

20-1025 (Lead); 20-1138 (Consolidated)

**UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT**

ENVIRONMENTAL HEALTH TRUST; CONSUMERS FOR SAFE CELL
PHONES; ELIZABETH BARRIS; THEODORA SCARATO

CHILDREN'S HEALTH DEFENSE; MICHELE HERTZ; PETRA BROKKEN;
DR. DAVID O. CARPENTER; DR. PAUL DART; DR. TORIL H. JELTER; DR.
ANN LEE; VIRGINIA FARVER, JENNIFER BARAN; PAUL STANLEY, M.Ed.

Petitioners

v.

FEDERAL COMMUNICATIONS COMMISSION;
UNITED STATES OF AMERICA

Respondents

Petition for Review of Order Issued by the
Federal Communications Commission

DEFERRED JOINT APPENDIX**VOLUME 11**

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Dr. Paul Dart MD. (Petitioner), Comments, Sep. 1, 2013

Paul Dart MD FCA
3495 Harris Street
Eugene, OR 97405
September 1, 2013

Federal Communications Commission

r.e. Comments on Notice of Inquiry, ET Docket No. 13-84

Dear Sirs,

I am part of a medical advisory group that has spent the last 18 months researching the current medical literature on the biological or “non-thermal” effects of microwave radio frequency transmissions, in an effort to assist the Eugene Water and Electric Board in making prudent decisions on their choices of technology as they consider installing an AMI infrastructure of RF-transmitting “smart” electric meters. This document contains the product of our efforts—an extensive written review of the research to date on biological effects of RF.

Also attached to this filing are five pdf documents from an audiovisual presentation on this subject, illustrating research evidence for adverse effects including EHS (electrohypersensitivity syndrome), alterations in hormone physiology, DNA damage, cancer, infertility, and increased brain tumor risk from cell phones.

The FCC has not chosen to implement any safety standards regarding non-thermal effects of microwave RF exposure. But the existing literature demonstrates that there is significant cause for concern regarding the growing impacts of these exposures on the public. Research documenting their adverse biologic and health effects is robust now. The implications of this research cannot be discounted, and must not be ignored.

The FCC should request that the EPA impanel a Working Group composed of health experts who have no conflicts of interest with industry to review the scientific literature on EMR. The Group should recommend biologically-based EMR standards that ensure adequate protection for the general public and occupational health based upon the precautionary principle. Finally, the FCC should adopt the standards, testing procedures, and appropriate precautionary warning language recommended by the Working Group.

It would be indefensible at this time for the FCC to take any actions that may increase exposure of the population to EMR from cell phones, base stations, Wi-Fi, Smart Meters and other RF or ELF-emitting devices. The current levels of exposure need to be reduced rather than increased further. The FCC must especially protect vulnerable groups in the population including children and teenagers, pregnant women, men of reproductive age, individuals with compromised immune systems, seniors, and workers.

Sincerely yours,

Paul Dart MD FCA

**BIOLOGICAL AND HEALTH EFFECTS OF
MICROWAVE RADIO FREQUENCY
TRANSMISSIONS**

A REVIEW OF THE RESEARCH LITERATURE

**A REPORT TO THE STAFF AND DIRECTORS OF
THE EUGENE WATER AND ELECTRIC BOARD**

June 4, 2013

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EXECUTIVE SUMMARY

The FCC regulations for permissible exposures to microwave radio frequency (RF) transmissions are only designed to protect against the thermal effects of high exposure levels. Representatives of the telecommunications industry usually assert that there is “no clear or conclusive” scientific evidence regarding the biological effects of low level or “nonthermal” RF exposures. But in actuality, a large body of scientific research documents that RF exposures at low levels can produce adverse biological or health effects.

The installation of RF-transmitting “smart meters” by our electric utility could significantly increase the level of RF exposure in Eugene’s residential neighborhoods. Such an increase carries potential health risks. The nature of these risks needs to be carefully considered before making a decision to deploy this technology.

Any decision-making process that ignores this possibility of harm could cause significantly damage both to community health and to EWEB’s goodwill in the community.

ELECTROHYPERSENSITIVITY (EHS)

Microwave RF exposures can produce acute symptoms in some individuals. These symptoms can include headache, sleep disturbance, difficulty in concentration, memory disturbance, fatigue, depression, irritability, dizziness, malaise, tinnitus, burning and flushed skin, digestive disturbance, tremor, and cardiac irregularities. This syndrome was described by Russian researchers in the 1950’s, who called it “microwave sickness”. Between 1953 and 1978 the Russian government purposefully targeted the U.S. embassy in Moscow with beams of microwave RF, producing symptoms of microwave sickness in many embassy employees.

In recent years, the buildout of the wireless telecommunications infrastructure has greatly increased the exposure of the general public to microwave RF, and this has led to an increased number of individuals experiencing symptoms that are now referred to as “Electrohypersensitivity Syndrome” (EHS). Multiple research studies have shown a correlation between these symptoms and residential exposure to radio, radar, and cell tower transmissions.

The prevalence of EHS appears to be increasing, as the exposure of the public to RF continues to expand. Based on recent epidemiologic research, it would be reasonable to assume RF exposures provoke some sort of symptoms in between 3 and 5% of the population of Eugene at the current time. Any significant increase in residential RF exposure is likely to make these individuals more symptomatic, and to produce some new cases of EHS by pushing some other individuals beyond their tolerance limit.

ALTERED PHYSIOLOGY

Laboratory research in animal and human subjects has shown that “nonthermal” levels of RF exposure can alter EEG, immune function, and hormone levels including adrenal and thyroid hormones, testosterone, prolactin, progesterone.

Research shows that low levels of microwave RF exposure can reduce melatonin levels in humans, and that some individuals are more sensitive than others to this effect. The adverse effects of nighttime RF exposure on melatonin secretion are particularly disturbing. The nocturnal rise in melatonin levels supports the natural function of sleep, and disrupting this cycle can produce insomnia. Melatonin is an extremely potent antioxidant, and helps to repair damaged DNA and heal the body from other

EXECUTIVE SUMMARY

effects of oxidant stress.

Melatonin is also protective against the growth of cancer cells, and disruption of the circadian melatonin cycle has been shown to lead to increased tumor growth in a variety of cancer types. Women who have lower levels of nocturnal melatonin are at greater risk for developing breast cancer. Reduced melatonin levels may also increase the incidence of prostate cancer.

OXIDATIVE STRESS AND DAMAGED DNA

In contrast with Xrays and gamma rays, Microwave radiation does not have sufficient power to directly break covalent bonds in DNA molecules. But microwave RF can produce resonance interactions with ions and with charged macromolecules, and such interactions can significantly alter biochemical functions. A large body of research has shown that microwave RF causes an increased production of free radicals and reactive oxidant species in living tissues, and that this increased oxidant stress damages DNA. This damage can and does occur at power levels well below those levels that could produce damage by thermal mechanisms.

Any chronic exposure to conditions that damage DNA can lead to an increased risk of cancer. Evidence of increased risk of certain types of cancer has been demonstrated in groups with occupational exposure to microwave RF, including radio technicians in private industry, military personnel, commercial airline pilots, and ham radio operators. Elevated levels of cancer have been demonstrated in populations with increased residential exposure to radio transmission towers. And in the last ten years, studies from Israel, Germany, Austria, and Brazil have documented significant increased in breast cancer and other cancers in individuals living less than 500 meters from cell phone towers, with measured exposure levels much lower than those permitted by current FCC guidelines.

Research has also shown that RF exposure levels well within current guidelines can cause DNA damage and reduced fertility in insects, birds, amphibians and mammals, and can lower sperm counts, sperm motility, and sperm motility in human beings.

RISKS OF CELL PHONE USE

Cell phone use expanded dramatically in Europe and the United States in the late 1990's. Early studies of the cancer risks of cell phone use were hampered by short latency periods of exposure. In general, studies funded by industry have reported lower levels of risk than independently funded studies. But in the last four years, all but the most poorly designed studies have shown an increased risk of brain tumors with more than ten years of use—a level of exposure which appears to double the risk of brain tumor on the side of the head where the cell phone is customarily held. This risk is higher in those who started using cell phones as children.

CONCLUSIONS

Existing scientific research offers strong evidence that the chronic exposure of the public to microwave RF transmissions produces serious acute and chronic health effects in a significant portion of the population. These findings can be summarized in the following precepts:

EXECUTIVE SUMMARY**Basic Precepts for Residential Exposures to RF Transmissions:**

- Excessive RF exposure can cause acute problems (headaches, insomnia, fatigue, vertigo, tinnitus, other symptoms of EHS).
- Excessive RF exposure can also cause chronic problems (oxidative stress, cancer, male infertility).
- Constant RF transmission is probably harmful, even at low levels, and should be avoided.
- Frequent and repetitive intermittent transmissions are also probably harmful, and should be avoided.
- Nocturnal exposures are more problematic than daytime exposures, because of RF's potential to suppress nocturnal melatonin secretion and disturb sleep, and because night is the time when we rest and heal from stresses (including oxidative stress).
- Occasional and infrequent daytime exposures are much less likely to cause an increase in chronic problems for the population at large.
- Occasional and infrequent daytime exposures are still likely to provoke acute symptoms in a small percentage of the population.

EWEB should adopt a policy of minimizing their RF footprint in the community.

A recognition of these precepts should lead EWEB to adopting a policy of minimizing their infrastructure's RF footprint in the community as much as possible during regular operations. This doesn't mean that staff would throw away their cell phones and communicate by semaphore. But it would mean that instead of combatting or ignoring the possibility that more RF in the community could cause harm, EWEB should acknowledge the potential risks of excessive residential exposure.

This would mean that such potential risks would be seriously considered in any discussion of the total risks and benefits involved (the "Total Bottom Line"), as EWEB decides *whether* to use RF technology for any given purpose. If, after such a discussion, a considered decision is made to use RF technology, then these same potential risks should be taken into serious consideration in determining *how* to use this technology in a manner that would minimize potential harm to the community.

In other words, don't use RF when you don't have to. Use hard-wired connections wherever it is feasible to do so. And if you do use RF, design the infrastructure in a way that uses as little of it as possible.

In the final section of this report, we discuss the perspectives that such a policy might bring to a consideration of the available AMI technologies.

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PREFACE

This paper represents the efforts of a group of physicians who have been in private practice in Eugene for decades. Our concerns are for the health of our patients as well as for our community as a whole.

When EWEB proposed installing a “mesh” smart meter network we became concerned. We know that there are people in this community who are highly sensitive to electromagnetic fields. The installation of the smart meter mesh would make Eugene a much more hostile environment for these individuals.

We also know that chronic exposures to microwave radio frequency (RF) transmissions can produce adverse long term physiological effects, even in individuals who do not consciously experience acute symptoms from exposure to such electromagnetic fields.

As we considered these issues, we were not sure if the policy makers at EWEB had sufficient current and applicable scientific information upon which to rely, as they evaluated the potential health effects of such an implementation. EWEB may have referred to FCC guidelines, without considering that the FCC regulations on radio frequency (RF) exposure are only designed to protect against the thermal effects of extremely high level RF exposures, and do not attempt to define a safe level of protection against other biological effects.

Because of these concerns, we have undertaken a sixteen month long investigation of the scientific literature, in order to present what we feel is a valid scientific basis for evaluating the potential health effects of a community-wide RF smart meter installation. This paper presents our findings to you.

We have organized this report into six sections:

1. An introduction into some of the issues involved in the “smart meter” Advanced Metering Infrastructure.
2. A review of the scientific research documenting the existence of acute reactions to “non-thermal” levels of RF exposure -- reactions which in their most severe form are called electrohypersensitivity syndrome (EHS).
3. A review of the function of melatonin, of evidence that RF exposure can suppress melatonin, and of the short and long term consequences of melatonin suppression.
4. A review of the long term effects of RF exposure, especially the production of oxidative stress that can lead to DNA damage and increased levels of cancer and infertility.
5. A review of current research regarding relationship of cellular and cordless telephone use to increased risk of brain tumors.
6. A discussion of our conclusions and recommendations to EWEB, based on this review of the scientific literature.

INTRODUCTION

AMI and the Smart Energy Grid

The Advanced Metering Infrastructure (AMI) technology is a key component of the smart energy grid that we heard discussed in very general terms in the 2008 presidential election. During the past two years, EWEB has been actively exploring the possibility of installing AMI in Eugene.

EWEB staff have described several purposes for going to an AMI “smart meter” infrastructure, including the following:

Reducing operating costs

Remote reading of meters would eliminate meter readers, allowing EWEB to save substantial costs in employee time and benefits, vehicle use, and gasoline costs. Smart meters can also be used to turn power on and off remotely, saving labor and travel costs when rentals become vacant or occupied.

Shifting time of use

Smart meters can measure and record total power usage for several intervals during the day. This will allow EWEB to bill customers more for electrical usage at peak use hours, typically the early morning (when people are getting up, taking showers, cooking breakfast) and late afternoon/early evening (when people return home from work, cook dinner, take showers, throw some clothes in the laundry, etc.). Time of use billing could create an incentive for customers to shift elective usage (laundry, recharging the electric car) away from peak usage hours.

Electrical utilities need enough generating capacity to meet peak demand. Reducing or restraining the growth of peak usage could reduce or slow the need to build more power generating capacity into the system.

Training customers to conserve electricity

Smart meter technology can allow home owners to monitor their usage in real time over a home network with the meter. EWEB hopes that this direct feedback will encourage people to reduce their energy consumption.

“Demand/Response” infrastructure

EWEB has invested a great deal in wind power. But the wind tends to blow hardest in the middle of the day and the middle of the night. At dawn and dusk (peak usage times for electrical consumers) the wind is more likely to calm down.

This creates a storage problem for the utility. When wind power production is high during the night, production can exceed demand, generating more electricity than can be used locally or sold interstate.

One way to distribute and store this energy is to put it in your water heater. Two way communication with your Smart Meter could allow the power company to turn your water heater on for 15 minutes in the middle of the night or the middle of the day, at a time when it would otherwise not be on [they can’t turn it on for two hours, when it gets to the maximum heat setting the thermostat will turn it off]. EWEB would seek customers willing to volunteer to allow this arrangement.

With “demand/response” control, EWEB could store excess wind power as heat by turn on clusters of water heaters for 15 minutes, then turn them off and turn on other clusters of water heaters, and continue to rotate the usage around the community during the middle of the night.

SECTION 1 – INTRODUCTION

Solar power generation creates another storage problem. Solar panel output can fluctuate rapidly during the day with changing cloud cover. Too sudden an increase in local production from multiple large panels could overload the grid. The AMI infrastructure would allow the utility to tell Smart Meters to turn off solar panel input into the electrical grid. Again, this requires rapid two-way communication between the utility and the Smart Meter, and between the Smart Meter and the solar panel in the house.

From an engineering point of view, the simplest and cheapest way to install this communications infrastructure is to have the meters communicate with the utility and with the “smart appliances” in the home using *wireless microwave radio technology*.

The use of this wireless technology for AMI communications has generated a good deal of political heat in the last two or three years. To understand where this heat has come from, it is instructive to review the history of the Pacific Gas and Electric Company’s smart meter rollout in California.

PG&E in California, 2010 – 2011

In 2010 and 2011 PG&E rolled out an AMI infrastructure in multiple cities in California. The metering technology that they chose to install was the Silver Springs AMI “smart meter”. These meters communicate with the utility by forming a “mesh” network in the neighborhood. The meters communicate with each other rather than with a central receiver, and pass data through this MESH network to the central collecting system of the electric utility.

The installation of such technology places a radio transmitter on every house in the community. Concerns about the potential health effects of this residential RF exposure led several members of the California Assembly to request that the California Council on Science and Technology (CCST) perform a study of whether current FCC standards for Smart Meters were sufficiently protective of the public health, and whether additional standards might be needed for such technology.

It should be noted that the regulatory standards established by the Federal Communications Commission are based on defining safe levels against the thermal effects of microwave radio frequency (RF) exposure (i.e. “Will it cook you?”) For example, the FCC has established Limits for Maximum Permissible Exposure (MPE). (FCC, 1999, page 15). The FCC has explicitly stated that they do not make any regulations or assurances whatsoever regarding the “nonthermal” biological effects of microwave exposure (other physiologic effect besides heat damage). (Hankin, 2002)

The CCST released a report on “Health Impacts of Radio Frequency from Smart Meters” in January, 2011. (CCST, 2011) This report stated (on page 5) that Smart Metering technology met the FCC standards for “safety against *known thermally* induced health impacts”. It also stated (on page 4) that “*To date, scientific studies have not identified or confirmed negative health effects from potential non-thermal impacts of RF emissions such as those produced by existing common household electronic devices and smart meters. Not enough is currently known about potential non-thermal impacts of radio frequency emissions to identify or recommend additional standards for such impacts.*” The CCST report concluded that “*There is no evidence that additional standards are needed to protect the public from smart meters.*” (page 26)

When the Draft Version of this CCST report was released, several experts in the field of research that studies the biological effects of RF communicated their disagree-

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ment with the study's conclusions. It was pointed out that the content of the CCST document was in major part a repetition of a document produced by the industry-sponsored Electric Power Research Institute a few weeks before (Tell, 2010), and that the analysis of AMI smart meter exposure levels in the report was incorrect in its design. (Hirsch, 2011)

These experts offered evidence of multiple scientific studies documenting the nonthermal health impacts of RF. (Sage, 2011b) (Johansson, 2011) Independent research was presented to the CCST documenting that the Silver Springs meters produced levels of household exposures significantly higher than levels shown to have adverse health effects in current scientific research. (Sage, 2011a)

These objections from the scientific community did not alter the CCST's stance on smart meters, which continued to be installed in California.

What happened next in California

PG&E's approach to the AMI rollout didn't involve a lot of public education. They just switched out the meters. And some people found that they were having trouble sleeping, or experiencing headaches, ringing in the ears, vertigo, or other symptoms that hadn't been bothering them before. Soon the internet was awash in anecdotal reports and commentary about these adverse effects. (emfsafetynetwork.org, 2011)

PG&E's public posture was that the meters only transmitted for an average of 45 seconds per day. They asserted that the total power output over time was well below the FCC guidelines for thermal risk, and well below that of other RF exposures in the community. Videos began to crop up on You Tube showing that the picture wasn't that simple (for example, <http://www.youtube.com/user/thisirradiatedlife/featured>).

Finally PG&E was served with a court order to provide clear documentation of what the meters actually were doing. (Yip-Kikugawa, 2011) In the response to that court order, PG&E provided documentation from the manufacturer of the meters that the *average* meter in the mesh network transmitted data signals to the utility 6 times a day, network management signals 15 times a day, timing signals 360 times a day, and beacon signals to the mesh network 9,600 times a day. (Kim et al., 2011) This penciled out to an average of roughly 7 transmissions a minute, 24 hours a day, coming out of every meter in the community.

As reports of provoked symptoms increased, the situation became more and more politically heated. Santa Cruz County banned the installation of smart meters. PG&E continued to install them, and the Santa Cruz County Sheriff's office refused to enforce the ban. Individuals started purchasing refurbished analogue electric meters and swapping them out themselves, attempting to return the smart meters to the utility. PG&E publicly stated (a week or two before Christmas) that they would turn off the power of anyone who removed a smart meter from their service box—but backed down from that threat due to public backlash.

By the end of 2011, multiple cities in California had either banned smart meters or placed a moratorium on their continued installation, and a lawsuit has been filed against PG&E with the California Public Utilities Commission. (Wilner, 2011)

EWEB's Elster MESH AMI Trial

In 2010 EWEB set up a trial of AMI infrastructure, using the Elster REX2 Smart Meter. Like the Silver Springs meter used by PG&E in California, the REX2 operates on a mesh network. The meters upload usage data to a central collection meter 4 to 6 times

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a day, but transmit short beacon signals to the network several times a minute.

EWEB stated on their website that these meters transmit “less than 10 seconds a day”. But they were unable to state how frequently transmissions actually occurred. In our communications with their public relations staff, we were told that Elster was unwilling to release this information. Information on the power output of these meters is available on the ELSTER website. (TUV Rheinland, 2010) But Elster does not discuss the actual frequency of transmission of the meters.

In January 2012 we used a Gigahertz Solutions HF35C analyzer to evaluate the output of one of these Elster meters in a residential neighborhood in Eugene.

Background RF signals coming through the neighborhood were measured in a 360 degree circle around the monitoring position. The background RF averaged around 4 microwatts/square meter ($\mu\text{W}/\text{m}^2$), increasing to 8 or 10 $\mu\text{W}/\text{m}^2$ when we aimed our directional antenna at the radio towers on Blanton Heights or at a distant cell phone tower.

The Elster meter’s transmission rate was variable. In our observations, they are definitely transmitting several times a minute, sometimes 4 or 5 times a minute, and occasionally in bursts of significantly higher frequency.

At 5 feet from the smart meter, the peak strength of the beacon signal coming off the meter measured from 3800 to 11,000 $\mu\text{W}/\text{m}^2$. At 20 feet from the meter, the power density of the signal ranged from 362 to 493 $\mu\text{W}/\text{m}^2$, with occasional bursts at higher power output.

This means that at a distance of 20 feet the power of the signal coming out of the Elster meter was *about 100 times* the power of the ambient background signal coming from any specific direction in the residential neighborhood.

This power density of 300+ to 400+ $\mu\text{W}/\text{m}^2$ was greater than the signal strength of the cell phone tower at 29th and Amazon, measured from about 200 meters away. So filling a neighborhood with a mesh network of the Elster smart meters would be similar to placing every house in that neighborhood closer than 200 meters from a cell phone tower, each house constantly being pinged by the chatter of multiple beacon signals from the mesh.

This was disconcerting, since recent research has shown that people living within 500 meters of a cell phone tower have increased incidence of headache, concentration difficulties, and sleep disorders, and also a significantly increased risk of some types of cancer. (Khurana et al., 2010) (Levitt and Lai, 2010) (Yakymenko et al., 2011) (Altpeter et al., 2006) (Abdel-Rassoul et al., 2007)

When you put these facts together, it is not so surprising that the installation of mesh smart meter networks in residential neighborhoods in California last year was followed by a surge of anecdotal evidence regarding headaches, insomnia and other health complaints. From a medical perspective, based on a familiarity with current research on the biological effects of RF, this was a predictable consequence of PG&E’s smart meter MESH network rollout.

Formation of our Advisory Committee

By late 2011 EWEB staff were working towards setting a specific timeline for installing AMI in Eugene. From our perspective, the potential health risks of such a project did not appear to have received any realistic discussion. EWEB’s web site implied that such risks were inconsequential. In January of 2012 EWEB’s Public Rela-

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tions staff started to test a public relations campaign promoting the AMI project. Their initial presentation minimized the possibility any health risks from this exposure.

Some physician members of our group became involved in discussions with EWEB staff. In these discussions, we tried to learn more about the technologies under consideration from EWEB engineers, and in turn we attempted to communicate our concerns about the potential health risks of this technology.

It became clear to us that EWEB staff did not have the time or the expertise to research this issue of health risks in any depth. Our sense of this was confirmed in April of 2012, when EWEB management presented the AMI Business Case to the EWEB Board. The discussion of “Potential Health Risks” in this document quoted government agency reports as if they were scientific studies, and stated that in an *“attempt to discover if there were any credible studies showing any health effect caused by long-term RF exposure in relatively high dosages (e.g. exposures much greater than an AMI meter) . . . no conclusive evidence was found that indicates that this higher magnitude RF exposure has created adverse health impacts.”*

EWEB is a locally owned utility with a lot of goodwill in the community. We were concerned that if EWEB continued forward without taking a deeper look at this issue, decisions might be made that would have the potential to cause significant harm to the health of the community, or to create political strife that could significantly damage EWEB’s local standing.

In an effort to help EWEB think this problem through in a more complete and considered fashion, we decided to form a group of physicians and other professionals with scientific and engineering expertise. Over the past 16 months, our group has studied the scientific literature on the biological effects of microwave RF. This report is the result of our efforts.

We hope that EWEB’s staff and Board will examine this information carefully, and that it will help them to make prudent choices as they consider the various AMI technologies that are currently available to them.

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ELECTROHYPERSENSITIVITY

"MICROWAVE SICKNESS"

Acute symptoms provoked by microwave radiation were first described by Russian medical researchers in the 1950's. They described a constellation of symptoms including headache, ocular dysfunction, fatigue, dizziness, sleep disorders, dermatographism, cardiovascular abnormalities, depression, irritability, and memory impairment. (Liakouris, 1998)

In the years between 1953 and 1978 the Russian government harrassed the U.S. Embassy in Moscow by targeting it with radiation from a microwave transmitter. Concern about health effects led to a detailed study by A.M. Lilienfeld, an epidemiologist at Johns Hopkins University. (Lilienfeld AM, 1979)

The abnormalities found in this study were an embarrassment to the U.S. government, since the levels of exposure experienced by embassy staff were in the order of 2 to 28 microwatts/cm², a level dramatically below the described U.S. safety standards for microwave exposure. The conclusions of the study were altered to soft-pedal any abnormal findings. (Goldsmith, 1995b) (Cherry, 2000)

But outside epidemiologic analysis of the Lilienfeld report's published data showed that exposed embassy staff experienced a statistically significant excess of several problems, including depression, irritability, difficulty in concentrating, memory loss, ear problems, skin problems, vascular problems, and other health problems. Symptom incidence increased significantly with accrued years of exposure. (Goldsmith, 1995a) (Cherry, 2000)

THE EMERGENCE OF "ELECTROHYPERSENSITIVITY" AS A DIAGNOSIS

In recent years the buildout of cellular communication networks has created a markedly increased exposure of the public to RF transmissions. Each new generation of cell phone technology has occupied a higher frequency on the microwave scale, with potentially increasing impact on body physiology. (Cherry, 2002) As this has occurred, mounting evidence has pointed to the fact that a percentage of the population experiences adverse reactions associated with these exposures. The term "electrohypersensitivity" (EHS) has been used to describe a constellation of symptoms, including headache, sleep disturbance, difficulty in concentration, memory disturbance, fatigue, depression, irritability, dizziness, malaise, tinnitus, burning and flushed skin, digestive disturbance, tremor, and cardiac irregularities. Sleep disturbance, headache, nervous distress, fatigue, and concentration difficulties are the most commonly described symptoms. (Roosli et al., 2004)

These symptoms are identical to the symptoms of "microwave sickness" described by Russian physicians in the 1950's.

SYMPTOMS PROVOKED BY TRANSMISSION TOWERS

In 2002, Santini reported significant increases in such symptoms in individuals living closer than 300 meters to cell towers. (Santini et al., 2002) (Santini R, 2003)

In Poland, Bortkiewicz found similar increases in symptoms among residents near cell towers. Symptoms showed equal association to proximity of the tower, regardless of whether or not the subject suspected such a causal association. (Bortkiewicz et al., 2004) (Bortkiewicz et al., 2012)

In two studies, Abelin and Altpeter found evidence of disruption of sleep cycle

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and melatonin physiology by RF transmission during the operation and subsequent shutdown of the short wave radio transmitter in Schwarzenburg, Switzerland. (Abelin et al., 2005) (Altpeter et al., 2006)

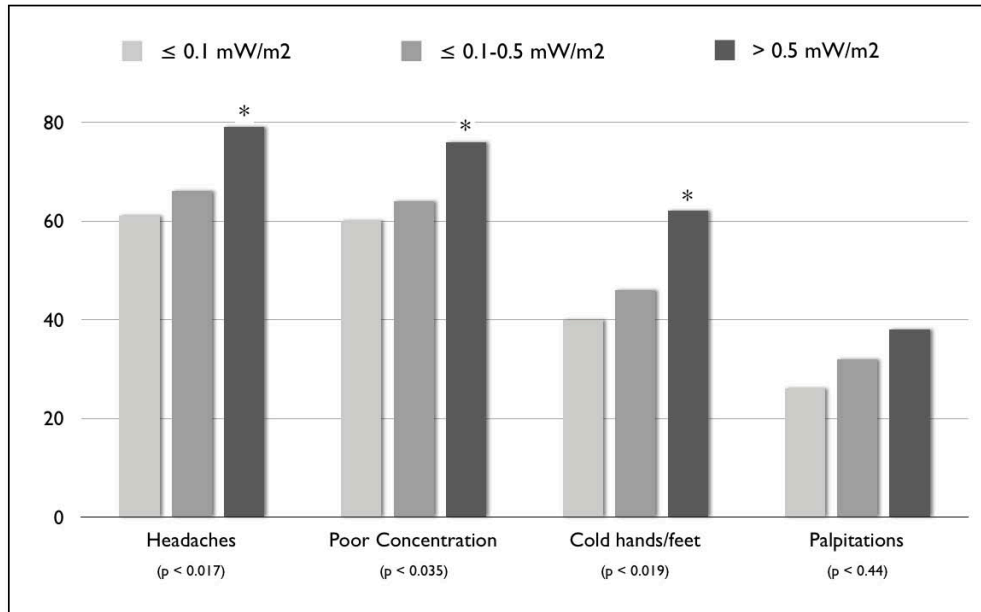


Figure 1: Percentage of subjects reporting symptoms, stratified by RF exposure levels as measured in subject's bedroom. (Hutter et al., 2006)

In a study done in urban and rural sites in Austria, Hutter found a clearly significant correlation between exposed signal power density and headaches and concentration difficulties—despite the fact that maximum measured power densities were only 4.1 mW/m^2 ($= 0.41 \text{ }\mu\text{W/cm}^2$, well below established “safe” limits). (Hutter et al., 2006)

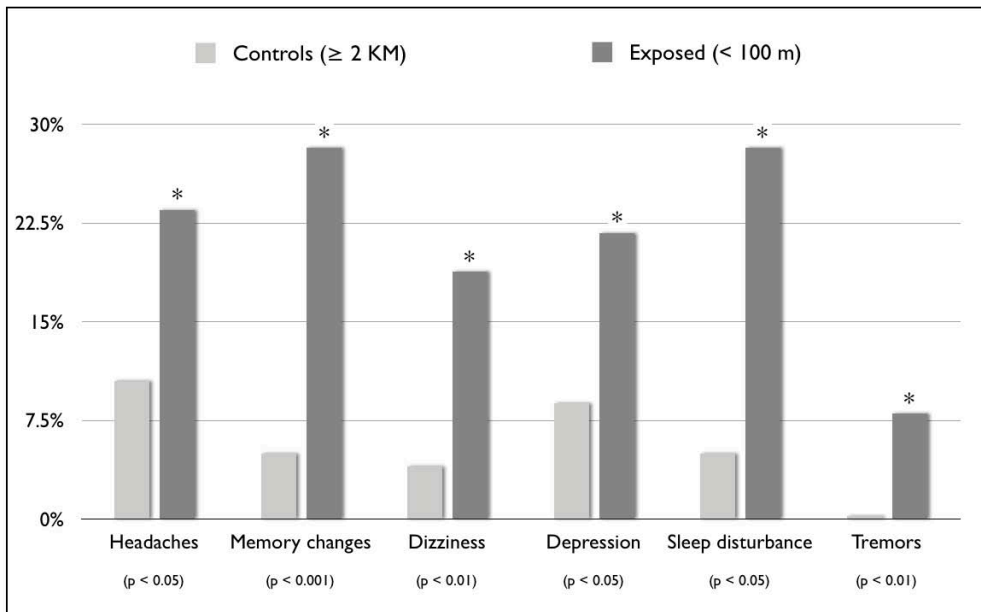


Figure 2: Percentage of subjects reporting symptoms, stratified by proximity to city's first cell phone tower. (Abdel-Rassoul et al., 2007)

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In Egypt, a study of inhabitants living near the first cell phone tower in the city of Shebeen El-Kom found a significant increase in headaches, memory changes, dizziness, tremors, depressive symptoms, and sleep disturbance, with lower performance on tests of attention and short-term auditory memory. (Abdel-Rassoul et al., 2007)

Research at the military radar installation in Akrotiri, Cyprus, showed that residents of exposed villages had markedly increased incidence of migraine, headache, dizziness, and depression, and significant increases in asthma, heart problems, and other respiratory problems. (Preece et al., 2007)

Studies in Murcia, Spain yielded similar findings, and based on measured exposures the authors suggested that safe levels of indoor exposure should not exceed $1 \mu\text{W}/\text{m}^2$ ($0.0001 \mu\text{W}/\text{cm}^2$) (Navarro et al., 2003) (Oberfeld et al., 2004)

In a study of residents of Selbitz, Bavaria, researchers found statistically significant increases in multiple health symptoms that demonstrated a dose-response relationship with cell phone tower transmissions. Individuals living within 400 meters of the cell phone tower had significantly more symptoms than those living > 400 meters from the tower. And individuals living within 200 meters of the tower had significantly higher symptoms than those living between 200 and 400 meters from the tower. (Eger and Jahn, 2010)

Two recent reviews provide a detailed overview of research in this area. (Khurana et al., 2010) (Levitt and Lai, 2010)

SYMPTOMS PROVOKED BY CELL PHONE USE

Multiple studies of cell phone users in the last decade found evidence of a similar pattern of symptoms to be provoked in some users. (Chia et al., 2000) (Ofstedal et al., 2000) (Santini R, 2002) (Wilén et al., 2003) (Salama and Abou El Naga, 2004) (Al-Khlaiwi and Meo, 2004) (Balikci et al., 2005) (Balik et al., 2005) (Szyjowska et al., 2005) (Meo and Al-Drees, 2005) (Soderqvist et al., 2008) (Landgrebe et al., 2009) (Hutter et al., 2010)

PHYSIOLOGY OF ELECTROHYPERSENSITIVITY

A variety of research models have demonstrated that RF exposure does not have a uniform effect on people. In many studies, a cohort of individuals has been identified that has a more sensitive response to RF in one way or another.

Reduced heart rate variability

In one study, patients with symptoms consistent with EHS were found to have decreased circadian changes in heart rate variability. (Lyskov et al., 2001) Similar changes in HRV were found in another study where subjects self-identified as having EHS symptoms from exposure to video display terminals, TV screens, fluorescent lights, or other electrical equipment. (Sandstrom et al., 2003) An occupational study of RF plastic sealer workers also found alterations in heart rate compared to normal controls.

Fatigue and reduced melatonin

In the more recent Schwarzenberg study, the effect of RF exposure on producing morning fatigue and reduced melatonin secretion was significantly greater in the subjects whose general quality of sleep was below the median. (Altpeter et al., 2006)

SECTION 2 – ELECTROHYPERSENSITIVITY**EEG changes**

Alterations in EEG have been found in animals and in people with exposure to both magnetic fields and cell phone transmission frequencies. (Marino et al., 2003) (Marino et al., 2004)

Nanou et al found the EEG response to be gender dependent after exposure both to 900 MHz and 1800 MHz signals. (Nanou et al., 2005) (Nanou et al., 2009)

Bachman found EEG changes with 450 MHz microwave exposure in 25 to 30% of healthy volunteers (Bachmann et al., 2005) (Bachmann et al., 2006). In another study, EEG changes were 5 times as common in depressive subjects as in healthy controls. (Bachmann et al., 2007)

Landgrebe found decreased intracortical excitability in EEG after transcranial magnetic stimulation in self-identified EHS patients, as compared with normal controls. (Landgrebe et al., 2007)

Schmidt found alteration in sleep EEG after exposure to a 900 MHz RF signal modulated at two different frequencies, and noted a marked individual variation in sensitivity to this effect. (Schmid et al., 2011)

Loughran found alterations in non-REM EEG after cell phone RF exposure. These alterations were consistently stronger in one subset of his study group, over multiple tests. (Loughran et al., 2012)

Altered Immune Function

Exposure to both GSM and UMTS cellular transmissions at nonthermal exposure levels have been shown to alter DNA repair mechanisms in lymphocytes. (Markova et al., 2005) (Belyaev et al., 2009) Multiple additional studies have demonstrated non-thermal biological effects of RF radiation on immune cell function, as reviewed here. (Johansson, 2007) (Johansson, 2009b)

One of the most intriguing findings is Johansson's research showing that patients with electrosensitivity have higher levels of mast cells in their skin, and that these mast cells migrate closer to the skin surface. (Johansson, 2006) Mast cells are responsible for the itching, burning, and skin flushing that occurs after sunburn exposure. The presence of higher levels of mast cells in EHS patients provides an explanation for the symptoms of flushed, itching, and burning skin on the face and other areas that is described by these patients, who appear to be reacting to RF exposure like others might react to excessive sun exposure. Since mast cells are distributed throughout the body, the presence of mastocytosis in EHS patients may relate to some other symptoms as well.

Hormonal Changes

Chronic exposures to electromagnetic field effects have also been shown to cause alterations in secretion of multiple hormones. A study published in 2007 showed that physiotherapists working with various electromagnetic treatment modalities had significantly elevated secretion levels of the stress hormones cortisol, adrenaline, and noradrenaline. (Vangelova et al., 2007)

Another study measured urinary secretion of the stress hormones adrenaline and noradrenaline, along with levels of dopamine and phenylethylamine, prior to and over the 1 1/2 years following the installation of a GSM cell phone tower in Rimbach, Bavaria. Levels of adrenaline and noradrenaline showed a significant increase over the first six months after exposure, and never returned to baseline levels. Responses

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showed a proportional relationship to residential exposure levels, and were clearly present at levels as low as 60 to 100 microwatts/m² (= 0.006 to 0.010 $\mu\text{W}/\text{cm}^2$). This suggested a chronic stress effect of the GSM microwave signal on the population. (Buchner K, 2011)

Chronic adrenal stress will in time lead to decompensation and symptoms of adrenal fatigue in a certain percentage of the population.

A recently published study evaluated human hormone profiles over six years of exposure to the microwave RF emissions of GSM cell phones or cell phone towers. Findings included highly significant decreases in ACTH, cortisol, both T4 and T3 thyroid hormones. In male subjects, serum testosterone levels gradually decreased with increased time of exposure. In females, alterations in serum prolactin and progesterone levels gradually increased over increased time of exposure. (Eskander et al., 2012)

Current Research

One of us had the opportunity this spring to visit the practice of Dr. Dominique Belpomme, Professor of Oncology at Paris Descartes University, who is conducting research on electrohypersensitivity with the Association for Research and Treatments Against Cancer (ARTAC) in Paris. The ARTAC group has been following several hundred patients with EHS over the last four years, and has documented that these patients have clear and consistent changes in oxidative metabolism, and also in blood flow to the limbic system (as measured by doppler studies). Dr. Belpomme considers these changes in the limbic system to directly correlate with many of the cognitive changes (memory problems, difficulty with concentration, etc.) that are experienced by these patients. The ARTAC group expects to publish a series of papers on their findings during the next year. (Dart, 2012)

PROVOCATION STUDIES

Over the last ten years, many attempts have been made to evaluate the nature of electrohypersensitivity through provocation studies. The limitations of these studies have been discussed in detail in some recent papers. (Loughran et al., 2012) (Regel and Achermann, 2011)

Problems of methodology that have compromised many provocation studies include:

- Many studies have been performed single-blind rather than double-blind.
- Many studies divide the study group and normal controls based on the individual's self-identification as having (or not having) electrohypersensitivity. Since it is certainly possible for people to have reactions to EMF without being aware of this connection, and since the entire population is exposed to EMF at this point in time, it is difficult to be sure that the "control" group is indeed composed of "non-reactors". This will tend to weaken the power of any study set up in this fashion.
- Many studies evaluate whether or not the subject can discern when the RF signal is present and when it is absent. Absence of the ability to make this judgement is taken as evidence that electrohypersensitivity does not exist. This is an extremely illogical assumption. A person can develop a headache during or after an RF exposure without knowing when the signal is "on" or "off", just as they can develop bacterial gastroenteritis without knowing what food was contaminated with the bacteria. Having symptoms from RF and being a reli-

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able RF meter are not the same thing.

- Unspecified or inadequate control of background levels of RF/EMF is also a problem with some “negative” studies. For example, one recent study (Kim et al., 2008) was performed with background RF levels in the study area of 0.5, 0.7, and 0.8 V/m from three different mobile phone service providers. This adds up to a reported 2.0 V/m of background RF, equivalent to several thousand microwatts/m², which is well above threshold levels reported to cause symptoms in many sensitive individuals.
- Many studies assume that all patients who complain of EHS will react to any constant RF signal, and that they will react to it every time. Yet some studies have demonstrated that patients vary in which frequencies they respond to, and that patients can react more strongly to the starting and stopping of a signal than they do to the presence of a steady signal.
- Furthermore, the assumption is often made that EHS symptoms will start when a signal is turned on, and stop when it turns off. These assumptions are problematic, since many patients with EHS report having symptoms that continue for a significant time (hours, in many cases) after a triggering exposure. Few studies discuss whether or not an adequate “washout time” was provided for before starting the study, or between provocation challenges. The absence of such washout times seriously weakens the power of these studies.

In order to do a reliable RF provocation study with EHS exposure, it is necessary to isolate the subjects from background RF levels, and to maintain them in this isolation for long enough that they stop reacting to any prior exposures which they have received, before attempting to provoke a new reaction.

Some studies that are designed to address all these methodologic issues have found clear evidence of electrosensitivity. For example, a study done in 1991 that was performed in an isolated EMF environment tested EHS patients with a variety of different frequencies of RF stimulus, to determine their individual reactivity spectrum. 100 patients who identified themselves as having electrohypersensitivity were tested single blind with a variety of RF frequencies. 25 of these 100 patients showed an increase in symptoms of 20% over baseline, with no more than one placebo response.

These 25 patients were retested in a double blind setting with 25 healthy controls. 16 of the 25 patients (64%) reacted to the positive challenges, which were performed at a variety of frequencies.

These 16 patients reacted to 53% of the 336 active challenges, and 7.5% of the 60 blanks. No patient reacted to all tested frequencies. The 25 healthy controls had no reactions to challenges or to blanks.

Finally, these 16 patients were again tested in a double blind setting, each patient challenged with the single frequency to which they were most sensitive. In this phase of the study, the patients reacted 100% of the time to the active transmissions (with both reported symptoms and autonomic changes on iriscorder) and did not report reactions to the sham transmissions. (Rea et al., 1991)

It must be reiterated that having an adverse reaction to a provoking RF signal and having the ability to determine when the signal is “on” and when it is “off” are two completely different things. A recent double blind study demonstrated that a patient can have consistent provocation of symptoms from a signal without having any clear awareness of when the signal is actually present. (McCarty et al., 2011)

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These provocation studies involve short term exposures to the RF signal (typically an hour or less). Since a great deal of the physiology research shows a more powerful effect with chronic exposures, these short-term studies are probably not the most effective way to assess the clinical significance of reactions to RF.

PREVALENCE OF EHS

Research in Stockholm County, Sweden in 1997 found that 1.5% of the population reported being hypersensitive to electrical or magnetic fields. (Hillert et al., 2002)

In California in 1998, Levallois et al found that 3.2% of the adult population reported being sensitive to sources of EMF. (Levallois et al., 2002)

In Switzerland in 2004, researchers studying a representative sample of the Swiss population found that 5% of the population had symptoms attributable to EHS, with sleep disorders and headaches being the most common reported symptoms. (Schreier et al., 2006)

In Austria in 2004, 2% of the population was estimated to have electrohypersensitivity. In a survey performed in Austria in 2008, 29.3% of respondents reported having some sort of adverse response to electromagnetic pollution. Of this cohort, 2.1% reported intense disturbance, and 3.5% had experienced enough difficulty that they had consulted a physician about the problem. (Schrottner and Leitgeb, 2008)

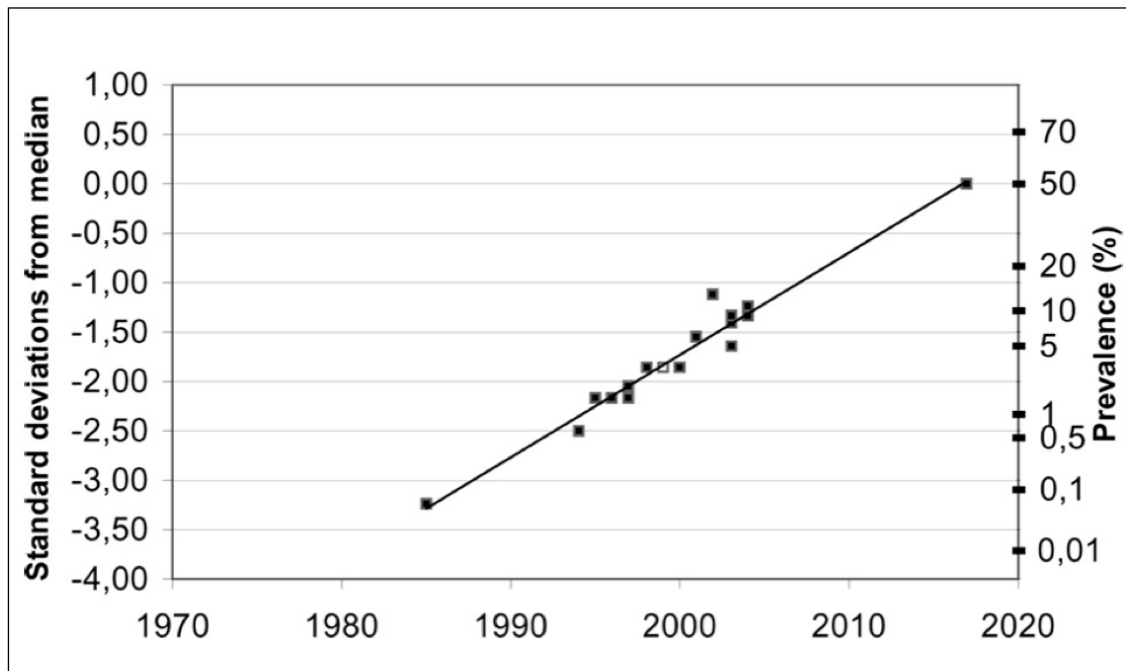


Figure 3: The prevalence of electrohypersensitivity syndrome is increasing.
(Hallberg and Oberfeld, 2006)

In much of the world, exposure to microwave radio signals has continued to significantly increase since the early 1990's. Reported electrosensitivity also appears to be increasing over time. In 2006, Halberg and Oberfeld reviewed research on this subject from 1985 forward, and estimated that if the trend in increased prevalence continues, fifty percent of the population could be reporting adverse effects from EMF by the year 2017 (Figure 1). (Hallberg and Oberfeld, 2006)

SECTION 2 – ELECTROHYPERSENSITIVITY**GOVERNMENTAL RESPONSE**

The various forms of research described above have provided strong support for the fact that RF/EMF exposures can produce symptoms in human beings and that there is a percentage of the population that is more sensitive to this effect. Continued research is suggesting that this is not a static situation—that the prevalence of electrohypersensitivity is a growing over time.

By the middle of the last decade, various government agencies were attempting to define the scope of the problem. (Irvine, 2005)

The rollout of mobile phone technology occurred earlier in scandinavia than in other places in the world, and governmental recognition of EHS as a health problem occurred earlier there than in other places. By the year 2000, EHS was recognized as a disability by the Swedish government. (Ministers, 2000)

In Stockholm, individuals with EHS can receive municipal support to reduce the presence of and penetration of EMF/RF into their homes. The construction of a village with houses specifically designed to mitigate this problem is being considered. Patients with EHS have the legal right to receive mitigations in their workplace, and some hospitals have build low EMF hospital rooms for use by such patients. (Johansson, 2006)

Various government reports or reviews on the question of electrohypersensitivity have been commissioned in the last few years. (Aringer et al., 1997) (Irvine, 2005) And legislation to address the problem has been proposed in some countries. (Snoy, 2011) (Parliamentary Assembly, 2011) Many libraries and schools in europe have banned WiFi due to concerns about health effects on employees and on the public.

REGULATORY RESPONSE

Regulations on exposure limits vary dramatically from country to country. In general, exposure limits have been mandated at a lower level in Russia and eastern Europe, where research on the health effects of RF exposure has been performed for a longer period of time. (Repacholi et al., 2012)

The regulatory standards established by the FCC and the World Health Organization are based on defining safe levels against the thermal effects of RF (i.e. damage from being cooked by high levels of microwave exposure). The FCC has not established exposure standards for potential nonthermal or biological effects of microwave exposure. (Hankin, 2002)

For example, the FCC has established Limits for Maximum Permissible Exposure (MPE). For the general population, the permissible level of exposure at 900 MHz is 600 $\mu\text{W}/\text{cm}^2$, and at 1800 MHz is 1000 $\mu\text{W}/\text{cm}^2$. (FCC, 1999) These exposure levels were last updated in 1996, and are considered to be protective against thermal effects of microwave radiation. However, current scientific research shows that these permissible levles of exposure are hundreds of times higher than the threshold levels for adverse “nonthermal” biological effects.

For the past ten years, the WHO has consistently equivocated on the issue of recognizing nonthermal biological effects from microwave RF exposure, despite the mounting research evidence of health problems and health risks produced by current levels of public exposure.

SECTION 2 – ELECTROHYPERSENSITIVITY

The following table shows exposure standards for various countries in 2001. (Firstenberg, 2001)

Country	($\mu\text{W}/\text{cm}^2$)
New South Wales, Australia	0.001
Salzburg, Austria (for pulsed transmissions)	0.1
Russia	2–10
Bulgaria	2–10
Hungary	2–10
Switzerland	2–10
China	7–10
Italy	10
Auckland, New Zealand	50
Australia	200
New Zealand	200–1000
Japan	200–1000
Germany	200–1000
United States	200–1000
Canada	200–1000
United Kingdom	1000–10,000

Figure 2: RF exposure limits (2001)

PHYSICIAN AND RESEARCHER RESPONSE

In response to this inaction on the part of government and international regulatory bodies over the past decade, a variety of groups of physicians and researchers in the field of RF/EMF health effects have called for regulatory action to address the documented biological consequences of the increasing exposure of the public to RF transmissions.

In 2000, the Salzburg Resolution suggested a total high frequency radiation limit of $100 \text{ mW}/\text{m}^2$ ($10 \mu\text{W}/\text{cm}^2$), and a total emission level of pulse modulated exposure (such as GSM) of $1 \text{ mW}/\text{m}^2$ ($0.1 \mu\text{W}/\text{cm}^2$). (Altpeter et al., 2000)

In 2002 a group of German physicians described a growing problem with adverse clinical effects from RF/EMF, and called for stricter safety limits on RF transmissions, restrictions on cell phone use by children and adolescents, and a ban on cellular and cordless phone use in preschools, schools, hospitals, nursing homes, event halls, public buildings, and vehicles. (2002)

Multiple similar appeals have been made by research groups and medical associations over the past ten years. (Association, 2004) (Leitgeb et al., 2005) (Association, 2012) (Dean A, 2012) (Johansson, 2011) (Johansson, 2009a) (Fragopoulou et al., 2010) (Israel et al., 2011)

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RADIOFREQUENCY EFFECTS ON MELATONIN

THE FUNCTION OF MELATONIN

Many physiologic functions in the human body are entrained in a circadian rhythm, fluctuating through the day/night cycle. The hormone melatonin, secreted by the pineal gland, is a key agent in coordinating these physiologic responses throughout the body. (Zawilska et al., 2009)

The entrainment of melatonin secretion with the day/night cycle is maintained by the suprachiasmatic nucleus in the hypothalamus, which receives input on the presence of light from the retina via the retinohypothalamic tract. In the presence of ambient light, melatonin secretion is suppressed. In the absence of ambient light, melatonin secretion increases. So melatonin secretion is high during the nighttime hours, peaking shortly after midnight. Higher melatonin levels are part of what makes us feel “sleepy” at night. Exposure to light during the nighttime hours will lead to a rapid suppression of melatonin secretion by the pineal gland, and this can cause disruption of sleep and derangement of the circadian rhythm.

Since the length of the day varies seasonally, melatonin also provides our physiology with information and influence produced by the different seasons of the year. This seasonal influence was obviously more profound prior to the widespread introduction of artificial electric lighting.

The circadian rhythm of high nocturnal melatonin levels supports the natural function of sleep, and disruption of this rhythm by bright light at night, night shift work, or travel to different time zones can produce sleep disturbances.

Melatonin is one of the most potent antioxidant molecules in the human body, and acts to reduce reactive oxidative processes in the body. Melatonin can quench the damaging free radical activity produced by inflammation. The presence of elevated melatonin at night is therefore a key factor in the healing and rejuvenating functions that we associate with “a good night’s sleep”.

Many body processes (serum cortisol levels, body temperature, patterns of digestive function, etc.) have a circadian rhythm that is coordinated by the timing signal of melatonin secretion. Melatonin has a protective effect on the health of the gastrointestinal tract. Melatonin is also protective against the growth of cancer cells, and disruption of the circadian melatonin cycle has been shown to lead to increased tumor growth in a variety of cancer types. (Reiter et al., 2011)

Research has clearly demonstrated that melatonin inhibits the proliferation, invasiveness, and metastasis of human breast cancer cells. Women who have lower levels of nocturnal melatonin are at greater risk for developing breast cancer. (Schernhammer et al., 2008) (Schernhammer and Hankinson, 2009) Breast cancer is more common in industrialized societies, and geographically the incidence of breast cancer is strongly associated with higher levels of “light-at-night”. (Kloog et al., 2008) (Kloog et al., 2010)

Current research suggests that disruption of nocturnal melatonin signals by “light at night” can promote both the development and the growth of breast cancer. (Hill et al., 2011) (Stevens, 2009) In 2007 the International Agency for Research on Cancer declared night shift work to be a probable carcinogen. Subsequent epidemiologic research continues to support this finding. (Bonde et al., 2012)

Recent research has also suggested similar associations between “light at night” and the incidence of prostate cancer. (Kloog et al., 2009)

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ELECTROMAGNETIC AND RADIOFREQUENCY EXPOSURES CAN REDUCE MELATONIN PRODUCTION IN THE PINEAL GLAND

In the 1990's, the Swiss government conducted a series of studies of sleep quality near the Swiss national short wave radio transmission tower in Schwarzenburg. These studies were initiated after the government received a petition stating that many residents living near the transmitter were experiencing problems including nervousness, headache, sleep disturbance, and fatigue.

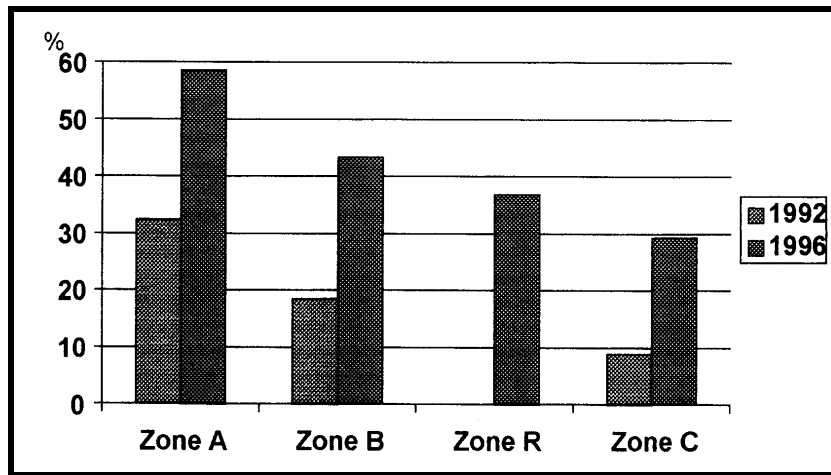


Figure 1: Sleep Disturbance by Proximity Zone in the Schwarzenburg Study. (Cherry, 2002)

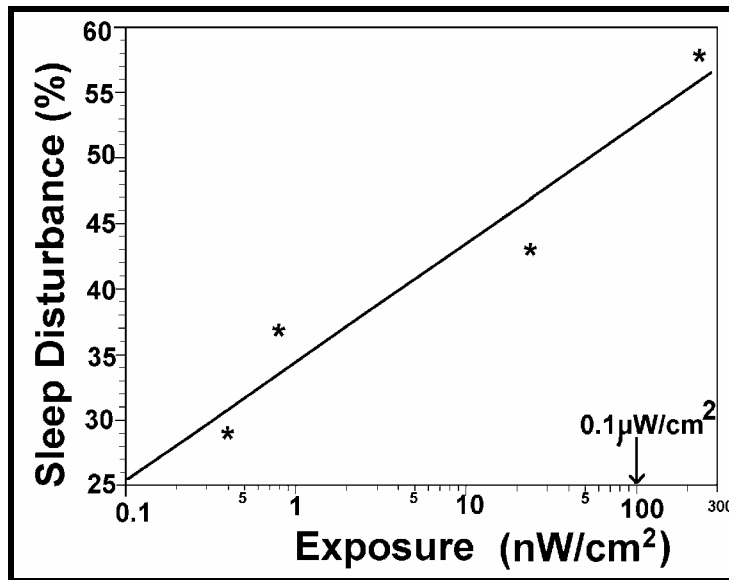


Figure 2: Sleep Disturbance by Exposure Levels in the Schwarzenburg Study. (Cherry, 2002)

In these studies, a statistically significant increase in sleep disturbance was found in residents living closer to the towers. Difficulty in maintaining sleep correlated with transmission field strength, at exposure levels as low as 0.1 nanowatts/cm². (Cherry, 2002) (Abelin et al., 2005)

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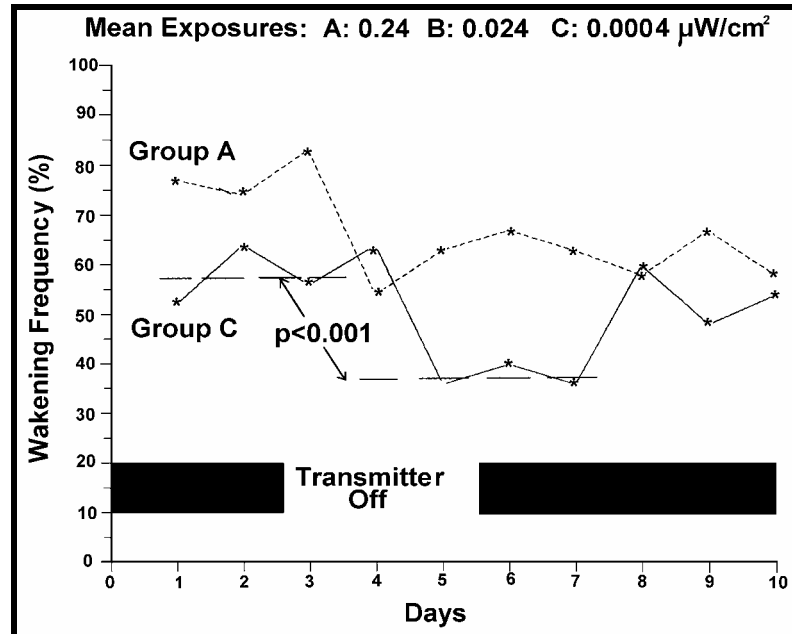


Figure 3: Reduction in Sleep Disturbance with Interruption of Tower Transmission in the Schwarzenburg Study. (Cherry, 2002)

During an interval when the transmitter was turned off for three days, statistically significant reductions in sleep disturbance were found in both the high and the low exposure groups (Figure 3). Note that Group C showed a reduction in sleep disturbance with absence of the signal, despite the fact that signal strength in Zone C averaged only $0.0004 \mu\text{W}/\text{cm}^2$ ($4 \mu\text{W}/\text{m}^2$).

The Schwarzenburg transmission tower was shut down permanently in 1998. In a final research project, sleep quality and salivary melatonin levels were measured in a group of 54 community residents for an interval before and after the end of radio transmission.

Baseline sleep quality was assessed by analysis of sleep diary records, and subjects were stratified into two groups classified as either “poor” or “good” sleepers. Salivary melatonin samples were collected before breakfast, lunch, tea, dinner, and before bed. Subjects recorded morning tiredness and sleep quality, time of falling asleep, and duration of sleep. Exposure levels were calculated for each subjects home.

During the baseline exposure period, scores of morning tiredness directly correlated with increased levels of exposure, and melatonin excretion levels were reduced by a factor of 0.90 for each mA/m of increase magnetic field exposure level. Peak melatonin excretion times were delayed by 4.4 minutes for every $1 \text{ mA}/\text{m}$ increase in exposure level.

After shutdown of the transmitter, subjects’ morning fatigue scores improved by 1.74 units for each $1 \text{ mA}/\text{m}$ of reduced exposure, and melatonin excretion levels increased by a factor of 1.15 per mA/m of reduced exposure. (Altpeter et al., 2006)

The Schwarzenburg shutdown study’s findings were remarkable for two additional reasons. First, there were no other significant levels of short wave radio exposure in the community at the time of the study. So this study provides a true elimination and challenge test of RF exposure effects on a fairly large group of people in their normal environment. Such a study setting was difficult to arrange at that time, and

SECTION 3 – MICROWAVE RF EFFECTS ON MELATONIN SECRETION

would be even more difficult to achieve today, as the number of sources of RF exposure in our communities have increased markedly with the rollout of the wireless telecommunications infrastructure.

Second, the stratification of the study group into “poor” and “good” sleepers allowed recognition of an important additional finding. Improvements in sleep quality and melatonin secretion levels after transmitter shutdown were significantly greater in “poor” sleepers than they were in “good” sleepers. This evidence supports the hypothesis that some individuals may be more sensitive to the effects of microwave exposure, a condition that has been called “electrohypersensitivity” or EHS.

Multiple additional studies in a variety of settings have demonstrated an effect of various forms of EMF/RF on melatonin physiology. Several comprehensive reviews of this research have been published in the last few years. (Cherry, 2002) (Davinipour and Sobel, 2007) (Davanipour and Sobel, 2009)

Performing large long-term studies of RF effects on humans in a sleep laboratory setting would be prohibitively difficult both logistically and financially. But several recent laboratory studies in animals have demonstrated suppression of melatonin by prolonged pulsed microwave RF exposures.

Kesari et al. exposed Wistar rats to 2.45 GHz mobile phone transmissions, 2 hours daily for 45 days, at a calculated SAR of 0.9 W/Kg. Pineal melatonin levels were significantly reduced in exposed animals. (Kesari et al., 2011)

Kumar et al. repeated this experiment with 2.5 GHz exposures of 2 hours per day for 60 days, at a much lower exposure level (power density of 0.21 mW/cm², calculated SAR of 0.014 W/kg). Even at this low level of exposure (= 210 mW/cm²), serum melatonin levels were significantly reduced in exposed animals. (Kumar et al., 2011)

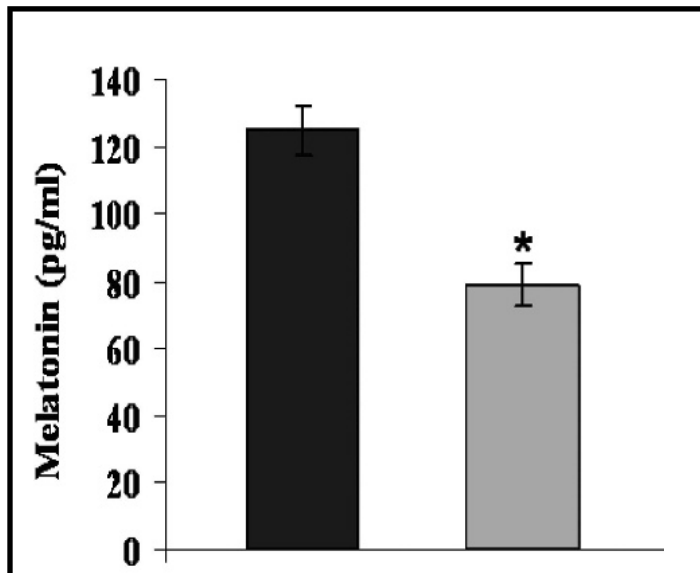


Figure 4: Serum melatonin levels in sham (black) and exposed (grey) Wistar rats after 2 hours daily exposure for 60 days to 2.45 GHz RF transmission at 0.21 milliwatts/cm². (from Kumar et al., 2011)

In another study, Kesari found significant reduction in pineal melatonin levels in rats exposed to 2.45 GHz mobile phone transmissions, 2 hours daily for 45 days, at a power density of 0.21 mW/cm² (calculated SAR of 0.014 W/kg). (Kesari et al., 2012)

SECTION 3 – MICROWAVE RF EFFECTS ON MELATONIN SECRETION**CONSEQUENCES OF REDUCTION OF MELATONIN LEVELS BY MICROWAVE RF EXPOSURE**

Reduction of melatonin levels by exposure to radio transmissions could be expected to cause sleep disturbance. Research findings like the Schwarzenburg studies strongly support this conclusion.

But melatonin has also been found to be protective against promotion of some types of cancer. If suppression of melatonin by “light at night” and night shift work can increase risk of breast cancer (as discussed above), then suppression of melatonin by radio transmissions could also be expected to increase cancer risk. Recently published research studies strongly support this conclusion.

A study in Israel found women living within 350 meters of a cell phone tower to have over 10 times greater risk of cancer than the community as a whole ($p < 0.0001$). (Wolf and Wolf, 2004)

A study of cancer patients in Germany found a 3.29 times greater risk of cancer ($p < 0.01$) in patients with residence closer than 400 meters to a cell phone tower. Risk of breast cancer was 3.4 times greater, and average age of diagnosis of breast cancer was 19 years earlier. (Eger et al., 2004)

In a case/control study of cancer patients residing near a cell phone transmission tower in Austria, those with external residential exposures of greater than $1000 \mu\text{W}/\text{m}^2$ ($> 0.1 \mu\text{W}/\text{cm}^2$) had a breast cancer risk that was 23 times higher ($p = 0.0007$) and brain tumor risk was 121 times higher ($p = 0.001$) than controls. (Oberfeld, 2008)

A recent study from Brazil found a clearly elevated relative risk of cancer mortality at residential distances of 500 meters or less from cell phone transmission towers. (Dode et al., 2011)

Several recent published reviews discuss the multiple epidemiologic studies that have shown an association between residential RF exposure from microwave transmission towers and increased breast cancer risk. (Cherry, 2005) (Khurana et al., 2010) (Levitt and Lai, 2010) (Yakymenko et al., 2011) We will discuss this issue more thoroughly in Section 3.

RAISING THE LEVEL OF RADIOFREQUENCY TRANSMISSION IN RESIDENTIAL NEIGHBORHOODS CARRIES SIGNIFICANT RISKS

Unlike visible light, microwave radio transmissions penetrate walls and human bodies. They are not easily blocked out by window blinds or eye shades. If microwave radio waves can disrupt melatonin secretion in a portion of the population, then a significant increase in nocturnal RF transmission levels in a residential neighborhood would be expected to produce an increase in sleep problems, and over the long run, an increase in the incidence of breast and prostate cancer. The first evidence of such an effect would be a significant increase in complaints of sleep disruption. It might require several years of exposure for the increase in cancer incidence to reveal itself.

If we use complaints of sleep disruption as a marker for this effect, we can suspect that the recent installation of MESH-networking smart meters in California and in other municipalities around the world has pushed many residential areas across a threshold, producing chronodysruption in a significantly increased portion of the population. The early evidence for this is that these smart meter rollouts have been followed by a dramatic increase in complaints of sleep difficulties received by physicians, by public utility commissions, and in postings on the internet.

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RADIOFREQUENCY EXPOSURE INCREASES OXIDATIVE STRESS AND DAMAGES DNA

Over the past 20 years, a great deal of research evidence has accrued which demonstrates that EMF and RF can alter cellular physiology.

INDUCTION OF STRESS PROTEINS

When cells are stressed in a way that damages DNA in cells, an early response of the cellular physiology is to increase the production of proteins involved in the repair of these structures. These repair proteins are called stress proteins or “heat shock” proteins (since early research models used heat to stress the cells). Increased production of these proteins are direct evidence of physiologic stress and damage to cell DNA, as they represent the effort of the cell to protect against and repair that damage.

The physiologic stressors that trigger this response stimulate specific regions on the cell’s chromosome. These regions initiate the transcription of the stress response genes that encode for these repair proteins.

In the late 1990’s research demonstrated that EMF exposures can produce these stress proteins. (Lin et al., 1997) (DiCarlo et al., 1998)

Further research demonstrated that EMF/RF stimulation promotes gene transcription at different promotion sites than those triggered by heat stress (Lin et al., 1998) (Lin et al., 1999), and that this promotion by EMF/RF can occur at power levels that are not high enough to produce thermal changes in the cells. (DiCarlo et al., 1999) (Weisbrot et al., 2003) (Blank and Goodman, 2004) (Blank, 2007)

Subsequent research has shown that at DNA transcription sites activated by low level EMF and RF exposure, higher levels of exposure can lead to single or double strand breakage of the DNA chain. (Blank and Goodman, 2009)

Current research confirms production of the stress protein response by microwave signals in the 900 MHz and 1800 MHz bands. (Cao et al., 2011) (Jiang et al., 2012) (Calabro et al., 2012)

DNA DAMAGE

Many research studies performed in the last decade have demonstrated that radio frequency radiation at nonthermal levels can produce fragmentation of DNA.

In 2003, Ivancsits reported that intermittent low frequency EMF could cause single and double strand breaks in DNA at magnetic flux densities as low as 35 microtesla, well below levels producing thermal effects. Effects were time and dose dependent. (Ivancsits et al., 2003)

This work was confirmed in 2004 in a study showing that 24 to 48 hour exposures to a 0.01 mT 60 hz magnetic field could produce single and double strand DNA cleavage, apoptosis, and necrosis of brain cells in rats. These effects could be blocked with antioxidants, suggesting that free radicals played a role in the damage process. (Lai and Singh, 2004)

Subsequent research demonstrated that these effects also could be produced by nonthermal effects of radiofrequency microwave exposures—at power levels that were below the levels producing thermal effects—and that this nonthermal damage could be prevented by administration of antioxidant free radical scavengers. (Adlkofer, 2006)

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The results of in vitro studies on DNA damage from EMF/RF are variable, since different cell types have different sensitivities to these effects. (Schwarz et al., 2008) Several detailed reviews of these studies have been published in the last five years. These reviews document multiple studies showing production of DNA damage at low power densities, with more prolonged exposure times producing more significant effects. (Lai, 2007) (Ruediger, 2009) (Phillips et al., 2009) (Levitt and Lai, 2010)

Current research continues to validate these findings. For example, Cam and Syhand found an increase in the production of single strand DNA breaks in hair root cells following 15 to 30 minutes of mobile phone use. (Cam and Seyhan, 2012)

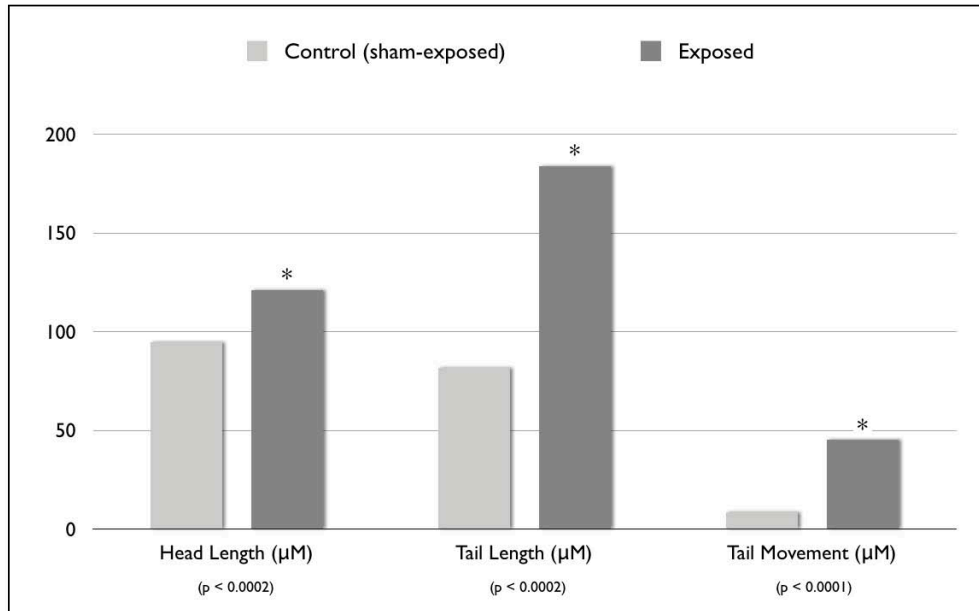


Figure 1: Comet Assay of DNA fragmentation in rat brains, produced by prolonged exposure to microwave RF. (Kesari et al., 2010a)

Kesari et. al. exposed Wistar rats to 2.45 GHz frequency at 0.34 mW/cm² power density (340 μW/cm², whole body SAR ~ 0.11 W/Kg), 2 hours a day for 35 days, and demonstrated increased double strand DNA breakage ($p \leq 0.0002$) in brain tissue. This was accompanied by decreased activity levels of glutathione peroxidase ($p < 0.005$) and superoxide dismutase ($p < 0.006$), and increased catalase activity ($p < 0.006$) suggesting that the microwave exposure produced severe oxidative stress. (Kesari et al., 2010a)

Kumar et. al. exposed Wistar rats to 50 GHz continuous source microwave transmission, 2 hours a day for 45 days, with a power density of 0.86 μW/cm² (calculated SAR 8.0×10^{-4} W/kg). Other rats were exposed to 10 GHz, 2 hours a day for 45 days, power density 0.214 mW/cm² (214 μW/cm², SAR 0.014 W/kg). Both forms of exposure produced significantly altered levels of reactive oxygen species, antioxidant enzyme activity, and blood cell micronuclei formation, demonstrating the production of oxidative stress with genotoxic effects. (Kumar et al., 2010)

RF EXPOSURE PRODUCES OXIDATIVE STRESS

It is a truism among apologists for the telecommunications industry that microwave radiofrequency transmissions cannot possibly cause cancer, because the energy of a photon of this wavelength is not powerful enough to directly break an ionic

SECTION 4 – OXIDATIVE STRESS, DNA DAMAGE, CANCER AND INFERTILITY

bond the way an xray can, and therefor could not possibly cause mutations in DNA. Such an argument sounds like good physics, but it isn't good biology. Ionizing radiation is only one way to cause the mutations in DNA that can produce cancer.

Chronic inflammation can cause cancer. Cigarette smoke can cause cancer. Toxins and autoimmune disease can cause cancer. One common pathway shared by these causes is that they produce an inflammatory response in the body that increases the activity of free radicals (reactive oxygen species). These free radicals produce oxidative damage in the tissues.

This oxidative activity is the tool that our bodies use to destroy foreign bacteria, which can be completely broken up—DNA and all—and digested by our immune system. Free radicals are an important defensive weapon for our bodies, but an excess of oxidative activity can lead to damage of our own tissues. Such excesses have been associated with many chronic problems including autoimmune disease, heart disease, and some forms of cancer. Every week another article is published suggesting that taking antioxidants may be protective against some of these problems.

The mechanisms through which EMF/RF increase oxidative stress in living tissues have not been clearly elucidated, although some ideas have been proposed. (Liboff, 2010) (Georgiou, 2010)

But in the last decade, the scientific research clearly established that EMF and RF exposure cause an increase in reactive oxygen species in living tissues, leading to oxidant damage of DNA. (Shiroff, 2008)

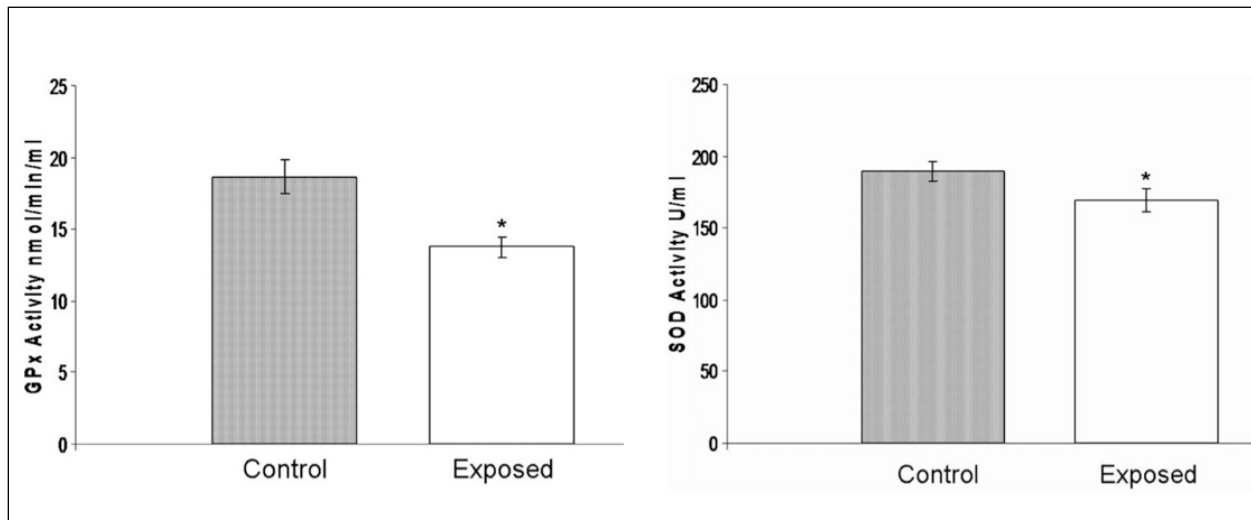


Figure 2: Depletion of antioxidants in RF-exposed rat brains, after exposure to 2.45 GHz, 2 h a day for 35 days at 0.34 mW/cm² power density, 2.45 GHz frequency. (Kesari et al., 2010a)

Studies cited above document that microwave RF exposures at very low power densities produce oxidant stress accompanied by DNA damage. (Kesari et al., 2010a) (Kumar et al., 2010)

Other recently published studies also show that RF exposure can increase oxidant stress and tissue damage in brain tissue (Maaroufi et al., 2011) (Avci et al., 2012), liver tissue (Guler et al., 2012), white blood cells (Lu et al., 2012), and human salivary glands (Hamzany et al., 2012).

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SUPPRESSION OF MELATONIN SECRETION COMPOUNDS THE PROBLEM.

The problems caused by increased oxidative stress from EMF/RF are compounded by the fact that EMF/RF can also suppress melatonin secretion by the pineal gland, since melatonin is one of the most potent antioxidant molecules produced in the body.

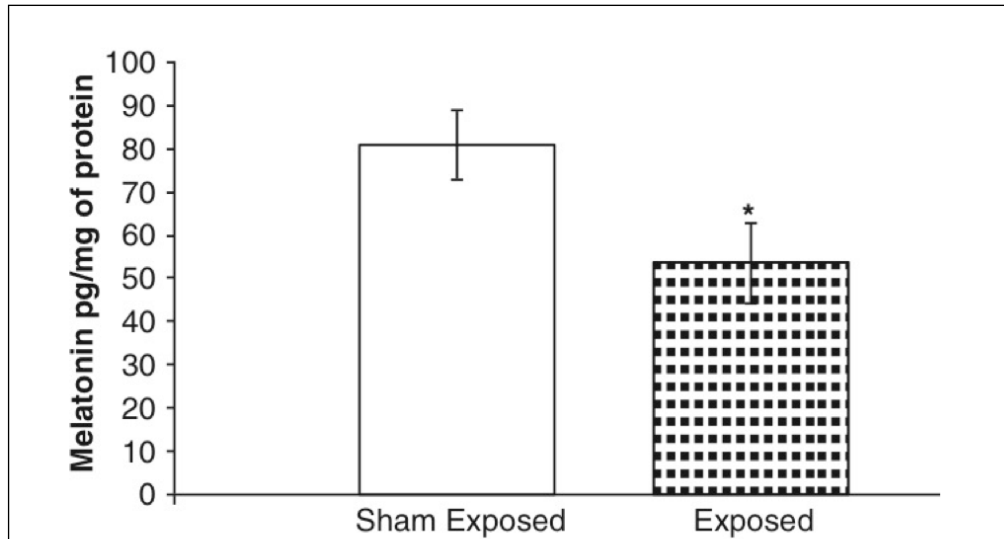


Figure 3: Suppression of melatonin secretion by 2.45 GHz RF, 2 hours a day for 45 days at 0.21 mW/cm². (Kesari et al., 2012)

In recently published study, Kesari et. al. exposed Wistar rats to 2.45 GHz microwave radio transmission, 2 hours a day for 45 days, at a power density of 0.21 mW/cm² (210 µW/cm², whole body SAR ~ 0.14 W/kg). Pineal melatonin was significantly decreased in the exposed group. (Kesari et al., 2012)

Multiple studies have documented that exposure to microwave RF can reduce melatonin levels in animals and in people. (see Section 3).

CONSEQUENCES OF OXIDATIVE DAMAGE TO DNA**EVIDENCE FOR CANCER**

When DNA is damaged, the body attempts to repair it. Errors in DNA coding sequence produced during the repair process can produce mutations. And it is hypothesized that such mutations in DNA are a major cause of cancer.

So if radio frequency (RF) and microwave (MF) exposure increase oxidative damage to DNA, we would expect to see evidence that chronic RF exposure increased the rate of some forms of cancer. A significant body of epidemiologic research in a variety of exposure settings suggests that this is indeed the case.

Electronics technicians

In the 1980's, Milham published evidence of increased leukemia in electrical workers (Milham, 1985b)

Another study of workers in the electronics industry found an increased risk of brain tumor associated with exposure to microwave radio transmission, with a highly significant increase in risk in those with more than 20 years of exposure. (Thomas et al., 1987)

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A case/control study of brain cancer deaths in Maryland found a threefold greater brain cancer incidence in electrical or electronic engineers and technicians, compared to the reference population. (Lin et al., 1985)

A study of leukemia rates in different occupational groups in the U.S. Navy showed increased leukemia risk in electrician's mates. (Garland et al., 1990)

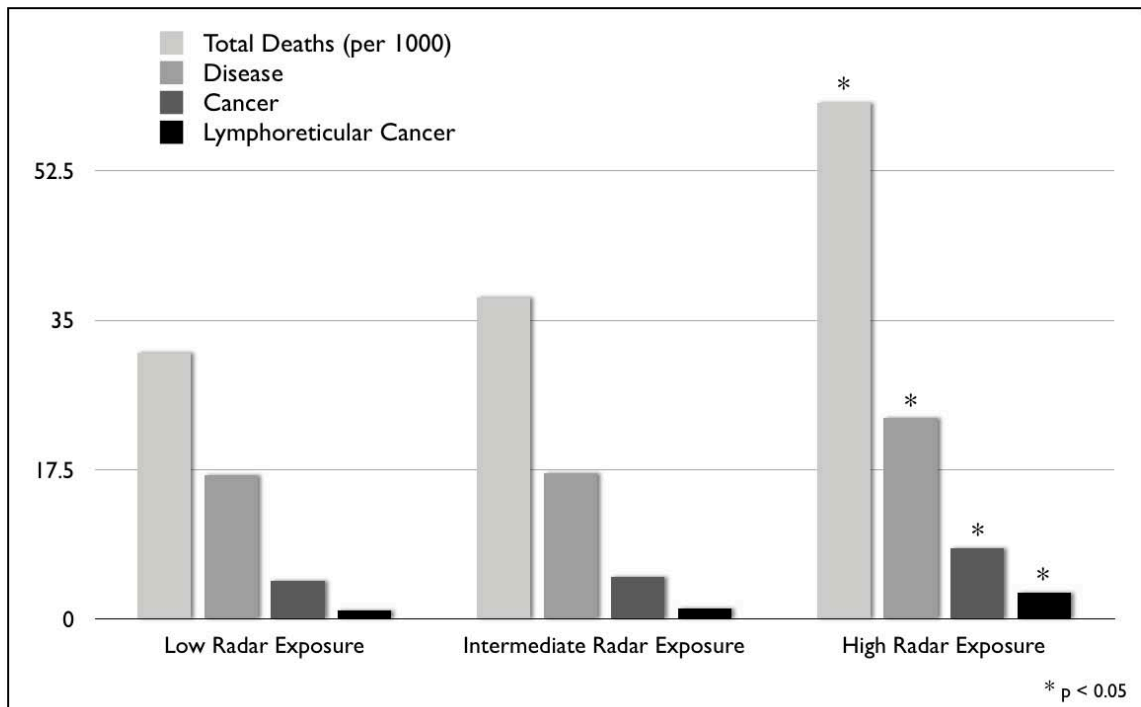


Figure 4: Mortality (1950–1974) in U.S. Navy Korean War Veterans, stratified by in-service levels of occupational radar exposure. (Cherry, 2002a, after Robinette, 1980)

A study performed for the U.S. military published data comparing a cohort of 20,000 Korean War veterans with higher occupational exposure levels to RF/MW exposure to 208,000 Korean war veterans with minimal occupational exposure during their service years. Mortality statistics were reviewed for the interval between 1950 and 1974. (Robinette et al., 1980) This data shows that the group with the highest rated occupational exposure level (aviation electronic technicians) had a significantly higher total death rate during the study period, and a higher death rate from disease, from malignancy, and from lymphatic and hematopoietic malignancies. (Goldsmith, 1997a)

A study of Polish career military personnel from 1971 – 1985 showed double the risk of cancer in personnel with occupational exposure to RF/MW transmission, as compared other personnel. The exposed cohort had higher morbidity rates for GI cancers (Observed versus Expected Ratio = 3.19 – 3.24), brain tumors (OER = 1.91), and hematopoietic malignancy (OER = 6.31), including chronic myelocytic leukemia (OER = 13.9), acute myeloblastic leukemia (OER = 8.62), and non-Hodgkin's lymphoma (OER = 5.82). (Szmigielski, 1996)

Radio Operators

Increased rates of acute myeloid leukemia and of other lymphatic malignancies have been found in large population based studies of amateur radio operators (Milham, 1985a) (Milham, 1988a) (Milham, 1988b).

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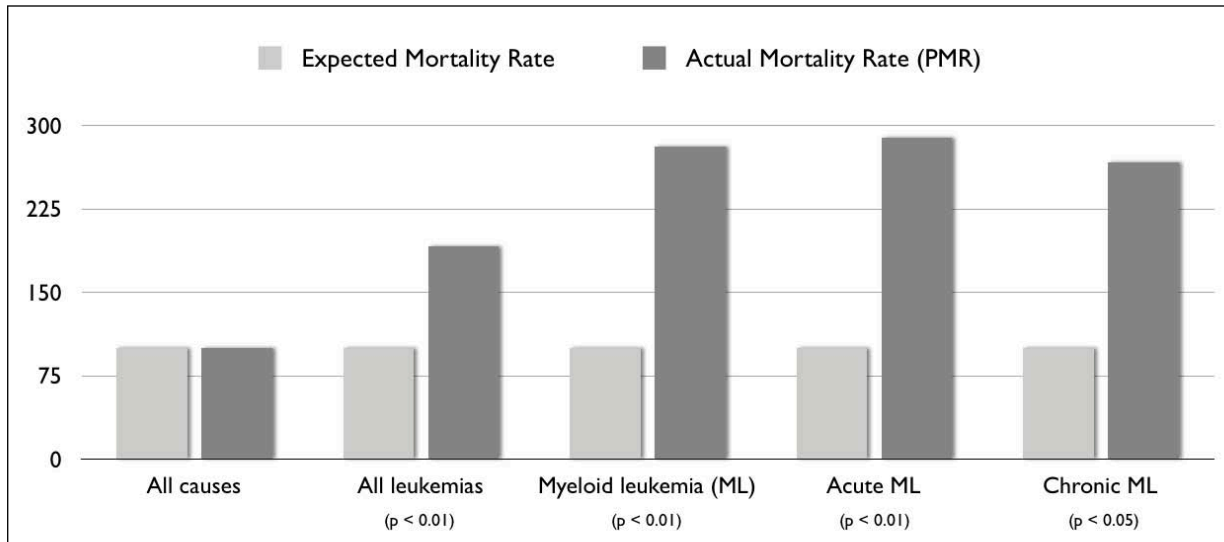


Figure 5: Analysis of leukemia deaths in male members of the American Radio Relay League resident in Washington and California, 1971 – 1983. (Milham, 1985a)

Another study of female radio and telegraph operators in Norway found an increased incidence of breast cancer in this group as compared to the standardized incidence rate in the female population of that country. (Tynes et al., 1996)

Police radar operators

Two studies have shown increased rates of testicular cancer (Davis and Mostofi, 1993), and of testicular cancer and melanoma (Finkelstein, 1998) in police officers with occupational exposure to handheld radar.

Airline pilots

Airline pilots have significant occupational exposure to RF/MF (radio frequency and microwave frequency) transmissions.

A study of U.S. Air Force personnel showed an increased risk of brain tumors associated with increasing rank, and associated with estimated exposures to both microwave radio and low frequency radio transmissions. No increased risk associated with exposure to ionizing radiation was found in this study population. (Grayson, 1996)

A study of commercial airline pilots in Iceland found an increased risk of malignant melanoma. (Rafnsson et al., 2000) Another study with Danish pilots showed increased risk of total cancer, melanoma, other skin cancers, and acute myeloid leukemia in commercial airline cockpit crews. (Gundestrup and Storm, 1999) Neither of these studies specifically controlled for RF/MF exposures as compared to other exposures (cosmic rays, tropical sun on the beach, etc.) incurred by flying personnel.

However, an extensive study of German commercial airlines crews (including 6,017 cockpit and 20,757 cabin crew members) showed an increased brain cancer risk for cockpit crew and an increased all cancer risk for cockpit crew with more than 30 years employment compared to those with under 10 years of employment. Notably, these increased risk were not found in cabin crew members, who share equal exposure to cosmic rays and tropical beaches, but are farther from the radios. (Zeeb et al., 2010)

U.S. Embassy Moscow 1953 – 1976

From the 1950's to the mid-1970's the U.S. Embassy in Moscow was exposed to a

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constant low intensity radar signal, as a form of harassment by the Russian government. The exposure level on the outside of the west facade of the building was measured at 5 microwatts/cm², and was present for 9 hours a day. Since the wall and windows attenuated the signal, inside exposure levels were likely to be in the range of 0.02 to 0.1 $\mu\text{W}/\text{cm}^2$.

The State Department contracted an epidemiologic analysis potential health effects on exposed personnel and their dependents, which was performed by A.M. Lilienfeld M.D., and epidemiologist at John's Hopkins University. This report was published including all of the tabulated raw data. (Lilienfeld AM, 1979)

The report as finally released stated as a conclusion that personnel "suffered no ill effects" from the microwave exposure. However, the published conclusions differed from the original conclusions written by Dr. Lilienfeld, and evidence suggests that the final conclusions were "whitewashed". (Goldsmith, 1997b) One can presume that this might have been done to avoid embarrassment of the federal government, since any harm, if produced, would have been produced at levels of exposure orders of magnitude less than those exposure levels permitted by United States FCC guidelines.

A hematologic study performed on employees at the Moscow embassy was submitted to the U.S. government in October, 1976. This study showed significant abnormalities in hematologic parameters in this group, in comparison with studies of foreign service workers in the United States. (Goldsmith, 1997a)

The published data from the Lilienfeld study of Moscow embassy workers and their dependents has subsequently been analyzed by other epidemiologists and found to show a statistically significant increase in total adult and childhood cancers, in breast cancer, and in childhood leukemia. (Goldsmith, 1995) (Cherry, 2002a)

Residential exposure to Radio/TV Transmission towers

By the late 1990's, a significant body of epidemiologic literature had accumulated that demonstrated an association between exposure to radar and RF radiation and the occurrence of certain types of cancer.

Evidence for association between radio transmission tower exposures and adult and/or childhood leukemia has been reported in studies from Hawaii (Maskarinec et al., 1994) and Australia (Hocking et al., 1996).

A study from England shows an increased risk of adult leukemia in those residing within two kilometers of the transmission tower, and decreased risk of leukemia, skin cancer, and bladder cancer with increased distance of residence from the tower. (Dolk et al., 1997b) A follow-up study involving multiple other sites in England also showed a statistically significant decline in risk of adult leukemia with increasing distance of residence from transmission sites. (Dolk et al., 1997a) (Hocking et al., 1998)

A study in Rome evaluated the incidence of adult and childhood leukemia as a function of residential proximity to the Vatican Radio transmission tower. Pediatric leukemia cases were more common than expected at less than 6 kilometers from the tower, and significantly elevated in adult men living within 2 km of the tower. Adult male leukemia mortality and childhood leukemia rates showed a significant decrease with increasing distance between tower and residence. (Michelozzi et al., 2002)

A study of cancer incidence in proximity to the Sutro radio/TV tower in San Francisco also showed a strong correlation of exposure and incidence of several types of childhood cancer. (Cherry, 2002b) This study was notable for its rigor in analyzing the actual exposure levels around the tower in relation to the data set. Power density/

SECTION 4 – OXIDATIVE STRESS, DNA DAMAGE, CANCER AND INFERTILITY

exposure levels around UHF and VHF broadcasting antennae are not distributed in a simple and symmetrical regression (“with the square of the distance”). Transmission exposure levels form a series of peaks and valleys around these antennae, and the antennae can be arranged to focus more power in one direction than another, aiming a stronger signal at the target audience in a population center. Studies that fail to take this distribution into account and assume that exposure is in direct ratio to distance will mix higher and lower exposure groups together, diluting the power of the study and underestimating true risk in relation to exposure.

In another paper, Dr. Cherry analyzes this issue in detail, and uses his more rigorous approach to review and refine the analysis of data from many of the earlier studies on health effects of radio/TV broadcast towers. His analysis strengthens the evidence for increased cancer risk from these exposures. (Cherry, 2002a)

A large population case/control study in south Korea looked at 1928 leukemia patients and 956 brain cancer patients under 15 years of age who were diagnosed between 1993 and 1999 at 14 large hospitals in Korea. These cases were matched with 3082 age matched patients who received respiratory disease diagnoses (primarily asthma) at the same hospitals during the study period. Case and control exposure levels were calculated for 31 transmitters in South Korea that had a transmission power greater than 20 kW, using a mathematical model that was correlated with field testing. Children residing within 2 kilometers of a transmission tower had a significantly increased risk of leukemia as compared to children with residence greater than 20 km from the tower (OR 2.15, 95% CI = 1.00 to 4.67). (Ha et al., 2007)

Residential Exposure to Cell Phone Tower (Base Station) Transmissions

With the dramatic rollout of commercial cell phone service in the 1990’s, large segments of the population became exposed to significantly higher levels of microwave RF exposure due to the installation of cell phone towers in urban areas. Several recent papers have reviewed the significant evidence for ill effects from these urban exposures. (Khurana et al., 2010) (Yakymenko et al., 2011) (Kumar, 2010)

Netanyu, Israel

Wolf and Wolf studied rates of cancer incidence during the second year of operation of a 1500 watt 850 MHz cell phone tower in Netanya, Israel. The study group was composed of 622 individuals who had lived in area A, within 350 meters of the tower, for the previous 3 to 7 years. A control group of 1,222 individuals living in an outlying area B was also studied.

During the study year, 8 cases of cancer occurred in the study group, and 2 cases occurred in the control group. The cancer rate for the entire town was 31 cases per 10,000. Relative cancer rates for females was 10.5 for the study group, 0.6 for the control group, and 1.0 for the town as a whole ($P < 0.0001$).

Signal power densities of the tower’s transmissions in the homes of the cancer cases ranged from 0.3 – 0.5 $\mu\text{W}/\text{cm}^2$. [note that FCC limits are 600 – 1000 $\mu\text{W}/\text{cm}^2$.]

In the year following the close of the study, another 8 new cases of cancer occurred in area A, and another 2 cases occurred in area B. (Wolf and Wolf, 2004)

Naila, Germany

A cell phone transmission tower was placed in the town of Naila, Germany, in 1993. Eger, Hagen, et. al. reviewed the medical health records from 1994 to 2004 for around 1000 residents of the municipality (roughly 90% of the population). All

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included patients had been living at the same address during the entire 10 years of observation.

Over the course of the entire study period, patients living in an inner area within 400 meter of the transmission tower had 2.27 times the relative risk of cancer incidence, compared to patients living more than 400 meters from the tower ($p < 0.05$). Cancer patients in the inner residential area also developed cancer an average of 8.5 years earlier in life than did cancer patients residing in the more distant area.

For the years 1999 to 2004 (after 5 years of tower operation) the relative risk of cancer incidence in residents less than 400 meters from the tower increased to 3.29 ($p < 0.01$). Relative risk of breast cancer was 3.4 in the inner area, where average age of diagnosis was 50.8 years, compared to 69.9 years in the outer area. (Eger et al., 2004)

Hausmannstätten and Vasoldsberg, Austria

Oberfeld performed a case/control study of cancer patients in the municipalities of Hausmannstätten and Vasoldsberg, Austria. All subjects had resided within 1,200 meters of an analogue cell phone tower that operated between 1984 and 1997 in the municipalities.

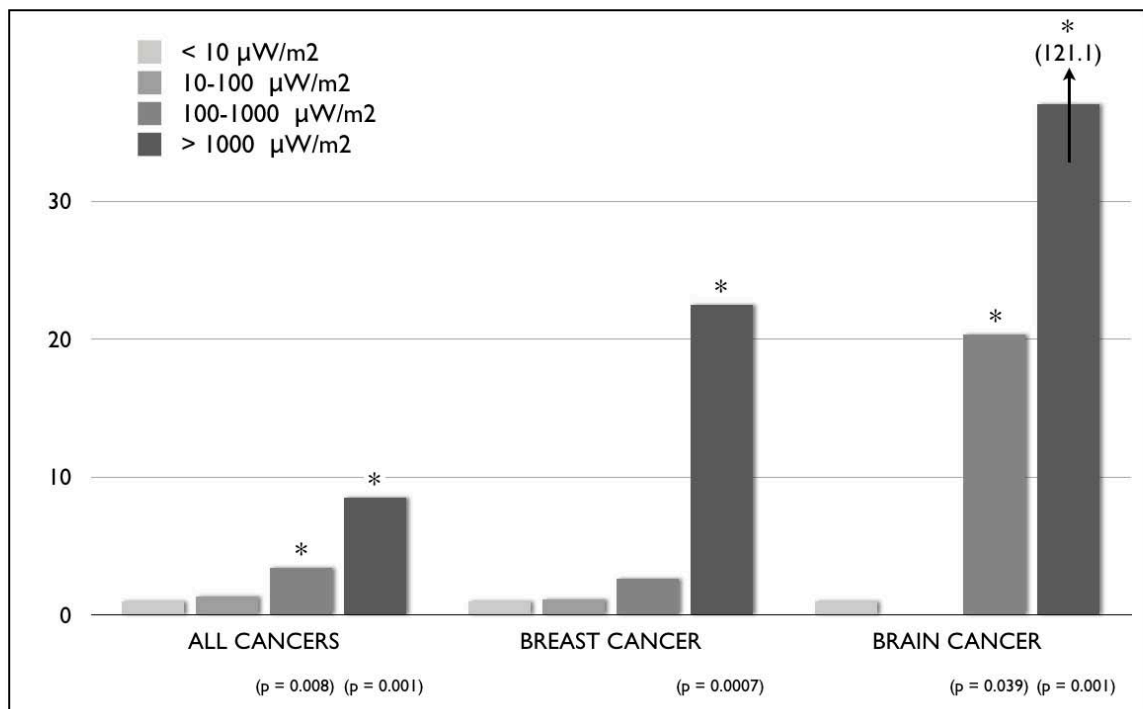


Figure 6: Odds ratio of cancer incidence, stratified by exposure levels (exterior to dwelling) in $\mu\text{W}/\text{m}^2$. (Oberfeld, 2008)

Residential outdoor exposure levels were measured, and three different case/control groups were assessed, for case exposure levels outside the residence of 10 – 100 $\mu\text{W}/\text{m}^2$ ($= 0.001 - 0.01 \mu\text{W}/\text{cm}^2$), 100 – 1000 $\mu\text{W}/\text{m}^2$ ($= 0.01 - 0.1 \mu\text{W}/\text{cm}^2$), and greater than 1000 $\mu\text{W}/\text{m}^2$ ($> 0.1 \mu\text{W}/\text{cm}^2$). respectively. The reference exposure level for the control group was less than 10 $\mu\text{W}/\text{m}^2$ ($= 0.001 \mu\text{W}/\text{cm}^2$). [Note that FCC thermal safety limits are 6,000,000 to 10,000,000 $\mu\text{W}/\text{m}^2$.]

Cancer risk for all cancers was significantly elevated for all three elevated exposure categories, and was 5 to 8 times higher in the $>1000 \mu\text{W}/\text{m}^2$ ($> 0.1 \mu\text{W}/\text{cm}^2$) cate-

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gory ($p=0.001$). In this highest risk group, breast cancer risk was 23 times higher ($p = 0.0007$) and brain tumor risk was 121 times higher ($p = 0.001$). (Oberfeld, 2008)

Belo Horizonte, Brazil

Dode et. al. studied deaths from cancer in the city of Belo Horizonte in southern Brazil from 1996 to 2006. This city of over 2 million inhabitants was rated by the United Nations in 2007 as having the best quality of life in Latin America. The researchers used the database of deaths by neoplasm of the City Health Department, the database of cell phone base station sites from the Brazilian Telecommunications Agency, and a database of the city census and demographics. Exposure duration was calculated from the date of installation of the first antenna to which the individual had been exposed, and residential distance from that exposure was calculated in 100 meter increments.

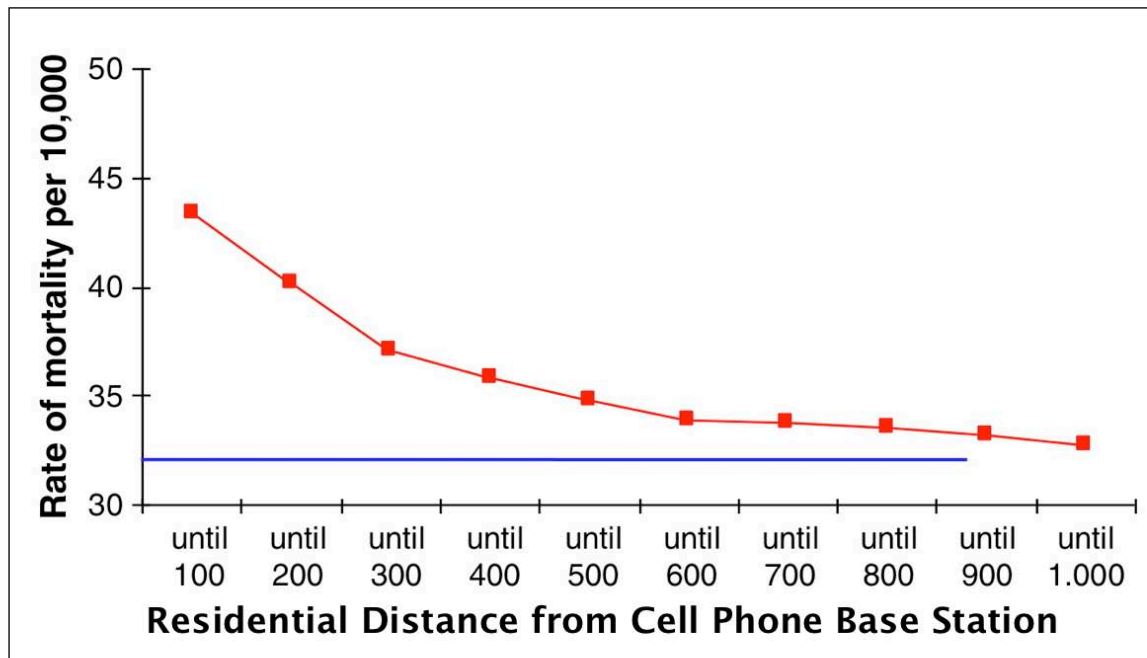


Figure 7: Cancer death rate as function of residential proximity to cell phone transmission towers in meters. Horizontal line = null hypothesis. (Dode et al., 2011)

The highest concentration of base stations was in the south central part of the city. In 2008, environmental monitoring of microwave radiation was performed at 400 sites, measuring frequency bands between 800 MHz and 1800 MHz. Signal intensity averaged 7.32 V/m ($\sim 14.2 \mu\text{W}/\text{cm}^2$), with a range from 0.4 to 12.4 V/m (~ 0.04 to $40.7 \mu\text{W}/\text{cm}^2$). These intensity levels are well below the ICNIRP guidelines for microwave radiation exposure, which are based on protection against thermal effects.

Analysis of the data showed that cancer mortality rates were higher near the cell phone transmission towers. Within the range of 100 meters of a tower, the mortality rate was 43.42 persons per 10,000 (compared to a rate of 32.12 per 10,000 for the city as a whole), with a relative risk of 1.35.

The mortality rate reduced in proportion to residential distance from cell phone tower. Relative risk of cancer mortality was clearly elevated at residential distances of 500 meters or less from a cell transmission tower (base station, or BS) as illustrated in Figure 7. (Dode et al., 2011)

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Taiwan

Li et. al. performed a case/control study of 2606 children age 15 or less who were diagnosed with a neoplasm in Taiwan between 2003 and 2007. Each case was matched with 30 controls. Residential exposure of cases and controls was calculated based on the annual power density in watt-years per kilometer squared for each of the 367 townships in Taiwan, averaged out for the 5 year period prior to diagnosis in the township where the subject resided at time of diagnosis.

This study is notable for the large number of cases and controls, which should increase the power of the study. On the other hand, if elevated microwave exposure is associated with cancer risk, assuming that power density of cell phone tower transmissions is constant throughout each township would serve to minimize the effects of higher exposure levels closer to the towers, minimizing the distinction between higher and lower cohorts, and diluting the power of the study.

Case/control analyses were performed for “all cancer types”, for leukemia, and for brain neoplasm. Odds ratio for cases of “all cancer types” with calculated exposure greater than median exposure value of controls were significantly elevated at 1.13 (95% CI = 1.01 to 1.28). Odds ratio for cases of leukemia with calculated exposure greater than median exposure value of controls were elevated at 1.23 (95% CI = 0.99 to 1.52). Odds ratio for cases of brain neoplasm with calculated exposure greater than median exposure value of controls were slightly elevated at 1.14 (95% CI = 0.83 to 1.55). (Li et al., 2012)

EVIDENCE FOR IMPAIRMENT OF FERTILITY

Toxic exposures that damage DNA can cause cancer. They can also cause damage to the production of healthy eggs and sperm, leading to infertility. If microwave RF exposure causes oxidative damage to DNA, this should lead to measurable alterations in function of reproductive function and fertility. Current research is beginning to prove the presence of this effect.

Laboratory studies in insects

In 2004, Panagopoulos et. al. demonstrated that exposure to a modulated GSM 900 MHz cell phone signal for 6 continuous minutes daily for two days decreased the fertility of both male and female fruit flies (*Drosophila melanogaster*). Exposure power density was ~ 0.436 milliwatts/cm² (= 436 µW/cm²). (Panagopoulos et al., 2004)

In a later study, Panagopoulos et. al. exposed *Drosophila* fruit flies to a cell phone transmitting GSM 900 MHz at 0.40 mW/cm² (= 400 µW/cm²—Group 1) or GSM 900 MHz at 0.29 mW/cm² (= 290 µW/cm²—Group 2), or DCS 1800 MHz at 0.29 mW/cm² (= 290 µW/cm²—Group 3). Transmission exposures were 6 consecutive minutes per day for six days. The exposure induced fragmented DNA during oogenesis. Cell death scores in the ovaries of female flies were 63% in Group 1, 45% in Group 2, and 39% in Group 3, as compared to 7.8% in the sham and control groups. (Panagopoulos et al., 2007)

Subsequent research exposed *Drosophila* fruit flies to GSM 900 MHz or DCS 1800 MHz signals for signal durations of 1 to 21 minutes a day for five consecutive days, at a power density of 10 µW/cm². Impairment of fertility increased linearly with duration of exposure (see figure 2). Even at 1 minute of exposure a day, fertility was significantly decreased in exposed versus sham exposure specimens (p < 0.00001). (Panagopoulos and Margaritis, 2010)

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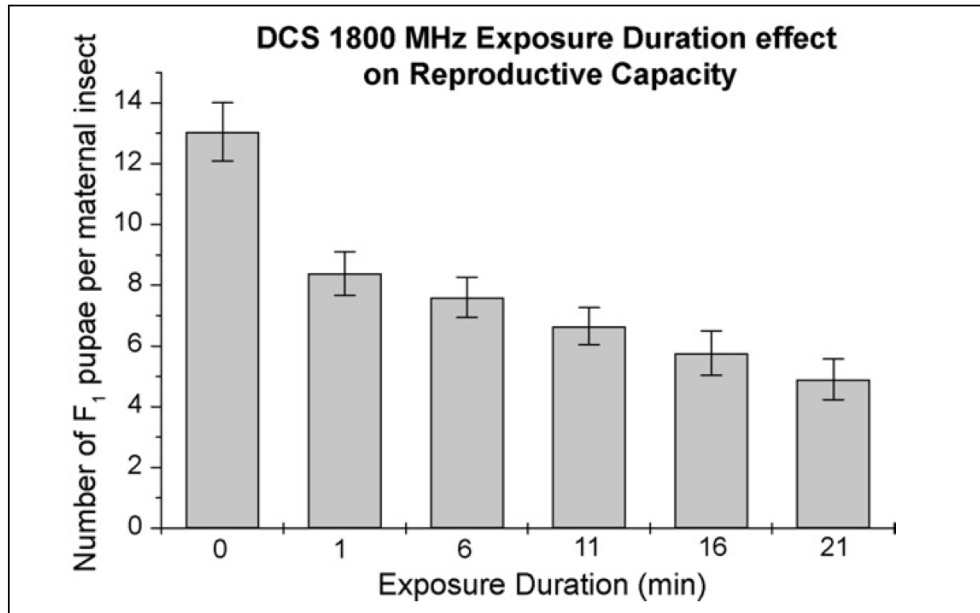


Figure 8: Decreased fertility of fruit flies at exposure level of $10 \mu\text{W}/\text{cm}^2$.
(Panagopoulos and Margaritis, 2010)

In another study using a GSM 900 MHz cell phone signal at $0.35 \text{ mW}/\text{cm}^2$ ($= 350 \mu\text{W}/\text{cm}^2$), six minutes of daily exposure was divided into one, two, or three minute segments, spaced 10 minutes apart. This was compared with one 6 minute constant exposure and with two 3 minute exposures spaced 6 hours apart. DNA damage and cell death in the intermittent exposures sequenced 10 minutes apart was essentially the same as with the constant 6 minute exposure ($p > 0.92$), and markedly higher than in the sham group ($p < 10^{-8}$). The group with divided exposures 6 hours apart had less cell death than the more frequently exposed group, but still showed significantly higher infertility than the control group ($p < 0.002$). (Chavdoula et al., 2010)

In yet another study, the Panagopoulos group evaluated influence of GSM 900 MHz and 1800 MHz cell phone transmissions on *Drosophila* fertility using exposures of 6 minutes per day for 6 days, at exposure distances varying from 0 to 100 cm. They were able to demonstrate an adverse effect on fertility for all exposures at all power densities greater than or equal to $1 \mu\text{W}/\text{cm}^2$. (Panagopoulos et al., 2010)

Recently Panagopoulos published another study demonstrating that exposure to a GSM 900 MHz modulated cell phone transmissions at $\sim 0.35 \text{ mW}/\text{cm}^2$ ($= 350 \mu\text{W}/\text{cm}^2$) for 6 minutes during ovarian development can seriously retard ovarian maturation and reduce final size of ovaries in *Drosophila* fruit flies. (Panagopoulos, 2012)

Laboratory studies in animals

Magras and Xenos placed caged mice at various locations in an antenna park in Thessaloniki, Greece, at locations with RF power densities ranging from $168 \text{ nW}/\text{cm}^2$ ($= 0.168 \mu\text{W}/\text{cm}^2$) to $1053 \text{ nW}/\text{cm}^2$ ($= 1.053 \mu\text{W}/\text{cm}^2$). The mice lived in these locations for six months, during which time they were mated repeatedly. Numbers of newborns per litter decreased progressively, and ended with complete infertility by the fifth mating cycle. This infertility was not reversible with removal to an unexposed laboratory environment. (Magras and Xenos, 1997)

Meo et. al. exposed Wistar rats to cell phone transmissions for either 30 or 60

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minutes a day for 3 months, and then measured serum testosterone levels. Testosterone levels decreased with increased duration of exposure, and the difference in testosterone level between subjects and controls was statistically significant in the 60 minutes per day group ($p < 0.02$) (Meo et al., 2010)

Otitolaju et. al. evaluated sperm head morphology in laboratory rats that were exposed to cell tower transmissions at two locations with mean RF exposure levels of 489 ± 43 mV/m (~ 0.6 $\mu\text{W}/\text{cm}^2$) and 625 ± 25 mV/m (~ 0.10 $\mu\text{W}/\text{cm}^2$). A control group was held in a laboratory with RF exposure levels of 59 ± 17 mV/m (~ 0.001 $\mu\text{W}/\text{cm}^2$). After six months of exposure, exposed rats showed mean sperm head abnormalities of 40% and 46%, versus 2% in control animals. (Otitolaju et al., 2010)

Kesari and Behari exposed male Wistar rats to 50 GHz continuous microwave radiation at a power density of 0.86 $\mu\text{W}/\text{cm}^2$ (calculated SAR 8×10^{-4} W/kg), 2 hours a day for 45 days. Sperm cells showed significant reductions of glutathione peroxidase and superoxide dismutase activity ($p \leq 0.05$) and increased catalase activity ($p < 0.02$), consistent with a significant increase in oxidative stress. Histone kinase activity was also increased ($p < 0.016$), and significantly increased apoptosis (programmed cell death) and alteration in phases of sperm development were also present. (Kesari and Behari, 2010)

In a similar study, Kesari et. al. confirmed a significant increase in cell death through apoptosis, reduced sperm count, and reduced protein kinase C activity in male Wistar rats exposed to cell phone transmissions 2 hours daily for 35 days. Exposure power densities ranged from $0.1 - 2.0$ mW/cm² ($= 100 - 2000$ $\mu\text{W}/\text{cm}^2$, calculated SAR 0.9 W/kg. (Kesari et al., 2010b)

In 2011 and 2012 Kumar and Kesari published four additional papers documenting the adverse effects of 10 GHz microwave exposure (2 hours daily for 45 days at power density of 0.21 mW/cm² ($= 210$ $\mu\text{W}/\text{cm}^2$, SAR 0.014 W/kg) on fertility in male Wistar rats. These studies document significant levels of pathological change including increases in reactive oxygen species, increased apoptosis (cell death) in sperm cells and altered sperm cell cycle (Kumar et al., 2011), increased free radical formation, decreased activity of glutathione peroxidase and superoxide dismutase, increased activity of catalase and malondialdehyde, decreased histone kinase (Kesari et al., 2011), reduced testosterone levels, shrinkage of seminiferous tubules and testicular size, distortion of sperm structure, decreased number and weight of progeny (Kesari and Behari, 2012), formation of micronuclei bodies in lymphocytes, DNA strand breakage, altered levels of histone kinase, altered percentage of spermatogenic phases, and (again) reduced testosterone levels and shrinkage of seminiferous tubules. (Kumar et al., 2012)

In 2012, Atasoy et. al. published a study of rats exposed to a WiFi router (802.11.g, 2.437 GHz) for 20 weeks, 24 hours a day. Histological and immunohistochemical examinations of the rats' testes showed evidence of DNA damage compared to controls ($p < 0.05$) and decreased activity levels of antioxidants (catalase and glutathione peroxidase, $p < 0.05$). (Atasoy et al., 2012)

Other animal studies

Experimental laboratory evidence clearly demonstrates that microwave RF radiation can adversely effect reproduction in insects and animals. Some evidence to support this is also available from studies of animals exposed to RF in their natural environment.

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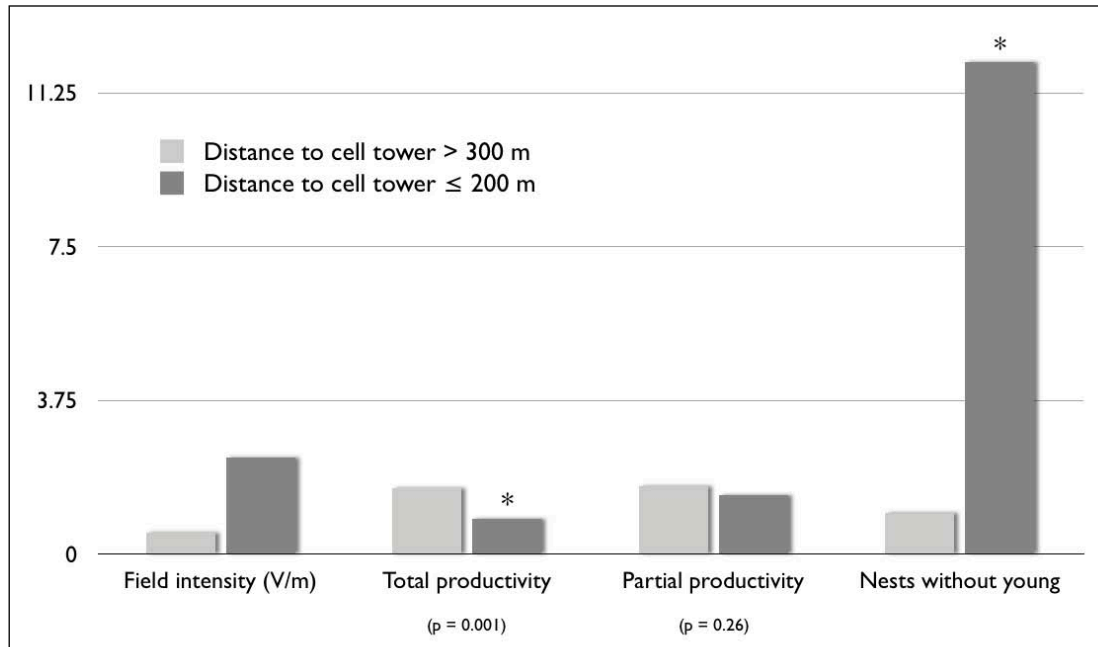


Figure 9: Impaired fertility in white storks nesting near cell phone towers.
(Balmori, 2005)

Balmori studied a white stork population that was nesting near a cluster of cell phone towers in Valladolid, Spain. Power densities at ground level ranged from $10 \mu\text{W}/\text{cm}^2$ at 50 meters from the towers to $1 \mu\text{W}/\text{cm}^2$ at 100 meters distance and a tenths of a $\mu\text{W}/\text{cm}^2$ at 150 to 200 meters distance. Total breeding productivity was significantly reduced at nests closer than 200 meters, compared to nests farther than 300 meters from the towers. (Balmori, 2005)

Balmori performed bird counts at 30 locations during 40 visits to Valladolid, Spain, over the interval between October 2002 and May 2006, and measured mean electric field strength at each counting site. Bird population density declined significantly over the observation period ($p = 0.0037$), and population density was significantly lower in areas with higher electric field strength ($p = 0.0001$). (Balmori and Hallberg, 2007)

Balmori also studied reproductive success of common frogs (*Rana temporaria*) at a breeding site 140 meters from a cluster of cell phone towers. Electric field intensities measured at 1.8 to 3.5 V/m (~ 0.9 to $3.2 \mu\text{W}/\text{cm}^2$). Some eggs were in enclosures that were permeable to microwave radiation, and others were shielded in grounded Faraday cages. Exposed eggs showed asynchronous growth with varying tadpole size and a 90% mortality rate, while shielded eggs developed synchronously with a 4.2% mortality rate. (Balmori, 2010a)

Much more work needs to be done on in vivo studies of the effects of microwave cellular transmissions on animals and plants. Two reviews of the existing research have been published. (Balmori, 2009) (Balmori, 2010b)

Human studies

Human sperm counts have been declining for decades. In 1992 Carlsen et. al. published a meta-review of 61 studies published between 1938 and 1991, with 14,947 subjects. They found a decreased in mean sperm count from 113 million/ml to 66 million/ml ($p < 0.0001$) between 1940 and 1990, with a decrease in seminal volume from

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3.40 ml to 2.75 ml ($p = 0.027$). Additionally, the percentage of men with sperm counts < 20 million/ml increased over this time period, while the percentage of men with sperm counts > 100 million/ml decreased. The incidence of testicular cancer increased between two and fourfold during this interval. (Carlsen et al., 1992)

Carlsen's analysis produced controversy initially. But subsequent analysis has shown that their results were essentially correct. Analytic approaches to their data set that refined the analysis to adjust for bias of various kinds have continued to support the validity of their conclusions. (Swan and Elkin, 1999)

In another meta-analysis, Swan et. al. looked at 54 of the most robust studies in the Carlsen data set, and at 47 additional studies, covering studies from 28 countries over a total time interval from 1934 to 1996. They found a rate of decrease in sperm counts of 0.80 million/ml per year in North America and 3.13 million/ml per year in Europe/Australia. (Swan et al., 2000)

And more recent studies have shown that this downward trend in sperm counts is continuing. Jorgensen et. al. found decreasing levels in sperm concentration, total sperm count, and percentage of morphologically normal sperm in Finnish men born in 1987 versus 1982 – 83 versus 1979 – 1981. (Jorgensen et al., 2011) Sperm counts in New Zealand sperm donors decreased 50% between 1987 and 2007, an average of 2.5% per year. (Shine et al., 2008)

In the early 1990's, it was hypothesized that this decrease in sperm counts and increase in testicular pathology might be due to exposure of male embryos to exogenous estrogens (DES, pesticide residues, plasticizers like Bisphenol A, etc.) early in development. (Sharpe and Skakkebaek, 1993) (Carlsen et al., 1995) (Irvine, 1997)

In 1994, Abell et. al. described higher sperm counts in members of a Danish organic farmer's association, as compared with Danish men who had occupational exposures to xenoestrogens. (Abell et al., 1994) Jensen et. al. found a 43.1% higher sperm concentration ($p = 0.033$) in 55 members of Danish organic foods associations who ate at least 25% organic foods, as compared with 141 normal controls. (Jensen et al., 1996)

Multiple studies in animal models have shown that in utero exposures to estrogenic chemicals can alter testicular health and function. Regional variations in sperm count and testicular cancer rates suggest the possibility of environmental influences. A recent paper by Nordkap et. al. reviews current perspectives on this subject. (Nordkap et al., 2012)

On the other hand, estrogenic xenobiotic chemicals have been present in the food chain since the 1950's. Adverse clinical effects of these exposures have been discussed since the early 1960's. (Randolph, 1962) Unless the human body burden of these chemicals has continued to significantly increase over the last 50 years, we would expect the influence of this effect on sperm counts to plateau.

But sperm counts have not plateaued. They have continue to decrease throughout the developed world. A recent study of 26,609 french partners of totally infertile women seeking in vitro fertilization found a 32.2% decrease in sperm concentration between 1989 and 2005, with projected sperm counts for a 35 year old man dropping from 73.6 million/ml to 49.9 million/ml. (Rolland et al., 2012)

This continued trend should be a cause for significant alarm. The World Health Organization defines sperm counts above 20 million/ml as normal. But studies have shown that couples take longer to get pregnant at sperm counts below 40 to 55 million/

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ml. (Bonde et al., 1998) (Guzick et al., 2001) (Slama et al., 2002) In Israel, a recent study of sperm donors showed that over the last 10 to 15 years the average sperm count has dropped from 106 million/ml to 68 million/ml, an average decrease of 2.5 million/ml (0.8%) per year. 15 years ago, 66% of sperm donations were of acceptable quality; using the same criteria, at the current time only 18% of donations would be of acceptable quality. (Haimov-Kochman et al., 2012)

As discussed above, studies in insects and animals have demonstrated that microwave radio exposure at remarkably low power densities can have an adverse effect on male fertility. With the rollout of cellular and WiFi infrastructure, exposure to these radio frequencies has increased dramatically in the last 20 years. Would it be reasonable to ask if such exposures have played a role in the continued decrease in male fertility that has occurred during this time period? The result of several recent studies suggests that the answer to this question is “Yes”.

Erogul et. al. split human sperm samples and exposed one part to signal from a 900 MHz cell phone. They found statistically significant decreases in motility of sperm in the exposed samples. (Erogul et al., 2006)

Fejes et. al. measured semen quality in a cohort of 371 subjects where confounding factors had been excluded, and found a significant decrease in sperm motility ($p < 0.01$) in individuals with talk time > 60 minutes/day versus talk time < 15 minutes/D. Decreased sperm motility also correlated with increased duration of cell phone ownership in months. (Fejes et al., 2005)

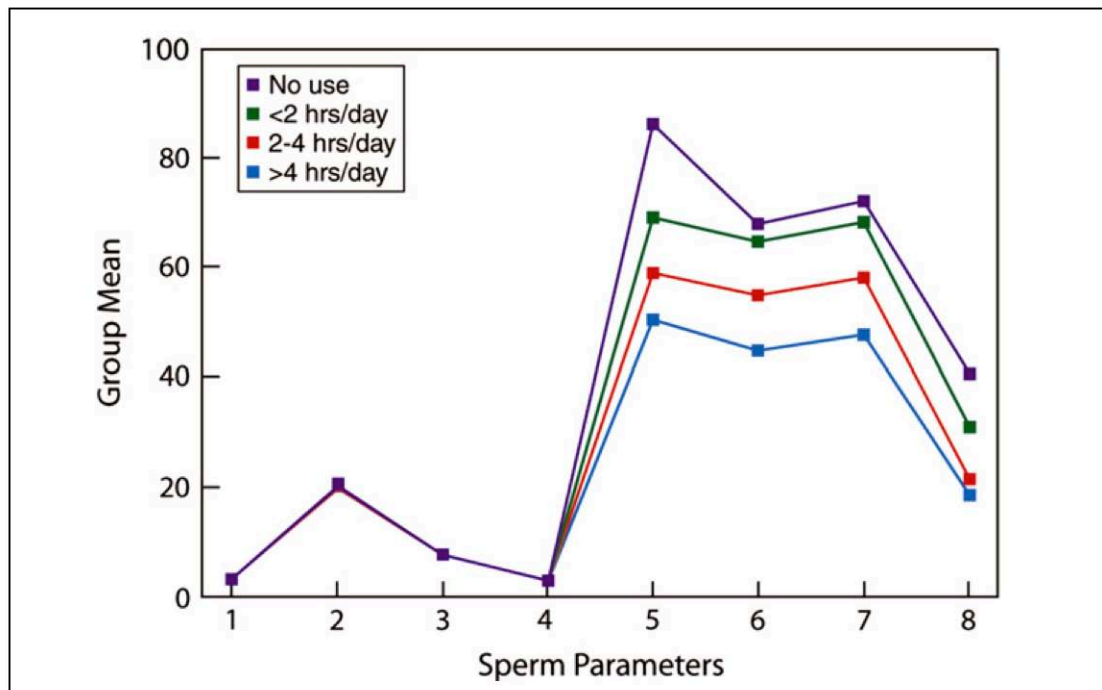


Figure 10: Decrease in sperm count (5), motility (6), viability (7) and normal morphology (8) with increased cell phone talk time. (Agarwal, 2008)

Agarwal et. al. studied semen quality in 361 subjects, divided into four groups based on daily cell phone usage (no use, < 2 hours/day, 2 to 4 h/D, > 4 h/D). They found that sperm count, motility, viability, and percent normal morphology all decreased with increased cell phone use. (Agarwal et al., 2008)

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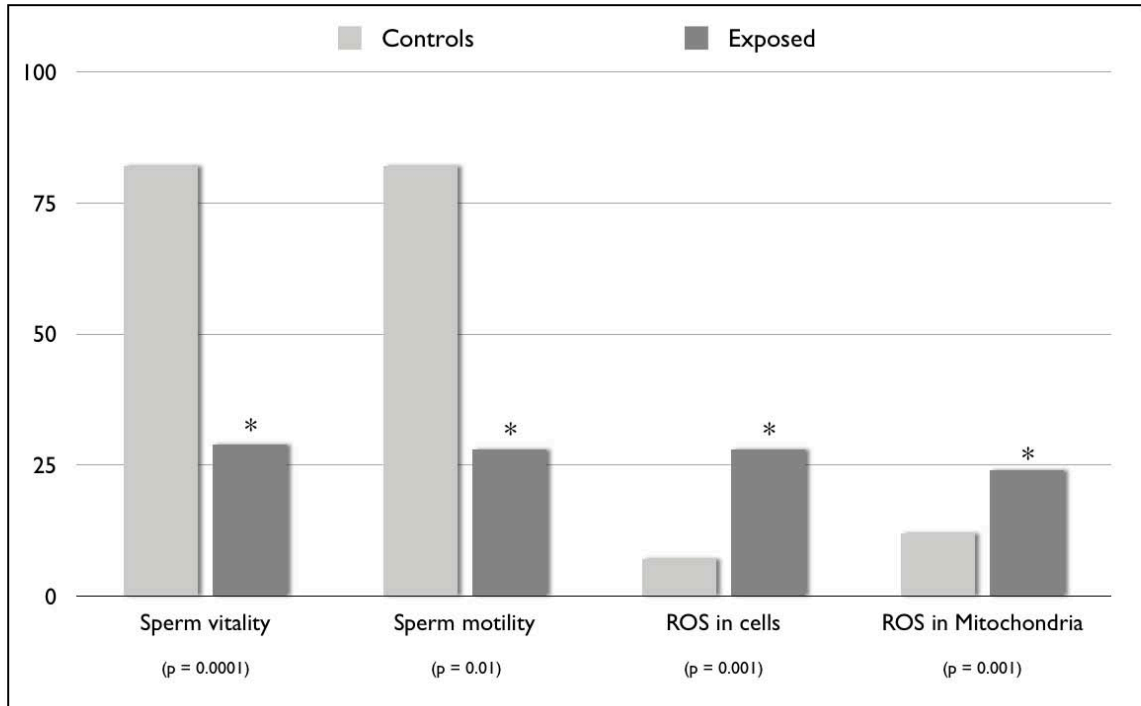


Figure 11: Sperm exposed in vitro to 1.8 GHz (SAR = 27.5 W/kg) for 16 hours @ 21°C (isothermal conditions). (De Iuliis et al., 2009)

De Iuliis et. al. exposed human sperm to 1.8 GHz microwave radio transmissions. Statistically significant decreases in sperm motility and vitality were demonstrate at exposure levels as low as 1.0 W/kg ($p < 0.01$). This study also found an increase in reactive oxygen species, oxidative damage to DNA, and DNA fragmentation, that was not dependent on thermal effects. (De Iuliis et al., 2009)

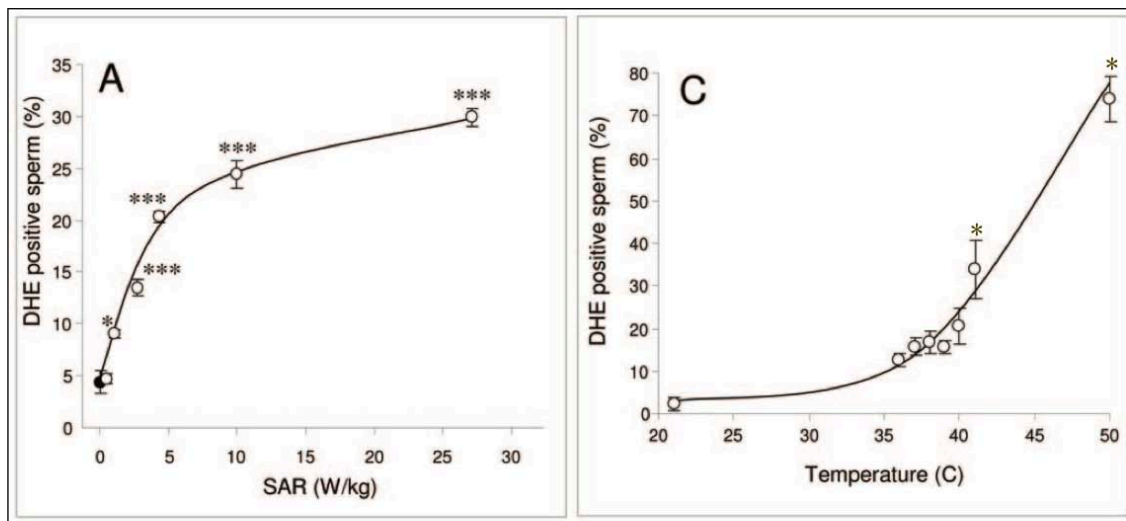


Figure 12: A) Production of ROS with increasing levels of microwave RF .
B) Production of ROS with increasing levels of temperature.
(De Iuliis et al., 2009)

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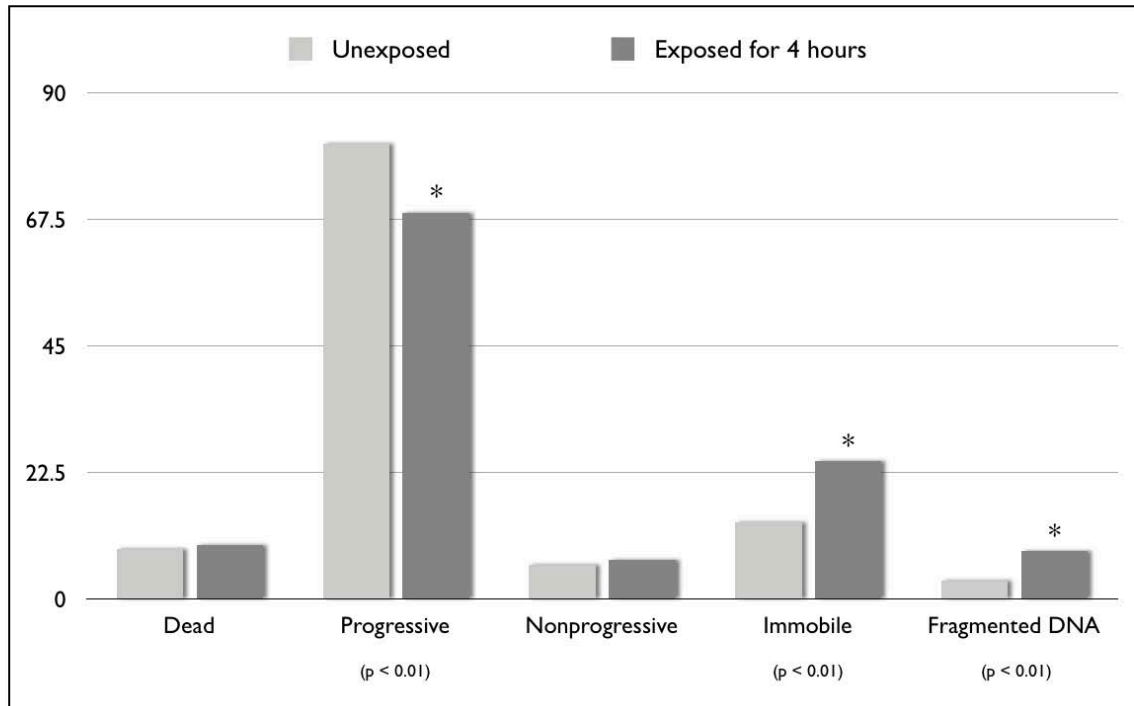


Figure 13: Sperm damage from exposure to laptop computer WiFi transmission.
(Avendano et al., 2011).

Another recent study the effects of exposing motile sperm to 4 hours of WiFi transmission at a position 3 cm beneath a laptop computer, at power densities between 0.45 and 1.05 $\mu\text{W}/\text{cm}^2$. Temperature was maintained at a constant 25°C. Exposed specimens showed a statistically significant decrease in sperm progressive motility, and a significant increase in non-motile sperm and in sperm DNA fragmentation. (Avendano et al., 2011)

The fact that multiple recent studies have demonstrated the ability of microwave RF exposure to cause nonthermal damage sperm function and sperm DNA with short exposure times and quite low exposure levels—the FCC exposure limit is 1000 $\mu\text{W}/\text{cm}^2$ —should be a source of grave concern. The presence of constantly transmitting WiFi networks in homes and schools may be much less innocuous than is generally supposed.

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CURRENT RESEARCH ON CELL PHONE USE AND BRAIN TUMOR RISK

INTRODUCTION

To be complete, any review of the health hazards of microwave radio exposures must include a discussion of the research on possible associations between cell phone usage and brain tumors.

This research is a hot topic politically. Cell phone use has permeated our society, and no one wants to think that use of a cell phone is going to increase their personal risk (or their child's personal risk) of acquiring a terrifying disease.

The rollout of the cellular communications infrastructure has also created an extremely profitable industry. The telecommunications industry made \$3.1 trillion in gross profits in 2010. (Plunkett Research, 2012) This industry has a powerful incentive to downplay the health effects of EMF, and has funded a good deal of research that serves to further that aim. Some studies regarding cell phones and brain tumors have been funded in large part by the telecommunications industry. These industry-designed studies have generally concluded that the use of cell phones does not create a health hazard. And these negative reports have received wide coverage in the news media. However, the study designs funded by industry are more likely to use unblinded protocols and to underestimate risk, as compared to studies funded by public bodies. (Levis et al., 2012)

When powerful financial interests are at play, industry funding of favorable research studies is often used to influence the political and scientific playing field. We've seen this play out in pharmaceutical research, where several recent scandals have highlighted the distorting effects of corporate financing on research outcomes. In the past few decades the production of research providing favorable (to corporate interests) results has become something of a science in itself, with corporations essentially gaming the academic system, funding studies designed to produce favorable outcomes for their products, and hiding studies that do not support their interests. The peer review process of the scientific journals has not proved to be an adequate defence against this problem. (Smith, 2005)

In the research on cell phones and brain tumors, the situation is further confounded by the fact that cell phone usage has only become wide spread in the last 15 years or so. The first digital cell phone infrastructure was pioneered in Scandinavia, and the first research that raised concerns about cell phone cancer risks was produced in Sweden in the late 1990's. But environmental influences that promote cancer generally take years to do so.

Take the question of the potential risk of cell phone use by teenagers. Does this cell phone use increase the risk of brain tumors later in life? The mass market for cell phone use by teenagers really started after 1995, and extended use of cell phones to surf the web ballooned after the introduction of the iPhone in 2007. Looking for brain cancer today in 30 year olds who started using a cell phone in 1997 would be similar to looking for lung cancer today in 30 year olds who started smoking in 1997 (and who would be most likely to develop lung cancer in their 50's or 60's).

This means we cannot find great reassurance in "negative" cell phone cancer risk studies performed 8 or 10 years ago. And similarly, any "positive" findings of cell phone cancer risk to date should produce real concern, since it is possible that they are identifying only the early cases of a larger problem.

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Three major and ongoing research studies have been performed in the last 10 years. One is the INTERPHONE Study, which is funded in major part by the telecommunications industry. A second study which received much recent media attention is the “Danish Cohort” study. A third body of research has been produced by the Hardell group in Sweden, a research group with no financial support from the telecommunications industry.

THE INTERPHONE STUDY

The INTERPHONE Study is a large standard protocol study of brain and salivary gland tumor risk in relation to mobile telephone use, with branches of the study being performed in 13 countries, and combined together to increase the statistical power of the results. This study was funded in major part by the wireless communications industry.

The first major summary of this research was published in 2010. This “case-control” study looked at patients with brain tumors (2708 glioma cases, 2409 meningioma cases) and matched controls, and compared their estimated cell phone usage to determine if regular cell phone usage increased the odds of being a brain tumor patient. The authors concluded that “Overall, no increase in risk of either glioma or meningioma was observed in association with use of mobile phones.” (Group, 2010)

This reported result was then widely quoted by the press and government agencies like the World Health Organization (IARC, 2010) as demonstrating the lack of risk of wireless technology.

However, this study defined a member of the risk group as any subject who “*had an average of at least one call per week for a period of 6 months*”. This definition of “regular cell phone use” diluted the risk pool out with lower risk individuals to the point that no difference between risk and control groups was visible in the study.

Interestingly, the study did report its statistics stratified by total time of reported use, and the top decile (greater than 1640 hours use over a ten year interval, averaging out as greater than 3 hours a week) had an increased risk of certain tumors. Individuals who accrued that greater than 1650 hours of use over a 1 to 4 year interval (ranging from 8 to over 30 hours a week) had a markedly higher odds ratio of meningioma (OR 4.80) or glioma (OR 3.27).

In the discussion of their data showing increased risk within the higher usage group, the authors failed to consider the possibility that this data showed a real risk. Instead, they discounted this trend of increased risk in the heavier users, stating that various “biases and errors limit the strength of the conclusions we can draw from these analyses and prevent a causal interpretation.” And it is this “biases and error’s” comment that has been quoted by industry apologists in subsequent publications, rather than the study’s actual statistical findings of increased odds of brain tumor with cell phone talk time greater than 3 hours a week over a ten year period, or greater than 8 hours a week over a 1 to 4 year period.

The discrepancy between actual data and concluding discussion in this study was not highlighted by mass media coverage of this study. One must assume that reporters read the abstract rather than the complete article, and accepted the author’s conclusions without question. Other researchers in the field were more critical in their assessments of the INTERPHONE project as compared to other published literature on the subject (Morgan, 2009), and pointed out that the INTERPHONE data really did

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document an increased risk, consistent with studies published by researchers in the field that were more independent from industry funding sources. (Hardell et al., 2011a) (Levis et al., 2011)

A more recent study from the INTERPHONE group found an increased risk for acoustic neuroma in individuals with > 1640 hours of talk time over up to 5 years of exposure (OR = 2.79, 95% CI = 1.51 – 5.16). For those subjects who routinely used their cell phone on the same side of the head where they had the acoustic neuroma, the odds ratio was 3.74 (95% CI 1.58 – 8.83). (Cardis and Schüz, 2011)

The most recent study from the INTERPHONE group showed increased odds ratio of glioma and meningioma with greater than 10 years of mobile phone use. The author's conclusions acknowledged this finding, but stated that "the uncertainty of these results requires that they be replicated before a causal interpretation can be made". This is an interesting comment, considering that this study result itself was essentially a replication of the actual findings of the earlier INTERPHONE study. (Cardis et al., 2011)

THE DANISH STUDY

A study from Denmark on the risk of mobile phones and brain tumors was published in the British Medical Journal in 2011. The conclusions of this study were that "there were no increased risks of tumors of the central nervous system, providing little evidence for a causal association". (Frei et al., 2011)

This study was widely quoted in the media and by government organizations as refuting the link between cell phones and brain tumors, with headlines like BBC News: "Mobile phone brain cancer link rejected." (Triggle, 2011)

In this case-control study, the risk group was composed of native Danes who had acquired a cell phone contract prior to 1995. However, any prior to 1995 corporate users were excluded from the risk group (this was 32% of the original cohort). Also excluded were all prior to 1995 subscribers who were less than 18 years old at the time they obtained their first subscription. The study did not determine how often members of the risk group used their phones, or make any determination as to exposure to portable phones in the home for risk or control group members.

The control group was composed of all Danes aged 30 or older and born after 1925 in Denmark. This of course means that the control group included all the early corporate subscribers (whom we might call the "power users"), and also included the 85% of Danes who obtained a cell phone *after* 1995.

This contamination of the control group with large numbers of cell phone users made the conclusions of the study essentially meaningless. To the BMJ's credit, letters that pointed this out were printed in the same issue with the original article (but apparently not read by the members of the press). (Khurana, 2011) (Philips and Lamburn, 2011)

The net result of all this was that the public was falsely reassured by media reports of a peer reviewed article in a prestigious medical journal, when the negative conclusions of that article were essentially meaningless. (Soderqvist et al., 2012)

THE HARDELL GROUP STUDIES

The first digital cell phone network (2G) was launched in Finland in 1991, and the cell phone communication infrastructure expanded widely in Scandinavia during that decade. In the late 1990's case reports of brain tumors in cell phone users lead to

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the first of multiple studies produced by the Hardell research group in Sweden. In this case control study of data collected between 1994 and 1996 from 233 living patients with biopsy-verified brain tumors, no clear distinction could be established between cell phone users and nonusers in the patient population, but a trend was observed of increased odds of tumor presence in the temporal or occipital lobe on the same side of the head habitually used to listen to the cell phone. (Hardell et al., 1999)

In 2002 Hardell et al. published another and larger case control study of 649 brain tumor cases diagnosed between January 1997 and June 2000. This study (and subsequent studies by the Hardell group) looked at exposure from both cellular phones and mobile (cordless) phones connected to land lines. Cumulative hours of cell phone use was calculated from questionnaires about phone usage habits. Increased risk of brain tumor was found for ipsilateral use (phone habitually on same side of head as brain tumor site) with both analogue and digital cellular phones and for cordless phones. Increased risk was also seen for increased duration of exposure. (Hardell et al., 2002)

Another expanded case control study with 1617 brain tumor patients diagnosed between 1997 and 2000 was published later that year showed similar findings, with the highest calculated risk being for ipsilateral acoustic neuroma in analog cellular phone users (the older technology). (Hardell et al., 2002)

Hardell et al. analyzed this same data set of 1617 patients for incidence of vestibular schwannoma (VS), and found an increased odds ratio for VS associated with the use of analogue cell phones. They found that the incidence of VS in Sweden had significantly increased during the time period from 1960 to 1998, with more of this increase occurring during from 1980 to 1998. All other brain tumors taken together had also showed a significant yearly increase between 1960 and 1998. (Hardell et al., 2003) (Hardell et al., 2003)

In 2006 and 2007, Hardell et al. published several more studies of brain tumor patients diagnosed between 1997 and 2003. Cell phones had been in wide use for a longer interval of time, and their data allowed evaluation of latency periods of > 10 years duration, and risk for subjects with first cell phone use at < 20 years of age. Cumulative lifetime use of > 2,000 hours showed elevated odds ratios for analog, digital, and cordless phones, and increased risk for malignant tumors with ipsilateral exposure. Risk of malignant tumors was more pronounced in individuals with first cell phone use at less than 20 years of age. (Hardell et al., 2006) (Hardell et al., 2006a) (Hardell et al., 2006b) (Mild et al., 2007)

Later in 2006, Hardell et al. published a pooled review of their data from all six of their previous case control studies. (Hardell et al., 2006) And they have subsequently published three more papers updating and consolidating their earlier findings. (Hardell and Carlberg, 2009) (Hardell et al., 2010) (Hardell et al., 2011b)

CRITIQUES AND REVIEWS

In 2004 Kundi et al. published a review of 9 existing epidemiologic studies on the relationship between cell phone use and brain tumor risk, and found that all studies approaching reasonable latencies of exposure time showed an increased relative risk (range 1.3 to 4.6) of brain tumor in cell phone users, with highest overall risk for acoustic neuroma (RR 3.5) and uveal melanoma (RR 4.2) (Kundi et al., 2004)

In 2007 Hardell et al. published a meta-analysis of two cohort studies and 15 case

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control studies on the association between long-term use of cell phones and brain tumor. They found increased risk for acoustic neuroma and glioma with ≥ 10 years of exposure, with higher risk of tumor on the exposed side of the head. (Hardell et al., 2007a)

Hardell, Mild, and Kundi published exhaustive reviews of the existing literature on this subject in 2007 in the Bioinitiative Report. (Hardell et al., 2007b) (Kundi, 2007)

In 2008, Hardell et al. published two meta-analyses of the existing case control studies in the literature including ten studies on glioma and nine studies on acoustic neuroma. They found “a consistent pattern of association between mobile phone use and ipsilateral glioma and acoustic neuroma using ≥ 10 years latency period”. (Hardell et al., 2008)

In another meta-analysis published in 2009, Hardell et al. again found “a consistent pattern of an increased risk for glioma and acoustic neuroma after > 10 year mobile phone use . . . with highest risk found in the age group < 20 years at time of first use of wireless phones.” (Hardell et al., 2009)

In a 2009 review, Ahlbom et al. stated that existing studies “do not demonstrate an increased risk within approximately 10 years of use for any tumor of the brain”. In a way, this statement is a somewhat backhanded acknowledgement of the fact that the published research to that date clearly does show increased risk with greater than 10 years of use. (Ahlbom et al., 2009)

In 2009 Khurana et al. published a metanalysis of the eleven existing long-term epidemiologic studies on cell phone use and brain tumor risk that met these criteria: Publication in a peer reviewed journal; inclusion of subjects with greater than 10 years of cell phone use; analyzing “laterality” of cell phone usage in relation to brain tumor incidence. Their conclusion was that “using a cell phone for ≥ 10 years approximately doubles the risk of being diagnosed with a brain tumor on the same (“ipsilateral”) side of the head as that preferred for cell phone use”. (Khurana et al., 2009)

In 2011 the WHO/International Agency for Research on Cancer (IARC) classified radiofrequency electromagnetic fields as “possibly carcinogenic to humans (Group 2B), based on an increased risk for glioma, a malignant type of brain cancer, associated with wireless phone use”. (WHO, 2011) (Baan et al., 2011)

In 2012, Levis et al. published an analysis of published case control studies, pooled analyses, and meta-analyses on head tumor risk with mobile phone use. They found that “in studies funded by public bodies, blind protocols give positive results revealing cause-effect relationships between long-term latency or use of mobile phones (cellulars and cordless) and statistically significant increases of ipsilateral risk of brain gliomas and acoustic neuromas, with biological plausibility. In studies funded or co-funded by the cellphone companies non-blind protocols give overall negative results with systematic underestimation of risk; however, also in these studies a statistically significant increase in risk of ipsilateral brain gliomas, acoustic neuromas, and parotid gland tumours is quite common when only subjects with at least 10 years of latency or exposure to mobile phones (only cellulars) are considered.” (Levis et al., 2012)

CONCLUSIONS

The current epidemiological research shows that greater than 10 years of cell phone use incurs a significantly increased risk of ipsilateral brain tumor (glioma or meningioma). This risk is greater in individuals that start using cell phones as children.

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This means that the RF exposure guidelines for cell phone use cannot be considered to be adequately protecting the public.

In light of these findings, current public policy that essentially ignores biological or “nonthermal” levels of RF exposure need to be reconsidered and revised, in order to significantly reduce the risk to the public health that is produced by these technologies.

SECTION 5 – CELL PHONE USE AND BRAIN TUMOR RISK

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CONCLUSIONS AND RECOMMENDATIONS

ADVERSE BIOLOGICAL EFFECTS—THE SCIENTIFIC EVIDENCE

In the previous sections we have reviewed the increasingly robust body of scientific evidence that excessive RF exposure can cause both acute and chronic adverse biological effects:

ACUTE EFFECTS

In susceptible individuals, excessive RF exposure can provoke acute symptoms. The most common symptoms are sleep disturbance, headache, irritability, fatigue, and concentration difficulties. Other symptoms may include depression, dizziness, tinnitus, burning and flushed skin, digestive disturbance, tremor, and cardiac irregularities.

As physicians, some of us have seen patients who are experiencing this problem, and are aware of the connection with RF exposure. Research suggests that 3 to 5% of the population fit into this category. If this is the case, there may be 4,700 people in Eugene who react to RF exposure in some way, and know it.

These symptoms are not uncommon in the population, of course. And in all probability there are many other people in Eugene who are having problems with insomnia or fatigue--problems provoked by EMF exposures--but are unaware of the connection between cause and effect.

Any significant increase in RF exposure in our residential areas will make these individuals more symptomatic. Such increases are likely to push additional individuals above their tolerance threshold, producing new cases of these problems. If increased RF levels from repeated daily transmissions between smart meters and their control towers pushed an additional 1% of the community into acute reactivity to RF exposures, this would mean an additional 1500 people in our city with insomnia, headaches, fatigue, ringing in the ears, or other debilitating symptoms.

CHRONIC EFFECTS

Chronic exposure to RF can also cause chronic physiologic changes, including altered endocrine function (both melatonin and other hormones), and increased oxidant stress that can lead to increased levels of cancer and male infertility. The public is already being subjected to increased levels of RF from wireless communications. Increasing the total load of transmission further will increase the occurrence of these adverse consequences.

PERSPECTIVE AS WE MOVE FORWARD

At the beginning of the last century, people began to use vehicles powered by internal combustion engines that burned gasoline. Gasoline power was cheap and convenient, and greatly increased the mobility of the population. And the companies that sold the gas and the cars made a lot of money.

This use of fossil fuels has had long term consequences--increased atmospheric CO₂ which through the greenhouse effect would lead to global climate change. Initially, these consequences went unrecognized. Then the scientific community began to predict and measure them.

Public acknowledgement of these consequences has gone through several stages. First, the science was ignored. Then the science was attacked or denied by those whose economic interests were threatened by it. Public recognition of the problem is only arriving as the long term consequences of climate change are beginning to be felt.

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The use of wireless communications technology is following a similar trajectory. Wireless communication is convenient, and increases our mobility. The installation of wireless networks is also significantly cheaper than installation of hard-wired networks. And the companies that provide these networks and the tools that we use to access them are making a great deal of money.

For decades, the biological consequences of this form of communication went unrecognized by both the public and the scientific community. As scientific evidence of biological and health effects began to emerge, this evidence was initially ignored by government regulating bodies, the media, and the public. As this evidence is getting harder to ignore, it is now being attacked or denied by the telecommunications industry. Wide public recognition of the problem and the science that describes it will arrive as the problem becomes more severe, and more people get sick.

The previous sections of this report describe the increasing body of science that clearly demonstrates the existence of adverse biological effects from chronic RF exposure. It is important for EWEB's Board and staff to recognize that this science is real, and that the science isn't going to go away. As the wireless communications infrastructure continues to grow, the magnitude and duration of public exposure are going to continue to increase, and the number of people with acute or chronic effects from this exposure will continue to grow. As recognition of the problem by the public increases, exposures and infrastructure that are currently unquestioned will become politically unacceptable.

EWEB has moved slowly in the process of investigating AMI technology. Recognition of the potential health effects of excessive RF exposure to the public should cause this appraisal to become even more deliberate and circumspect. EWEB needs to avoid investing millions of dollars on infrastructure that becomes part of the problem. Instead, EWEB needs to think about making engineering choices that recognize this problem, and seek to become a part of its solution.

RECOMMENDATIONS**BASIC PRECEPTS FOR RESIDENTIAL EXPOSURES TO RF TRANSMISSIONS**

- Excessive RF exposure can cause acute problems (headaches, insomnia, fatigue, vertigo, tinnitus, other symptoms of EHS).
- Excessive RF exposure can also cause chronic problems (oxidative stress, cancer, male infertility).
- Constant RF transmission is probably harmful, even at low levels, and should be avoided.
- Frequent and repetitive intermittent transmissions are also probably harmful, and should be avoided.
- Nocturnal exposures are more problematic than daytime exposures, because of RF's potential to suppress nocturnal melatonin secretion and disturb sleep, and because night is the time when we rest and heal from stresses (including oxidative stress).
- Occasional and infrequent daytime exposures are much less likely to cause an increase in chronic problems for the population at large.
- Occasional and infrequent daytime exposures are still likely to provoke acute symptoms in a small percentage of the population.

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Based on our review of the existing science, we suggest that the above basic precepts be considered when thinking about residential exposures to microwave RF transmissions. We consider this to be important for the population at large, and even more important for those in our community who suffer from symptoms of electrohypersensitivity. For all of us, our homes are the place where we rest and where we sleep, where we rejuvenate ourselves from the stresses of the wider world. It is important that our residential environments be a place where this can occur. Our homes need to be part of the solution, not part of the problem.

EWEB SHOULD ADOPT A POLICY OF MINIMIZING THEIR RF FOOTPRINT IN THE COMMUNITY

A recognition of these precepts should lead EWEB to adopting a policy of minimizing their infrastructure's RF footprint in the community as much as possible during regular operations. This doesn't mean that staff would throw away their cell phones and communicate by semaphore. But it would mean that instead of combatting or ignoring the possibility that more RF in the community could cause harm, EWEB should acknowledge the potential risks of excessive residential exposure.

This would mean that such potential risks would be seriously considered in any discussion of the total risks and benefits (the "Total Bottom Line") in deciding whether to use RF technology for any given purpose. If, after such a discussion, a considered decision is made to use RF technology, then these same potential risks should be taken into serious consideration in determining how to use this technology in a manner that would minimize potential harm to the community.

In other words, don't use RF when you don't have to. Go hard-wired wherever it is feasible to do so. And if you do use RF, design the technology to use as little of it as possible.

Current engineering choices in AMI technology have not been designed with these goals in mind, since the industry has not had an practical incentive to recognize the problem and to "work the problem". But EWEB as a purchaser of technology could choose to push vendors towards designing and providing hardware options that would address these goals. This would put EWEB in the position of being part of the solution rather than just another part of the problem.

FLAWS IN THE CONCEPT OF "OPTING OUT"

It has been suggested that people who have problems with EHS or concerns about health exposures to RF can be taken care of by creating an "opt out" program, allowing them to decline the installation of a smart meter on their home. This suggestion overlooks some obvious and important problems:

- You can't "opt out" of exposure to your neighbor's meter, that is ten feet away from your bedroom window.
- You can't "opt out" of all the meters on the wall of your rental apartment complex. Or the ones on the wall of the complex right across the alley from your apartment.
- You can't "opt out" of exposure to the meter on the other side of your bedroom wall if you are a baby in a crib.
- You can't "opt out" of exposure to transmissions from the radio tower 100 meters from your house.

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The idea of an “opt out” program is an effort to address the concerns of people who are personally worried about RF exposures, either because they are aware of having acute reactions to these exposures, or because they have a general concern about the acute or chronic effects from such exposure.

But a voluntary “opt out” program does not protect the community at large from adverse effects that they are unaware of and unconcerned about. For example, the current research shows that cancer rates are higher in residences near cellular transmission towers. Most people don’t know this. How does a voluntary “opt out” program help the person who develops breast cancer three years after installation of a transmission tower across the street from her house? She didn’t know it was a problem . . .

DISCUSSION OF THE TECHNOLOGY OPTIONS

How would adopting these precepts and goals play out in practice? Several factors come into consideration:

- The scientific evidence on biological effects of RF, summarized in the basic precepts listed above.
- The various possible functional goals of the AMI program:
 - Reducing operating costs by reading and switching meters remotely.
 - Training customers to conserve electricity.
 - Shifting time of use by measuring and billing time of day usage.
 - Absorbing fluctuations in renewable energy supply by “demand/response” control of usage.
- The different AMI technologies that are available.

When our committee puts our best understanding of these three factors into consideration, and look at each choice in AMI technology through this combined frame of reference, the discussion runs something like this:

MESH Network

From a biological point of view, AMI meters that are transmitting several times a minute can be considered to be an essentially constant source of RF exposure. Where these networks have been established in the last two years, large increases in reported acute symptoms have occurred. We think it is medically probable that that this technology will be found to cause an increase in chronic health problems, including increased cancer, once sufficient time has passed for this to occur.

EWEB staff has already explored and tested a MESH option and chosen not to go forward on that path. We applaud EWEB’s decision to steer away from this technology.

Powerline Communications (PLC)

From a public health point of view, PLC is less problematic than an RF AMI communication technology. And PLC could be used to reduce operating costs, train customers to conserve electricity using in-house monitors, and record and transmit time of day usage measurements to the utility.

EWEB has turned away from the choice of PLC for two main reasons. Firstly, because it won’t allow measurement of water meter readings, limiting the reduction of operating costs from elimination of meter reading. Secondly, because PLC as currently designed does not have the bandwidth to sustain rapid “demand/response” control communications.

There are some other technical considerations that make PLC infrastructure more awkward to set up in an environment where some transmission wires are on poles and

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others are underground.

If “demand/response” was not on the table, and if a Total Bottom Line analysis of the options included the potential health costs of using RF technology, the financial analysis of the PLC option might look different than it did in the AMI Business Case prepared by EWEB staff last April. A decision to read the water meters once every 3 months rather than monthly could also realize additional savings, if this option was under serious consideration.

Fiber Optic Communications

Fiber optic communication between the utility and the house meter is an ideal solution from a health/environmental point of view, providing ample bandwidth without RF transmission. However, this technology would be quite expensive to install, especially in the parts of Eugene where the power grid is underground. The cost might be prohibitive for EWEB at this point in time. Like PLC, fiber optics would not communicate with the water meters.

Tower Communications Network (SENSUS)

The engineering system that EWEB is currently considering is the SENSUS company’s technology, where central towers communicate directly with the meters on the houses. SENSUS owns the sole rights to a certain transmission frequency on the communications bandwidth. This allows them to use more powerful radios on the smart meters, strong enough to communicate directly with a transmission tower without requiring that the message be passed from meter to meter across a MESH network. The community would be divided into about 13 zones, each of which would have a communication tower placed on an existing EWEB property within the zone, and these towers would communicate directly with the house electric meters and with radios on the house water meters.

With 88,000 electric meters and 52,000 water meters in the city, an average zone would have 6770 electric meters and 4000 water meters in the zone. How long a transmission interval would be required for a tower to collect the data from 10,770 meters? We don’t know the answer to this question, and EWEB engineers may not know either, until they set up a trial system and test it out. But clearly, the RF footprint created by this sort of system could vary significantly, depending on how the system was used.

It is routine for utilities to collect data from these systems four times a day. But this routine was developed without consideration of the potential health risks of excessive RF transmission in the community. And usage data does not need to be collected this frequently to achieve the main goals of the AMI program. From a practical point of view, the utility will continue to bill once a month, and in theory could remotely collect that usage data once a month, minimizing the community’s exposure to frequent and repetitive RF transmissions.

We think usage data should be collected from these meters at an interval of once every two to four weeks, with transmission occurring during the daytime hours. Transmission events at this level of infrequency would represent a minimal increase in the RF exposure to the community, and would be unlikely to significantly increase the risk of chronic health problems in the community.

Each data transmission event would still be likely to provoke acute symptoms in individuals with EHS who lived near these transmission towers. But if these events occurred at an interval of once every two weeks or longer, and at a predictable time of

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day, this might be a manageable level of exposure for those individuals.

In our informal discussions with EWEB engineers, we have been told that they have looked into the issue of data collection frequency, and that the longest that they could go between data collection events with the SENSUS system would be about three and one half days.

This would appear to be a case where the technology has not been designed with an eye to minimizing RF transmission. Six daily time-of-use intervals times 30 days equals 180 intervals of usage data. We think that if an iPod can store 64 gigabytes of music, it ought to be possible to give a smart meter enough memory to store 180 readings before transmitting them to the utility. We would recommend that EWEB ask their potential vendors to provide a meter with enough memory to store two to four weeks of data, to enable the minimal RF footprint that we are recommending.

Tower communications and the water meters

Water usage is billed once a month, and a single monthly reading of the meters would collect this data with minimal RF exposure to the community. Again, this data collection should occur in the day time, not in the middle of the night.

Tower communications and “demand/response”

From a public health perspective, the use of the system for “demand/response” load control is more problematic. As we understand it, a lot of this transmission would occur at night, when wind power production is high and demand is low. Towers would be transmitting every 15 minutes, to turn one cohort of water heaters on and another cohort off. And the protocols required by the grid would require a two way communication with each meter in the cohort, acknowledging that house’s participation in the cohort at that time.

This will involve a good deal of transmission in the system every 15 minutes, both from the towers potentially talking to hundreds of meters across the neighborhood, and from the 2 watt radios on each house in the cohort talking back to the tower.

Communication of this frequency from the towers would be a significant additional layer of frequent nocturnal RF signal exposure to the residences within a few hundred meters of the towers.

And enough cohorts of houses are involved, the transmissions from the meters on the houses could also increase the signal density in the residential areas enough to disrupt melatonin and sleep in a percentage of the population.

We think that this frequent level of activity in the demand/response system would be a significant additional RF burden on the community. It would make life in the residential area significantly more difficult for those individuals in the community that is currently already having acute problems. It would probably cause the onset of acute symptoms in a small percentage of the population who are not currently experiencing them. And it would be likely to further increase the incidence of chronic adverse RF effects in our community.

Demand/response and the in-home “Zigbee” network

Once the AMI smart meter on the house gets a demand/response signal from the control tower, it must tell the water heater in the house to turn on. Existing technology does this through wireless communication over a “Zigbee” WiFi network in the home. This network is maintained by constant transmissions of signals between the meter and the Zigbee appliances in the home network, 24 hours a day.

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The research that we've reviewed above shows that biological effects can be produced by low power levels of RF exposure, and that prolonged, constant exposures can have effects even at extremely low exposure levels.

For demand/response to work in the community, at least 20% of the homes in the community will need to volunteer for the program, and have it set up in their houses. In undertaking to install demand/response infrastructure in its current form, EWEB would be making several presumptions:

- A presumption that the Zigbee system is low enough in power that it won't cause any harm.
- A presumption that public acceptance should be good, since the public at large isn't really concerned about the health effects of RF at this time.
- A presumption that since most people have WiFi now anyway, they aren't going to be concerned about the additional exposure.
- A presumption that because the system will be voluntary, so no one can or will complain about involuntary exposure.

While it may be true that the public isn't that worried at present, and that many people have WiFi in their homes and aren't worried about it at all, we do not think that EWEB can assume that this will continue to be the case throughout the investment lifetime of the installed demand/response infrastructure.

As we've discussed in the prior sections, signals of WiFi power are strong enough to cause severe symptoms in individuals with EHS. Several hours of WiFi exposure has been shown to cause damage to healthy sperm. The general public is unaware of these facts. But we think that this is less likely to be the case 8 or 10 years from now, much less 20 years from now. As increased exposure to wireless RF communications causes more health problems in the population, and the scientific evidence of this effect continues to become more robust, public attitudes about this exposure are going to change. Within 20 years, the public—especially parents with young children—will be much less open to having constant WiFi signal in their homes. If this assumption is correct, the purchase of many millions of dollars in demand/response infrastructure that is based on wireless in-home communications would appear to be an unwise investment.

The “demand/response” infrastructure is still immature

We think that the “demand/response? infrastructure is still immature. This technology may be mature from an engineering point of view, in that “it works”. But from a public health perspective, it is completely immature. We state this because the technology has been designed around RF communications (because this infrastructure is quicker and cheaper to set up than a hard wired system) without any consideration of the health effects of exposure to excessive or prolonged RF transmissions, and without any considered effort to engineer the hardware or the software protocols in a way that would minimize such exposures.

The Zigbee network is a case in point. In modern construction, most electric meters are sitting on the outside of the circuit breaker box. Within that breaker box, there are dedicated circuits with hard-wired connections to the electric water heater, the electric stove, and the electric clothes drier.

Why not set up communications between these utilities with powerline communications protocols over these hard-wired connections? All it would take would be

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some intelligent technology in the 220 circuit breakers for the appliances, and a smart switch at the other end of the circuit, and connections to the network controls in the smart meter that is plugged into the breaker box. All this could be done without putting any RF transmission into the house?

Why hasn't this been done yet? Because a wireless solution is easier to install? Because changing the hard wiring would require changing electrical codes? Because no one thinks it's necessary to get this clever, since no one is worried about RF exposures?

Solutions like this could be created, if industry and government had enough incentive to work the problem, rather than to deny the existence of the problem. Until such alternatives to constant in-home RF exposure are developed, we think that EWEB would be wise to avoid getting married to this technology. Developing demand/response using a constantly transmitting in-home RF network will mean investing a great deal of money in infrastructure that is likely to become extremely unpopular within the next 10 to 15 years. What we look at now as "quick and cheap" will come to be viewed as "quick and dirty".

Other communication options

We've been told that the powerline communication option is not a feasible solution for demand/response control, since it lacks the bandwidth necessary for rapid communications between server and meters.

We think that serious consideration should be given to the potential use of broadband internet connections for demand/response communications. We understand that EWEB does not have the financial power to build their own fiberoptic network at this time. But in 2010, 82% of the households in our part of the state had broadband internet connections, and this proportion continues to grow. Would it be technically possible to use these wired internet connections to communicate with the vast majority of the electric meters in our city, rather than building a new wireless infrastructure to do the job? Broadband internet communications would certainly have the bandwidth to do this, and a demand/response system is not expected to require the participation of every household in the community. If we acknowledge the health risks of RF communication (especially the robust night-time communication expected for demand/response control), then an internet-based demand/response control system should be given serious consideration.

IN CONCLUSION

We hope that our report and recommendations will be helpful to EWEB staff, the EWEB Board of Governors, and to members of our community. We think that review of this information should allow a more realistic appraisal of the health risks involved in establishing an AMI network that utilizes microwave RF communication. Such a measured and realistic appraisal is a necessary part of the Total Bottom Line Analysis that EWEB has promised to bring to any major initiative in our community.

This is a lengthy document, and discusses complex issues. We would welcome the opportunity to meet with EWEB staff and members of the Board, in order to give a more extensive audiovisual presentation and clarification of this material, and to answer any questions that you wish to ask us about this research.

We hope to be part of an ongoing dialogue about the potential health effects of RF technology, as EWEB continues to deliberate on the various choices that they face with the AMI program.

The Biological Effects of Weak Electromagnetic Fields, Problems and
Solutions, Prof. Andrew Goldsworthy; 2012

The Biological Effects of Weak Electromagnetic Fields

Problems and solutions

Andrew Goldsworthy March 2012

Foreword

I am a retired lecturer from Imperial College London, which is among the top three UK universities after Oxford and Cambridge and is renowned for its expertise in electrical engineering and health matters. I spent many years studying calcium metabolism in living cells and also how cells, tissues and organisms are affected by electrical and electromagnetic fields.

In this article, I will try to explain in lay-person's language how weak electromagnetic fields from cell phones, cordless phones and WiFi can have serious effects on human and animal health. These include damage to glands resulting in obesity and related disorders, chronic fatigue, autism, increases in allergies and multiple chemical sensitivities, early dementia, DNA damage, loss of fertility and cancer.

All this happens at levels of radiation that the cell phone companies tell us are safe because the radiation is too weak to cause significant heating. **This is the only criterion that they use to assess safety.** In fact, the direct electrical effect on our cells, organs and tissues do far more damage to us at energy levels that may be hundreds or thousands of times lower than those that cause significant heating. These are termed non-thermal effects. As yet **our governments and health authorities are doing nothing to protect us from them.**

This need not be so. By understanding the mechanisms of these non-thermal effects, it is possible to put most of them right, as I will show in the following article.

Abstract

Many of the reported biological effects of non-ionising electromagnetic fields occur at levels too low to cause significant heating; i.e. they are non-thermal. Most of them can be accounted for by electrical effects on living cells and their membranes. The alternating fields generate alternating electric currents that flow through cells and tissues and remove structurally-important calcium ions from cell membranes, which then makes them leak.

Electromagnetically treated water (as generated by electronic water conditioners used to remove lime scale from plumbing) has similar effects, implying that the effects of the fields can also be carried in the bloodstream. Virtually all of the non-thermal effects of electromagnetic radiation can be accounted for by the leakage of cell membranes.

Most of them involve the inward leakage of free calcium ions down an enormous electrochemical gradient to affect calcium-sensitive enzyme systems. This is the normal mechanism by which cells sense mechanical membrane damage. They normally respond by triggering mechanisms that stimulate growth and repair, including the MAP-kinase cascades, which amplify the signal.

If the damage is not too severe or prolonged, we see a stimulation of growth and the effect seems beneficial, but if the exposure is prolonged, these mechanisms are overcome and the result is ultimately harmful. This phenomenon occurs with both ionising and non-ionising radiation and is called radiation hormesis. Gland cells are a good example of this, since short term exposures stimulate their activity but long term exposures cause visible damage and a loss of function. Damage to the thyroid gland from living within 100 metres of a cell phone base station caused hypothyroidism and may be partially responsible for our current outbreak of obesity and chronic fatigue.

Secondary effects of obesity include diabetes, gangrene, cardiac problems, renal failure and cancer. Cell phone base station radiation also affects the adrenal glands and stimulates the production of adrenalin and cortisol. Excess adrenalin causes headaches, cardiac arrhythmia, high blood pressure, tremors and an inability to sleep, all of which have been reported by people living close to base stations. The production of cortisol weakens the immune system and could make people living near base stations more susceptible to disease and cancer.

Inward calcium leakage in the neurons of the brain stimulates hyperactivity and makes it less able to concentrate on tasks, resulting in attention deficit hyperactivity disorder (ADHD). When this happens in the brains of unborn babies and young children, it reduces their ability to concentrate on learning social skills and can cause autism. Leakage of the cells of the peripheral nervous system in adults makes them send false signals to the brain, which results in the symptoms of electromagnetic intolerance (aka electromagnetic hypersensitivity). Some forms of electromagnetic intolerance may be due to cell phone damage to the parathyroid gland, which controls the calcium level in the blood and makes cell membranes more inclined to leak. Further exposure could then tip them over the edge into full symptoms of electromagnetic intolerance.

Cell phone radiation damages DNA indirectly, either by the leakage of digestive enzymes from lysosomes or the production of reactive oxygen species (ROS) from damaged mitochondrial and plasma membranes. The results are similar to those from exposure to gamma rays from a radioactive isotope.

Effects of DNA damage include an increased risk of cancer and a loss of fertility, both of which have been found in epidemiological studies. The effects of cell phone and WiFi radiation have also been determined experimentally using ejaculated semen. The results showed the production of ROS, and a loss of sperm quality and, in some cases, DNA fragmentation.

The inward leakage of calcium ions from electromagnetic fields also opens the various tight junction barriers in our bodies that normally protect us from allergens and toxins in the environment and prevent toxic materials in the bloodstream from entering sensitive parts of the body such as the brain. The opening of the blood-brain barrier has been shown to cause the death of neurons and can be expected to result in early dementia and Alzheimer's disease. The opening of the barrier in our respiratory epithelia by electromagnetic fields has been shown to increase the risk of asthma in children and the opening of the blood-liver barrier may be partially responsible for the current outbreak of liver disease. The opening of other barriers, such as the gut barrier allows foreign materials from the gut to enter the bloodstream, which may also promote allergies and has been linked autoimmune diseases.

Cell membranes also act as electrical insulators for the natural DC electric currents that they use to transmit power. Mitochondrial membranes use the flow of hydrogen ions to couple the oxidation of food to the production of ATP. The outer cell membrane uses the flow of sodium ions to couple the ATP produced to the uptake of nutrients. If either of these leak, or are permanently damaged, both of these processes will be compromised leading to a loss of

available energy, which some people believe to be a contributory factor to chronic fatigue syndrome.

The mechanism underlying electromagnetically-induced membrane leakage is that weak ELF currents flowing through tissues preferentially remove structurally important calcium ions, but they have been shown to do so only within certain amplitude windows, above and below which there is little or no effect. This means that there is no simple dose-response curve, which many people find confusing, but a plausible theoretical model is described. The mechanism also explains why certain frequencies especially 16Hz is particularly effective.

Living cells have evolved defence mechanisms against non-ionising radiation. These include pumping out surplus calcium that has leaked into the cytosol, the closure of gap junctions to isolate the damaged cell, the production of ornithine decarboxylase to stabilize DNA and the production of heat-shock proteins, which act as chaperones to protect important enzymes. However, this is expensive in energy and resources and leads to a loss of cellular efficiency. If the exposure to the radiation is prolonged or frequently repeated, any stimulation of growth caused by the initial ingress of calcium runs out of resources and growth and repair becomes inhibited. If the repairs fail, the cell may die or become permanently damaged.

To some degree, we can make our own electromagnetic environment safer by avoiding ELF electrical and magnetic fields and radio waves that have been pulsed or amplitude modulated at ELF frequencies. The ELF frequencies that give damaging biological effects, as measured by calcium release from brain slices and ornithine decarboxylase production in tissue cultures, lie between 6Hz and 600Hz. It is unfortunate that virtually all digital mobile telecommunications systems use pulses within this range. The Industry clearly did not do its homework before letting these technologies loose on the general public and this omission may already have cost many lives.

Even now, it may be possible reverse their effects by burying the pulses in random magnetic noise, as proposed by Litovitz in the 1990s or by cancelling out the pulses using balanced signal technology but, at present, the Industry does not seem to be interested in either of these.

Until the mobile telecommunications industry makes its products more biologically friendly, we have little alternative but to reduce our personal exposure as far as possible by using cell phones only in emergencies, avoiding DECT cordless phones and substituting WiFi with Ethernet . The only DECT phones that are even remotely acceptable are those that automatically switch off the base station between calls; e.g. the Siemens Gigaset C595 operating in Eco Plus mode. If you are highly electromagnetically intolerant, you may need to screen your home or at the very least your bed from incoming microwave radiation and sleep as far away as possible from known sources of ELF.

INTRODUCTION

There have been many instances of harmful effects of electromagnetic fields from cell phones (aka mobile phones), DECT phones (aka cordless phones), WiFi, power lines and domestic wiring. They include an increased risk of cancer, loss of fertility, effects on the brain and symptoms of electromagnetic intolerance. Many people still believe that, because the energy of the fields is too low to give significant heating, they cannot have any biological effect. However, the evidence that alternating electromagnetic fields can have non-thermal biological effects is now overwhelming. See www.bioinitiative.org and www.neilcherry.com . The explanation is that it is not a heating effect, but mainly an electrical effect on the fine structure of the electrically-charged cell membranes upon which all living cells depend.

Alternating electromagnetic fields can induce *alternating currents* to flow through living cells and tissues. These can interfere with the normal *direct currents* and voltages that are essential for the metabolism of all cells. Virtually every living cell is a seething mass of electric currents and electrical and biochemical amplifiers that are essential for their normal function. Some have tremendous amplifying capacity; e.g. it is claimed that a dark adapted human eye can detect a single photon (the smallest possible unit of light) and the human ear can hear sounds with energies as low as a billionth of a watt. We should therefore not be too surprised to find that our cells can detect and respond to electromagnetic fields that are orders of magnitude below the strength needed to generate significant heat.

My main objective here is to show how most of the adverse health effects of electromagnetic fields can be attributed to a single cause; that being that they remove structurally-important calcium ions (electrically-charged calcium atoms) from cell membranes, which then makes these membranes leak. I will explain the scientific evidence leading to this conclusion and also how we can put matters right, but still keep on using cell phones and other wireless communications. I have included key references that should enable the more inquisitive reader to delve deeper. In many cases, you should be able to find the abstract of the paper in question by copying into Google its entry in the list of references.

Electromagnetic fields affect many but not all people

Many of the experiments on the biological effects of alternating electromagnetic fields appear to give inconsistent results. There are many reasons for this, including differences in the genetic make-up, physiological condition and the history of the test material. In humans, reported effects include an increased risk of cancer, effects on brain function, loss of fertility, metabolic changes, fatigue, disruption of the immune system, and various symptoms of electromagnetic intolerance.

Not everyone is affected in the same way and some may not be affected at all. However, there is increasing evidence that the situation is getting worse. Our electromagnetic exposure is rapidly increasing and previously healthy people are now becoming sensitised to it. In this study, I am concentrating on the cases where there have been definite effects; since this is the most efficient way in which we can find out what is going wrong and what can be done to prevent it.

The frequency of the fields is important

The fields that give the most trouble are in the extremely low frequency range (ELF) and also radio frequencies that are pulsed or amplitude modulated by ELF. (Amplitude modulation is where the strength of a *carrier wave* transmits information by rising and falling in time with a lower frequency that carries the information.).

Why microwaves are particularly damaging

The frequency of the carrier wave is also important. Higher frequencies such as the microwaves used in cell phones, WiFi and DECT phones, are the most damaging. Our present exposure to man-made microwaves is about a million billion billion (one followed by eighteen zeros) times greater than our natural exposure to these frequencies. We did not evolve in this environment and we should not be too surprised to find that at least some people may not be genetically adapted to it. As with most populations faced with an environmental change, those members that are not adapted either become ill, die prematurely or fail to reproduce adequately. Ironically, those who are electromagnetically intolerant may be better equipped to survive since they are driven to do whatever they can to avoid the radiation.

The main reason why microwaves are especially damaging is probably because of the ease with which the currents that they generate penetrate cell membranes. Cell membranes have a very high resistance to direct currents but, because they are so thin (about 10nm), they behave like capacitors so that alternating currents pass through them easily. Since the effective resistance of a capacitor to alternating current (its *reactance*) is inversely proportional to its frequency, microwave currents pass through the membranes of cells and tissues more easily than radio waves of lower frequencies and can therefore do more damage to the cell contents.

Calcium loss from cell membranes explains most of the adverse health effects

I became interested in this topic when I was working on the biological effects of physically (magnetically) conditioned water, which is widely used to remove lime scale from boilers and plumbing. It is made by allowing tap water to flow rapidly between the poles of a powerful magnet or by exposing it to a weak pulsed electromagnetic field from an electronic water conditioner. Water treated in this way can remove calcium ions (electrically charged calcium atoms) from surfaces, and the effect on the water can last for several days. I was following up some Russian and Israeli work that had shown that magnetically conditioned water could increase the growth of crops, but it turned out to be far more important than that. The underlying principle was also to explain the mechanisms by which weak electromagnetic fields can damage living cells and also what can be done to stop it.

Magnetically conditioned water and electromagnetic fields have similar effects

Probably, our most important discovery was that when tap water was conditioned by weak electromagnetic fields, the treated water gave similar effects in yeast to those from exposing the yeast itself, amongst which was an increased permeability of their cell membranes to poisons (Goldsworthy *et al.* 1999). Since it had been known since the work of Bawin *et al.* (1975) that weak electromagnetic fields could remove calcium ions from the surfaces of brain cells, it seemed likely that both the conditioned water and the electromagnetic fields were working in the same way; i.e. **by removing structurally-important calcium ions from cell membranes, which then made them leak.** We now know that membrane leakage of this kind can explain most of the biological effects of both conditioned water and of direct exposure to electromagnetic fields.

The effects on growth depend on the length of the conditioning treatment

We also showed that the effects of conditioned water on the growth of yeast cultures depended on the length of the conditioning process. Less than 30 seconds of conditioning stimulated growth but more than this inhibited growth. It was as if the conditioning process was steadily generating one or more chemical agents in the water. A low dose from the shorter conditioning period stimulated growth, but longer conditioning periods gave higher doses, which were inhibitory. This toxic effect of heavily conditioned water, where the water is recycled continuously through the conditioner, has now been exploited commercially to poison blanket weed in ornamental ponds (www.lifescience.co.uk/domestic_blanketweed.htm). By the same token, blood continually circulating for prolonged periods under the pulsating fields from a cell phone or similar device could become toxic to the rest of the body. This means that no part of the body, from the brain to the liver and gonads, can be considered to be safe from the toxic effects of pulsed electromagnetic fields.

Radiation hormesis

Many people have shown similar dual effects with direct exposure to both *ionising and non-ionising radiation*. Small doses of otherwise harmful radiation often stimulate growth and appear to be beneficial (a phenomenon known as *radiation hormesis*) but larger doses are harmful. It also explains why small doses of pulsed magnetic fields are effective in treating some medical conditions such as broken bones (Bassett *et al.* 1974) but prolonged exposure (as we will see later) is harmful.

It also explains some of the apparent inconsistencies found when comparing different experiments and why meta-analysis of the data should be treated with caution. Clear positive and clear negative results (depending on the dose and the condition of the material) when taken together could be mistaken for no effect, but with a high degree of variability.

Cells have tremendous powers to amplify and respond to weak signals

We now know that electromagnetic growth stimulation is almost certainly due to electrochemical amplification followed by the activation of the MAP kinase cascades by free calcium ions leaking into the cytosol (the main part of the cell). The inward leakage of calcium ions is the normal mechanism by which a cell senses that it has been damaged and triggers the necessary repair mechanisms. This involves huge amplification processes so that even minor leakage (e.g. due to membrane perforation or weak electromagnetic fields) can give rapid and often massive responses.

The first stage in the amplification is due to the calcium gradient itself. There is an enormous (over a thousand fold) concentration difference for free calcium between the inside and outside of living cells. In addition, there is a voltage difference of many tens of mV acting in the same direction. This means that even a slight change in the leakiness of the cell membrane can permit a very large inflow of calcium ions. It's like a transistor, where a slight change in the charge in the base can allow a massive current to flow through it under the influence of a high voltage gradient between the emitter and collector.

The next stage in the amplification is due to the extremely low calcium concentration in the cytosol so that even a small ingress of calcium ions makes a big *percentage* difference, to which many enzymes within the cell are sensitive.

Even more amplification comes from the MAP-kinase cascades. These are biochemical amplifiers that enable tiny amounts of growth factors or hormones (perhaps even a single molecule) to give very large effects. They consist of chains of enzymes acting in sequence so that the first enzyme activates many molecules of the second enzyme, which in turn activates still more of the third enzyme etc. The final stage then activates the protein synthesising machinery needed for cell growth and repair.

At least some of these cascades need calcium ions to work (Cho *et al.* 1992) so the inward leakage of calcium through damaged cell membranes will increase the rate of these processes to stimulate growth and repair. However, these repairs can make deep inroads into the cell's energy and resources, and its ability to make good the damage will depend on its physiological and nutritional condition. This means that, if the damage is prolonged or persistent, sooner or later it runs out of resources and gives up, which is when we see the inhibitory phase, perhaps followed by apoptosis (cell death) or the loss of some of the cell's normal functions. We are now seeing this loss of function increasingly after prolonged human exposure to cell phone base station radiation; e.g. the loss of thyroid gland function after six years of exposure (Eskander *et al.* 2012).

Effects on Glands

Gland cells are particularly sensitive to radiation

Gland cells may be particularly sensitive to radiation because their secretions are normally produced in internal membrane systems, which can also be damaged. Their secretions are usually released in vesicles (bubbles of membrane) that fuse with the external cell membrane and disgorge their contents to the outside (exocytosis). The vesicle membrane then becomes part of the external membrane. The resulting excess external membrane is counterbalanced by the reverse process (endocytosis) in which the external membrane buds off vesicles to the inside of the cell, which then fuse with the internal membranes. In this way, an active gland cell may internalise the equivalent of its entire surface membrane about once every half an hour. This means that if the surface membrane is damaged directly by the fields, or by electromagnetically conditioned blood, the damaged membrane rapidly becomes part of the internal membrane system, upon which its normal activity depends. If the damage is too severe, the whole gland may lose its normal function.

Electromagnetic effects on the endocrine system and obesity

Although electromagnetic fields frequently stimulate glandular activity in the short term, long term exposure is often harmful in that the gland ceases to work properly. This is particularly serious for the glands of the endocrine system (those that coordinate our bodily functions) since it can affect many aspects of metabolism and throw the whole body out of kilter. For example it may be responsible, at least in part, for the current outbreak of obesity and the many other illnesses that stem from it.

A good example of this is the thyroid gland, which is in an exposed position in the front of the neck. Rajkovic *et al.* (2003) showed that after three months exposure to power line frequencies, the thyroid glands of rats showed visible signs of deterioration. They also lost their ability to produce the thyroid hormones, which they did not recover even after the fields were switched off. Esmekaya *et al.* (2010) found a similar visible deterioration of the thyroid gland in rats exposed to simulated 2G cell phone radiation for 20 minutes a day for three weeks. Eskander *et al.* (2012) found that people living for six years within 100 metres of a cell phone base station showed a significant reduction in the release into the blood of a number of hormones, including ACTH from the pituitary gland, cortisol from the adrenal glands, and prolactin and testosterone from organs elsewhere. However, the most highly significant loss was in their ability to produce the thyroid hormones. The expected consequence of this is hypothyroidism, the most frequent symptoms of which are **fatigue** and **obesity**. It may not be a coincidence that about a quarter of a million UK citizens are now suffering from what is being diagnosed as chronic fatigue syndrome, and about eight out of ten are either overweight or clinically obese.

The incidence of obesity may be exacerbated by effects on the release of the appetite regulating hormones ghrelin and peptide YY. Ghrelin is synthesised in the stomach wall and makes us feel hungry, whereas peptide YY is made in the intestine wall and makes us feel full. In normal people the level of ghrelin in the blood is high before a meal and goes down afterwards whereas peptide YY goes up, so we go from feeling hungry to feeling full, which stops us overeating.

However, in obese people the level of both hormones stays roughly the same throughout so that they never feel completely full and eat in an unregulated manner (Le Roux *et al.* 2005, Le Roux *et al.* 2006). If prolonged exposure to electromagnetic fields limits the release of these hormones in the same way as they affect the release of ACTH, cortisol, prolactin, testosterone and the thyroid hormones, it may explain why so many people find it difficult to stop eating and end up being clinically obese.

If you are affected in this way, you may be forced to go on a life-long diet, undergo gastric bypass surgery to drastically reduce the size of your stomach or risk the many serious diseases that stem from obesity **AND IT MAY NOT HAVE BEEN YOUR FAULT**. Think twice before you use a cell phone or install a cordless phone or WiFi. The consequences are only now becoming apparent; neither the Government nor the telecommunications industry will tell you what they are, but they are not good.

Obesity can trigger many other illnesses

The consequences of obesity include **diabetes, gangrene, high blood pressure, cardiac problems, renal failure and cancer**. Between them, they cause a great deal of human suffering and cost the nation's economy a great deal of money. The annual cost of obesity and related illnesses to the UK economy has been estimated as being around £6.6 – 7.4 billion (McCormick *et al.* 2007).

The annual cost of chronic fatigue syndrome is about \$20000 per affected person in the USA (Reynolds *et al.* <http://www.resource-allocation.com/content/2/1/4>) and about £14000 in the UK (McCrone *et al.* 2003) so a fair estimate of the total annual cost of chronic fatigue syndrome to the UK economy would be somewhere in the region £3.5 billion. The total annual cost of both conditions together is about £10 billion. If part of this is due to microwave telecommunications, measures need to be taken to minimise their effects, and it would be only fair to ask the Industry to pay for this.

Electromagnetic effects on the adrenal gland

Cortisol: - Augner *et al.* (2010) in a double blind study (where neither the subject nor the person recording the results knows whether the radiation is switched on or off) showed that short-term exposure to the radiation from a 2G (GSM) cell phone base station increased the cortisol level in the saliva of human volunteers. Cortisol is a stress hormone that is normally produced in the cortex of the adrenal glands and is controlled by the calcium level in its cells (Davies *et al.* 1985) so electromagnetically- induced membrane leakage letting more calcium into the cytosol should also have this effect.

Cortisol is part of a mechanism that puts the body into a “fight or flight” mode, in which more sugar is released into the blood, sensitivity to pain is reduced and the immune system is suppressed. In fact, cortisol and its relatives are used medicinally to relieve pain and also to suppress the immune system after transplant surgery. However, when exposure to base station radiation does it, it is not good news since the suppression of the immune system will also increase the risk of infection and of developing tumours from precancerous cells that might otherwise have been destroyed.

Adrenalin: - Buchner and Eger (2011) studied the effect of a newly installed 2G cell phone base station on villagers in Bavaria and found that it caused a long-lived increase in the production of adrenalin. This is an important neurotransmitter which acts on adrenergic receptors to increase the calcium concentration in the cytosol. It is also synthesised in the adrenal medulla in response to signals from the sympathetic nervous system. Adrenalin too puts the body into fight or flight mode by diverting resources from the smooth muscles of the gut to the heart muscle and the skeletal muscles needed for flight or combat. In addition, it stimulates the production of cortisol by the adrenal cortex, and indirectly reduces the activity of the immune system, resistance to disease and increases the risk of getting cancer.

Some people get pleasure from the “adrenalin rush” caused by doing energetic or dangerous things, and this could be a contributory factor to the addictive nature of cell phones. However, on the down side, known effects of excess adrenalin include, headaches, cardiac arrhythmia, high blood pressure, tremors, anxiety and inability to sleep. These results confirm and explain some of the findings of Abdel-Rassoul *et al.* (2007) who found that people living near cell towers (masts) had significantly increases in headaches, memory loss, dizziness, tremors and poor sleep.

Effects on the Brain

Calcium leakage and brain function

Normal brain function depends on the orderly transmission of signals through a mass of about 100 billion *neurons*. Neurons are typically highly branched nerve cells. They usually have one long branch (*the axon*), which carries electrical signals as *action potentials* (nerve impulses) to or from other parts of the body or between relatively distant parts of the brain (a nerve contains many axons bundled together). The shorter branches communicate with other neurons where their ends are adjacent at *synapses*. They transmit information across the synapses using a range of *neurotransmitters*, which are chemicals secreted by one neuron and detected by the other.

Calcium ions play an essential role in brain function because a small amount of calcium must enter the cytosol of the neuron before it can release its neurotransmitters (Alberts *et al.* 2002). Electromagnetically-induced membrane leakage would increase the background level of calcium in the neurons so that they release their neurotransmitters sooner. This improves our reaction time to simple stimuli but it can also trigger the spontaneous release of neurotransmitters to send spurious signals that have no right to be there, which makes the brain hyperactive and less able to concentrate.

Autism

Possibly, the greatest damage to the brain from microwaves is when it is first developing in the foetus and the very young child, where it can lead to autism. Dr Dietrich Klinghardt has shown a relationship between microwaves and autism; a summary of his work can be found at <http://electromagnetichealth.org/media-stories/#Autism>.

What is autism?

Autism is a group of life-long disorders (autistic spectrum disorders or ASD) caused by brain malfunctions and is associated with subtle changes in brain anatomy (see Amaral *et al.* 2008 for a review). The core symptoms are an inability to communicate adequately with others and include abnormal social behaviour, poor verbal and non-verbal communication, unusual and restricted interests, and persistent repetitive behaviour. There are also non-core symptoms, such as an increased risk of epileptic seizures, anxiety and mood disorders. ASD has a strong genetic component, occurs predominantly in males and tends to run in families.

Genetic ASD may be caused by calcium entering neurons

It has been hypothesised that some genetic forms of ASD can be accounted for by known mutations in the genes for ion channels that result in an increased background concentration of calcium in neurons. This would be expected to lead to neuronal hyperactivity and the formation of sometimes unnecessary and inappropriate synapses, which in turn can lead to ASD (Krey and Dolmetsch 2007).

Electromagnetic fields also let calcium into neurons

There has been a 60-fold increase in ASD in recent years, which cannot be accounted for by improvements in diagnostic methods and can only be explained by changes in the environment. This increase corresponds in time to the proliferation of mobile telecommunications, WiFi, and microwave ovens as well as extremely low frequency fields from household wiring and domestic appliances. We can now explain at least some of this in terms of electromagnetically-induced membrane leakage leading to brain hyperactivity and abnormal brain development.

How membrane leakage affects neurons

Neurons transmit information between one another in as chemical neurotransmitters that pass across the synapses where they make contact. Their release is normally triggered by a brief pulse of calcium entering their cytosols. If the membrane is leaky due to electromagnetic exposure, it will already have a high internal calcium concentration as calcium leaks in from the much higher concentration outside. This puts the cells into hair-trigger mode so that they are more likely to release neurotransmitters and the brain as a whole may become hyperactive (Beason and Semm 2002; Krey and Dolmetsch 2007, Volkow *et al.* 2011). This results in the brain becoming overloaded with sometimes spurious signals leading to a loss of concentration and attention deficit hyperactive disorder (ADHD).

How does this impact on autism?

Before and just after its birth, a child's brain is a blank canvas, and it goes through an intense period of learning to become aware of the significance of its new sensory inputs, e.g. to recognise its mother's face, her expressions and eventually other people and their relationship to him/her (Hawley and Gunner 2000). During this process, the neurons in the brain make countless new connections, the patterns of which store what the child has learnt. However, after a matter of months, connections that are rarely used are pruned automatically (Huttenlocher and Dabholkar 1997) so that those that remain are hard-wired into the child's psyche. The production of too many spurious signals due to electromagnetic exposure during this period will generate frequent random connections, which will also not be pruned, even though they may not make sense. It may be significant that autistic children tend to have slightly larger heads, possibly to accommodate unpruned neurons (Hill and Frith 2003).

Because the pruning process in electromagnetically-exposed children may be more random, it could leave the child with a defective hard-wired mind-set for social interactions, which may then contribute to the various autistic spectrum disorders. These children are not necessarily unintelligent; they may even have more brain cells than the rest of us and some may actually be savants. They may just be held back from having a normal life by a deficiency in the dedicated hard-wired neural networks needed for efficient communication.

Autism costs the UK economy more than the tax income from cell phones

The incidence of autism has occurred in parallel with the increase in electromagnetic pollution over the last thirty years. The chance of having an autistic child may now be as high as one in fifty. Apart from the personal tragedies for the affected children and their families, autism is of enormous economic importance. In the UK alone, the **annual cost to the Nation in care and lost production exceeds the annual tax revenue from the entire cell phone industry**, which is about 20billion UK pounds.

<http://www2.lse.ac.uk/newsAndMedia/news/archives/2009/05/MartinKnappAutism.aspx> If it

were all due to cell phones, the Government could close down the entire industry and actually show a profit! There may be ways in which the modulation of the signal can be changed to avoid this (see later), but in the meantime, we should do whatever we can to minimise our exposure to information-carrying microwaves, including those from cell phones, DECT phones, WiFi and smart meters. Failure to do this could be very costly.

Electromagnetic intolerance (aka electromagnetic hypersensitivity or EHS)

Electromagnetic intolerance is a condition in which some people experience a wide range of unpleasant symptoms when exposed to weak non-ionising radiation. About 3 percent of the population suffers in this way at present, although only a small proportion of these are as yet so badly affected that they can instantly tell whether a radiating device is switched on or off. At the other end of the scale, there are people who are sensitive but do not yet know it because they are chronically exposed to electromagnetic fields and accept their symptoms as being perfectly normal. Electromagnetic intolerance is in fact a continuum with no clear cut-off point. In some cases there may only be relatively mild symptoms on or after using a cell phone but in severe cases it can prevent people living a normal life and force them to live in almost total isolation. There is every reason to believe that prolonged exposure will increase the severity of the symptoms, so if you suffer from any of them you should do whatever possible to minimise further exposure.

Symptoms of electromagnetic intolerance

Symptoms include skin rashes, cardiac arrhythmia, headaches (sometimes severe), pain in muscles and joints, sensations of heat or cold, pins and needles, tinnitus, dizziness and nausea. A more complete list can be found at <http://www.es-uk.info/info/recognising.asp>. Most if not all of these can be explained by the radiation making cells leak.

When skin cells leak, it is perceived by the body as damage to the tissue. This increases the blood supply to the area to repair the damage and causes the rash.

When the cells of the heart muscle leak it weakens the electrical signals that normally control its contraction. The heart then runs out of control to give cardiac arrhythmia. This is potentially life threatening.

When sensory cells leak, they become hyperactive and send false signals to the brain. We have a variety of sensory cells, but they all work in much the same way. Whenever they sense what they are supposed to sense, they deliberately leak by opening ion channels in their membranes. This reduces the natural voltage across these membranes, which makes them send nerve impulses to the brain. Electromagnetically induced cell leakage would have the same effect, but this time it would make them send *false* signals to the brain to give the false sensations of electromagnetic intolerance. This could also be exacerbated by the nerve cells involved being made hyperactive due to calcium ingress.

When leakage occurs in the sensory cells of the skin, it can give sensations such as heat, cold, tingling, pressure etc, depending on which types of cell are most sensitive in the individual concerned.

When leakage occurs in the sensory hair cells of the cochlea of ear it gives tinnitus, which is a false sensation of sound. When it occurs in the vestibular system (the part of the inner ear that deals with balance and motion) it results in dizziness and symptoms of motion sickness, including nausea.

Hypocalcaemia, electromagnetic intolerance and the parathyroid gland

Symptoms of hypocalcaemia are very similar to those of electromagnetic intolerance and include skin disorders, pins and needles, numbness, sensations of burning, fatigue, muscle cramps, cardiac arrhythmia, gastro-intestinal problems and many others. A more comprehensive list can be found at <http://www.endotext.org/parathyroid/parathyroid7/parathyroid7.htm>. It is possible that some forms of electromagnetic intolerance are due to low levels of calcium in the blood. Electromagnetic exposure would then remove even more calcium from their cell membranes to push them over the edge and give the symptoms of electromagnetic intolerance.

The amount of calcium in the blood is controlled by the parathyroid hormone secreted by the parathyroid gland, which is in the neck, close to where you hold your cell phone. It is adjacent to the thyroid gland and, if it were to be damaged by the radiation in the same way, the production of the parathyroid hormone would go down, the amount of calcium in the blood would be reduced and the person concerned would become electromagnetically intolerant.

Effects on DNA

Cell phone radiation can damage DNA

Lai and Singh (1995) were the first to show this in cultured rat brain cells, but it has since been confirmed by many other workers. A comprehensive study on this was in the Reflex Project, sponsored by the European Commission and replicated in laboratories in several European countries. They found that radiation like that from GSM (2G) cell phone handsets caused both single and double stranded breaks in the DNA of cultured human and animal cells. Not all cell types were equally affected and some, such as lymphocytes, seemed not to be affected at all (Reflex Report 2004).

In susceptible cells, the degree of damage depended on the duration of the exposure. With human fibroblasts, it reached a maximum at around 16 hours (Diem *et al.* 2005). However, it would be unwise to assume that exposures of less than 16 hours are necessarily safe since DNA damage may give genetically aberrant cells long before it becomes obvious under the microscope. It would also be unwise to assume that the damage would be restricted to the immediate vicinity of the handset since, as described earlier, the effects of the radiation can be transmitted in the bloodstream in the form of magnetically conditioned blood; so nowhere is safe, not even the sex organs.

How the DNA is damaged

Because of the very high stability of DNA molecules, they are unlikely to be damaged directly by weak radiation. The most plausible mechanism is that DNase (an enzyme that destroys DNA) and other digestive enzymes leak through the membranes of lysosomes (organelles that digest waste) that have been damaged by the radiation. Other mechanisms involve the leakage of reactive oxygen species (ROS) such as hydrogen peroxide from damaged peroxisomes and superoxide free radicals from damaged mitochondrial membranes and NADH oxidase in the plasma membrane. According to Friedman *et al.* (2007), the first to respond to non-thermal cell phone frequencies is the NADH oxidase in the plasma membrane, which is activated within minutes of exposure.

However, all of these ROS can initiate peroxidation chain reactions in the polyunsaturated phospholipids of cell membranes (the same thing that makes fats go rancid)

which disrupts the membranes further and exacerbates the effect. Only one molecule of ROS is needed to initiate a domino-effect chain reaction, in which each damaged lipid molecule generates a free radical that damages the next one. The process normally stops when it reaches an anti-oxidant molecule, which sacrifices itself by combining with the free radical in such a way that it does not generate a new one. Most of our anti-oxidants come from our diet (e.g. vitamin E) but the most important one that we make ourselves is *melatonin*. It's unfortunate that the production of melatonin by the pineal gland is also disrupted by electromagnetic fields (Henshaw and Reiter, 2005) which makes matters worse.

These ROS are highly reactive and can also damage DNA. In fact, much of the damage done to cells by *ionising radiation* such as *gamma rays* is due to damage to cell membranes and DNA by free radicals from the radiolysis of water. There may therefore be little difference between holding a cell phone to your head and holding a radioactive source of gamma rays. Both can damage cell membranes, cause the fragmentation of DNA and also do considerable collateral damage to other cellular components, which may either kill the cells or make them lose their normal function over time.

Cell phones increase the risk of cancer

If similar DNA fragmentation were to occur in the whole organism, we would expect an increased risk of cancer, since essential genes that control cell division may be either damaged or lost. Recent studies on the incidence of brain cancer are already beginning to show this. Heavy cell phone use roughly doubles the risk of getting brain cancers in adults on the side of the head used for the cell phone. For younger people, the risk increases to five times more (Hardell and Carlberg 2009). Since brain cancers normally take decades to develop, it is too soon to assess the final impact of the radiation, but the World Health Organisation has already classified cell phones as a Group 2B Carcinogen (possibly carcinogenic) similar to benzene and DDT. Other head cancers are also on the increase, including cancers of the parotid salivary gland (next to where you hold your cell phone) and the thyroid gland, which is in the neck.

Cell phones reduce male fertility

We might expect DNA damage in the cells of the germ-line (the line of cells starting in the embryo that eventually gives rise to eggs and sperm) to result in a loss of fertility. A number of epidemiological studies have shown significant reductions in sperm motility, viability and quantity in men using cell phones for more than a few hours a day (Fejes *et al.* 2005; Agarwal *et al.* 2006) and the subject was reviewed by Desai *et al.* (2009). A common finding is that these effects were associated with the production of reactive oxygen species (ROS) which can damage many cellular components, including cell membranes and DNA.

More recently, Agarwal *et al.* (2009) found in controlled experiments that ejaculated sperm from healthy donors showed reduced viability and motility and an increase in ROS after one hour's exposure to a cell phone in talk mode. More recently still, Avandano *et al.* 2012 found that exposing ejaculated semen to a WiFi laptop for four hours gave a decrease in sperm motility and an increase in DNA fragmentation as compared with samples exposed to a similar computer with the WiFi switched off.

A similar relationship between sperm quality and electromagnetic exposure has also been found for low frequency alternating magnetic fields (Li *et al.* 2010). It is therefore advisable for men to avoid strong magnetic fields, restrict their cell phone calls to a minimum and keep them switched off (or in airplane mode if it has this facility). Otherwise, the phones

transmit regularly at full power to the base station, even when not in use. If they have to be switched on for any reason, men should at least keep them out of their trouser pockets.

Possible effects on female fertility

We do not yet know the effects of cell phone use on human female fertility, but . Panagopoulos *et al.* (2007) showed that exposing adult *Drosophila melanogaster* (an insect widely used in genetic experiments) to a GSM phone signal for just six minutes a day for six days fragmented the DNA in the cells that give rise to their eggs and half of these eggs died. We humans should therefore exercise caution since, although our sperm are produced in their countless billions and take about three months to mature, all the eggs that a woman will ever have were in her ovaries before she was born and will be exposed to the radiation (and electromagnetically conditioned blood) throughout her life. There could therefore be considerable cumulative damage, both to the eggs and the follicle cells that nourish and protect them. Damage to either, beginning when the child is in the womb, can be expected to cause a loss of fertility. Pregnant mothers should avoid all present forms of microwave telecommunications, including cell phones and WiFi. Her child could be damaged by their radiation, but she will not know until she reaches puberty and wants a child herself.

Effects on tight junction barriers

Tight junction barriers are layers of cells where the gaps between them are sealed by *tight-junctions* to prevent materials leaking around their sides. They protect all of our body surfaces from the entry of unwanted materials and often protect one part of the body from being unduly influenced by the others. For example, the blood-brain barrier prevents toxins entering the brain from the bloodstream. Normally, these barriers are closed but they are programmed to open if calcium ions enter their cells. This was demonstrated by Kan and Coleman (1988) who showed that the calcium ionophore A23187 (an antibiotic that kills bacteria and fungi by letting calcium ions leak into their cells) opened tight junction barriers in the liver. The electromagnetic opening of the blood-liver barrier could be a contributory factor to the current outbreak of liver disease in the UK among the under forties (the cell phone generation), which is at present being blamed on alcohol abuse. Since all tight junction barriers have basically the same design, unscheduled calcium entry resulting from electromagnetic exposure is likely to open all of them in much the same way. The opening of our tight junction barriers by electromagnetic fields can account for many modern illnesses, ranging from asthma to multiple allergies and Alzheimer's disease.

The blood-brain barrier and early dementia

The blood-brain barrier normally prevents possibly toxic large molecules from the bloodstream entering the brain. The radiation from cell phones, even at one hundredth of the permitted SAR value, can open the blood brain barrier in rats so that protein molecules as large as albumin could enter their brains (Persson *et al.* 1997). Later experiments by Salford *et al.* (2003) showed that this was associated with the death of neurons. We would not expect an immediate effect because the brain has spare capacity, but prolonged or repeated exposure to cell phone or similar radiation would be expected to cause a progressive loss of functional neurons and result in early dementia and Alzheimer's disease in humans. The extreme sensitivity of the blood-brain barrier to the radiation could mean that even sitting close to someone using a cell phone could affect you too. It may not be too surprising to find that early onset Alzheimer's disease is now on the increase in modern society.

The respiratory barrier and asthma

Di *et al.* (2011) showed that exposure to weak ELF electromagnetic fields during pregnancy increased the risk of asthma in the offspring (they did not test microwaves). This

can be explained by the radiation removing structural calcium from the cells of the tight junction barrier lining the respiratory tract, which then opens. This is supported by the findings of Chu *et al.* (2001) who showed that either low levels of external calcium or the addition of EGTA, both of which would remove structural calcium ions from cell surfaces, caused massive increases in its electrical conductance (a measure of its permeability to ions) and also to its permeability to much larger virus particles. We would therefore expect many allergens to enter by the same route and predispose the child to asthma. There are about 5.4 million people with asthma in the UK and the estimated annual cost to the NHS alone is about £1 billion (http://www.asthma.org.uk/news_media/news/new_data_reveals_hig.html)

The skin barrier, allergies and multiple chemical sensitivities

The skin tight junction barrier is in the *stratum granulosum*, which is the outermost layer of *living* skin cells just underneath the many layers of dead cells (Borgens *et al.* 1989). Furuse *et al.* (2002) showed that mutant mice deficient in Claudin-1 (a vital component of the sealing mechanism) died within a day of birth and their skin barriers were permeable to molecules as large as 600D, which is enough to admit many unwanted foreign materials, including potential allergens. In humans, this could be the basis of *multiple chemical sensitivities*, where people have become allergic to a wide range of chemicals, although they leave most of us unaffected. People suffering from multiple chemical sensitivities are often also electromagnetically intolerant and many of their symptoms are very similar.

Virtually all of our body surfaces are protected by cells with tight junctions, including the nasal mucosa (Hussar *et al.* 2002), the lungs (Weiss *et al.* 2003) and the lining of the gut (Arrieta *et al.* 2006). An electromagnetically-induced increase in the permeability of any of these would allow the more rapid entry into the body of a whole range of foreign materials, including allergens, toxins and carcinogens.

Loss of barrier tightness can trigger autoimmune diseases

An electromagnetically-induced increase in the permeability of any of the tight-junction barriers has been linked to the occurrence of autoimmune diseases, in which lymphocytes the immune system attacks the body's own components as if they were foreign materials or pathogens.

The immune system is quite complicated but basically lymphocytes (a type of white blood cell) are trained and selected before they mature to recognise the body's own cells, which are normally present in the bloodstream, by virtue of chemical patterns on their surfaces (the major histocompatibility complexes).

B-lymphocytes make specific antibodies that combine with foreign cells and substances that do not have this pattern, which marks them for eventual ingestion and digestion by phagocytes (another type of white blood cell). T-lymphocytes kill the body's own cells if they are infected with a virus, which is normally displayed on the cell surface. In both cases, the presence of the foreign material or infected cells trigger the rapid multiplication of a clone of lymphocytes that recognise them. They can then attack it in force.

However, if the substance concerned belongs to the body itself but is normally prevented from entering the bloodstream by a tight-junction barrier such as the blood-brain barrier, when that barrier opens, it increases the likelihood of its leaking unfamiliar materials into the bloodstream and triggering an autoimmune response. For example, Grigoriev *et al.* (2010) showed that 30 days exposure to unmodulated 2450MHz microwave radiation triggered a small but significant increase in anti-brain antibodies in the blood of rats. In other

words, the radiation had sensitised the body's immune system to one or more components of its own brain, which could then result in an autoimmune attack on the brain and/or nervous system. An example of an autoimmune disease of the brain is Graves disease in which the pituitary gland (at the base of the brain) is affected.

In addition, an increase in the permeability of the gut barrier has been linked to several other autoimmune diseases, including type-1 diabetes, Crohn's disease, celiac disease, multiple sclerosis and irritable bowel syndrome (Arrieta *et al.* 2006).

Cell membranes as current generators and electrical insulators

Cell membranes not only keep apart materials that must not be allowed to mix, they also act as electrical insulators for the natural electric currents upon which all of our cells depend.

Natural electric currents are important in power and information transfer

Almost every living cell is a seething mass of electric currents and amplifiers. For example, these currents are important in energy production in mitochondria (the cell's power stations) and in cell signalling (the transfer of information within and between cells). They are carried as flows of ions, which are the normal ways in which electricity is carried through water and through living cells.

These natural currents are generated by cell membranes.

Natural electric currents are normally generated by molecular ion pumps in cell membranes. These are proteins that use metabolic energy to transport specific ions, usually one or two at a time, from one side of the membrane to the other. This generates a voltage across the membrane (*the membrane potential*) and a chemical imbalance between the concentrations of ions on either side. Their combined effect gives an *electrochemical gradient*, which provides energy for other functions.

Mitochondria use electrochemical gradients to transmit power

Mitochondria are tiny structures, about the size of bacteria, inside almost all of our cells. They evolved when an aerobic bacterium, which used oxygen to metabolise its food, was engulfed by an anaerobic organism, which could not do his, but was more efficient in other respects. From then on they lived together symbiotically, but are still separate in that the mitochondria are surrounded by two membranes; the inner one belonging to the bacterium and the outer one to its host.

The inner membrane does the electrical work by a process known as chemiosmosis. The inside of the mitochondrion contains enzymes that convert materials from our food into forms that can combine with oxygen. This combination with oxygen occurs using enzymes actually within the membrane, and the released energy is used to expel hydrogen ions to create an electrochemical gradient between the inside and the outside of the mitochondrion. They are then allowed back through another enzyme in the membrane called ATP synthase that uses the gradient to make ATP, which is the main energy currency of the cell. The cycle then repeats to give an electrical circuit with hydrogen ions carrying the electricity from where it is made to where it is used, with the membrane being the insulator (Alberts *et al.* 2002).

What happens if the mitochondrial membrane is damaged?

Damage to the inner mitochondrial membrane can have two main effects. If it just leaked it would short circuit the system, reduce ATP synthesis and deprive the cell of energy. If the damage were also to include the oxidising enzymes, they could release free radicals, which are normal intermediates in the process. This would damage both the inside of the mitochondrion (including its DNA) and also the rest of the cell. Mitochondrial dysfunction of this sort is thought to be a possible cause of chronic fatigue syndrome.

Other membranes also use ion currents to transfer energy

Most other cell membranes use ion currents as a source of energy. For example, enzymes in the outer membrane of each cell (*the plasma membrane*) use energy from ATP to pump positively charged sodium ions out of the cell. This generates its own membrane potential, which typically makes the inside of the cell about 70-100mV negative to the outside. This provides energy for the active transport of other materials across the membrane against a concentration gradient. In this case, the sodium ions that have been expelled are allowed back in, through transporter enzymes, but they carry with them nutrients from the outside by a process called ion co-transport (Alberts *et al.* 2002) If this membrane leaks, it will short circuit the voltage across it and reduce nutrient uptake as well as a number of other processes which use this voltage as a source of energy.

Ion channels in cell membranes are used for cell signalling

Ion channels are pores in cell membranes that can let large quantities of specific ions through very quickly, but only down their own electrochemical gradient. They normally open and close in response to specific stimuli; e.g. changes in voltage across the membrane or the presence of other chemicals. They can be thought of as amplifiers by which a tiny stimulus can cause a very large current to flow almost instantly to give a rapid biological effect. An example of this is the coordinated opening and closing of sodium and potassium channels that continuously amplify nerve impulses and enable them to travel from one end of the body to the other, both rapidly and without loss.

The mechanisms of cell membrane leakage.

We have known since the work of Suzanne Bawin and her co-workers (Bawin *et al.* 1975) that electromagnetic radiation that is far too weak to cause significant heating can nevertheless remove radioactively labelled calcium ions from cell membranes. Later, Carl Blackman showed that this occurs only with weak radiation, and then only within one or more '*amplitude windows*', above and below which there is little or no effect (Blackman *et al.* 1982; Blackman 1990).

The apple harvester: an explanation for amplitude windows

A simple way to explain the selective removal of divalent ions is to imagine trying to harvest ripe apples by shaking the tree. If you don't shake it hard enough, no apples fall off, but if you shake it too hard, they all fall off. However, if you get it just right, only the ripe ones fall off and are 'selectively harvested'.

We can apply the same logic to the positive ions bound to cell membranes. Alternating voltages try to drive these ions off and then back onto the membranes with each cycle. If the voltage is too low, nothing happens. If it is too high, all the ions fly off, but return when the voltage reverses. However, if it is just the right, it will tend to remove only the more

strongly charged ones, such as divalent calcium with its double charge. If the frequency is low, at least some of these divalent ions will diffuse away and be replaced at random by other ions when the field reverses. There will then be a net removal of divalent ions with each successive cycle until enough have been removed to cause significant membrane leakage and give a biological effect, but only within a narrow range of field strength to give an *amplitude window*. Pulses are more effective than smooth sine waves because their rapid rise and fall times catapult the ions quickly away from the membrane and leave more time for them to be replaced by different ions before the field reverses.

Frequency windows and resonance effects

If a molecule or structure has a natural resonant frequency, it may respond selectively to that frequency. For example, if you keep giving a pendulum a gentle push at just the right time at the end of its travel, the energy of each push builds up and is stored in the ever increasing violence of its motion. If you were suddenly to stop it by putting your hand in the way, the combined energy of each push is released in one go and could do more damage to your hand than the energy you gave it from each individual push.

In the same way, if an electrically charged atom or molecule has one or more natural resonant frequencies and you give it an electromagnetic pulse at that frequency, it may store the combined energy of each pulse as some sort of vibration. This could enable it to bring about a chemical reaction that would not have been possible from the energy of each pulse alone, *but only at its resonant frequency*. Some frequencies are especially effective in giving biological effects. An example is 16Hz, which is the ion cyclotron resonance frequency of potassium ions in the Earth's magnetic field.

Ion cyclotron resonance occurs when ions move in a steady magnetic field such as that of the Earth. They are deflected sideways by the magnetic field and go into orbit around its lines of force at a frequency that depends on the charge to mass ratio of the ion and the strength of the steady field (see Liboff *et al.* 1990). If they are simultaneously exposed to an alternating field at this frequency, they absorb its energy and increase the diameter of their orbits, which increases their energy of motion and chemical activity. Potassium resonance is particularly important because potassium is the most abundant positive ion in the cytosols of living cells, where it outnumbers calcium by about ten thousand to one. It is therefore the ion most likely to replace any calcium that has been lost by electromagnetic exposure. An increase in the chemical activity of potassium will therefore increase its ability to replace calcium and so increase calcium loss from the membrane and further reduce its stability.

Calcium loss and leaky membranes underlie many biological effects.

We have seen how the loss of calcium from cell membranes is enhanced at the 16Hz potassium resonant frequency. Also, any metabolic consequences of this calcium loss may be similarly enhanced. Any bioelectromagnetic responses that peak or trough at 16Hz is evidence that they stem from divalent ion depletion in membranes. In fact, many biological responses appear to peak at 16Hz.. These include stimulations of the growth of yeast (Mehedintu and Berg 1997) and higher plants (Smith *et al.* 1993), changes in rate of locomotion in diatoms (McLeod *et al.* 1987), and the especially severe neurophysiological symptoms reported by electrosensitive people exposed to the radiation from TETRA handsets (which is pulsed at 17.6Hz). All of this supports the notion that a large number of the biological responses to weak electromagnetic radiation stem from the loss of calcium (and possibly other divalent ions) from cell membranes.

How calcium removal makes cell membranes leak

Positive ions strengthen cell membranes because they help bind together the negatively charged phospholipid molecules that form a large part of their structure. Calcium ions are particularly good at this because their double positive charge enables them to bind more strongly to the surrounding negative phospholipids by mutual attraction and hold them together like mortar holds together the bricks in a wall. However, monovalent ions are less able to do this (Steck *et al.* 1970, Lew *et al.* 1998, Ha 2001). Therefore, when electromagnetic radiation replaces calcium with monovalent ions, it weakens the membrane and makes it more likely to tear and form temporary pores, especially under the stresses and strains imposed by the moving cell contents. Normally, small pores in phospholipid membranes are self healing (Melikov *et al.* 2001) but, while they remain open, the membrane will have a greater tendency to leak. This can have serious metabolic consequences as unwanted substances diffuse into and out of cells unhindered, and materials in different parts of the cell that should be kept separate, become mixed.

Demodulation

Both extremely low frequencies and radio waves that have been amplitude modulated at extremely low frequencies give biological effects, but unmodulated radio waves are relatively (but not completely) innocuous. This implies that living cells can demodulate a modulated signal to extract the biologically active ELF. Furthermore, if they are to respond to cell phone and WiFi signals, they must be able to do it at microwave frequencies, but how do they do it?

The most likely explanation lies in asymmetric electrical properties of ion channels in cell membranes imposed by the *membrane potential* between the inside and outside of the cell. They will behave like electrically biased point contact Schottky diodes in which electricity passes more easily in one direction than the other. This is all that is needed to rectify and demodulate the signal. A non-biological example of this effect is a radio set that was made from a single carbon nanotube (see <http://tinyurl.com/m4u75o>). The asymmetry induced by applying a DC voltage between its ends allowed it to demodulate and even to amplify radio signals, including those at microwave frequencies.

The nanotube has a similar diameter to a typical ion channel in a cell membrane, so it seems likely that the ion channels in cell membranes could perform a similar function, powered by the cell's membrane potential. The low-frequency component would then appear across the membrane, where it could do most damage. In as much as our *tight junction barriers* have a similar trans-barrier potential (around 70mV for the skin barrier with the inside of body positive) the ion channels of the whole barrier could act in concert to demodulate the signal, the damaging low frequency components of which could then be applied to and affect the whole body.

Natural defence mechanisms

The body is able to detect electromagnetic radiation and so minimise resulting damage. This ability probably evolved over countless millions of years to mitigate the effects of ionising radiation from cosmic rays and non-ionising radio frequencies from lightning during thunderstorms. Some of them are as follows: -

Calcium expulsion

The concentration of free calcium in the cytosols of living cells is normally kept extremely low by metabolically-driven ion pumps in the cell membrane. Under normal circumstances, the entry of free calcium ions is carefully regulated and small changes in

their concentration play a vital role in controlling many aspects of metabolism. These processes can be disrupted if electromagnetically-induced membrane leakage lets extra and unscheduled amounts of calcium into the cell, either from the outside or from calcium stores inside. To compensate for this, the mechanism that normally pumps surplus calcium out can go into overdrive. However, its capacity to do this is limited because, if the pumping were too effective, it would hide the small changes in calcium concentration that normally control metabolism.

Gap junction closure: - If calcium extrusion fails and there is a large rise in internal calcium, it triggers the isolation of the cell concerned by the closure of its gap junctions (tiny strands of cytoplasm that normally connect adjacent cells) (Alberts *et al.* 2002). This also limits the flow of electric currents through the tissue and so reduces the effects of radiation.

Ornithine decarboxylase (ODC)

The activation of the enzyme *ornithine decarboxylase* is triggered by calcium leaking into cells through damaged membranes and by nitric oxide produced by damaged mitochondria. This enzyme leads to the production of chemicals called *polyamines* that help protect DNA and the other nucleic acids needed for protein synthesis. One such polyamine is spermine, which normally protects the DNA of sperm and is also responsible for the characteristic smell of semen.

Heat shock proteins

These were first discovered after exposing cells to heat, but they are also produced in response to a wide variety of other stresses, including weak electromagnetic fields. They are normally produced within minutes of the onset of the stress and combine with the cell's enzymes to protect them from damage and shut down non-essential metabolism (the equivalent of running a computer in "safe mode").

When the production of heat shock proteins is triggered electromagnetically it needs 100 million million times less energy than when triggered by heat, so the effect is truly non-thermal (Blank & Goodman 2000). Their production in response to electromagnetic fields is activated by special base sequences (the nCTCTn motif) in the DNA of their genes. When exposed to electromagnetic fields, they initiate the gene's transcription to form RNA, which is the first stage in the synthesis of the protein (Lin *et al.* 2001). The job of these heat-shock proteins is to combine with vital enzymes, putting them into a sort of cocoon that protects them from damage. However, this stops them working properly and also drains the cell's energy and resources, so it isn't an ideal solution either.

Our defences protect us from thunderstorm radiation but not from cell towers, DECT phones and WiFi

As we can see, our natural defence mechanisms try to limit the electromagnetically-induced damage, but they cannot be deployed without using extra energy and disrupting the cell's normal functions. They originally evolved to protect us from occasional weak natural radiation, such as that from thunderstorms. However, prolonged or repeated exposure such as that from cell towers, WiFi and most DECT base stations is harmful because they normally run continuously and disrupt metabolism for long periods and is expensive in bodily resources.

These resources have to come from somewhere. Some may be drawn from our physical energy, making us feel tired, some may come from our immune systems, making us less resistant to disease and cancer. There is no hidden reserve. As it is, our bodies are constantly juggling resources to put them to best use. For example, during the day, they are

directed towards physical activity but during the night, they are diverted to the repair of accumulated damage and to the immune system. Day and night irradiation from cell phone towers (which run continuously) will affect both, with little or no chance to recover. In the long term, this is likely to cause chronic fatigue, serious immune dysfunction (leading to an increased risk of disease and cancer) and many of the neurological symptoms frequently reported by people living close to mobile phone base stations (see Abdel-Rassoul *et al.* 2007).

How can we make our electromagnetic environment safe?

Firstly, there may be no need to give up our electrical appliances domestic appliances or cell phones. It is possible to make most of them much safer. All that is needed with domestic wiring is low-tech electromagnetic hygiene. As for cell phones, the operators have known for over a decade how to modify the radiated signal to make it safe; they have just chosen not to do so. I will deal with these one at a time.

Domestic wiring

It is easy to screen the electrical field from wiring by enclosing it in earthed metal conduits or using screened cable with an earthed screen. We cannot screen the magnetic field in this way but by careful design of the circuits, we can make the magnetic fields of the live and neutral wires cancel each other out. To do this, all you need is to make sure that the live and neutral wires to any device are as close together as possible (preferably twisted together) with each device having its own connection to the main distribution panel. The cheap UK practice of using ring mains (where many plug sockets are connected in a ring, beginning and ending in the distribution panel) should be made illegal. This is because differences in the resistance of the conductors mean that electricity flowing to any plug socket may not flow back the way it came so that their magnetic fields do not cancel and there will be an unnecessarily high field surrounding the whole ring.

Another source of problems is the use of unearthed double insulated appliances. Although there is very little risk of shock, they still emit strong magnetic fields and electric fields at about half the supply voltage, which some people find intolerable.

Cell phones

While we can block or cancel the electromagnetic fields associated with domestic wiring, we cannot do this with cell phones or DECT phones, which depend on radio frequency radiation transmissions if they are to work. However, we can make this radiation much less biologically active. There are at least two ways to do this. The first was devised tested and patented by Theodore Litovitz working at the Catholic University of America in the 1990s. All you have to do is to add low frequency electromagnetic noise to the signal.

The theory behind Litovitz's method.

His idea was to add a random ELF (noise) magnetic field to the regularly repeating fields from power lines or cell phones. It works on the principle that most of the biological effects of electromagnetic fields are due to the relatively slow but progressive loss of calcium from cell membranes, which then makes them leak. However, the effect on any cell takes place only within certain amplitude windows, as I described earlier. We may not be able to prevent this leakage just by reducing the power of the field. All this might do is to put other cells (perhaps nearer the source) into their amplitude windows and we may be no better off.

However, if we add a second magnetic field with a randomly varying amplitude, cells are constantly being driven in and out of their amplitude windows and do not spend long

enough in their windows to lose significant amounts of calcium before leaving their windows. The lost calcium then floods back and there is no biological effect. This theory has been tested in several biological systems and found to work.

Much of Litovitz's work used the in production of the enzyme ornithine decarboxylase (ODC) by tissue cultures as an indicator of radiation damage to living cells. The activity of this enzyme increases several fold when exposed to electromagnetic fields (Byus et al. 1987). ODC is part of a defence mechanism against the radiation and an increase in its production is taken as an indication that damage is occurring. Conversely, if the random signal prevents its production, it is an indication that damage is not occurring.

Work in Litovitz's laboratory was mainly concerned with mitigating the effects of 60Hz power line frequencies and he found that adding a random (noise) magnetic field of about the same strength completely reversed their effects on ODC production in mouse tissue cultures (Litovitz *et al.* 1994b) and also the deformities induced by 60Hz fields in chick embryos (Litovitz *et al.* 1994a)

They then went on to study the effects of modulation frequency on 845MHz microwave radiation on ODC production in mouse tissue cultures. They found that constant frequencies between 6 and 600Hz were harmful as measured by ODC production. Simple amplitude modulated speech (which is more random) did not stimulate ODC production, neither did frequency modulated microwaves and frequency modulated analogue phone signals. Continuous microwaves had only a slight effect.

Most microwave pulse frequencies are harmful

Penafiel et al. (1997) working in Litovitz's laboratory concluded that there were only serious health problems when the microwaves were modulated to give pulses of a standard height (amplitude) generated at frequencies between 6 and 600Hz. There was virtually no effect above 600Hz. This corresponds to Blackman *et al.* (1988) observation that calcium release from brain tissue did not occur above 510Hz.

It would appear that the mobile telecommunications industry had not done their homework before selecting the pulse frequencies for their digital communications, since they virtually all fall within this biologically active range; e.g. 2G GSM cell phones (217Hz), TETRA (17.6Hz), DECT phones (100Hz), WiFi (10Hz), and 3G UMTS signals with time division duplex (100Hz and 200Hz) all of which are potentially harmful. There could be other harmful effects of the radiation that do not trigger ODC production or calcium release but, at the very least, these pulse frequencies should not have been used if the cell phone industry had acted due diligence. .

However, Litovitz (1997) found that even these could be made safe by superimposing a low frequency magnetic field on the signal. They found that it prevents the production of ornithine decarboxylase (ODC) by mouse tissue cultures in response to digital cell phone signals. For example, a random field between 30 and 100Hz with an RMS strength of 5 microtesla completely inhibited the ODC production induced by a cell phone signal with an SAR of about 2.5 W/kg. A coil within the handset could easily deliver a random magnetic field of this magnitude and probably protect the user from the harmful effects of its radiation.

Also Lai (2004) showed that a 6 microtesla random noise field completely reversed the deleterious effect of 2450 MHz continuous waves with an SAR of 1.2 W/kg on rat memory. In none of the above experiments did the random noise have any effect in its own right and, on these criteria, is completely harmless.

Balanced signal technology

While Litovitz's method might protect the user from the radiation, because magnetic fields dissipate rapidly as you move away from the source, they may not protect other people nearby, who are out of range of the protective random field. By the same token, random low frequency magnetic fields emitted by a cell phone base station would not be able to protect most users. For this you may need something like a system that I devised myself, to which I gave the name "Balanced Signal Technology". I am not claiming any patent rights and anyone who wants to test and use it can do so free of charge.

The principle is very simple and involves transmitting two complementary mirror image signals on different carrier frequencies; i.e. when one has a pulse, the other has a gap. The base station would have no problem with this since they would look like two separate phone calls. However, living cells would be unlikely to distinguish between the two carrier frequencies and the pulses on each would cancel and it would look like a relatively harmless continuous wave. It would need very little extra bandwidth since only one of the signals need be used, with the other one being effectively thrown away and they could all be dumped on the same frequency. In theory, this technology could be applied to both handsets and base stations, but has not yet been tested.

The cell phone companies should know about both methods to make cell phones safer but there is no evidence that they are interested, possibly because to implement them would cost money with no extra benefit to themselves. It looks very much as if they would prefer many people to become sick and perhaps die, rather than admit that their safety rules are based on false premises and that their current technologies are not yet safe.

What can we do about it ourselves?

Very few people would want to give up their cell phones, but if you have one, for your own personal safety, keep your calls on it short and infrequent so that your body has a chance to recover in between times. Use text (which takes seconds to transmit) rather than voice calls and avoid unnecessary Internet downloads. The choice is yours, but spare a thought for the people living near the base stations. Some may be badly affected by their continuous radiation but they have no choice. Your cell phone calls will contribute to their problems, so your restraint may help them too.

Also, don't forget your own personal sources of continuous radiation such as WiFi routers and DECT phone base stations, which can be even more harmful since they are closer. Avoid using WiFi altogether. Ethernet connections via cable are not only safer, but faster, more reliable and offer greater security. Various "Homeplug" devices that connect an the Ethernet socket of your computer to the router via the household electricity supply are second best alternatives. They are not perfect since there is still some radiation from the wiring; especially with those offering faster speeds.

DECT phones should also be avoided if at all possible. But, if you must have one, a reasonable compromise is to use only one that switches off its base station automatically between calls. At the time of writing, the only DECT phones that do this are the Eco Plus models manufactured by Siemens; e.g. the Siemens Gigaset C595. However, make sure they are programmed to work in the Eco Plus mode since this is not the default setting.

Screening and its limitations

Many electromagnetically intolerant people will want to screen themselves from the fields but we need to understand a little about them to get the best results.

The near-field

An alternating electromagnetic field consists of an electrical field and a magnetic field. The electrical field is produced by a voltage gradient and is measured in volts per metre. The magnetic field is generated by a flow of current and is measured in tesla. When you are close to the source (typically within one wavelength) you are in the *near-field*, where the electrical and magnetic fields are mainly separate.

At power line frequencies, the wavelengths run into thousands of miles, so you are bound to be in the near field for power lines. For example, standing under an alternating power line would expose you to a voltage gradient due to the difference between the voltage of the line (set by the power company) and the Earth. You would also be exposed to a *magnetic* field proportional to the current actually flowing through the line, which depends on consumer demand. Both the magnetic and the electrical fields can induce electric currents in your body and are potentially harmful, but the magnetic field is worse because it penetrates living tissues more easily, goes through most walls and aluminium foil as if they were not there, and is very difficult to screen.

The far field

However, as you move away from the source, the two fields feed on each other's energy and combine to give photons of radio waves. This is usually complete within a few wavelengths, after which you are in the so called *far-field* where all the power takes the form of radio waves. Your exposure to these is usually measured in units of power (e.g. microwatts per square metre) or its associated voltage gradient (e.g. volts per metre).

The importance of this as far as we are concerned is that radio waves, are like light waves and are relatively easy to absorb and reflect. This can be done, using earthed metal foil or other electrically conductive materials such as carbon-based paints and metallised textiles. For practical purposes, this means that you can screen yourself against the radiation from a cell tower, WiFi router, or DECT phone base station if they are several wavelengths away (several tens of centimetres) but not from a cell phone held against your head, where you are in the near field and the raw magnetic component will penetrate deep into your brain.

To give an idea of the hazard, magnetic fields lower than one microtesla (a millionth of a tesla) can produce biological effects, but using a 2G (GSM) cell phone or a PDA exposes you to low frequency magnetic pulses that peak at several tens of microtesla (Jokela *et al.* 2004; Sage *et al.* 2007). These come mainly from the battery circuits and are well over the minimum needed to give harmful effects. When they are added to the damaging effects of their microwave fields themselves, these devices are potentially the most dangerous sources of electromagnetic fields and radiation that the average person possesses.

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Dr. Richard Meltzer Comments, Radio Frequency (RF) Exposure:
A Cautionary Tale; Sep. 3, 2013

FCC 12-152

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

In the Matter of	)	
	)	
Notice of Proposed Rulemaking	)	
18 FCC Rcd 13187, 13188 ¶1 (2003)	)	ET Docket No. 03-137
	)	
And	)	
	)	
Service Rules for the Advanced Wireless Services	)	WT Docket No. 12-357
H Block---Implementing Section 6401 of the	)	
Middle Class Tax Relief and Job Creation Act of	)	
2012 Related to the 1915-1920 MHz and	)	
1995-2000 MHz Bands ¶53 footnote 95	)	

To: Office of the Secretary
Federal Communications Commission
Washington, DC 20554

Reply Filed by: Michael Schwaebe
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February 23, 2013

AFFIDAVIT OF Michael Schwaebe

State of California

San Diego County

I, Michael Schwaebe, attest that my statements are true to the best of my knowledge.

Reply Comment round for ET Docket No. 03-137 and WT Docket No. 12-357.

1. My name is Michael Schwaebe. My address is 215 Andrew Ave, Encinitas, CA 92024.
2. I am a professional engineer and a Building Biology Environmental Consultant.
3. and onward. Radiofrequency radiation has been known to cause biological effects for more than 40 years. In 1972, Zorach R. Glaser, Ph.D., LT, MSC, USNR of the Naval Medical Research Institute, published a paper called *Bibliography of Reported Biological Phenomenon ('Effects') and Clinical Manifestations Attributed to Microwave and Radio-frequency Radiation* (<http://www.dtic.mil/dtic/tr/fulltext/u2/750271.pdf>), where he categorized the different biological effects from RFR based on more than 1,000 research citations.

A modern day version of this document is the *BioInitiative Report*, found at [BioInitiative.org](http://www.bioinitiative.org). Biological effects in 8 categories (stress proteins, HSP, disrupted immune function; brain tumors and blood-brain barrier; reproductive/fertility effects; sleep, neuron firing rate, EEG, memory, learning, behavior; oxidative damage/ROS/DNA repair failure; cancer, other than brain, cell proliferation; disrupted calcium metabolism; and cardiac, heart muscles, blood pressure, vascular effects) are listed as a function of RFR power density here: <http://www.bioinitiative.org/report/wp-content/uploads/pdfs/BioInitiativeReport-RF-Color-Charts.pdf>.

When looking at biological effects it is peak power that is most damaging and so it is crucial in setting protective limits that this be addressed. Otherwise, the peak power is deluded using averaging criteria.

Respectfully submitted by

Michael Schwaebe
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February 23, 2013

Dr. Donald R. Maisch PhD. Comments, Feb. 6, 2013

FCC 12-152

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

In the Matter of	)	
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1995-2000 MHz Bands ¶53 footnote 95	)	

To: Office of the Secretary
Federal Communications Commission
Washington, DC 20554

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February 6 , 2013

AFFIDAVIT OF Donald R Maisch

State of Tasmania, Australia]

I, Donald R. Maisch, attest that my statements are true to the best of my knowledge.

Comment round for ET Docket No. 03-137 and WT Docket No. 12-357.

1. My name is Donald R. Maisch and my address is 143 Gordons Hill Road, Lindisfarne, Tasmania, Australia, 7015. I am a citizen of both Australia and the United States.

2. I am an environmental consultant advising on both power frequency and telecommunications frequency issues and science writer for the Australasian College of Nutritional & Environmental Medicine. I have been directly involved in telecommunications standard setting since 1996. From 1998 to 2001, I was a member of the Standards Australia TE/7 Committee: Human Exposure to Electromagnetic Fields. (Radiofrequency standards) which concluded in 2001. From 2004 to 2009 I was enrolled in a PhD research program at the University of Wollongong, New South Wales, Australia. My area of research was examining the health risk assessment process as it applies to the development of Western telecommunications standard setting. In 2010 my thesis, *The Procrustean Approach: setting Exposure Standards for Telecommunications Frequency Electromagnetic Radiation*, passed external review and was accepted by the university. I have included that document as an essential part of my submission to the FCC.

3. I have focused my PhD research on the controversy over the level of health protection that is provided by the internationally recognized radiofrequency exposure standards / guidelines. These are the RF standard developed under the auspices of the Institute of Electrical and Electronic Engineers (IEEE C95.1) and the RF guidelines promoted by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). In my examination of the established literature base used to set thermally based RF standards such as IEEE C95.1, and ICNIRP's RF guidelines, it is seen that consideration of other possible biological effects not related to heating have not been taken into account in the setting of the exposure limits in these standards / guidelines. It is my opinion that there is now sufficient scientific data in the peer reviewed and published RF literature base to justify a re-examination of possible non-thermal biological effects from human exposure to radiofrequency and microwave (RF/MW) exposure with the aim of including these effects in setting human exposure limits.

4. This idea is not new, and was a concern of the U.S. Radiofrequency Interagency Work Group (RFIAWG) a governmental interagency committee

working under the House of Representatives' Committee on Commerce. Working group membership included the Food and Drug Administration (FDA), the Center for Device and Radiological Health (CDRH), the National Institute for Occupational Safety and Health (NIOSH), the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), the National Telecommunications and Information Administration (NTIA) and the Federal Communications Commission (FCC)¹ (Appendix B). With this work group membership, a significant difference of opinion was expressed over the adequacy of the thermally based proposed IEEE C95.1 standard revisions, compared to that of the industry make up of the IEEE standard setting committee, SCC-28 subcommittee IV. These differing expert opinions illustrated that differing scientific interpretations of the same scientific literature base was very much according to one's affiliations.

In June 1999 Gregory Lotz, representing NIOSH on the RFIAGWG, presented the Chairman of the SCC-28 subcommittee IV a list of issues that RFIAGWG considered needed to be addressed in the IEEE RF standard. The list was in response to previous requests from the work group for greater participation in SCC-28 discussions on RF standards.² In particular, RFIAGWG criticised the biological rationale of the standard on a number of fronts. A fundamental issue was the standard's failure to address chronic (low intensity/prolonged) as opposed to acute (high intensity/short term) exposures. This was seen in the standard's limiting the definition of an "adverse effect level" to only acute exposure situations and the use of time-averaged calculations that were not suitable for prolonged exposure situations and therefore may not adequately protect the public. RFIAGWG recommended that a clear rationale needed to be developed to also include chronic exposures.³ Another concern was the standard's incorrect assumption that all tissues are equally sensitive (other than the eyes and testicles) to RF. This failed to take into consideration the differing sensitivity of human tissue when calculating SAR limits.⁴ There was also a concern expressed about failure to include consideration of the body of research on the biological effects of exposure to ELF-modulated and pulse modulated RF that was relevant to public exposures. In addition, the SAR time- averaging calculations as used in the standard hid any biological effects resulting from modulated RF exposures.⁵ RFIAGWG also questioned the biological validity of the IEEE's two-tier exposure classification, "controlled" vs. "uncontrolled". Besides not being adequately explained, a rationale needed to be given as to why people in uncontrolled environments needed to be protected to a greater extent than persons in controlled environments, when such situations historically were based on biological considerations.⁶ Another issue for RFIAGWG was the rationale

¹ E. Jacobson, Deputy Director, Center for Devices and Radiological Health, FDA Letter Regarding Cellular Phones, May 5, 1997

² G. Lotz, RFIAGWG, RF Guideline Issues: Identified by members of the Federal RF Interagency Work Group, June 1999, letter from Gregory Lotz to Richard Tell, Chair of IEEE SCC28 IV

³ Lotz, op. cit., p. 1-2.

⁴ ibid.

⁵ Lotz, op. cit., p. 5

⁶ Lotz, op. cit., pp. 3-4

for the relaxation of the exposure limits above 1.5 Ghz that “caused concern that the standard is not restrictive enough for continuous exposures at lower microwave frequencies where new wireless applications for consumers could make this an issue in the future”.⁷ To address these concerns the working group recommended a comprehensive review of long-term, low-level exposure studies that had relevance to environmental chronic occupational RF exposures and neurological-behavioural effects to better define the adverse effect level for RF, and micronucleus assay studies with relevance to carcinogenesis.⁸

5. Despite the concerns raised by the RFIAGWG these were simply ignored in subsequent IEEE C95.1 standard revisions, as seen in relation to the IEEE’s 12 guiding principles for RF standard setting. These 12 “Guiding principles” for setting RF exposure standards were published in 2003 by the IEEE’s International Committee on Electromagnetic Safety’s (ICES) Subcommittee 4 (SC4). These ‘principles’ were referred to as “a valuable reference on the subject for many years to come”⁹ They state in part that standard exposure limits should be based on established adverse effects, that the thermal effect is the only established adverse effect and that non-thermal effects are not established. These so-called principles could only be set by ignoring the very valid concerns of the RFIAGWG. Setting such a firm principle on scientific inquiry for years to come, based on a very selective assessment of the science, is ill advised as it can limit the scope of future scientific research to what is already “established”. I would urge the FCC not to go down this path.

6. Two alternative reviews of the RF literature base, the “Bioinitiative Report”¹⁰ and the ICEMS review, “Non-Thermal Effects and Mechanisms of Interaction Between Electromagnetic Fields and Living Matter”¹¹ are in general agreement with the RFIAGWG concerns over limiting public health protection in RF standard setting to thermal considerations only. What the RFIAGWG concerns, and these two reviews indicate, is that there is substantial peer reviewed and published research in existence that found scientific evidence of adverse biological effects at exposure levels far below the official standard limits/ guidelines that are based on thermoregulatory considerations.

7. It is my opinion that this extensive data base should no longer be ignored in setting human exposure standards which should be based on biologically relevant end points and not just thermal considerations.

⁷ Lotz, op. cit., p. 6

⁸ Lotz, op. cit., p.7

⁹ C-K. Chou, J. D’Andrea, ‘Reviews of the Effects of RF Fields on Various Aspects of Human Health: Introduction’, *Bioelectromagnetics, Supplement 6*, 2003, pp. S5-S6.

¹⁰ Blackman, C. et al., “BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)”, Updated Jan. 2013

¹¹ Giuliani, L. and M. Soffritti (eds), “Non-Thermal Effects and Mechanisms of Interaction Between Electromagnetic Fields and Living Matter”, ICEMS Monograph for the European Journal of Oncology, vol. 5, 2010

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Biological Effects from RF Radiation at Low-Intensity Exposure, based on the BioInitiative 2012 Report, and the Implications for Smart Meters and Smart Appliances; Dr. Ron M. Powell PhD.; 2013

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Biological Effects from RF Radiation at Low-Intensity Exposure, based on the BioInitiative 2012 Report, and the Implications for Smart Meters and Smart Appliances

Introduction and Conclusions

The Biological Effects Chart, at the end of this document, has been produced using data from a massive new review of the medical research literature on the biological effects of electromagnetic fields. That review is called the BioInitiative 2012 Report.² The purpose of the Biological Effects Chart is to show the radiofrequency (RF) exposure levels at which biological effects were found in 67 studies from the RF Color Charts of the BioInitiative 2012 Report, and then to compare those exposure levels to the following:

- (1) current FCC Maximum Permitted Exposure (MPE) limits that govern Smart Meters and Smart Appliances in the United States
- (2) new biologically based RF exposure limits proposed in the BioInitiative 2012 Report
- (3) calculated RF exposure levels produced by a single Smart Meter at various distances
- (4) calculated RF exposure levels produced by a single Smart Appliance at various distances

This comparison is based on RF exposure levels expressed as the RF power density (RF power per unit area). This comparison does not address other potentially important factors such as carrier continuity (continuous versus pulsed radiation) and modulation technique (the method used to impress information on the carrier), among others. The purpose is to identify what biological effects arise from exposure to RF power density levels like those produced by Smart Meters and Smart Appliances.

This comparison indicates the following:

- (1) The current FCC Maximum Permitted Exposure (MPE) limits are so high that they provide no protection for the public from the biological effects found in any of the 67 studies.
- (2) New biologically based RF exposure limits proposed in the BioInitiative 2012 Report are 1 million times lower than current FCC limits and would protect against the biological effects found in nearly all of the 67 studies.
- (3) A single Smart Meter on a home can produce RF exposure levels that caused the biological effects found in either most or many of the 67 studies, depending on the distance from the Smart Meter.
- (4) A single Smart Appliance in the home can produce RF exposure levels that caused the biological effects found in nearly half or fewer of the 67 studies, depending on the distance from the Smart Appliance. Multiple Smart Appliances in a home multiply the total exposure.

¹ The author holds a Ph.D. in Applied Physics from Harvard University, 1975.

² BioInitiative Working Group, Cindy Sage and David O. Carpenter, Editors, BioInitiative Report: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation, December 31, 2012 (<http://www.bioinitiative.org>).

(5) A single Smart Meter on a nearest neighbor's home can produce RF exposure levels that caused the biological effects found in many of the 67 studies. A given home may have one to eight nearest neighbors, each with a Smart Meter, multiplying the total exposure in the given home.

Other observations:

(1) Most biological effects of RF exposure cannot be sensed by human beings. Examples are the onset of cancer, DNA damage, and fertility effects. One category of effects that can often be sensed includes neurological effects on sleep, memory, learning, and behavior.

(2) Unborn and very young children may be more affected by RF exposure than adults.

This document provides background information, an explanation of each feature of the Biological Effects Chart, and a detailed discussion of each of the conclusions and observations summarized above. That discussion begins on page 11.

Figure 1, on page 9 in this document, and the Biological Effects Chart, at the end of this document, are in color, and are most easily understood when viewed in color. But they can also be understood in black and white. To make that possible, key lines in Figure 1 and in the Biological Effects Chart are identified not only by color but also by line thickness and line style (solid versus dashed).

Terminology for Parts of the Electromagnetic Spectrum

Electromagnetic fields occur over a wide range of frequencies, referred to as the electromagnetic spectrum.³ But the terms used for parts of that spectrum are not consistently named or defined. The BioInitiative 2012 Report uses the following definitions for two key parts of the electromagnetic spectrum:

extra low frequency (ELF): electromagnetic fields with frequencies from 1 to 300 Hz⁴
radiofrequency (RF): electromagnetic fields with frequencies from 100 kHz to 300 GHz⁵

Within the *radiofrequencies* lie the *microwave* frequencies. Microwaves, too, are variously defined. Here are two common definitions:

microwaves: electromagnetic fields with frequencies from 300 MHz to 300 GHz⁶
microwaves: electromagnetic fields with frequencies from 1 GHz to 100 GHz⁷

This document focuses on the biological effects of the frequencies at which the following devices operate. Those frequencies are shown in round numbers.

³ Explanation of units of measure for frequency: 1 hertz is 1 cycle per second. 1 kilohertz is equivalent to 1000 hertz. 1 megahertz is equivalent to 1000 kilohertz and to 1,000,000 hertz. 1 gigahertz is equivalent to 1000 megahertz and to 1,000,000 kilohertz and to 1,000,000,000 hertz. These units are abbreviated as follows: hertz (Hz), kilohertz (kHz), megahertz (MHz), and gigahertz (GHz).

⁴ BioInitiative 2012 Report cited in footnote 2 on page 1, Section 26, Glossary of Terms and Abbreviations, page 3. The Report notes that the term Extremely Low Frequency is used in Europe and the term Extra Low Frequency is used in the United States. Wikipedia uses the term Extremely Low Frequency to refer to 3 to 300 hertz (http://en.wikipedia.org/wiki/Extremely_low_frequency).

⁵ BioInitiative 2012 Report cited in footnote 2 on page 1, Section 26, Glossary of Terms and Abbreviations, page 5.

⁶ (<http://en.wikipedia.org/wiki/Microwaves>)

⁷ (<http://en.wikipedia.org/wiki/Microwaves>)

cell towers ⁸	300, 400, 700, 800, 900, 950, 1800, 1900, 2100 MHz
Wi-Fi (most common type of WLAN) ⁹	2400, 2500 MHz (predominant) 2600, 3600, 5000 MHz (emerging)
wireless laptops ¹⁰	2400 MHz (predominant) 5000 MHz (emerging)
Smart Meters ¹¹	900, 2400 MHz (Smart Meters and Collector Smart Meters) 850 MHz (Collector Smart Meters only)
Smart Appliances ¹²	2400 MHz

Note that that all of these devices operate at frequencies between 300 MHz and 5000 MHz. The frequencies at which Smart Meters and Smart Appliances operate are right in the middle of this range. According to one or more of the definitions given above, all of these frequencies may be referred to as either *radiofrequencies (RF)* or *microwaves*. Since the BioInitiative 2012 Report refers to these frequencies as *radiofrequencies (RF)*, that term will be used here. But the term *microwaves* could have been used just as well.

The BioInitiative 2012 Report

The BioInitiative 2012 Report was developed by an international group of 29 individuals with expertise on the biological effects of electromagnetic fields, or on the related public-health issues.¹³ As a group, these experts hold 20 PhD degrees, one DrSc degree, 9 MD degrees, one DVM degree, and four degrees of MSc, MA, MPH, or MSPAS. These experts come from ten countries, each with the following number of participants:

USA	10	India	2
Sweden	6	Italy	2
Austria	2	Denmark	1
Canada	2	Russia	1
Greece	2	Slovak Republic	1

The goal of the BioInitiative Report is to present “a solid scientific and public health policy assessment that is evidence-based.” The report was prepared “independent of governments, existing bodies and industry professional societies that have clung to old standards.”¹⁴

⁸ (http://en.wikipedia.org/wiki/Cellular_network), (http://en.wikipedia.org/wiki/GSM_frequency_bands), and (http://en.wikipedia.org/wiki/UMTS_frequency_bands)

⁹ (<http://en.wikipedia.org/wiki/Wi-Fi>) and (http://en.wikipedia.org/wiki/List_of_WLAN_channels)

¹⁰ (http://en.wikipedia.org/wiki/Wireless_LAN)

¹¹ Both the Landis-Gyr FOCUS AXR-SD and the General Electric I-210+c Smart Meters, being installed in Maryland, have FCC ID OWS-NIC514. They send and receive information in two microwave frequency ranges: (1) 902.3 to 926.9 MHz, and (2) 2405.8 to 2480.9 MHz (<http://stopsmartmeters.org/wp-content/uploads/2012/01/OWS-NIC514-FCC-specifications.pdf>). Collector Smart Meters have a third transmission frequency of 850 MHz (http://sagereports.com/smart-meter-rf/?page_id=210). They receive and retransmit the signals from Smart Meters to assure that those signals reach the antennas of the electric power company. It is not clear to me at this time whether Collector Smart Meters are employed in all installations of Smart Meters.

¹² The most likely transmitter/receiver in the Smart Appliances is the so-called ZigBee device. ZigBee devices operate at 865 MHz (in Europe) and 915 MHz (in the USA and Australia) as well as 2.4 GHz (worldwide) (<https://en.wikipedia.org/wiki/ZigBee>). But the Smart Meters first observed in installations in Maryland seem to require that the ZigBee devices operate at 2.4 GHz.

¹³ BioInitiative 2012 Report cited in footnote 2 on page 1, cover page of the full report, as a single PDF file.

¹⁴ BioInitiative 2012 Report cited in footnote 2 on page 1, Section i, Preface 2012, page 2.

The Scope of the BioInitiative 2012 Report

The 1479-page BioInitiative 2012 Report considers the “content and implications of about 1800 new studies” since the last BioInitiative Report was published in 2007.¹⁵ The 2012 Report contains 16 chapters that address key categories of biological effects. The 2012 Report also contains several chapters that address key public policy issues, such as the nature and shortcomings of the current exposure standards, and the bases for sufficient argument for changing those standards. Emphasized is the importance of weighing the magnitude of potential harm against the evidence of potential harm, to determine when protective action should be triggered.¹⁶ Since Smart Meters are being mandated for entire populations in the United States, the magnitude of potential harm is considerable, so prudence dictates serious consideration of the increasing evidence of harm.

The Data Source for the Biological Effects Chart

The data for the appended Biological Effects Chart were drawn from the so-called RF Color Charts in the BioInitiative 2012 Report.¹⁷ The RF Color Charts contain two charts:

The first chart describes 67 studies of the biological effects of radiofrequency (RF) radiation.¹⁸ Each study represents one or more biological effects found at a one value of the RF power density (RF power per unit area) or within a range of such values. These data are especially useful when considering whole-body exposure, which is the type of exposure that human beings receive from Smart Meters at a distance of 1 meter or more.¹⁹ These data form the basis for the appended Biological Effects Chart.

The second chart describes 68 studies of the biological effects of radiofrequency (RF) radiation.²⁰ In this chart, each study represents one or more biological effects found at one Specific Absorption Rate, or SAR value, or within a range of such values. A SAR value is the RF power absorbed per unit mass of the biological entity being irradiated. These data are especially useful when less than the entire body is irradiated, and at very close distances, such as when a cell phone irradiates the head.

¹⁵ BioInitiative 2012 Report cited in footnote 2 on page 1, Section 1, Summary for the Public and Conclusions, 2012 Supplement: Summary for the Public – Ms. Sage, page 3.

¹⁶ BioInitiative 2012 Report, cited in footnote 2 on page 1, Table 1-1, Section 23: The Precautionary Principle, 2012 Supplement: The Precautionary Principle – Mr. Gee, page 2.

¹⁷ BioInitiative 2012 Report, cited in footnote 2 on page 1, Section 1, Summary for the Public and Conclusions, Table 1-2 Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure 2012, no page numbers.

¹⁸ Each study in the first chart derives from one publication. But three publications contributed two studies, and one publication contributed three studies. As a result, the 67 studies derive from 62 publications. So the terms *studies* and *publications* have slightly different meanings as used here.

¹⁹ More specifically, the power density values used in the first table are valid in the “far field” (also called the “radiative field”) of the Smart Meter. For the type of antenna in a Smart Meter or a Collector Smart Meter, the far field should begin about two wavelengths from the meter (http://en.wikipedia.org/wiki/Far_field). A Collector Smart Meter transmits on three frequencies (850, 900, and 2400 MHz). The longest wavelength transmitted by a Collector Smart Meter is determined by the lowest frequency which it transmits, which is 850 MHz. That wavelength is 0.35 meters (about 1 foot). A Smart Meter transmits on two frequencies (900 MHz and 2400 MHz), so the lowest frequency transmitted by a Smart Meter is 900 MHz, and the longest wavelength it transmits is 0.33 meters (again about 1 foot). Smart Appliances are expected to transmit at 2400 GHz, with has a wavelength of 0.13 meters (about 5 inches). So for all three devices, the far field begins about 0.7 meters (about 2 feet), or less, from them. This document addresses distances from 1 meter (about 3 feet) up, so all such distances are in the far field for all three devices.

²⁰ Each study in the second chart derives from one publication. But two publications contributed two studies each. As a result the 68 studies derive from 66 publications. So the terms *studies* and *publications* have slightly different meanings as used here.

This is not the usual case for RF exposure from Smart Meters, so these data were not used for the appended Biological Effects Chart.

Criteria for Selection of the Studies in the RF Color Charts

The criteria used in the BioInitiative 2012 Report to select the studies for the RF Color Charts, and thus for the appended Biological Effects Chart, were the following:²¹

- (1) A selection of good examples only. Not intended to be comprehensive.
- (2) Peer-reviewed and published studies only.
- (3) Good exposure data (numeric).
- (4) Author(s) have clear methods and conclusions.
- (5) Cover wide range of topics, such as genotoxicity, neurological, immune, cancers, behavior, attention, memory, sleep, etc.
- (6) Cover wide range of exposure levels, with an emphasis on the lowest levels and the more recent studies.

Every study in the first chart of the RF Color Charts, and thus every study in the appended Biological Effects Chart based on that first chart, except one (Dumansky, 1974), was published after 1986. 1986 is the year of publication of the document on which the current FCC Maximum Permitted Exposure (MPE) limits are principally based.²² That was 27 years ago, which is one factor in explaining why the current FCC MPE limits are out of date. The references for the studies in the RF Color Charts, and thus for the biological effects data in the appended Biological Effects Chart, are included in the reference list that immediately follows the RF Color Charts in the PDF file of the full BioInitiative 2012 Report.²³

Explanation of the Appended Biological Effects Chart

The Horizontal Axis of the Biological Effects Chart

The studies are presented in order of increasing RF power density along the horizontal axis of the Biological Effects Chart. That order facilitates comparing effects observed at similar RF power densities. Each position along the horizontal axis of the Biological Effects Chart represents one study whose principal author and date of publication are written under that axis. The studies could just as well have been ordered alphabetically by the authors' last names, or numerically by the publication dates.

The Vertical Axis of the Biological Effects Chart

The vertical axis represents the RF power densities at which each study was conducted. These power densities cover a wide range of values, so a logarithmic vertical axis was employed. This approach permitted displaying 11 orders of magnitude on the Biological Effects Chart.²⁴ The units of measure

²¹ The criteria were provided by Cindy Sage, co-editor of BioInitiative 2012, in a private communication, April 23, 2013.

²² The current FCC exposure limits are based principally on a 1986 publication of the National Council on Radiation Protection and Measurements (NCRP). That publication is "Report No. 086 - Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields". The NCRP was chartered by the U.S. Congress in 1964, but is not a Government agency and is not subject to oversight by the Congress.

²³ BioInitiative 2012 Report cited in footnote 2 on page 1, Reported Biological Effects from Radiofrequency Radiation (RFR) at Low-Intensity Exposure Levels, sequential pages 112-121 in the 1479-page PDF version of the full Report.

²⁴ Each order of magnitude is a factor of 10.

selected for the vertical axis are milliwatts per square meter (mW/m^2).²⁵ These units work well for the wide range of power densities required for the vertical axis, making the length of the smallest number, 0.000001, not too much longer than the length of the largest number, 10000.

The selected units for the vertical axis also work well for relating the RF power density shown to the total RF power that an adult human would receive. The surface area of an adult human is about 2 square meters (m^2).²⁶ So the surface area that an adult human presents to an RF wave arriving from the front, or from the back, is about 1 square meter (m^2). So when an adult human faces an oncoming wave of radiation with a power density of, say, 10 milliwatts per square meter (mW/m^2), that human will receive a total of 10 milliwatts (mW) of radiation over the entire body. That is, the number describing the power density will be the same as the number describing the total power received, even though the units of measure are different in the two cases. So, when examining the vertical axis of the attached Biological Effects Chart, each number on that axis may be taken to mean *both* the power density (in mW/m^2) of the oncoming wave of RF radiation *and* the total RF power (in mW) received by an adult human when standing with the front, or the back, facing the direction from which the radiation is coming.

The Round Red Dots on the Biological Effects Chart

Each round **red** dot • on the attached Biological Effects Chart indicates the RF power density at which the study named on the horizontal axis, directly below the dot, was conducted. Some studies were conducted over a range of power densities. In such cases, the average value of the high and low ends of the range determines the location of the dot on the vertical axis. The range of power densities applicable is shown as a black vertical line through the dot. The top of the vertical line marks the high end of the range, and the bottom of the vertical line marks the low end of the range. On those vertical lines, the dots appear higher than the middle. That effect results from the logarithmic vertical axis, even though the dots are located at the true average value of the high and low ends of the range.

The Alphabetic Codes above the Dots on the Biological Effects Chart

A one- or two-letter code appears just above each of the dots on the Biological Effects Chart. Each code, such as “CB”, identifies the category into which the biological effects found by a given study fall. Those one- and two-letter codes are translated in the table on the Biological Effects Chart, first into the one or two words represented by the letters of the codes, and then into a fuller description of the category, as reported in the RF Color Charts of the BioInitiative 2012 Report. For example, the code “CB” stands for the words “Cancer, Brain” and represents a category that contains “Brain tumors and blood-brain barrier”.²⁷ Similarly, the code “CO” stands for the words “Cancer, Other” and represents a category that contains “Cancer (other than brain), cell proliferation”.

The Thick Horizontal Blue Line at the Top of the Biological Effects Chart

The thick horizontal **blue** line, which appears at the top of the Biological Effects Chart, represents the Maximum Permitted Exposure (MPE) limits of the Federal Communications Commission (FCC). These are the limits applicable to the general population for uncontrolled exposure for the frequencies that Smart

²⁵ 1 milliwatt (mW) is one-thousandth of a watt (W).

²⁶ The surface area of a man is about 1.9 square meters (m^2); and the surface area of a woman is about 1.6 square meters (m^2), both according to Wikipedia (http://en.wikipedia.org/wiki/Body_surface_area).

²⁷ The reference to blood-brain barrier refers to the weakening of the barrier that the body erects between the blood and the brain to prevent harmful entities circulating in the blood from entering the brain.

Meters, Collector Smart Meters, and Smart Appliances use: 2400 MHz, 900 MHz, and 850 MHz. The top edge of the blue line is the limit applicable to 2400 MHz. The bottom edge of the blue line is the limit applicable to 850 MHz. The limit applicable to 900 MHz falls in between.

Frequency (MHz)	FCC Maximum Permitted Exposure (MPE) Limits ²⁸ (mW/m ²)	
2400	10,000	(Smart Meters, Collector Smart Meters, and Smart Appliances)
900	6000	(Smart Meters and Collector Smart Meters)
850	5700	(Collector Smart Meters)

However, those FCC limits apply to the time-average RF power density over a period of 30 minutes. So, pulsed signals, like those issued by Smart Meters and Smart Appliances, are permitted to assume even higher peak values, as long as the time-average over a period of 30 minutes is below the FCC limits shown.

The Thick Horizontal Yellow Line on the Biological Effects Chart

The thick horizontal yellow line, which appears about one-third from the bottom of the Biological Effects Chart, shows the new RF exposure limits proposed in the BioInitiative 2012 Report for chronic exposure to pulsed radiation. Pulsed radiation is the type of radiation that Smart Meters and Smart Appliances emit. The top of this line is located at 0.006 milliwatts per square meter (mW/m²). The bottom of this line is located at 0.003 milliwatts per square meter (mW/m²).²⁹

New Biologically Based RF Exposure Limits Proposed in the BioInitiative 2012 Report³⁰ (as expressed, equivalently, in various units of measure)

0.3 to 0.6	nanowatts per square centimeter (nW/cm ²)	(units used in BioInitiative 2012)
0.003 to 0.006	milliwatts per square meter (mW/m ²)	(units used in appended Chart)
3 to 6	microwatts per square meter (μW/m ²)	

The data from the 67 studies in the Biological Effects Chart indicate why this level might have been judged appropriate by the authors of the BioInitiative 2012 Report: This level would protect against the biological effects found by all but five of the 67 studies. The BioInitiative 2012 Report indicates that these proposed new limits “may need to change in the future, as new and better studies are completed.”³¹ Note that this level, which can also be expressed as 3 to 6 microwatts per square meter (μW/m²), is in agreement with the level of 5 microwatts per square meter (μW/m²) proposed by Dietrich Klinghardt, M.D., Ph.D., in his detailed video treatment of the health hazards of Smart Meters.³²

²⁸ Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields, OET (Office of Engineering and Technology) Bulletin 56, Fourth Edition, Federal Communications Commission, August 1999. See Table 1(B), Limits for General Population/Uncontrolled Exposure, page 15.

(http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet56/oet56e4.pdf)

²⁹ BioInitiative 2012 Report cited in footnote 2 on page 1, Section 1, Summary for the Public and Conclusions, 2012 Supplement: Summary for the Public – Ms. Sage, pages 25-26.

³⁰ 1 milliwatt (mW) is one thousandth of a watt (W). 1 microwatt (μW) is one millionth of a watt (W). 1 nanowatt (nW) is one billionth of a watt (W). 1 centimeter (cm) is one hundredth of a meter (m). So, 1 square centimeter (cm²) is one ten thousandth of 1 square meter (m²).

³¹ See footnote 29 above.

³² Dr. Klinghardt’s video, and further information about him, can be found on the following web sites:

(<http://marylandsmartmeterawareness.org/smart-meter-news/dr-dietrich-klinghardt-smart-meters-emr-the-health-crisis-of-our-time>) and (<http://www.klinghardtacademy.com/BioData/Dr-Dietrich-Klinghardt.html>).

The Thin Horizontal Green Lines on the Biological Effects Chart

The four thin horizontal green lines show the power density of the RF radiation emitted by a Smart Meter at four different distances. To determine these levels, I assumed that the Smart Meter is the type being installed in Maryland, as described in footnote 11 on page 3:

P = RF power output = 1 watt

g = antenna gain = 4 dBi = 2.5 (a pure number, a ratio)³³

This Smart Meter has an RF power output, P , of approximately 1 watt. The antenna used in the Smart Meter is a variation of a vertical dipole antenna which provides a gain, g , of 4 dBi, or 2.5, in the horizontal direction. I have not accounted for absorption by obstructions, such as walls and other objects, which can lower RF power density levels. Nor have I accounted for reflections from walls or other objects, which can raise or lower RF power density levels. So the actual power densities would likely fall somewhere between the two extremes that could apply if these other factors had been considered. The RF power density, P_D , in watts per square meter (W/m^2) can be calculated from this equation:

$$P_D = g \left[\frac{P}{4\pi r^2} \right]$$

In the above equation, r is the distance, in meters, from the Smart Meter, in the horizontal direction. This equation can be understood this way: The radiation from the Smart Meter travels outward from the meter and is initially regarded as spreading uniformly over the surface of a sphere (centered on the Smart Meter) which has a radius, r , and thus a surface area of $4\pi r^2$. So the part of the equation in square brackets [] indicates the power density that would be produced, at a distance, r , if the radiation from the Smart Meter spread uniformly over the surface of that sphere. The antenna used in the Smart Meter increases the power density in the horizontal direction, at the expense of a decrease in the power density in the vertical direction, because all receivers of interest are in the horizontal direction. Those receivers include the antennas of the electric power company and the antennas of other Smart Meters in the area with which a given Smart Meter communicates. The antenna gain, g , accounts for this characteristic of the antenna and causes P_D to represent the power density in the horizontal direction.

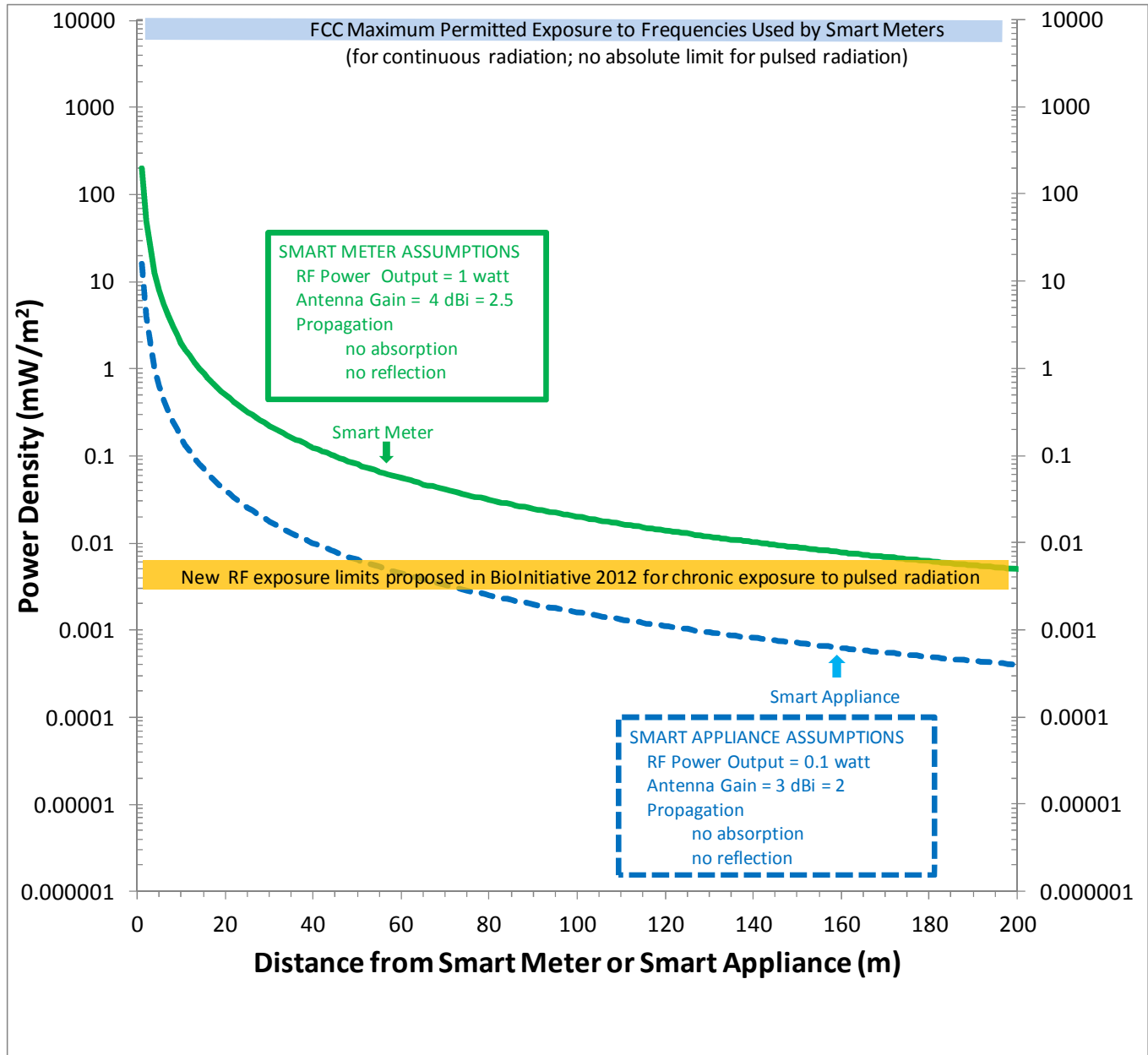
The RF power density, P_D , computed from the above equation is plotted in Figure 1 on page 9 as a function of the distance from the Smart Meter. The power density is expressed in units of milliwatts per square meter (mW/m^2) to match the units in the Biological Effects Chart under discussion. A logarithmic vertical axis is used for the power density, again to match the logarithmic vertical axis of the Biological Effects Chart. The vertical axis appears on both sides of Figure 1 to facilitate easier reading.

The power density is strongest near the Smart Meter and falls off quickly with increasing distance, but persists at lower levels to great distances. The P_D of the Smart Meter drops to the maximum

³³ The antenna gain, g , is usually specified in dBi, which means the gain, in decibels, relative to an ideal isotropic antenna, which is an idealized antenna that radiates equally in all directions. The gain of the antenna in a Smart Meter (with FCC ID OWS-NIC514) is 4 dBi and translates to a factor of 2.5. That is, the power density in the horizontal direction is 2.5 times greater than it would be if the antenna radiated equally in all directions. In the case of Smart Meters, the power density in the vertical direction is reduced in favor of increased power density in the horizontal direction where all intended receivers are located. To access the reference, start at (<http://transition.fcc.gov/oet/ea/fccid>). In the box Grantee Code, enter OWS. In the box Product Code, enter -NIC514 (including the hyphen), press Search, click on the first entry Detail, and click on Test Report. This should take you to this location (<https://apps.fcc.gov/eas/GetApplicationAttachment.html?id=1174749>) which you cannot address directly. Then see page 3 of 66 of the document found.

exposure level proposed in the BioInitiative 2012 Report at a distance of about 180 meters. On the appended Biological Effects Chart, the four thin horizontal green lines show the power densities, taken from Figure 1, for distances of 1 meter (3 feet), 5 meters (16 feet), 20 meters (66 feet), and 100 meters (328 feet).

Figure 1: Smart Meter and Smart Appliance RF Power Densities versus Distance



The Thin Dashed Horizontal Blue Lines on the Biological Effects Chart

Smart Meters are designed to communicate wirelessly with new Smart Appliances that are now becoming available. The Smart Appliances contain RF transmitters and receivers of their own. Through the Smart Meters, the Smart Appliances can report, to the electric power company, data sufficient to identify the specific appliances and to indicate when they were installed or removed, and how much power they are

consuming throughout the day and the night, every day of the year. Less certain is whether the electric power company will be able to turn off the Smart Appliances by sending a wireless signal to them through the Smart Meter. (For example, the electric power company might want to turn off appliances that draw a lot of electricity at certain times of day, and in certain seasons, when the load on the electric power system is high. An example would be turning off the air-conditioner at midday in midsummer.)

Such Smart Appliances will increase the RF radiation inside each home. Verifiable data on the actual RF power output of the transmitters that will be used in the Smart Appliances is hard to find at present; but a likely value is 0.1 watt, since that is a common value used for other short-range wireless devices.³⁴ The antenna gain is assumed to be 3 dBi or 2.³⁵ The frequency of operation is assumed to be 2.4 GHz to communicate with the Smart Meters.³⁶

The RF power density for Smart Appliances is calculated with the same equation used for Smart Meters above but with the different values for P and g just cited:

$$P = \text{RF power output} = 0.1 \text{ watt}$$

$$g = \text{antenna gain} = 3 \text{ dBi} = 2 \text{ (a pure number, a ratio)}$$

The result for a single Smart Appliance is shown by the dashed blue line in Figure 1 on page 9. Once again, I have not accounted for absorption and reflection during propagation. Absorption can lower the power density. Reflection can lower or raise the power density. So the power densities shown in Figure 1 would likely fall somewhere between the two extremes that could apply if these other factors had been considered. The patterns of absorption and reflection inside homes vary greatly, so many different situations are possible.

The power density from a single Smart Appliance does not fall to the new maximum exposure level proposed in the BioInitiative 2012 Report until a distance of 50 meters (164 feet) from the Smart Appliance has been reached. So there will be no location within the typical home that will be that far from a Smart Appliance. Of course, over time, many such Smart Appliances may be purchased for a home, multiplying the total exposure produced.

In the appended Biological Effects Chart, the thin dashed blue lines show the RF power density, taken from Figure 1, for a single Smart Appliance at three distances: 1 meter (3 feet), 3 meters (10 feet), and 10 meters (33 feet) from the Smart Appliance. 10 meters is about as far from a Smart Appliance as a person can get inside the typical home with a single centrally located Smart Appliance.

³⁴ The most likely transmitter/receiver in the Smart Appliances is the so-called ZigBee device. These devices have RF outputs ranging from 0.001 watt to 0.1 watt, which is equivalent to a range of 1 milliwatt (mW) to 100 milliwatts (mW).

(<https://en.wikipedia.org/wiki/ZigBee>)

³⁵ The assumed gain, g , in this case, is 3 dBi, which is based on the performance of an ordinary vertical dipole antenna. That is, the power density in the horizontal direction is 2 times greater than it would be if the antenna radiated equally in all directions.

³⁶ ZigBee devices operate at 865 (in Europe) and 915 MHz (in the USA and Australia), as well as 2.4 GHz (worldwide); but the design of the Smart Meters installed in Maryland seems to require that the ZigBee devices operate at 2.4 GHz.

(<https://en.wikipedia.org/wiki/ZigBee>)

Conclusions and Observations

Current FCC Maximum Permitted Exposure (MPE) Limits Are Too High to Protect the Public

Because the FCC Maximum Permitted Exposure (MPE) limits are at power densities higher than the power densities addressed in all of the 67 studies, those limits provide no protection against the biological effects found in any of the 67 studies, no matter what the source of the RF radiation.

Further, the FCC Maximum Permitted Exposure limits apply to each source of radiation, individually, not to the combined exposure from all sources. But a person will generally be exposed to radiation from a combination of sources. So the FCC Maximum Permitted Exposure limits not only are too high to protect a person from a single source of radiation, but also do not consider the actual exposure received by a person from multiple sources of radiation.

New Biologically Based RF Exposure Limits, Proposed in the BioInitiative 2012 Report, are 1 Million Times Lower than the FCC Limits, to Protect the Public

The new RF exposure limits proposed in the BioInitiative 2012 Report are about 1 million times lower (stricter) than the current FCC Maximum Permitted Exposure Limits in the frequency ranges at which Smart Meters, Collector Smart Meters, and Smart Appliances operate.

Comparison of RF Exposure Limits

BioInitiative 2012 Report (RF)	FCC MPE (850 to 2400 MHz)	Ratio (FCC/BioInitiative 2012)
.003 to .006 mW/m ²	5700 to 10,000 mW/m ²	950,000 to 3,000,000

As shown in the appended Biological Effects Chart, the new RF exposure limits in the BioInitiative 2012 Report are low enough to protect against the biological effects found in nearly all of the 67 studies covered by that Chart.

A Single Smart Meter Can Produce RF Power Density Levels Shown to Cause Biological Effects

The Biological Effects Chart enables a comparison between the RF power densities produced by a Smart Meter, at various distances from that Smart Meter, and the RF power densities that triggered biological effects in the 67 studies.

The power density at 1 meter (3 feet) from a Smart Meter is higher than the power density that triggered biological effects in 50 of the 67 studies.

The power density at 5 meters (16 feet) from a Smart Meter is higher than the power density that triggered biological effects in 26 of the 67 studies.

The power density at 20 meters (66 feet) from a Smart Meter is higher than the power density that triggered biological effects in 14 of the 67 studies.

This distance of 20 meters is likely as far from a Smart Meter as a person can get and still be inside the typical home. So living and sleeping on the side of a home that is farthest from the Smart Meter is helpful but still may not reduce the received power densities to biological insignificance. Further, one or more of the neighbors' Smart Meters may be closer and may thus be the stronger source.

The power density at 100 meters (328 feet) from a Smart Meter is higher than the power density that triggered biological effects in 6 of the 67 studies.

So, even at the distance of a football field from the Smart Meter, the power density received may still be biologically significant.

As shown in Figure 1, the RF power density from a Smart Meter does not drop down to the level of the proposed new RF exposure limits until distances of 180 to 200 meters from the Smart Meter are reached. In most residential communities, whether composed of single-family homes, townhomes, or apartments, it will not be possible to get sufficiently far away from *all* of the Smart Meters present in that community.

A Single Smart Appliance inside a Home Can Produce RF Power Density Levels Shown to Cause Biological Effects

Unfortunately, the problem of excess exposure to RF radiation will get worse as Smart Appliances are adopted. They contain their own internal RF transmitters and receivers. Those Smart Appliances are designed to communicate with Smart Meters and to report through the Smart Meters to the electric power company. The data the Smart Appliances report will be sufficient for the electric power company to identify which appliances you own, when you use them, and how much power they consume, throughout the day and the night. The electric power company may even be able to turn the Smart Appliances off by sending a wireless signal to the Smart Meter that is then transferred to the Smart Appliances, but that is less certain at this time.

When these Smart Appliances are installed in a home, they will significantly increase the radiation levels in that home for several reasons:

They will begin transmitting, and from distances very close to the residents.

The number of Smart Appliances in the home may increase with time as the residents gradually replace their old appliances with new Smart Appliances, increasing the total radiation level.

The Smart Meters will transmit more frequently, in order to communicate with the Smart Appliances.

Even a single Smart Appliance can produce RF power densities of concern. An inspection of the appended Biological Effects Chart indicates the following:

The power density at 1 meter (3 feet) from a Smart Appliance is higher than the power density that triggered biological effects in 32 of the 67 studies.

The power density at 3 meters (10 feet) from a Smart Appliance is higher than the power density

that triggered biological effects in 21 of the 67 studies.

The power density at 10 meters (33 feet) from a Smart Appliance is higher than the power density that triggered biological effects in 10 of the 67 studies.

These observations do not bode well for having 5, 10, or 15 Smart Appliances in a home. The RF radiation from even a few Smart Appliances, because they will be so close to the residents, may rival that of a home's more distant Smart Meter. And the RF radiation from a large number of Smart Appliances may exceed that of a home's Smart Meter.

A Single Smart Meter on a Neighbor's Home Can Produce RF Power Density Levels Shown to Cause Biological Effects

For some locations in a given home, the distance to a neighbor's Smart Meter may be less than the distance to the resident's own Smart Meter. Thus, a neighbor's Smart Meter may be the principal source of radiation for some locations in the given home. The Biological Effects Chart shows that a single Smart Meter can produce RF power densities found to cause biological effects even at distances greater than 20 meters, and certainly up to 100 meters. And the number of neighbors within that range can be large. A given single-family home in a residential community may have one to eight nearest neighbors, and even more next nearest neighbors, all within 100 meters (328 feet) of a given home, and each with a Smart Meter.

The problem of exposure from the neighbors' Smart Meters becomes more serious as the distances between adjacent homes, and thus the distances between adjacent Smart Meters, get smaller. So, generally speaking, residents of townhouses will receive more radiation from their neighbors' Smart Meters than residents of single-family homes. And residents of apartments will receive even more radiation from their neighbors' Smart Meters, depending on the location of the Smart Meters in the apartment buildings.

So Smart Meters are a community concern, not just an individual concern. To resolve the problems of RF exposure for a given home, it will be necessary to address all of the Smart Meters near that home. Smart Appliances, too, contribute to this concern. While, individually, they have a lower RF power output than a Smart Meter, the Smart Appliances of neighbors can also increase the RF exposure in the given home.

Fortunately, some states have offered an individual OPT OUT from the installation of a Smart Meter.³⁷ While such an OPT OUT is very helpful, and is definitely the **vital first step**, the data on biological effects discussed here suggest the limitations of such an OPT OUT in resolving the problem of excess radiation from Smart Meters. There is no substitute for a roll back of all Smart Meters at the community level, or higher.

Most Biological Effects of RF Radiation Cannot be Sensed by Human Beings

Most biological effects of RF radiation cannot be sensed by human beings. This fact is evident from an inspection of the categories of biological effects from the RF Color Charts in the BioInitiative 2012 Report, as shown below. For example, humans cannot sense the onset of cancer, DNA damage, or fertility effects.

³⁷ Maryland, through the Maryland Public Service Commission, currently offers a temporary OPT OUT, with the future of that OPT OUT yet to be decided. And the Maryland House of Delegates is currently considering legislation (HB1038) that would make the OPT OUT permanent and would provide other protections for Maryland homeowners.

Categories of Biological Effects in the RF Color Charts of the BioInitiative 2012 Report

Code	Code Translation	Biological Effects Category
CB	Cancer, Brain	Brain tumors and blood-brain barrier
CO	Cancer, Other	Cancer (other than brain), cell proliferation
H	Heart	Cardiac, heart muscle, blood-pressure, vascular effects
MC	Metabolism, Calcium	Disrupted calcium metabolism
OD	Oxidation, DNA	Oxidative damage/ROS/DNA damage/DNA repair failure
R	Reproduction	Reproduction/fertility effects
S	Sleep	Sleep, neuron firing rate, EEG, memory, learning, behavior
SI	Stress, Immune	Stress proteins, HSP, ³⁸ disrupted immune function

The principal category of biological effects that humans *can* often sense is the S (or Sleep) category. This category includes neurological effects on sleep, memory, learning, and behavior, among others. Unfortunately, not sensing these particular effects does not guarantee that other biological effects are not occurring.

RF Radiation May Affect Unborn and Very Young Children More Severely than Adults

The BioInitiative 2012 Report presents evidence that unborn and very young children may be more greatly affected by RF radiation than adults because unborn and very young children are in “critical phases of growth and development”.³⁹

Concern for unborn and very young children is shared by the American Academy of Pediatrics (AAP) which wrote to the U.S. Congress in support of a bill before the U.S. House of Representatives (H.R. 6358).⁴⁰ This bill would fund development of better founded RF exposure limits to protect against cell phones and other wireless sources of RF radiation. The AAP made the following statement:

*The AAP strongly supports H.R. 6358’s emphasis on examining the effects of radiofrequency (RF) energy on vulnerable populations, including children and pregnant women. In addition, we are pleased that the bill would require the consideration of those effects when developing maximum exposure standards. Children are disproportionately affected by environmental exposures, including cell phone radiation. The differences in bone density and the amount of fluid in a child’s brain compared to an adult’s brain could allow children to absorb greater quantities of RF energy deeper into their brains than adults. It is essential that any new standards for cell phones or other wireless devices be based on protecting the youngest and most vulnerable populations to ensure they are safeguarded through their lifetimes.*⁴¹

³⁸ HSP stands for Heat Shock Proteins. BioInitiative 2012 Report, cited in footnote 2 on page 1, Section 1, Summary for the Public and Conclusions, Table 1-2 Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure 2012, no page numbers.

³⁹ BioInitiative 2012 Report cited in footnote 2 on page 1, Section 1: Summary for the Public and Conclusions, 2012 Supplement: Summary for the Public – Ms. Sage, pages 8-10.

⁴⁰ Summary of H.R. 6358 can be found here:

(<http://marylandsmartmeterawareness.org/smart-meter-news/ask-your-congressional-rep-to-co-sponsor-h-r-6358>). Full copy of H.R. 6358 can be found here: (http://thomas.loc.gov/home/gpoxmlc112/h6358_ih.xml).

⁴¹ (http://ehtrust.org/wp-content/uploads/2012/12/aap_support_letter_cell_phone_right_to_know_act.pdf)

Smart Meters and Smart Appliances operate in the same frequency ranges as cell phones. Further, Smart Meters have twice the RF power output of the typical cell phone, as shown in the table below, and will be transmitting day and night. Emerging Smart Appliances will likely have about one-fifth the RF power output of the typical cell phone. But a given home may have several Smart Appliances; and they, too, will be transmitting day and night.

Device	RF Power Output				
Smart Meter ⁴²	1.115	watts	which is	1115	milliwatts
Typical leakage from a microwave oven ⁴³	1	watt	which is	1000	milliwatts
Typical cell phone ⁴³	0.5	watt	which is	500	milliwatts
Wireless LAN (802.11a) ⁴³	0.251	watt	which is	251	milliwatts
Wireless LAN (802.11n) ⁴³	0.250	watt	which is	250	milliwatts
Cordless phone ⁴⁴	0.230	watt	which is	230	milliwatts
Smart Appliance ⁴⁵	0.100	watt	which is	100	milliwatts
Wireless LAN (802.11 b, g) ⁴³	0.100	watt	which is	100	milliwatts
Typical laptop wireless LAN (Wi-Fi) ⁴³	0.032	watt	which is	32	milliwatts

A Final Note

The Smart Meter is the first source of RF exposure that is mandated for installation in every home in an entire region without the informed consent, or any consent, of the residents, and that is not under the control of the residents.

For other sources of RF exposure in the home, the residents have a choice to use them, or not to use them, and how often, and how long. Some of those other sources are included in the table above.

The Smart Appliances, while not mandated, will be the second source of RF exposure in a home that is not under the control of the residents -- if manufacturers of the Smart Appliances provide no way of turning off the RF transmitters in those appliances.

The only solution for the individual homeowner, at present, is the removal of the Smart Meter and the avoidance of the Smart Appliances. This is a vital first step; but it is only a partial solution for a given home, because the radiation from the neighbors' Smart Meters and Smart Appliances will cross property boundaries. Collaboration with the neighbors on reducing exposure levels is needed; and a solution at the community level, or higher, will be even more effective.

⁴² The Landis+Gyr FOCUS AXR-SD and the General Electric I-210+c, being installed in Maryland, have FCC-ID OWS-NIC514 which indicates that they send and receive information in two microwave frequency ranges: (1) 902.3 to 926.9 MHz, and (2) 2405.8 to 2480.9 MHz. The RF power output in the first frequency range is 0.968 watts. The RF power output in the second frequency range is 0.147 watt. These values sum to the 1.115 watts shown here, to provide an indication of the total RF power output capability of a Smart Meter. I have used an approximate value of 1 watt for the RF power output of a Smart Meter throughout this document (<http://stopsmartmeters.org/wp-content/uploads/2012/01/OWS-NIC514-FCC-specifications.pdf>).

⁴³ The RF power output levels come from this web site: (<http://en.wikipedia.org/wiki/DBm>). 1 watt equals 1000 milliwatts.

⁴⁴ Panasonic specifies the power output of its DECT 6.0 cordless telephone Model KXTG1061 as 115 milliwatts for the handset and another 115 milliwatts for the base station, for a total capability of 230 milliwatts.

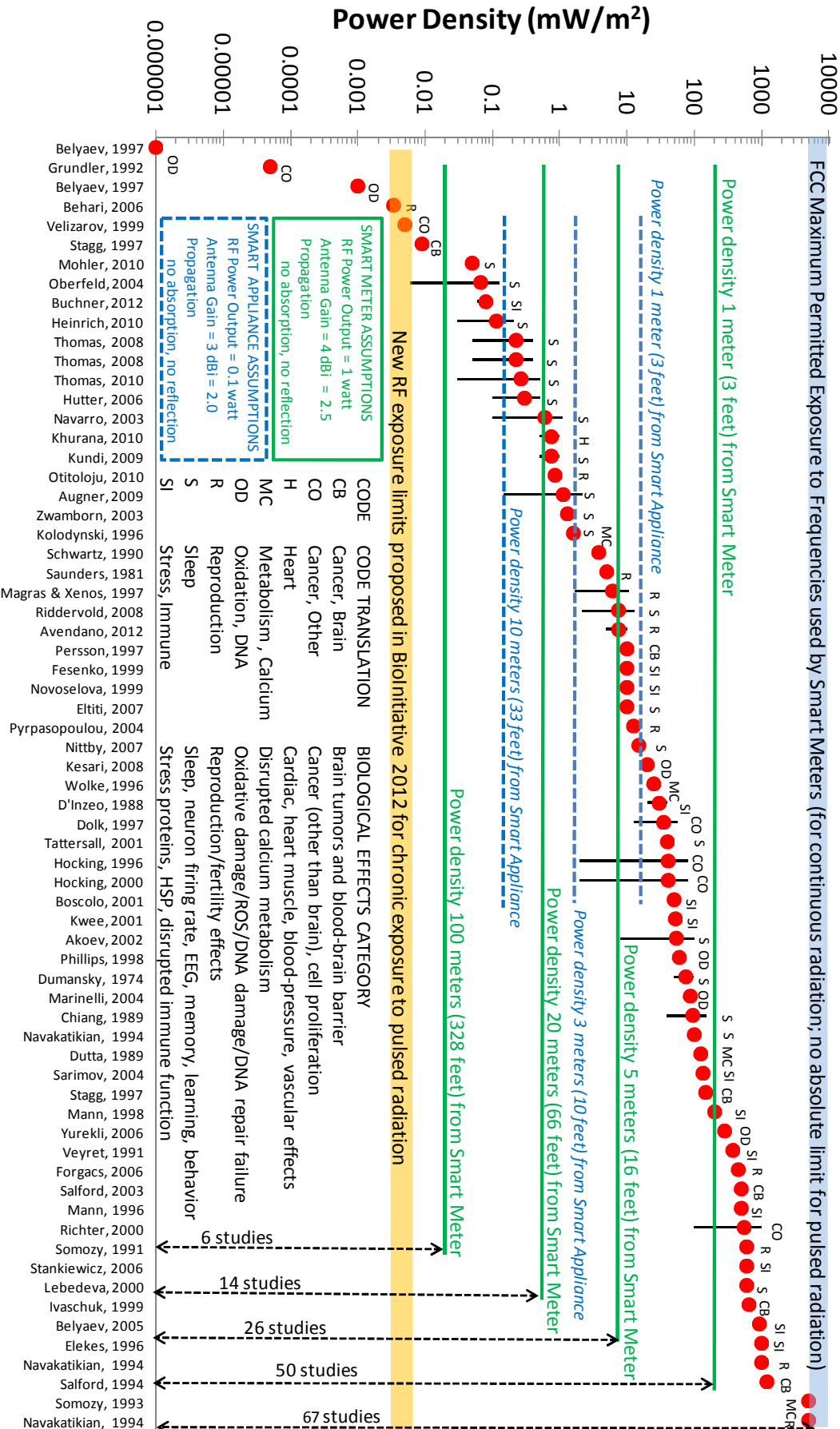
⁴⁵ For a reference, see footnote 34 on page 10.

June 11, 2013

Reported Biological Effects from RF Radiation at Low-Intensity Exposure in Each of the 67 Studies Referenced in the "BioInitiative 2012" Report (Cell Tower, Wi-Fi, Wireless Laptop, and Smart Meter Power Densities)

Ronald M. Powell, Ph.D.

Reference for data dots (red), data range indicators (vertical black lines through red dots), biological effects categories for the red dots, and new proposed limits (yellow line): BioInitiative Working Group, Cindy Sages and David O. Carpenter, Editors, *A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation* at www.bioinitiative.org, December 31, 2012. For references for other information on this chart, including the FCC Maximum Permitted Exposure limits, and the power densities of Smart Meters and Smart Appliances, see accompanying paper.



Eng. Lawrence James Gust Comments, Aug. 20, 2013

AFFIDAVIT OF (your name) LAWRENCE JAMES GUST

State of California

Ventura County

I, Lawrence James Gust, attest that my statements are true to the best of my knowledge.

Comment round for FCC ET Docket No. 013-84 and ET Docket No. 03-137

1. My name is Lawrence James Gust . My address is 211 S Brent St, Ventura, CA
2. I am an electrical engineer and a certified Building Biology Environmental Consultant.
3. My statement follows on pages 3 and 4

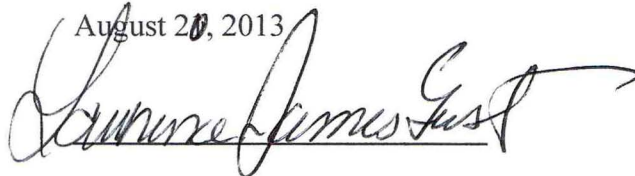
Respectfully submitted by

Lawrence James Gust

211 S. Brent St.

Ventura, CA, 93003

August 20, 2013



(your signature)

(should you so choose)

Sworn to before me

This 20 day of Aug, 2013


Notary Public



GUST ENVIRONMENTAL

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Monday, August 19, 2013

Federal Communications Commission
Washington, DC

Comments for Dockets - ET Docket No. 03-137 and ET Docket No. 13-84.

My name is Lawrence J. Gust, Ventura, CA. I am a degreed electrical engineer with an MBA. I have been an environmental consultant for 20 years working through doctors with patients suffering from multiple chemical sensitivities and electrical Hyper Sensitivity. In these cases the doctor believes that the patient's home plays a role in their illness or in their inability to respond to treatment.

I would like to remind the FCC of the Federal court's decision in In 1965, dealing with a this federal agency's responsibility to protect the environment (Scenic Hudson v. Federal Power Commission) in which the court said:

- If the Commission is properly to discharge its duty in this regards, the record on which it bases its determination must be complete. The petitioners and the public at large have a right to demand this completeness. It is our view, and we find, that the Commission has failed to compile a record which is sufficient to support its decision. The Commission has ignored certain relevant factors and failed to make a thorough study of possible alternatives . . .
- . . . the public is entitled to know on the record that no stone has been left unturned.
- The Commission of its own motion, should always seek to insure that a full and adequate record is presented to it.
- A regulatory commission can insure continuing confidence in its decisions only when it has used its staff and its own expertise in manner not possible for the uninformed and poorly financed public.
- The Commission must see to it that the record is complete. The Commission has an affirmative duty to inquire into and consider all relevant facts.

Over my 20 year career in this field, the instances of people with Electromagnetic Hyper Sensitivity Syndrome (EHS) has increased from nearly zero to more than 50% of my practice. There is no factor that can so fully account for this dramatic increase across such a broad population other than the increase in man-made electromagnetic radiation now millions of times greater than it was 20 years ago.

Just to be clear EHS is also referred to as Idiopathic environmental intolerance to electromagnetic fields. Sufferers of electromagnetic hypersensitivity report responding to non-ionizing electromagnetic fields (or electromagnetic radiation) at intensities well below the limits permitted by international radiation safety standards.

Page 3/4

Electrical Engineer

Certified Electromagnetic Radiation Safety Advisor

Certified Building Biological and Ecology Consultant

Member, National Electromagnetic Field Testing Association

Faculty and Board of the International Institute for Building Biology and Ecology, Inc.

JA 04133

The client reported symptoms of EHS include severe and frequent headache, fatigue, stress, sleep disturbances, skin symptoms like prickling, burning sensations and rashes, pain and ache in muscles, digestive disturbances and many other health problems. EHS symptoms are a real and sometimes disabling problem for the affected persons.

When I have been called into such cases, measurements of RF radiation has shown power density levels significantly below levels now set by FCC regulations. However, the power density levels in these cases are above levels described in peer reviewed research looking at cellular level affects of RF radiation. These studies are cited in the *2012 Bio-Initiative Report* which is appended to this statement.

Many of the patients I deal with had no history of sensitivity to chemicals or EMF including RF prior to the onset of some initial sensitizing RF event. These people led what would be described as normal lives in middle class and upper middle class surroundings. The most frequent initial sensitizing event over the last two years has been the installation of a power company smart meter.

The human dimension of EHS is tragic. I have people calling me in ever increasing numbers reporting the total change in their life circumstances and begging me for help to return to a normal life. These people are enduring enormous suffering. They have very painful, frequent headaches; they have burning skin; they have heart arrhythmia; they have pain in extremities; they have mental confusion; they have memory loss. They have lost their unalienable rights...

"We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness.--That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed."

My clients are unable to work because places of employment are loaded with wireless devices. They are unable to drive to work because the roadways are flanked by cell phone towers irradiating passing vehicles with significantly high levels of RF compared to studies on cellular level effects. They are unable to live in urban and suburban areas of California as houses are being irradiated by ever increasing numbers of cell phone antennas, utility smart meters and neighbor's wireless devices.

More to the point, when remediation was done to reduced RF radiation through shielding of the residence, symptoms were abated or reduced depending on the initial power density and the overall ability of the shielding plan to obtain significant reduction in RF. The ability to reduce RF enough to be effective is a costly process and economic constraints prevent many people from effecting the best remediation plan or any plan at all.

Finally, I am greatly concerned about the 4G cell phone system as the frequencies envisioned for this service go as high as 8 GHz, more than four time the current maximum frequency. The four fold reduction in wave length will significantly reduce the effectiveness of some types of already installed shielding. This situation will adversely affect people who have already paid thousands of dollars for shield to provide themselves with some measure of relief from the health problem brought on by their original exposure.

Respectfully Submitted this 19th day of August, 2013,

Lawrence James Gust
Ventura, CA



BioInitiative 2012

A Rationale for Biologically-based Exposure Standards for Low-Intensity Electromagnetic Radiation

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Cite this report as: BioInitiative Working Group, Cindy Sage and David O. Carpenter, Editors.
BioInitiative Report: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation at
www.bioinitiative.org, December 31, 2012

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PREFACE

The Organizing Committee thanks the participants of the BioInitiative Working Group for their integrity and intellectual courage in dealing with this controversial and important topic; and for devoting the time and energy to produce their chapters. The information and conclusions in each chapter are the responsibilities of the authors of that chapter.

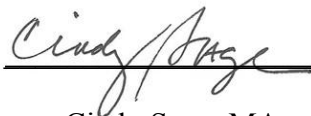
The Group has produced what the authors hope will be a benchmark for good science and public health policy planning. It documents bioeffects, adverse health effects and public health conclusions about impacts of non-ionizing radiation (electromagnetic fields including extremely-low frequency ELF-EMF and radiofrequency/microwave or RF-EMF fields).

Societal decisions about this body of science have global implications. Good public health policy depends on acting soon enough, but not without cause, and with enough information to guide intelligent actions. To a great degree, it is the definition of the standard of evidence used to judge the scientific reports that shapes this debate. Disagreement about when the evidence is sufficient to take action has more to do with the outcome of various reviews and standard-setting proceedings than any other single factor. Whatever “standard of evidence” is selected to assess the strength of the science will deeply influence the outcome of decisions on public policy.

We are at a critical juncture in this world-wide debate. The answers lie not only in the various branches of science; but necessarily depend on the involvement of public health and policy professionals, the regulatory, legal and environmental protection sectors, and the public sector.

This has been a long-term collaboration of international scientists employing a multi-disciplinary approach to problem assessment and solving. Our work has necessarily relied on tools and approaches across the physical, biological and engineering sciences; and those of the environmental scientist and public health professional. Only when taken

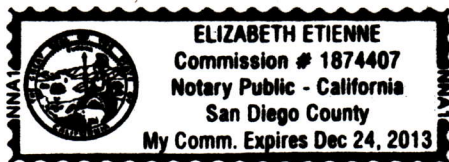
together can we see the whole and begin to take steps that can prevent possible harm and protect future generations.

Signed:  Signed: 
David Carpenter, MD
Co-Editor
BioInitiative Report
Cindy Sage, MA
Co-Editor
BioInitiative Report

Eng. Michael Schwabe Comments, Feb. 23, 2013

CALIFORNIA ALL-PURPOSE ACKNOWLEDGMENT

State of California

County of San DiegoOn September 3, 2013 before me, Elizabeth Etienne, Notary Publicpersonally appeared Michael J. Schwaabe
Name(s) of Signer(s)

who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) ~~is~~ subscribed to the within instrument and acknowledged to me that ~~he~~~~she~~~~they~~ executed the same in his/~~her~~/their authorized capacity(ies), and that by his/~~her~~/their signature(s) on the instrument the person(s), or the entity upon behalf of which the person(s) acted, executed the instrument.

I certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

Signature: Elizabeth Etienne

Signature of Notary Public

Place Notary Seal and/or Stamp Above

OPTIONAL

Though the information below is not required by law, it may prove valuable to persons relying on the document and could prevent fraudulent removal and reattachment of this form to another document.

Description of Attached DocumentTitle or Type of Document: Affidavit of Michael J. SchwaabeDocument Date: September 2, 2013 Number of Pages: 7

Signer(s) Other Than Named Above: _____

Capacity(ies) Claimed by Signer(s)

Signer's Name: _____ Signer's Name: _____

☐ Corporate Officer — Title(s): _____ ☐ Corporate Officer — Title(s): _____☒ Individual ☐ Partner — ☐ Limited ☐ General ☐ Individual ☐ Partner — ☐ Limited ☐ General☐ Attorney in Fact ☐ Attorney in Fact☐ Trustee ☐ Trustee☐ Guardian or Conservator ☐ Guardian or Conservator☐ Other: _____ ☐ Other: _____

Signer Is Representing: _____ Signer Is Representing: _____

document scanned and emailed

AFFIDAVIT OF Michael J. Schwaebe

State of California

San Diego County

I, Michael Schwaebe, attest that my statements are true to the best of my knowledge.

Comment round for FCC ET Docket No. 013-84 and ET Docket No. 03-137

1. My name is Michael Schwaebe. My address is 215 Andrew Ave, Encinitas, CA 92024.
2. I am a Professional Engineer and Building Biology Environmental Consultant.
3. **Request for Exposure Limits That Protect Humans from the Biological Effects of Non-Ionizing Radiation**

In this request I'm going to tell you what I would like to see come of this rule-making. Then I am going to provide examples, in my personal experience and those of my clients, as well as examples in the science supporting my request. I include reviews of some RFR exposure limits globally, along with a reference to a current trend where insurance companies are declining to cover damage from RFR exposure. I've also included a biography so that you know from where these comments are coming, e.g., an engineer that served in USN nuclear submarines and worked at SCE's San Onofre Nuclear Generating Station.

4. What I Would Like to See in the Reassessment of RFR Exposure Limits for the General Public

- A. Acknowledge that the current thermal limits, based on a 6 minute RMS average, do not address the biological effects associated with the peak signal of our wireless devices, nor all of the research that shows biological effects as low as one millionth of the current limit.
- B. Reduction of the MPE limits to $10 \mu\text{W}/\text{cm}^2$, as is already the standard in China, India, Italy and Russia."
- C. Locate antennas and set maximum power levels in a way that minimizes effects on health and environment.
- D. Establish SAR limits that provide protection from the biological effects for all the possible users, e.g., age and size of head with handset pressed against the ear.
- E. Publish an FCC guidance document with a title something like this: "Moderating Personal Exposure (And Biological Health Effects) from Non-Ionizing Radiation Emitted by Wireless Electronic Devices."
- F. Publication of a standard that sets limits for RFR emissions from personal wireless devices, e.g. Wi-Fi, WLAN, cordless mouse, keyboard, monitor, cordless telephone, tablets, eReaders and game toys, that provides guidelines to minimize personal exposure to the devices.
- G. Establishment of an independent research fund and organization to manage RFR research.