1.43	1
Blood Disorders	1.7	0.42	4.05	7
Mental, Nervous Cond^{n}.	1.8	0.36	5.0	8
Behavioural Problems	1.4	0.68	2.06	7
Chronic Disease	1.1	0.88	1.25	7

Blood samples were taken and tested for chromosome aberrations. Table 4 shows that in the reported samples a large proportion had above to well above average chromosome aberrations.

Comparing the 23 cases with above average and 11 cases within the average range gives:

RR = 2.09, 95%CI: 1.22-3.58, p=0.004

Table 4: Blood samples showed a high proportion of the staff had significantly altered red and white blood cell counts and well above average chromosome aberrations (CA). The CA data is set out in Goldsmith (1997), i.e.

Mutagenic Level	Designator	Subjects, No.	
5	Extreme	0	
4	Severe	6	
3.5	Intermediate	5	
3	Moderate	7	↑
2.5	Intermediate	5	Much more then average
2	Questionable	5	
1	Normal	6	

Korean War Study, Robinette et al. (1980):

Robinette et al. (1980) studied the health effects of radar exposed naval technical personnel who had served on ships during the Korean War. When a 5% sample of servicemen were assessed for personal exposure in a job-matrix exposure survey, they were shown to have a significant dose-response increase in Total Mortality and Respiratory Cancer as a function of exposure level as assessed by the Hazard Number. Figure 29 shows the dose-response relationships for these mortalities with the lowest exposure range used as a reference with RR=1.0.

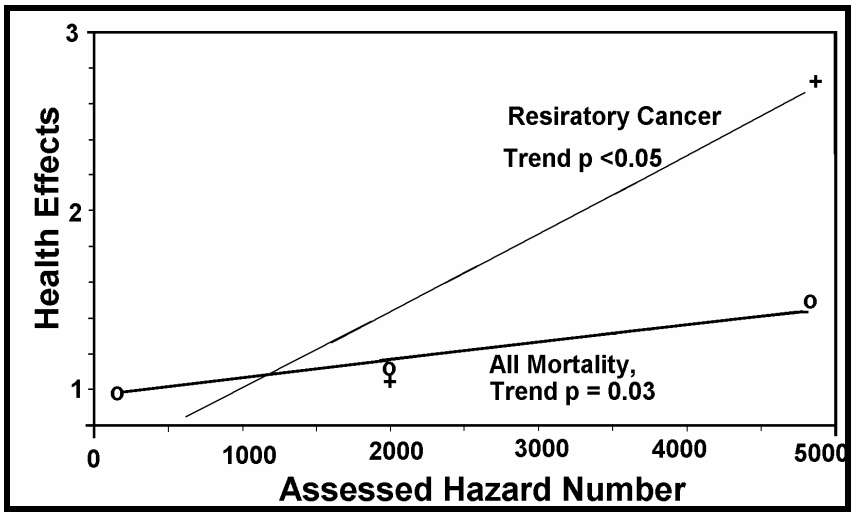

Figure 29: Dose-response relationships of mortality from all causes and respiratory cancer for radar exposure assessed personnel, Robinette et al. (1980).

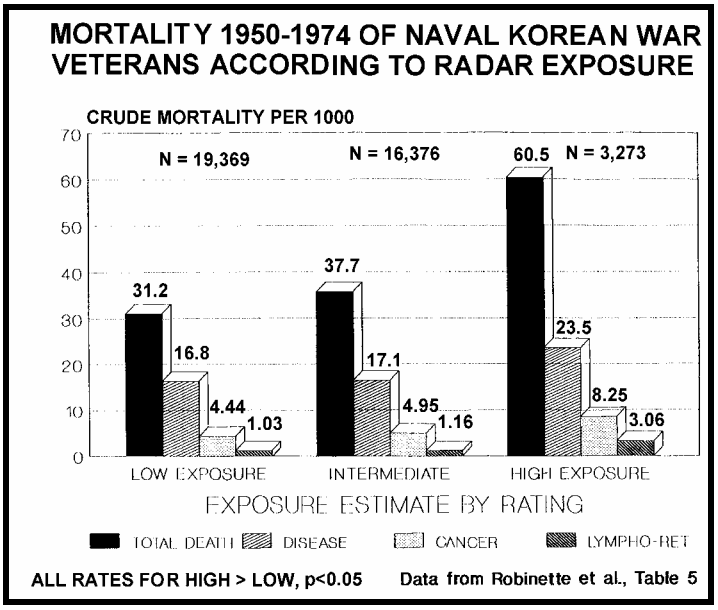

Figure 30: Naval occupations grouped by exposure category, showing dose response increases in mortality for all mortality, all disease, cancer and Lymphatic/Leukaemia. Low exposure (RM+RD), Intermediate exposure ET+FT), High exposure (AT).

Grouping occupational groups according to exposure levels also reveals dose-response increases for Total Death, All Disease, All Cancer and Lymphatic/hematopoietic Cancer, Figure 30.

From Table 5 in Robinette et al, (1980) the AT group has 3273 member, 198 of whom had died with the defined period. The ET group had 13078 members of whom 441 had died in the same period. This gives:

OR = 1.85 RR = 1.79, 95% CI: 1.52-2.11, Chi Squared = 49.97, $p<0.0000001$

It is not credible to claim that this study shows no adverse effects from radar exposure. The effects are extremely and causally relating radar exposure to increased mortality, disease and cancer death.

Hence it is shown that these are not "no effects" studies. Rather they show significant dose response increases in death, cancer and a wide range of diseases. They also show significant increases of many mortality and morbidity health effects.

Global Leukaemia dose response for RF/MW exposure:

Leukaemia is frequently significantly raised in RF/MW exposed populations. Table 5 summarizes several studies that are ranked in mean exposure order. Military, occupational and residential studies taken together show a global dose response relationship for increased adult leukaemia and RF/MW exposure with a dose-response threshold close to zero.

All exposures, even in Szmigielski (1996), are below the level where a temperature rise is sensed. Professor Szmigielski confirmed this in response to my direct question at the Vienna Conference in 1998.

When actual residential exposures are considered, dose responses for residential cancer are also shown by Dolk et al. (1997 a,b) and Michelozzi et al. (2002). These show a causal effect of adult and childhood leukaemia are levels of residential exposure involving exposure levels produced by cell sites out to over 500m.

Childhood Cancer in the vicinity of the Sutro Tower, San Francisco:

Many studies have identified elevated childhood leukaemia for children living in the vicinity of high voltage powerlines, Hardell et al. (1995). This includes dose-response relationships, Figure 31, Wertheimer and Leeper (1979), Savitz et al. (1988), London et al. (1991) and Feychting et al. (1995). These should be sufficient for a causal relationship between ELF exposure and childhood leukaemia.

Table 5: A summary of epidemiological studies involving adult leukaemia mortality or incidence, ranked by probable RF/MW exposure category.

Study	Reference	Exposure Category	Leukaemia Type	Risk Ratio	95% Confidence Interval
Polish Military (Mortality)	Szmigielski (1996)	High	ALL	5.75	1.22-18.16
			CML	13.90	6.72-22.12
			CLL	3.68	1.45-5.18
			AML	8.62	3.54-13.67
			All Leuk.	6.31	3.12-14.32
Korean War Radar Exposure	Robinette et al. (1980) (Mortality)	High AT/ET	Leuk/Lymp	2.22	1.02-4.81
Radio and TV Repairmen	Milham (1985)	Moderate	Acute Leuk.	3.44	
			Leuk.	1.76	
Amateur Radio (Mortality)	Milham (1988)	Moderate	AML	1.79	1.03-2.85
UK Sutton Coldfield <=2km	Dolk et al. (1997a)	Moderate	Leuk	1.83	1.22-2.74
North Sydney TV/FM towers (Mortality)	Hocking et al.(1996)	Low	All Leuk.	1.17	0.96-1.43
			ALL+CLL	1.39	1.00-1.92
			AML+CML	1.01	0.82-1.24
			Other Leuk	1.57	1.01-2.46
UK TV/FM (Incidence)	Dolk et al. (1997b)	Low	Adult Leuk.	1.03	1.00-1.07

Note: ALL : Acute Lymphatic Leukemia; CLL: Chronic Lymphatic Leukaemia; AML Acute Myeloid Leukaemia; CML: Chronic Myeloid Leukaemia; and All Leuk.: All Adult Leukaemia.

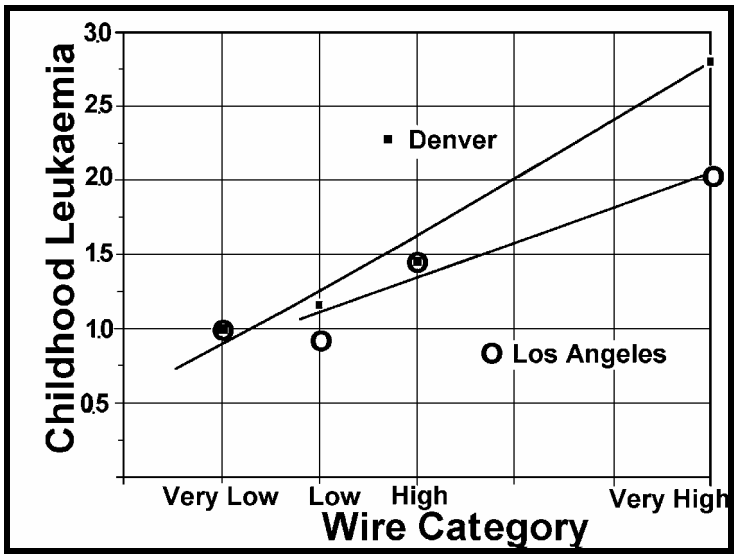

Figure31: Two early childhood leukaemia studies show dose response relationships for the Wire Category which is the best estimate of the long-term mean magnetic field.

Selvin et al. (1992) studied the spatial distribution of 4 childhood cancers in relation to the Sutra Tower in San Francisco to test a cluster method. The radial childhood cancer rates can be compared with the radial RF exposure pattern. This was obtained from measurements and the typical UHF vertical antenna pattern, both provided by Hammett and Edison (1997). These produce the pattern in Figure 32.

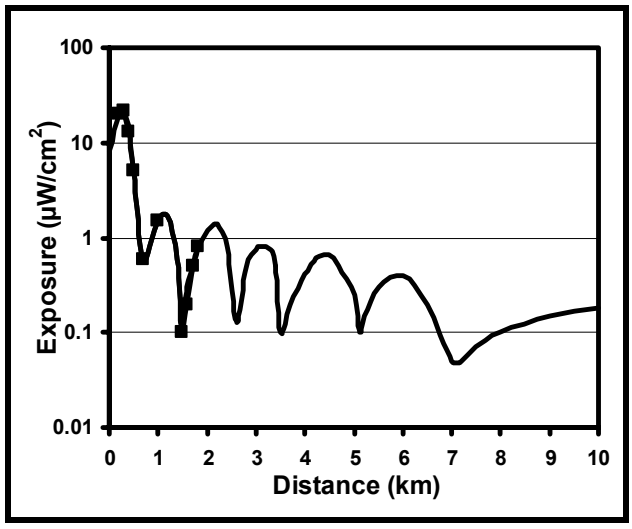

Figure 32: The measured and estimated power density (exposure in $\mu W/cm^2$) with distance from the Sutro Tower. Squares show the 1988 measurements. The line follows measurement points and the radial pattern of a typical UHF transmission beyond 2 km. From Hammett and Edison (1997).

When measured and practical radial exposure patterns are compared with the radial brain cancer rates a very similar radial pattern of the exposure in Figure 32, in Figure 33.

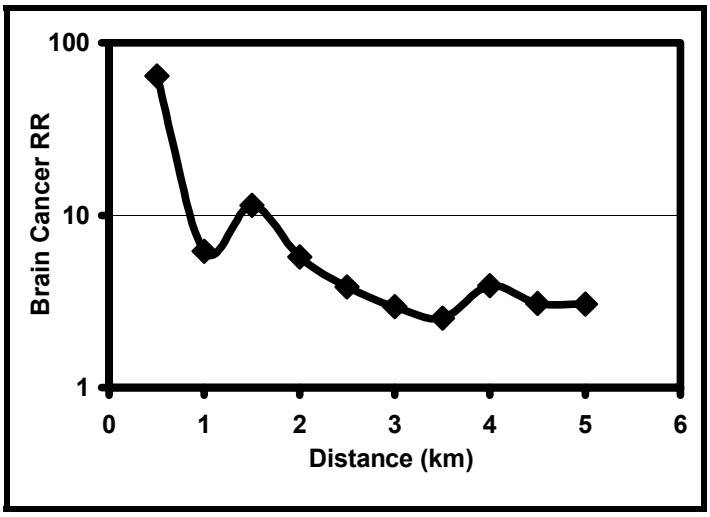

Figure 33: The Childhood Brain Cancer Radial RR 0.5 km pattern around the Sutro Tower, showing a Pattern B consistent with the radiation Pattern B.

When the brain cancer is graphed against the rising exposure level, Figure 34, a highly significant dose response relationship results. Because of the complex nature of residential radial broadcast tower exposure patterns, Figure 33, the chance of confounding effects are extremely small. Thus this indicates a causal relationship because no other factor can explain this result than the RF exposure from the Sutro Tower.

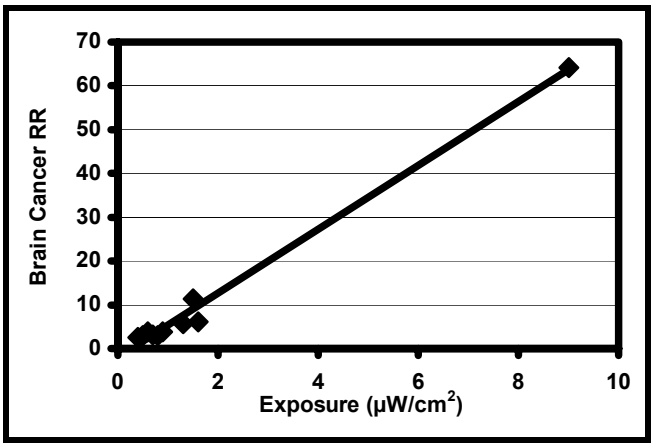

Figure 34: Childhood Brain Cancer as a function of measured and estimated RF/MW exposure in 0.5 km radial rings. Trend p<0.00001.

Figure 35 shows the equivalent graph for childhood all cancers.

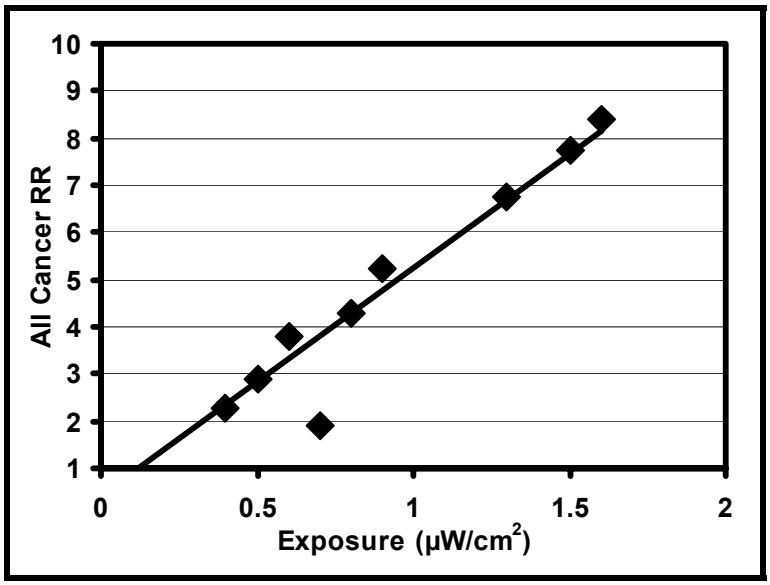

Figure 35: All Childhood Cancer as a function of measured and estimated RF/MW exposure in 0.5 km radial rings, ignoring the 9 $\mu W/cm^2$ outlier that only contained Brain Cancer. Trend p<0.0001.

As an alternative check on the analysis of this data a 2x2 analysis was carried out using five 1km radial rings exposure groups, the near, middle and far groups, with high, middle and low mean exposures. Comparing the highly exposed inner group within 1km of the tower, with the low exposure group outside 5km radius gives the results in Table 6. Here n is the exposed population and Chi Squ. is the Mantel-Haenszel Chi Squared estimate. When n<5 then the Fisher exact test is used for p-value (*).

Table 6: The Near Sutro Tower (<1km) Childhood Cancer rates compared with the remote >5km rates. (* Fisher Exact p-value for n<5).

Cancer Type	Cases	RR	95%CI	p-value
Brain Cancer	3	15.5	3.14-76.8	0.004*
Leukaemia	2	5.2	1.05-25.6	0.08*
Lymphoma	2	15.5	2.19-110	0.02*
Leukaemia/Lymphoma	4	7.8	2.34-25.7	0.0045*
All Cancer	7	9.9	3.84-25.4	<0.0000001

All cancer types are significantly elevated, except the lowest, Leukaemia, RR = 5.2, 95%CI: 1.05-25.6, n=2. For All Cancer the RR = 9.9, 95%CI 3.84-25.4, p<0.0000001. Brain Cancer (RR = 15.5) and Lymphoma (RR=15.5) are highly significantly elevated. The strength of the relationship of the All Cancer is classically causal, Hill (45). This occurs despite the very small sample size but the strength of the relationship is supported by several previous studies showing elevated cancer rates around broadcast towers.

Table 7: The broad ring trend analysis with distance from the Sutro Tower, with Childhood Cancer rates relative to the remote >5km ring. The brackets show p-value adjusted for the single low data outlier.

Ring	Brain Cancer		Leukaemia		Lymphoma		All Cancer	
km	RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI
0.1-1	15.5	3.14-76.8	5.2	1.05-25.6	15.5	3.19-110	9.9	3.84-25.4
1-2	7.8	2.1-30.9	7.2	3.07-20.8	3.4	0.48-24.3	7.2	3.45-14.7
2-3	3.3	0.84-13.4	3.3	1.25-8.9	11.0	2.48-48.6	4.7	2.37-9.35
3-4	3.2	0.85-12.1	1.8	0.64-5.1	6.6	1.47-29.9	3.1	1.53-6.17
4-5	3.07	0.81-11.6	1.5	0.53-4.4	4.0	0.84-19.4	2.41	1.17-4.93
>5	1.00		1.00		1.00		1.00	
Trend p-value		0.03	0.02 (<0.005)		0.08 (<0.001)		<0.001	
Log/Lin Trend		p<0.001	0.05 (<0.03)		0.07 (<0.02)		<0.0001	

Table 7 shows significantly elevated childhood cancer rates in all 1km rings for All Cancer. For Brain Cancer all rates are significantly elevated for <2km and with a consistently declining with a significant linear trend, p=0.03, and highly significant log-linear trend, p=<0.001. Leukaemia and Lymphoma rates show quite variable patterns, especially for the small samples in ring <1km for Leukaemia and out to 2km for Lymphoma. They both show significant linear and log-linear trends, especially when the small sample outliers are removed. When all the data is combined to form the All Cancer trend, it is significantly elevated in all 1km rings and consistently declines with distance. There is also a highly significant linear trend, p<0.001, and a log-linear trend, p<0.0001.

It is unusual for one study to be significant enough to show a causal relationship. The data in Selvin et al. does show a causal relationship between RF exposure from the transmitters on the Sutro Tower and childhood cancers. The causal relationship is shown by the complex radial cancer and RF exposure patterns matching, significant dose-response relationships, and consistent and extremely significantly increased Rate Ratios. These results are confirmed in an Italian study of cancer around the high-power Vatican radio station near Rome, Michelozzi et al. (2002).

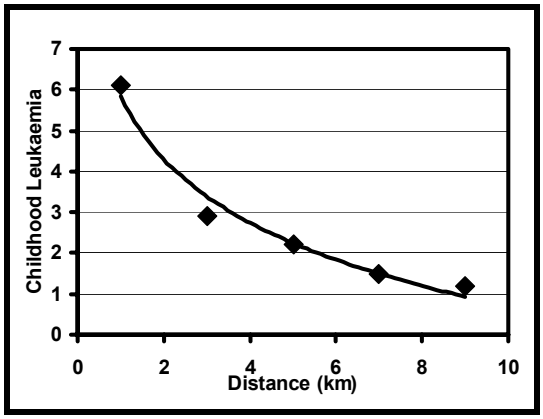

Figure 35: Cumulative childhood leukaemia near the Vatican Rome Radio Station with an exponential fitted trend line, R^2=0.9756, p = 0.002, Michelozzi et al. (2002).

Neurological effects:

Brains are very electromagnetically sensitive because our sight, thoughts, memories, learning and emotions use complex electromagnetic signals. Research in Germany in the post war period proved that human brains detect and use extremely small natural low frequency (ELF) EMR signals, Wever (1974), Konig (1974). Since RF/MW signals induce higher currents in human tissues and low frequency signals it is inevitable that we will observe neurological effects from chronic RF/MW exposures.

Recent studies have revealed some neurological dose response relationships for sleep disturbance, Multiple Sclerosis and Suicide at extremely low exposures to RF and ELF exposures. Beale et al. (1997) found significant dose response for psychological symptoms, including anxiety and depression, living in proximity to high voltage powerlines. This strongly confirms the sensitivity of human brains to EMR exposure.

These studies have early roots in U.S. Embassy in Moscow study. Lilienfeld et al. (1978), showed significant neurological effects from chronic low level radar exposure, including Depression ($p=0.004$), Irritability ($p=0.009$), Memory Loss ($p=0.008$) and Difficulty in Concentrating ($p=0.001$).

These are all symptoms related to melatonin reduction. The Korean War Study, Robinette et al. (1980) also found increased neurological health effects from personnel who were exposed to radar on ships during the Korean War. These symptoms between a high exposure group (FT+AT) and a low exposure group (ET), Mental Conditions, RR = 1.68, 95%CI: 1.13-2.50, $p<0.01$ and Neurological illness, RR = 1.42, 95%CI: 0.74-2.72.

Mild et al. (1998) show significant dose-response relationships for cell phone usage and headaches, dizziness, memory loss, discomfort, fatigue, and loss of concentration. Dose responses were shown for both calls/day and minutes/day. Figures 36 and 37 show the minutes/day graphs for Norway and Sweden, respectively. Norway is dominantly analogue and Sweden digital.

The analogue phones used in Norway typically have higher SAR levels than the digital phones used in Sweden. The sensation of warmth on an behind the ear is much stronger in Norway. The symptoms reported in Norway are somewhat more prevalent than in Sweden. For example, the Fatigue prevalence in Norway for more than 60 mins per day is 28% and in Sweden it is 20%. The difference is quite marked for all symptoms except Concentration and Memory Loss. These are the same symptoms that have frequently been reported as "Microwave Sickness Syndrome" or "Radiofrequency Sickness Syndrome", Baranski and Czerski (1976) and Johnson-Liakouris (1998).

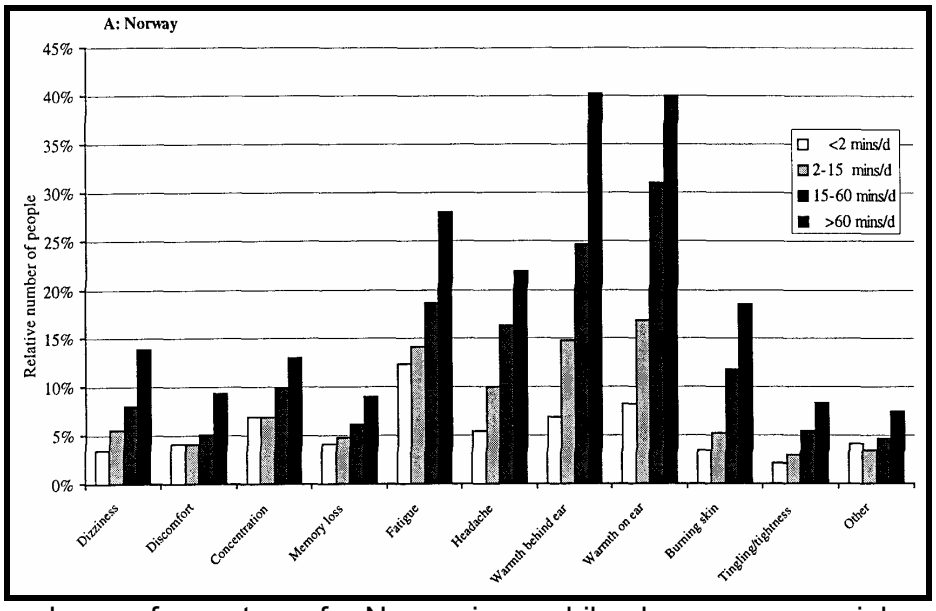

Figure 36: Prevalence of symptoms for Norwegian mobile phone users, mainly analogue, with various categories of length of calling time per day, Mild et al. (1998).

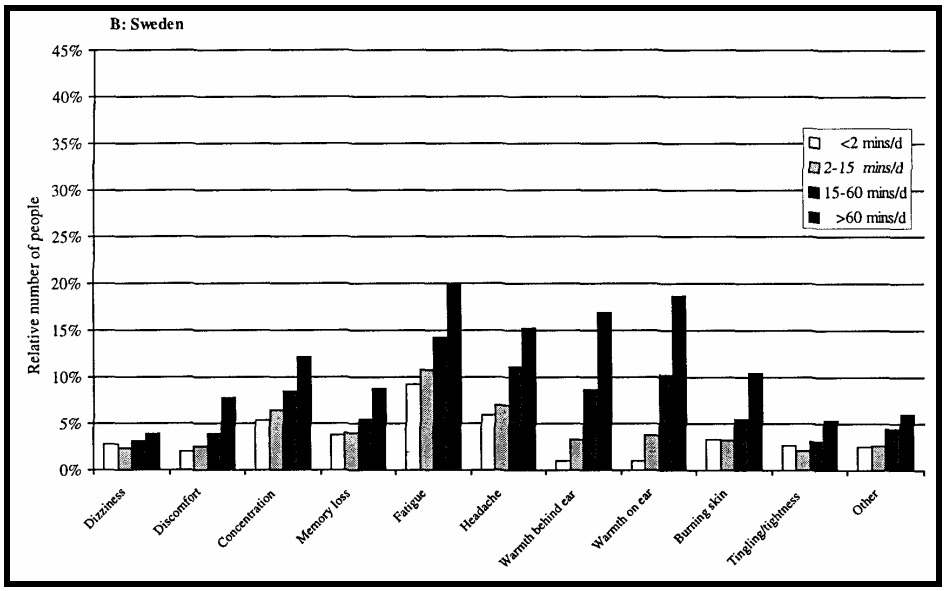

Figure 37: Prevalence of symptoms for Swedish mobile phone users, mainly digital, with various categories of length of calling time per day, Mild et al. (1998).

Sleep Disturbance near a Shortwave Radio Tower, Schwarzenburg, Switzerland:

The Schwarzenburg Study, Alpeter et al. (1995) and Abelin (1999) showed a causal relationship of sleep disturbance with exposure to a short wave radio signal. The effect is assessed as causal because of the significant dose-response relationship, the variation of sleep disturbance in two experiments, one involving changing the beams and one turning the transmitter off, and the identification of significant melatonin reduction. Professor Abelin told seminars in Christchurch that they had measured a significant increase in melatonin after the tower transmission was turned off permanently compared to the levels while it was on.

Groups B, R and C are all exposed to a mean RF signal of less than 0.1μW/cm^2 and they experienced highly significant sleep disturbance and reduced melatonin. Since sleep disturbance, Mann and Roschkle (1995), and melatonin reduction, Burch et al. (1997), has been observed with cell phone exposure. Hence these observations also apply to cell phones and cell sites.

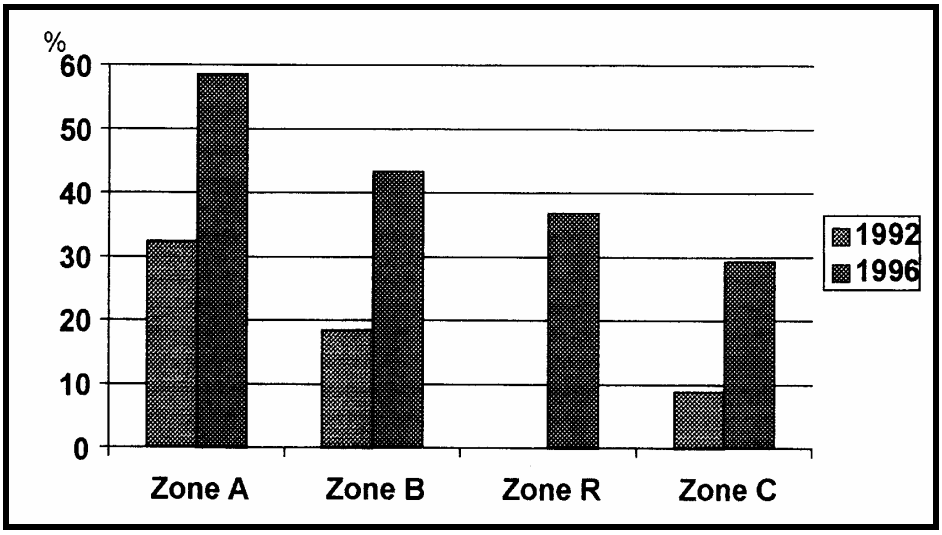

Figure 38: Adult Sleep Disturbance with RF exposure at Schwarzenburg, Switzerland, Abelin (1999).

Sleep disruption occurs in a dose-response manner with a threshold below 0.1nW/cm^2. ie. very close to zero, Figure 39.

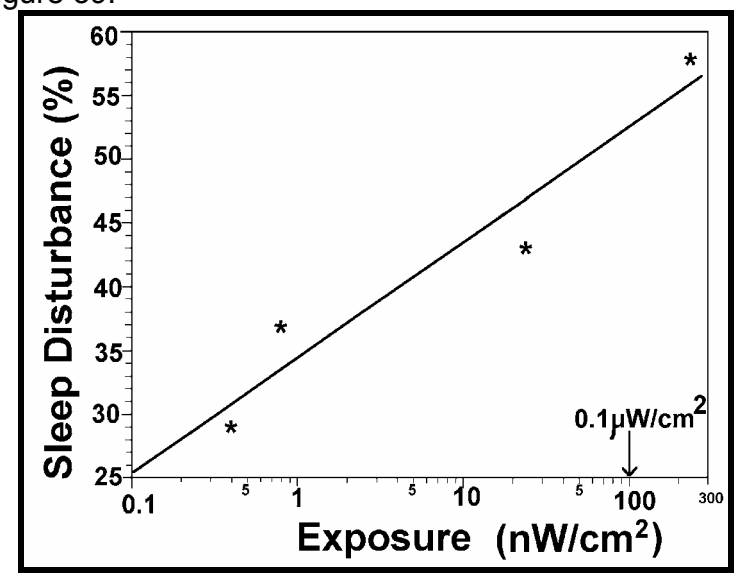

Figure 39: Dose-response relationship for Sleep Disturbance at Schwarzenburg with exposure in nW/cm2. Note: 1nW/cm^2= 0.001μW/cm^2

Multiple Sclerosis in Danish Electric Utility Workers:

A study of 26,124 men working in Danish utility companies were studied for their incidence of multiple sclerosis (MS) in relation to average work-related exposure to electromagnetic fields. A small group of 15 men were shown to have a dose-response incidence of MS as a function of EMF exposure, Figure 40. The lowest group is used as a reference (RR=1.0).

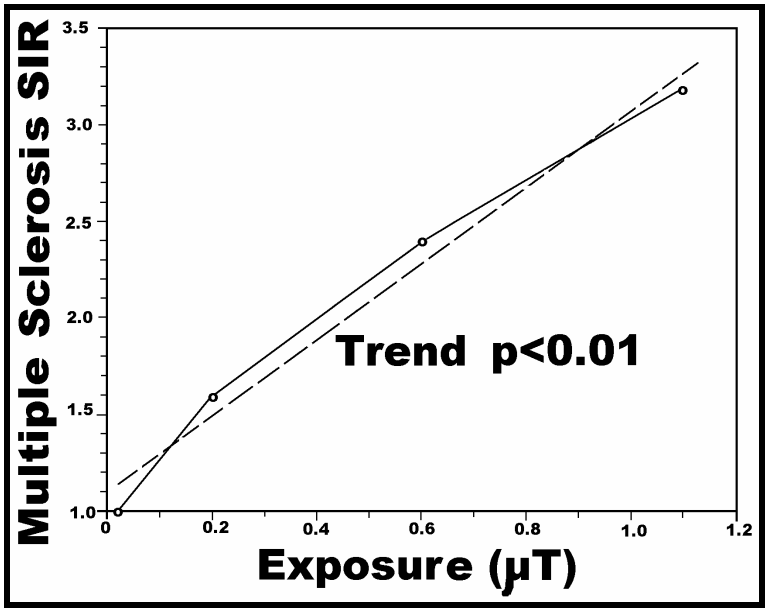

Figure 40: Dose response relationship of Multiple Sclerosis for a small group (N=15) of men occupationally exposed to typical peak magnetic fields in a Danish utility company, Johansen et al. (1999).

The authors conclude that they find no support for the hypothesis. In fact, despite the small sample size, their data shows very strong support for the hypothesis that EMR is associated with adverse neurological effects at extremely low mean exposure levels.

Suicide in U.S. Electric Utility Workers:

A very large study of men working in U.S. electric utility companies included monitoring time weighted average ELF exposures of 2842 people and the identification of 536 deaths from suicide and 5348 controls. For recent exposure and 1 to 5 years of recent exposure there were significant dose-response relationships with cumulative exposure to electromagnetic fields. The recent exposure result is shown in Figure 41.

This confirms the results of Perry et al. (1981) who found a highly significant association between suicide and the exposure to magnetic fields from High Voltage Powerlines. Baris and Armstrong (1990) also found RF exposure shows a significant 53% increase in suicide or British Radio and Radar Mechanics, and 156 % increase for Telegraph radio operators.

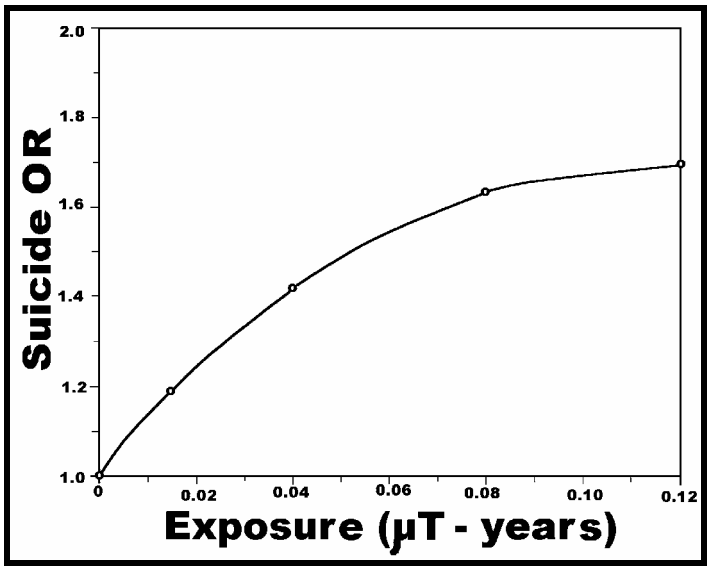

Figure 41: Dose response relationship of Suicide after recent monitored exposure to cumulative 50 Hz magnetic fields for men <50 years, adjusted for work, class, location and exposure to sunlight and solvents, Wijngaarden et al. (1999).

Non-linear response for neurological effects at extremely low exposure levels are evident in the three studies presented here for sleep disturbance, multiple sclerosis and suicide

Brain Tumour with VDT exposure:

Beall et al. (1997) found significant increases in brain tumour, especially glioma, among long-term workers using computers who are exposed to a mix of ELF and RF radiation from the VDTs. For long-term computer users, Engineering/technical users show a non-significant dose response, but computer programmers show a significant dose-response relationship, Figure 42.

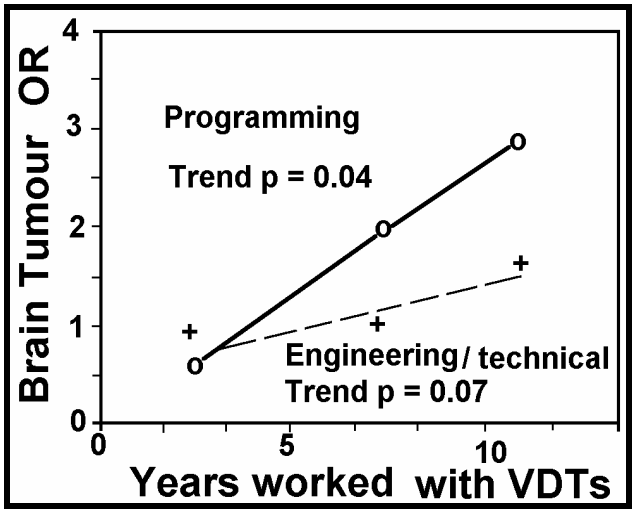

Figure 42: Dose-response increases in brain tumour from years of working with computers, Beall et al. (1997).

Melatonin reduction, clinical depression (Verkasalo et al., 1997), and suicide are all significantly and/or dose response related to EMR exposure. Along with sleep disruption and brain tumour, this constitutes a very strong and coherent set of data supporting a causal relationship between ELF to RF/MW exposure, including cell phone usage, and neurological illness and death.

GABA is a primary neurotransmitter that is involved in many neurological processes. Many neurological systems have up to 60% of the synapses that are regulated by GABA (gamma-amino butyric Acid). Substances that alter GABA can cause abnormal pathologies. Kolomytkin et al. (1995) conclude that GABA systems are very sensitive to microwaves. GABA indicator molecules are altered in a dose-response manner by microwaves in living rat brains, Figure 43.

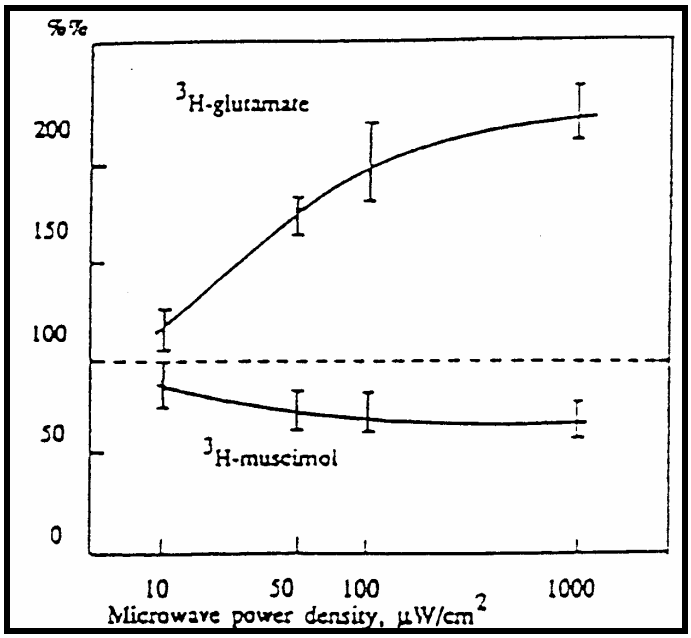

Figure 43: Exposure related alteration of GABA related molecules in rat brains exposed to 915 MHz microwaves, pulsed at 16 pps. Differences from controls are still significant at 10μW/cm^2, Kolomytkin et al. (1995)

Natural EMR Sensitivity of the Human brain:

Since human brains detect and use naturally occurring ELF signals under 1pW/cm^2 then our brains can detect and react to signals many orders of magnitude higher than this. Interactions include resonant absorption of signals with particular ELF signal or modulation frequency ranges, and interference with the natural signals so that they cannot reliably perform their functions. These functions include regulations of hormones such as melatonin and thyroid stimulating hormone (TSH). Both of these have been shown to be reduced by cell phone exposures. Reduced melatonin leads to increased DNA strand breaks and chromosome aberrations. These in turn lead to cancer and reproductive effects.

Cardiac Effects of EMR:

Hearts use natural electric pulses to produce heart-beats. An electric pulse produces a cascade of calcium ions that cause the heart muscle to contract. The Electrocardiogram (ECG) is used to monitor heart activity and can detect heart disease through the altered electrical signals. Hence it is biologically plausible that electric signals, that are shown to interfere with artificial pacemakers, can also interfere with the natural heart-beat. This has been shown in several studies in relation to reduction of the heart rate variability (HRV). This is a known risk factor for heart disease.

Satre, Cook and Graham (1998) observed significantly reduced heart rate variability (HRV) in volunteers sleeping in 60Hz fields. Extrinsic EMR signals interfere with hearts and cause heart disease and death. Bortkiewicz et al. (1995, 1996, 1997) and Szmigielski et al. (1998) found that RF exposure altered heart rate variability and blood pressure. Forman et al.(1982) present case studies of microwave exposed personnel with induced hypertension. Braune et al. (1998) showed that cell phone significantly increased blood pressure. Savitz et al. (1999) found a highly significant dose response relationship for mortality from Arrhythmia related heart disease and heart attack (Acute Myocardial Infarction) for exposed electrical occupations and for individual occupations of electrician, lineman and power plant operator.

Hamburger, Logue and Silverman (1983) observed significant dose responses for heart disease for male physiotherapists as a function of treatments per month with microwaves, OR = 2.51 (1.09-5.78), Trend $p<0.05$); shortwave, OR = 3.40 (1.56-7.39), trend $p=0.005$; and Combined Microwave and Shortwave, OR = 2.88 (1.21-6.70), trend $p=0.025$.

This is a powerful set of epidemiological evidence showing that EMR across the spectrum increases the incidence and mortality from arrhythmia related heart disease and from heart attack. The following graph shows the dose-response curve for Acute Myocardial Infarction (Heart Attack) in electric utility workers, Figure 44.

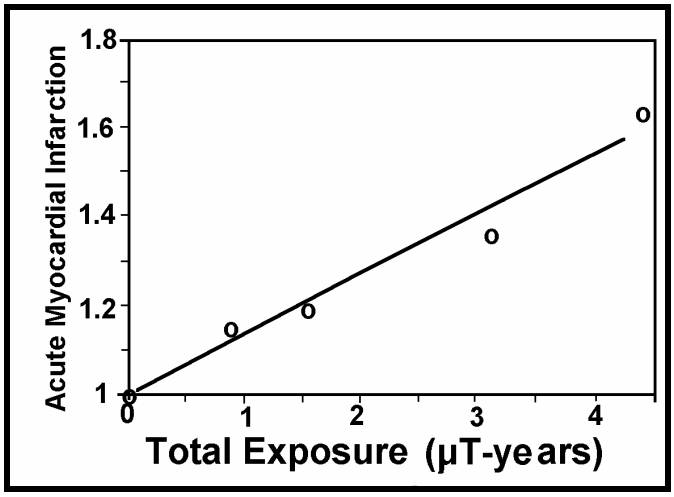

Figure 44: Acute Myocardial Infarction as a function of cumulative exposure to 60 Hz fields in U.S. electricity utility workers, Savitz et al. (1999).

Savitz et al. (1999) show crude dose-responses for Cardiac Arrhythmia related heart disease and a highly significant dose-response, Figure 43, for Heart Attack.

Reproductive Effects of EMR:

Residents of Greece who were exposed to low level radio and TV radiation convinced authorities to carry out a study using mice. Three groups of 8 mice were used, one with no exposure by being kept in shielded cages, one with a "high" exposure or 1.05μW/cm^2, and one with "low" exposure, 0.17μW/cm^2, Magras and Xenos (1997). They observed that in the "high" exposure group they became totally infertile after 3 generations while the "low" exposure group took 5 generations, Figure 45.

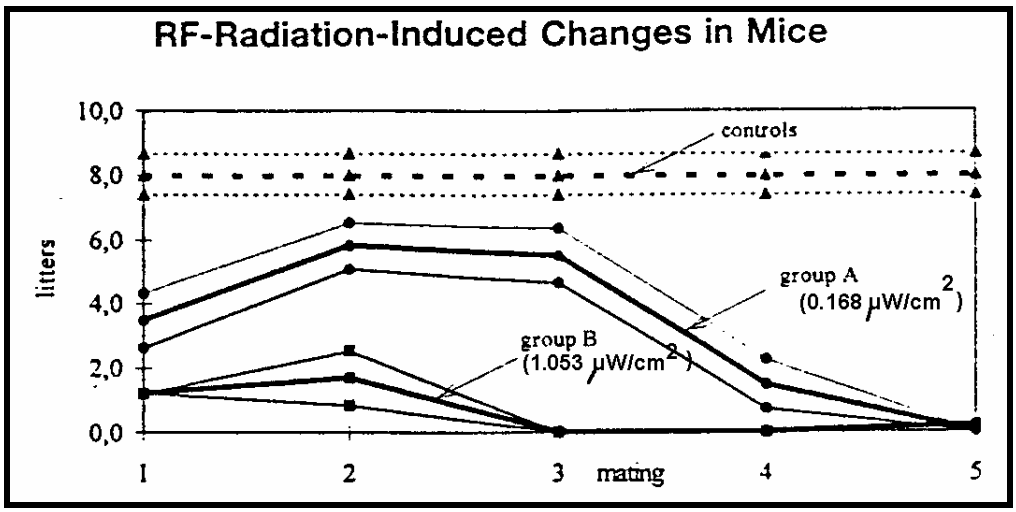

Figure 45: Reproductive rates in two groups of mice exposed to extremely low intensity radio signals, showing a dose response in the time taken to achieve full infertility of 3 matings for 1.053μW/cm^2 and 5 matings for 0.168μW/cm^2.

At the first mating the number of offspring were significantly reduced in a dose-response manner. The time to infertility decreases in a dose-response manner. Thus extremely low intensity caused mice to be come infertile in a dose-response manner at levels of exposure typically found km from radio masts and 100's of metres from mobile phone base stations. Nawrot, McRee and Galvin (1985) showed that 2.45 GHz microwaves significantly increased mice embryo lethality on Days 1-6. Youbicier-Simo et al. (1998) showed that mobile phone significantly increased the mortality of chicken embryos.

These animal experiments show that microwaves cause early fetal mortality and RF signals cause multigenerational infertility.

In human populations sperm counts are highly significantly reduced in radar exposed personnel, Lancranjan et al. (1975) and Weyandt et al. (1996).

Multiple studies show elevated and significantly elevated congenital malformations, still birth, low birth weight and miscarriage with electric blankets, Wertheimer and Leeper (1986) and Belanger et al. (1998); withn high voltage powerlines, Juutilainen et al. (1993); in electrical

occupations, Vaughan et al. (1984), Sanjose et al. (1991), Evans et al. (1993) and Savitz et al. (1996); and for physiotherapists, Kallen et al. (1982), Taskinen et al. (1990), Larsen (1991), Larsen et al. (1991) and Ouellet-Hellstrom and Stewart (1993).

Physiotherapists have been exposed to microwaves and shortwave radiation in the course of diathermy of patients. From a large survey group 6,684 women reported using microwave or shortwave radiation at some time during their work history. A total of 1753 pregnancies involving first trimester miscarriage were matched to 1753 control pregnancies. This revealed a 7%, but non-significant rise in miscarriage associated with shortwave exposure and a significant 28% increase in first trimester miscarriage for those exposed to microwaves, including a highly significant ($p<0.005$) dose response relationship, Figure 46.

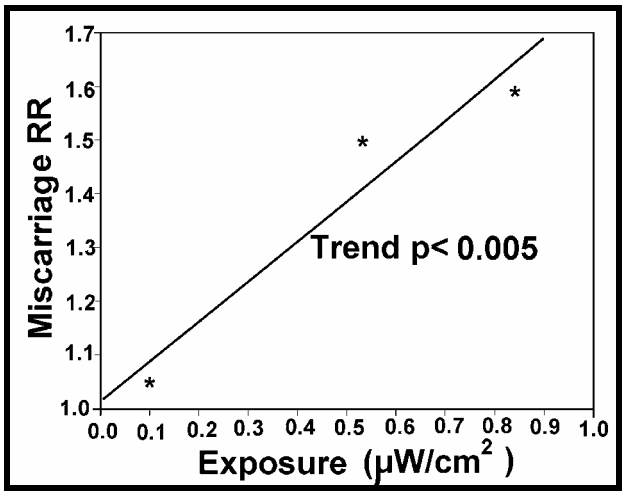

Figure 46: Microwave exposure associated miscarriage for pregnant physiotherapists, Ouellet-Hellstrom and Stewart (1993).

Exposure levels were based on 3 minutes exposure per treatment to 600$\mu W/cm^2$, a peak exposure level near the middle of the reported range. This gives 0.042$\mu W/cm^2$ per treatment per month, to give a month mean dose response based on treatments per month.

A great deal of concern has been expressed for many years about the risks of miscarriage with the exposures to a wide range of frequencies of EMR from visual display units (VDUs) on computers. With the very low monthly mean microwave exposures causing miscarriage for physiotherapists it is not surprising that many workplace stories were published about clusters of miscarriages in association with VDU or VDT uses. These were dismissed by computer manufacturers and employers as anecdotal and unlikely to be actually associated with VDT exposure that was so much lower than standards allowed.

In 1992 the American Journal of Epidemiology published a paper by Lindbohm et al. that observed a dose-response increase in miscarriage as a function of magnetic fields strength of exposure from VDTs, Figure 47.

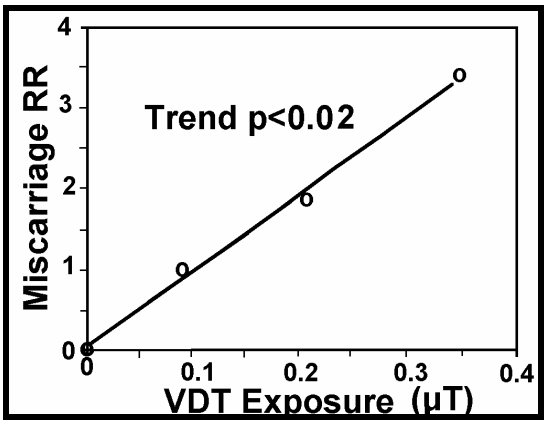

Figure 47: ELF/RF/MW exposure from VDT usage increases miscarriage in a dose-response manner, Lindbohm et al. (1992).

Hence human studies confirm the results of animal studies that microwave exposure at extremely low mean exposure levels causes early pregnancy miscarriage and RF exposure is more associated with late pregnancy miscarriage, still birth, SIDS and congenital malformation.

Conclusions:

The predictions of adverse health effects from the interference with the natural EMR systems of the brain, heart, hormones and cells, that through calcium ion alteration and melatonin reduction, in addition to the genotoxic cellular DNA damage effects, there would be risks of cancer, cardiac, neurological and reproductive effects from EMR exposure across the spectrum, including microwaves and cellphone radiation from mobile phones and base stations. These are all confirmed from human studies with a consistency, strength and dose-response relationships that are strong enough to show a causal relationship.

This evidence proves that the new paradigm is scientifically justified and proven with the safe level of artificial EMR being zero exposure. International guidelines and national standards that are based on the presumption that the only possible effect of RF/microwave exposure is tissue heating is proven to be totally wrong. This false assumption is putting the world's population at severe risk of wide ranging, highly significant health effects. In fact this evidence shows that much of the present illness and death in the world is caused by exposure to man-made electromagnetic radiation.

Only a massive movement to a totally new way of thinking will correct this extremely serious situation.

Summary:

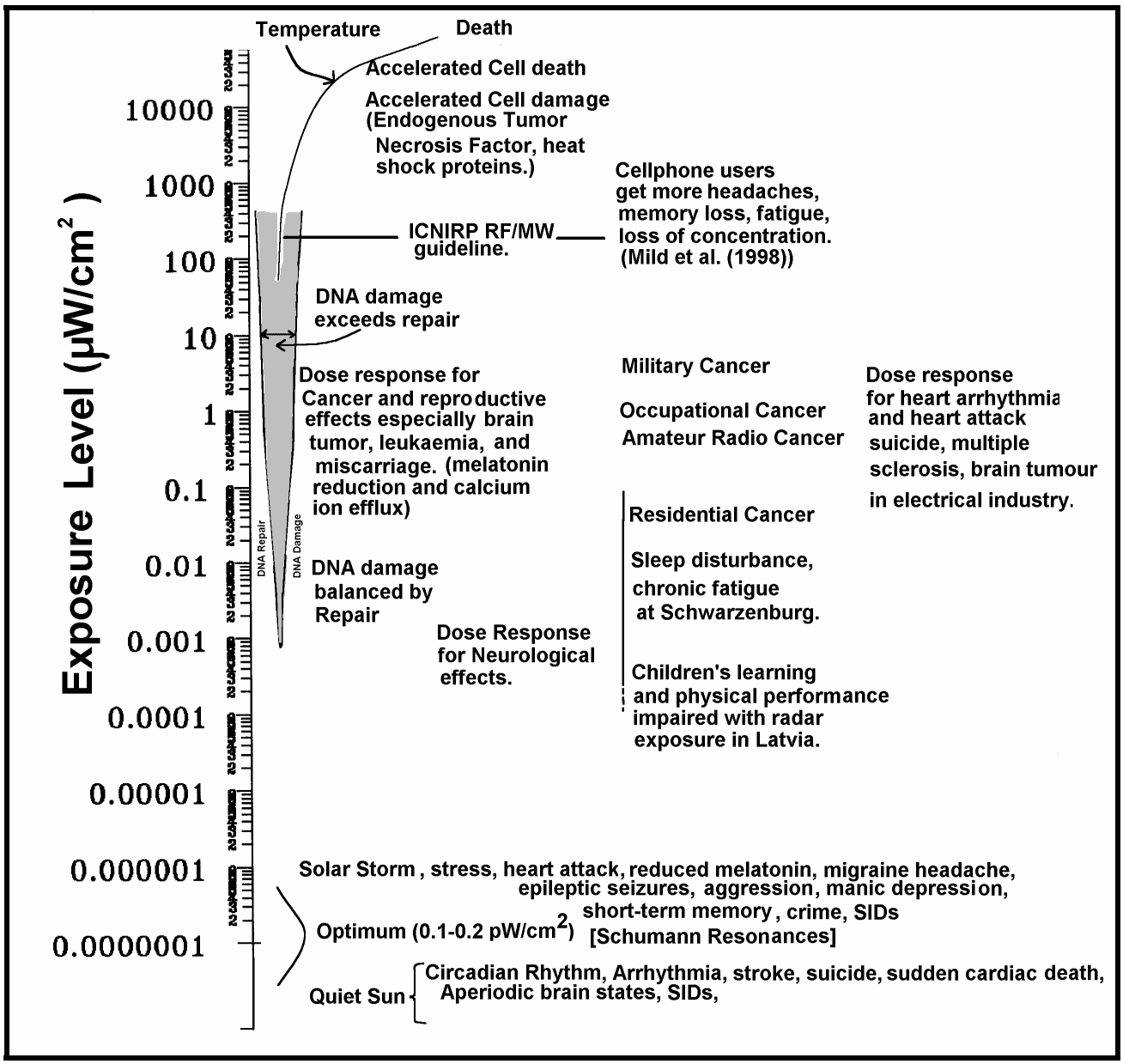

Figure 48: Summary of observed effects, and the mean levels of the exposure for human studies of exposure to electromagnetic radiation. All epidemiological studies occur below the ICNIRP and WHO guidelines.

Cell phone and cell site Conclusions:

Cell phones are extremely dangerous because of their high exposures being held close to heads, hearts and bodies.

Cell phones will highly probably increase many neurological diseases and brain tumours over the next 10 to 20 years. The latest Swedish study shows a 9-fold increase in Astrocytoma for cell phone usage.

Cell sites will highly probably increase miscarriage, many cancers, many diseases, significant neurological and cardiac diseases and death. Neurological and cardiac effects have been observed in dose-response manner in Europe. Childhood cancer near a cell site in Spain, site closed by the High Court.

Thousands of cell sites are being installed in communities around the world. They are significantly raising the exposure of millions of people to RF/MW at levels that are known to cause serious adverse health effects.

The recommended target risk reduction level for the maximum exposure at the boundary of residential and occupational properties is 0.1$\mu W/cm^2$ that will achieve less than 0.01$\mu W/cm^2$ inside.

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