



## **SECTION 23**

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# **The Precautionary Principle**

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## I. INTRODUCTION

In 2007, the evidence for EMF, and in particular radiofrequency radiation (RFR) from the use of mobile phones, was a focus for discussion in the BioInitiative Report (2007). It arose from growing scientific evidence of possible health risks, with a very large global population that could presumably be affected by the outcome.

Illustrating the importance of observing ‘early warnings’ of environmental and public health risks arising from emerging scientific studies and direct observation of impacts to peoples’ health, this author wrote about the importance of applying ‘lessons learned’ from the histories of selected public and environmental hazards, from the first scientifically based early warnings about potential harm, to the subsequent precautionary and preventive measures, as reviewed by the European Environment Agency in Late Lessons from Early Warnings: the Precautionary Principle 1896-2000 (EEA, 2001). In considering the evidence on mobile phones and head cancers the EEA concluded that it would be prudent and timely to issue an “early warning” on the issue, in September, 2007. Five years on, this note briefly updates our opinion on this issue.

## II. NEED FOR PRECAUTIONARY ACTIONS ON MOBILE PHONES

The communication leaflet for publication of “Late Lessons from Early Warnings 2: Science, Precaution, Innovation.” (EEA, 2012) includes this message:

*“In the context of scientific uncertainty and ignorance, the decision-makers responsible for incentivising and regulating innovation face a significant challenge in balancing opportunities against risks. The precautionary principle can help to better manage such choices. It requires actions to prevent potentially serious harm before the likelihood or severity of an innovation's impacts become all too clear.”*

Volume 2 of ‘Late Lessons’ includes a chapter on mobile phones and brain tumour risk by Hardell, Carlberg and Gee. Inclusion of a full chapter on the science and public health implications of the mobile phone-brain cancer issue underscores the importance to the European Environmental Agency that mobile phone radiation is a possible health threat. This position is supported by the 2011 classification by the World Health

Organization International Agency for Research on Cancer (IARC) of radiofrequency radiation as a Group 2B Possible Human Carcinogen (Baan et al, 2011).

The evidence in 2012 is stronger than in 2007, and based essentially on two large population studies, the Hardell group in Sweden and the Interphone Study Group which involved 13 countries (WHO Interphone Final Report, 2010; Cardis & Radetski 2010; Hansson Mild et al, 2007; Hardell et al, 2006a, 2006b, 2006c; Hardell et al, 2008; Hardell et al, 2009a, 2009b; Hardell et al, 2010; Hardell et al, 2011a, 2011b; Hardell et al, 2012a in press; Hardell et al, 2012b in press). Are all 12 refs from Hardell needed? Looks like overkill...how about those from 2009?

Some researchers have identified in the last five years “*a consistent pattern of increased risk of glioma and acoustic neuroma associated with use of mobile phones and cordless phones.*” (Hardell et al, 2012b in press), a view that is essentially supported by the leader of the Interphone study. (Cardis & Radetski )

The European Environmental Agency’s view on the need for precautionary measures on mobile phones is more warranted in 2012, than it was in 2007, or even early 2011, prior to the IARC decision, when we last reviewed the evidence for a presentation to the Council of Europe (EEA, 2011).

Precautionary actions that can be taken to reduce exposures to RFR would be consistent with actions that have been recommended for other emerging environmental and health issues, for example some uses of the common plastic, BPA, some nanotechnologies, and some food chain additives or contaminants, such as antibiotics, beef hormones, and GMOs. The 25 or so more historical case studies in the ‘Late Lessons’ volumes such as those on the Minamata Bay disaster, asbestos, leaded petrol, and tobacco illustrate the huge costs of not taking robust early warnings seriously.

Precautionary measures are of particular importance in regard to children, who are generally more biologically sensitive, may be unable to protect themselves; and for whom such exposures may carry greater life-time health risks than they do for adults.

The evidence for a brain tumour risk from mobile phones is still not well established

amongst all researchers in the field and there is much scientific controversy about what the current evidence means. The debate is not helped by what might be termed ‘trial by media’ where some scientific advocates leap into the lay press to argue their own case just as, or even before, their research is published. The effects of this behaviour would be minimized if the results of genuine differences of scientific opinion were made transparent when they were published, with clear explanations about the origins of divergent views, such as the scientific paradigms used (“tissue heating” or “information physics” ?); assumptions made; evidence rejected; and values chosen. This does not tend to happen. Divergent scientific views are often smoothed over with the use of what one respected commentator on the reporting of the Interphone results called “oracular” sentences (Saracci & ?? 2010 ?) which thereby give the media and others the opportunity to report quite opposite conclusions from the same study, as was the case with the Interphone study.

We note that countries including France, Germany, Belgium, Austria, Italy, Russia, India and others have moved toward cautionary warnings and some have revised some target exposure levels for new wireless facilities in line with recommendations issued in 2007. Further actions appear now to be warranted, especially in light of the authoritative 2011 IARC cancer classification.

The IARC, and the EEA, may be wrong to suggest there could be a brain tumour risk from the extensive use of mobile phones, and we dearly hope we are wrong. However, it is worth noting that during over 30 years of classifying cancer risks, covering around 900 agents, IARC very rarely downgrades its judgements: in most cases tentative carcinogens become more certain carcinogens as time since first exposures and further research accumulates. Is it not worth gambling that mobile phones will be one of those very rare cases where IARC has over-classified an agent? We think not. The human cost of getting such a gamble wrong would be too great, especially in light of the relatively low cost of reducing exposures significantly.

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## **SECTION 24**

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# **Key Scientific Evidence and Public Health Policy Recommendations**

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## I. INTRODUCTION

In public health and environmental policy-making, asking the right questions is a highly evolved art form. It is necessary to periodically look for ‘*not-so-early-now warnings*’ from new science and medical information. At some point it becomes ‘*old news*’ in the real-world process of commercializing new technologies\* and is ignored. Precious time is lost if the ‘*evidence curve*’ does not come quickly enough to ‘*change the rollout curve*’ and result in early enough interventions. EMF may be a highly preventable source of disease but not without early enough translation of the science into action. The time for arguing whether EMF health effects exist is over. We know they exist and that they result in human disease.

Asking the right questions and looking for proportionate responses necessarily involves make mid-course corrections guided by new evidence. This is particularly true when the consequences of doing nothing are too great to ignore – because they will affect billions of people in societies around the world. “*While there are many unanswered questions, the cost of doing nothing will result in an increasing number of people, many of them young, developing cancer.*” (Carpenter, 2010).

What questions should be asked now, to move forward on the body of evidence? How much evidence do we need to act? Do we have enough? What standard of evidence should be used to judge (purely scientific vs precautionary public health). What is a relevant biological ‘dose’? How long does a biological effect last? Are we accounting for differences among individuals or different types of cells?

Which of the studies are truly measuring chronic exposures (is a one-month or a one-year study really revealing chronic effects; if mid-length studies show no effect, does this tell us anything useful)? Why is it still considered reasonable to base safety standards on time-averaged radiofrequency exposures when the technologies today use pulsed RFR?

\*Electronics, the internet, cellular telecommunications, wireless medical technologies, and wireless sensors for energy conservation, electric utilities management, transportation, education, banking and national security.



For example, the collective behavior of neurons is established through synchrony.

*“Individual neurons have a time window of tens of milliseconds range for single neurons, but oscillatory coalitions of neurons can expand the effect window of synchronization from hundreds of milliseconds to many seconds”* (Buzsaki, 2006). This means the time span a bioeffect can last long enough to overlap with the next environmental provocation (pulsed RFR in this case) so that repetitive exposures may induce an unending cascade of neurological firing that eventually disrupts normal homeostasis and causes chronically abnormal function in cooperative assemblies of cells like neurons. RFR is bioactive and already classified as a Possible Human Carcinogen but the relevant RFR bursts are camouflaged and their relevant metrics are diluted away by time averaging. Why is it reasonable to use safety standards that were developed to guard against induced currents in tissue (ELF-EMF) or that heat or burn tissue (RFR)?

Briefly stated, here is what we knew in 2007.

- Bioeffects and adverse health effects of chronic exposure to low-intensity (non-thermal) non-ionizing radiation are established.
- Existing FCC and ICNIRP public safety limits are not sufficiently protective of public health.
- The World Health Organization has classified ELF-EMF as a Group 2B Possible Human Carcinogen (2001).
- New, biologically-based public exposure standards are critically needed.
- It is not in the public interest to wait.

Here is what we know in 2012. There is more evidence, over a broader range of studies. The levels of biological responses are extraordinarily low (down to the nanowatt and picowatt power density level).

New studies address fertility and reproduction, fetal and neonatal effects, cognitive and behavioral problems in children and neurological damage. There are more mobile phone base station studies with longer testing periods, much more information on genetic damage and confirmation of increased risk of brain cancers from not one or two

studies, but from many studies and many authors including the World Health Organization's massive 13-country INTERPHONE STUDY (Interphone Study Group, 2010).

There are many studies reporting effects of cell phone radiation (even on standby-mode), wireless laptop exposure, cell phone use by mothers resulting in altered fetal brain development in the offspring, and more evidence that the blood-brain barrier and memory are at risk from cell phone use. There is evidence from human and animal studies that key areas of the brain are negatively affected by RFR at legal levels.

There is better understanding of the important physical and biological factors that make ELF-EMF and RFR potent disruptors of living tissues and basic metabolic processes. More and more, EMF devices are being used for medical treatments in cancer, bone and wound healing and re-tuning the nervous system. Increased depth of evidence in many threads is presented in this report by well-regarded scientists and researchers from around the world. The number of good studies has grown. The exposure levels causing effects are documented to be much lower than in the past. The epidemiological evidence is now showing risks for a variety of adverse health outcomes. All this should be taken seriously by governments, and translated quickly into more protective safety standards, and in the interim, into strong preventative actions, warnings and substitution of safer technologies and redesigned devices.

Bioeffects are clearly established and occur at very low levels of exposure to electromagnetic fields and radiofrequency radiation. Bioeffects can occur in the first few minutes at levels associated with cell and cordless phone use. Bioeffects can also occur from just minutes of exposure to mobile phone masts (cell towers), WI-FI, and wireless utility 'smart' meters that produce whole-body exposure. Chronic base station level exposures can result in illness.

Many of these bioeffects can reasonably be expected to result in adverse health effects if the exposures are prolonged or chronic. This is because they interfere with normal body processes (disrupt homeostasis), prevent the body from healing damaged DNA, produce immune system imbalances, metabolic disruption and lower resistance to disease across multiple pathways. Essential body processes can eventually be disabled by incessant external stresses (from system-wide electrophysiological interference) and lead to pervasive impairment of metabolic and reproductive functions.

## **What does the WHO IARC Classification of ELF-EMF and RFR as Group 2B Possible Human Carcinogens Mean?**

The World Health Organization International Agency for Cancer Research (IARC) designated ELF-EMF as a Group 2B (Possible) Carcinogen in 2001. This is the kind of exposure from power lines, battery switching in cell phone devices, laptop computers and appliances. The World Health Organization specifically reaffirmed its finding that EMF is classifiable as a Group 2B Possible Human Carcinogen in 2006 in their Health Criteria Monograph #238 (WHO, 2007).

### **World Health Organization International Agency for Research on Cancer (IARC) Cancer Classifications**

Group 1	Known Carcinogen
Group 2A	Probable Carcinogen
Group 2B	Possible Human Carcinogen
Group 3	Insufficient Information
Group 4	Not a Carcinogen

In 2011, IARC determined that scientific evidence is sufficient now to classify radiofrequency radiation as a Group 2B Possible Human Carcinogen (Baan et al, 2011). This is the kind of exposure coming from cell and cordless phones, cell towers, WI-FI, wireless laptops, electronic baby monitors and wireless ‘smart’ utility meters.

So, what does this mean? According to the classification categories, it is again clear IARC did NOT find so little clear and consistent evidence that it should support a finding of “Not A Carcinogen”. That would be the valid test that RFR is safe, as best public health experts can judge the evidence. Nor did IARC find that the evidence sufficient so as to make a stronger classification (Probably or Known Carcinogen). Rather, IARC found the evidence supports classification as a “Possible” cancer-causing

agent. That is not a weak or reckless judgment made with few facts. It should be a strong warning to governments to reconsider their safety standards, particularly in light of the billions of people at potential health risk from new wireless technologies. Studies of cell and cordless phones and of wireless whole-body RFR exposures consistently show human health impacts that have become ‘epidemiologically visible’ (Sections 11 and 21).

### **ELF-EMF AND RFR ARE CLASSIFIED AS POSSIBLE CANCER-CAUSING AGENTS – WHY ARE GOVERNMENTS NOT ACTING?**

The World Health Organization International Agency for Research on Cancer has classified wireless radiofrequency as a Possible Human Carcinogen (May, 2011). The designation applies to low-intensity RFR in general, covering all RFR-emitting devices and exposure sources (cell and cordless phones, WI-FI, wireless laptops, wireless hotspots, electronic baby monitors, wireless classroom access points, wireless antenna facilities, etc). The IARC Panel could have chosen to classify RFR as a Group 4 – Not A Carcinogen if the evidence was clear that RFR is not a cancer-causing agent. It could also have found a Group 3 designation was a good interim choice (Insufficient Evidence). IARC did neither.

## **II. KEY SCIENTIFIC EVIDENCE (2006- 2012)**

Many thousand scientific studies over four decades have provided warnings of serious biological effects and potential health harm from EMF and RFR. About 1800 new, scientific papers published in the last five years report more bioeffects and adverse health effects of EMF and RFR, and are presented in great detail in the BioInitiative Report 2012.

These studies since 2006 give critical support to the argument that current safety standards are grossly inadequate. They cannot be protecting public health if they do not prevent harm to a variety of types of human cells, human sperm and the developing fetus *in-utero*. These are all effects reported today due to cell phone radiation exposures that are both legal and common in daily home, business and school environments. These effects are shown to occur at very low-intensity permissible levels that have become ‘typical’ for pregnant women, the fetus, the infant, the child, and for adults. Such effects are occurring at hundreds to thousands of times lower intensity exposure levels than the current FCC public safety limits allow. These exposure levels are common in the

environment, but worst in close proximity to wireless devices like cell and cordless phones, ‘smart’ wireless utility meters, wireless routers, wireless classroom access points and laptops, to baby surveillance devices, and in the first few hundred meters of cell towers. WI-FI levels of RFR and cell phones-on-standby mode are sufficient to cause effects that, if chronic, may be damaging to the health of cellular DNA, reproductive germ cells (sperm) and the male reproductive organs.

Overall, these new studies report abnormal gene transcription (Section 5); genotoxicity and single-and double-strand DNA damage (Section 6); stress proteins because of the fractal RF-antenna like nature of DNA (Section 7); chromatin condensation and loss of DNA repair capacity in human stem cells (Sections 6 and 15); reduction in free-radical scavengers - particularly melatonin (Sections 5, 9, 13, 14, 15, 16 and 17); neurotoxicity in humans and animals (Section 9), carcinogenicity in humans (Sections 11, 12, 13, 14, 15, 16 and 17); serious impacts on human and animal sperm morphology and function (Section 18); effects on offspring behavior (Section 18, 19 and 20); and effects on brain and cranial bone development in the offspring of animals that are exposed to cell phone radiation during pregnancy (Sections 5 and 18). This is only a snapshot of the evidence presented in the BioInitiative 2014 updated report.

Many of these bioeffects are associated with disruption of normal biological functioning in the genes, and in the physiology of the nervous and cardiac systems of the body (brain, blood-brain barrier, heart, vascular system). Sleep disruption (insomnia) is a hallmark bioeffect of RFR. Hypersensitivity disorders like allergies and asthma are reported from exposure to environmental chemicals and to EMF. A pregnant woman’s exposure to EMF has been linked to increased asthma and behavioral problems in the human child after *in-utero* exposure. Pregnant mice exposed to cell phone radiation give birth to baby mice with attention disorders, hyperactivity and impaired memory function, similar to effects seen in human babies as reported by Divan et al (2008).

**A. Stress, Stress Proteins and DNA as a Fractal Antenna:** The word stress invokes different concepts for people, but needs to be understood as a physiological response. BioInitiative author Martin Blank has described how both ELF-EMF and RFR produce stress proteins at very low exposure levels, and why this is only adaptive in the short-

term. Chronic exposures that trigger stress responses (stress proteins) regardless of their environmental cause are mal-adaptive if they go on too long. Any agent (EMF, ionizing radiation, chemicals, heavy metals, etc) that continuously generates stress proteins is not adaptive, and is harmful, if it is a constant provocation.

The work of Martin Blank and Reba Goodman of Columbia University has established that stress proteins are produced by ELF-EMF and RFR at levels far below current safety standards allow. Further, they think DNA is actually a very good fractal RF-antenna which is very sensitive to low doses of EMF, and may induce the cellular processes that result in chronic ‘unrelenting’ stress. That daily environmental levels of ELF-EMF and RFR can and do throw the human body into stress protein response mode (out of homeostasis) is a fundamental and continuous insult. Chronic exposures can then result in chronic ill-health.

**B. Fetal Effects and Fetal Development Studies:** Effects on the developing fetus from *in-utero* exposure to cell phone radiation have been observed in both human and animal studies since 2006. Divan et al (2008) found that children born of mothers who used cell phones during pregnancy develop more behavioral problems by the time they have reached school age than children whose mothers did not use cell phones during pregnancy. The July 2008 issue of Epidemiology reports that children whose mothers used cell phones during pregnancy had 25% more emotional problems, 35% more hyperactivity, 49% more conduct problems and 34% more peer problems (Divan et al, 2008).

Aldad et al (2012) showed that cell phone radiation significantly altered fetal brain development and produced ADHD-like behavior in the offspring of pregnant mice. Exposed mice had a dose-dependent impaired glutamatergic synaptic transmission onto Layer V pyramidal neurons of the prefrontal cortex. The authors conclude the behavioral changes were the result of altered neuronal developmental programming *in utero*. Offspring mice were hyperactive and had impaired memory function and behavior problems, much like the human children in Divan et al (2008).

A new study from Greece reports altered development of the cranial bones of the mouse fetus from low intensity (0.6 to 0.9 W/kg) *in-utero* 900 MHz cell phone radiation (Fragopoulou et al, 2009). They report “*our results clearly show that even modest exposure (e.g., 6-min daily for 21 days) is sufficient to interfere with the normal mouse developmental process.*”

Other new studies by Fragopoulou et al report that brain astrocyte development followed by proteomic studies is adversely affected by DECT (cordless phone radiation) and mobile phone radiation (Fragopoulou et al, 2012); and that whole body exposure with GSM 900MHz affects spatial memory in mice (Fragopoulou et al, 2010).

### **FETAL BRAIN DEVELOPMENT MAY BE ALTERED**

There is increasing evidence that fetal (*in-utero*) and early childhood exposures to cell phone radiation and wireless technologies in general is a risk factor for hyperactivity, learning disorders and behavioral problems in school.

Neonatal physician Carlo Bellieni of Italy found that heart rate variability is adversely affected in infants hospitalized in isolettes or incubators where ELF-EMF levels are in the 0.8 to 0.9  $\mu$ T range (8 to 9 mG) (Bellieni, 2008). Infants suffer adverse changes in heart rate variability, similar to adults. He also reported that newborns cared for in the high ELF-EMF environments of isolettes have disrupted melatonin levels (Bellieni et al, 2012a).

**C. Studies of Sperm:** Several international laboratories have replicated studies showing adverse effects on sperm quality, motility and pathology in men who use and particularly those who wear a cell phone, PDA or pager on their belt or in a pocket (Agarwal et al, 2008; Agarwal et al, 2009; Wdowiak et al, 2007; De Iuliis et al, 2009; Fejes et al, 2005; Aitken et al, 2005; Kumar, 2012). Other studies conclude that usage of cell phones, exposure to cell phone radiation, or storage of a mobile phone close to the testes of human males affect sperm counts, motility, viability and structure (Aitken et al, 2004; Agarwal et al, 2007; Eroglu et al., 2006). Animal studies have demonstrated oxidative and DNA damage, pathological changes in the testes of animals, decreased sperm mobility and viability, and other measures of deleterious damage to the male germ line

(Dasdag et al, 1999; Yan et al, 2007; Otitolaju et al, 2010; Salama et al, 2008; Behari et al, 2006; Kumar et al, 2012). There are fewer animal studies that have studied effects of cell phone radiation on female fertility parameters. Panagopoulous et al. 2012 report decreased ovarian development and size of ovaries, and premature cell death of ovarian follicles and nurse cells in *Drosophila melanogaster*. Gul et al (2009) report rats exposed to stand-by level RFR (phones on but not transmitting calls) caused decrease in the number of ovarian follicles in pups born to these exposed dams. Magras and Xenos (1997) reported irreversible infertility in mice after five (5) generations of exposure to RFR at cell phone tower exposure levels of less than one microwatt per centimeter squared ( $\mu\text{W}/\text{cm}^2$ ).

Agarwal et al (2009) evaluated the effect of cell phone radiation during talk mode on human sperm samples. The authors found *“radiofrequency electromagnetic waves emitted from cell phones may lead to oxidative stress in human semen. We speculate that keeping the cell phone in a trouser pocket in talk mode may negatively affect spermatozoa and impair male fertility.”*

Aitken et al (2005) studied the effect of 900 MHz cell phone radiation on mice (7 days, 12-hr per day at 0.09 W/kg). The authors found statistically significant damage to the mitochondrial genome of epididymal spermatozoa ( $p < 0.05$ ).

Avendano et al, 2012 provided evidence that a 4-hr exposure to WI-FI at exceeding low levels ( $0.5\text{--}1.0 \mu\text{W}/\text{cm}^2$ ) near a laptop computer caused decreased sperm viability and DNA fragmentation in human sperm samples. Avendado says *“(T)o our knowledge, this is the first study to evaluate the direct impact of a laptop use on human spermatozoa. Ex vivo exposure of human spermatozoa to a wireless internet-connected laptop decreased motility and induced DNA fragmentation by a nonthermal effect. We speculate that keeping a laptop connected wirelessly to the internet on the lap near the testes may result in decreased male fertility.”*

De Iuliis et al (2009) reported that *“RF-EMR in both the power density and frequency range of mobile phones enhances mitochondrial reactive oxygen species generation by human spermatozoa, decreasing the motility and vitality of these cells*



*while stimulating DNA base adduct formation, and ultimately DNA fragmentation.”* They warned their findings “*have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and wellbeing of their offspring*” based on damage from a 6-hr exposure to 1800 MHz cell phone radiation in human sperm cells. This 6-hr exposure caused reduced sperm motility and viability and caused a significant increase in reactive oxygen species (free radicals that are associated with oxidative damage to DNA), and the effects were worse with more exposure (a significant dose-response was observed). Atasoy (2012) also questioned the safety of 2400 MHz exposure to those of reproductive age. This study reports that WI-FI internet access devices can damage DNA and reduce DNA repair when the exposures are very low (exposure level of 0.091 W/kg) and chronic; damage can occur even at levels that comply with 802.11 g WI-FI public safety limits.

Behari et al (2006) reported that chronic exposure of rats to cell phone radiation caused double-strand DNA breaks in sperm cells (35 days, 2-hr per day). This study also showed that the mobile radiation exposure at 900 MHz (at 0.9 W/kg) and at 2.45 GHz (at 0.1 W/kg) caused a statistically significant decrease in sperm count and the weight of testes.

Otitolaju et al., (2010) graphically describe sperm head abnormalities in mice exposed for six months to base-station level RF/MW at 70 to 100 nanowatts/cm<sup>2</sup> (0.07 – 0.1 µW/cm<sup>2</sup>). Only 2% of controls but a stunning 39% to 46% of exposed mice had damaged sperm.

*“The major abnormalities observed were knobbed hook, pin-head and banana-shaped sperm head. The occurrence of sperm head abnormalities was also found to be dose dependent. The implications of the observed increased occurrence of sperm head abnormalities on the reproductive health of humans living in close proximity to GSM base stations were discussed.”*

These studies taken together should provide a strong warning that ‘normal’ use of a cell phone presents risks that warrant strong preventative actions to protect the integrity of the human genome from de novo mutations and loss of fertility across entire male populations of cell phone users. Further, even the much lower exposure levels associated with mobile phone base station (cell tower) RFR levels are deleterious over time.

## HUMAN SPERM AND THEIR DNA ARE DAMAGED

Human sperm are damaged by cell phone radiation at very low intensities (0.00034 – 0.07  $\mu\text{W}/\text{cm}^2$ ). There is a veritable flood of new studies reporting sperm damage in humans and animals, leading to substantial concerns for fertility, reproduction and health of the offspring (unrepaired de novo mutations in sperm). Exposure levels are similar to those resulting from wearing a cell phone on the belt, or in the pants pocket, or using a wireless laptop computer on the lap. Sperm lack the ability to repair DNA damage.

**D. Human Stem Cell Studies:** Markova et al (2010) reported that 915 MHz microwave exposure significantly affects human stem cells. They found that very low-intensity microwave radiation from mobile phones can inhibit DNA repair processes in human stem cells. By placing a mobile phone at one meter distance from human stem cells in petri dishes (SAR = 0.037 W/Kg), they found a significant reduction in 53BP1 foci.

These foci are a measure of DNA repair in cells with double strand DNA damage. The damage was greater to stem cells (derived from adipose tissue in humans) than in fibroblasts. Stem cells did not repair over time - and the damage was done within one hour of microwave exposure. Fibroblasts were similarly affected (inhibited 53BP1 foci) but repaired over time. The effects are carrier-frequency dependent. The effects occurred with GSM exposure at 915 MHz, but not at 905 MHz. The failure of DNA repair also occurred at the mobile phone UTMS carrier frequency of 1947 MHz. Analysis of the 53BP1 foci is a sensitive technique to measure double-strand DNA breaks in both unexposed cells and in cells exposed to cytotoxic agents. In the authors' words, "*this represents a direct mechanistic link to epidemiological data showing an association of MW exposure with increased cancer risk.*" The data obtained from human stem cells is of "*utmost relevance for assessment of possible health risks of MW exposure from mobile phones.*" Most, if not all adult tissues and organs including blood, skin and brain contain stem cells. Therefore, "*stem cells like blood cells and fibroblasts are always subjected to exposure from mobile phones.*" With respect to children, because "*almost all organs and tissues possess stem cells and stem cells are more active in children, the possible relationship of chronic MW exposure and various types of tumors and leukemia especially in children should be investigated.*"

Czyz et al (2004) reported that GSM cell phone exposure affected gene expression levels in embryonic stem cells (p53-deficient); and significantly increased heat shock protein HSP 70 production.

#### **HUMAN STEM CELL DNA DOES NOT ADAPT OR REPAIR**

Human adipose tissue stem cells lack the ability to repair DNA damage caused by chronic exposure to non-thermal microwaves. Damage to DNA in some other cells may be incompletely repaired.

#### **E. Mobile Phone Base Station (Cell Tower) Studies**

Human Studies: Hutter et al (2006) reported that short-term exposure to GSM cell phone radiation resulted in complaints of headache, neurological problems, sleep and concentration problems in adults with 0.01 - 0.05  $\mu\text{W}/\text{cm}^2$  exposure levels. Kundi and Hutter (2009) reviewed human effects in fourteen (14) mobile phone base station studies and reported *“(F)rom available evidence it is impossible to delineate a threshold below which no effect occurs, however, given the fact that studies reporting low exposure were invariably negative it is suggested that power densities around 0.5–1 mW/m<sup>2</sup> [0.05 – 0.1  $\mu\text{W}/\text{cm}^2$ ] must be exceeded in order to observe an effect.”*

Buchner and Eger (2012) conducted an eighteen (18) month study to assess changes in stress hormones in 60 persons exposed before and after a mobile phone base station went into operation in the Rimbach village in Germany. The study showed that chronic exposure to base station RF (whole-body) at 0.006 - 0.01  $\mu\text{W}/\text{cm}^2$  in humans had significant impacts on stress hormones over time. In the beginning months, adrenaline levels first increased in a dose-dependent fashion according to exposure level ( $p < 0.002$ ) and then decreased below normal levels ( $p < 0.005$ ). Both the average as well as the median adrenaline values increased after the activation of the transmitter and decreased again after one year with exposure levels  $>0.006 \mu\text{W}/\text{cm}^2$ . Chronically ill subjects and children showed especially strong responses; except for some "outliers," no effect was observed in healthy adults (Buchner and Eger, 2012). For dopamine, inverse effects to

those for adrenaline and noradrenaline were observed. The median dopamine levels decreased from 199 to 115 µg/g creatinine between January and July 2004. The fact that the dopamine levels of the study subjects decreased during this period is highly significant ( $p < 0.0002$ ). Thereafter, the median increased again: In January 2005, it was at 131 µg/g creatinine, in July of 2005. This increase is also significant between July 2004 and July 2005 ( $p < 0.05$ ).

Buchner (2012) indicates that the RFR transmitter induced changes in stress hormones that follow the classic stress syndrome of adaptation, then exhaustion established by Hans Selye in the 1950's. *"After the stages of alarm and resistance, the last stage of exhaustion sets in. The parameters investigated in the Rimbach study follow this pattern"*.

A long-term 6-yr study assessed the role of exposure to radio frequency radiation (RFR) emitted either from mobiles or base stations and its relations with human's hormone profiles. The study revealed significant RFR effects on pituitary–adrenal axis, resulting in reduction of ACTH, cortisol, thyroid hormones, prolactin in young females, and testosterone levels in males (Eskander et al, 2012). But no direct measurements of RFR power density levels were made, only categories of distance from transmitter.

Oberfeld et al (2004) reported that populations exposed to base stations transmitting cell phone frequencies had more fatigue, depressive tendency, sleeping disorders, concentration difficulties, and cardio-vascular problems reported with exposure to GSM 900/1800 MHz cell phone signal.

Navarro et al (2003) reported that exposure levels of 0.01 - 0.11 µW/cm<sup>2</sup> resulted in fatigue, headaches, sleeping problems in populations around mobile phone base stations.

Thomas et al (2008) reported an increase in adult complaints of headaches and concentration difficulties with short-term cell phone use at 0.005 to 0.04 µW/cm<sup>2</sup> exposure levels.

Heinrich et al (2010) reported that children and adolescents (8-17 years old) with short-term exposure to base-station level RFR experienced headache, irritation, and concentration difficulties in school. RFR levels were 0.003 - 0.02 µW/cm<sup>2</sup>.

Thomas et al (2010) reported that RFR levels of 0.003 - 0.02  $\mu\text{W}/\text{cm}^2$  resulted in conduct and behavioral problems in children and adolescents (8-17 years old) exposed to short-term cell phone radiation in school.

Mohler et al (2010) reported that adults exposed to 0.005  $\mu\text{W}/\text{cm}^2$  cell phone radiation (base-station exposure levels) had sleep disturbances with chronic exposure, but this effect was not significantly increased across the entire population.

### **Human Studies at Base Station Exposure Levels (Cell Towers)**

At least five new cell tower studies with base-station level RFR at levels ranging from 0.003  $\mu\text{W}/\text{cm}^2$  to 0.05  $\mu\text{W}/\text{cm}^2$  published since 2007 report headaches, concentration difficulties and behavioral problems in children and adolescents; and sleep disturbances, headaches and concentration problems in adults. This is highly consistent with studies done prior to 2007, but the 'effect levels' are significantly lower (dropping from the microwatt to the nanowatt range per square centimeter).

Public safety standards are 1,000 – 10,000 or more times higher than levels now commonly reported in mobile phone base station studies to cause bioeffects.

Sperm studies are showing DNA damage, impaired sperm quality, motility and viability from cell phones on standby mode and wireless laptop use at exposures of 0.00034  $\mu\text{W}/\text{cm}^2$  to 0.07  $\mu\text{W}/\text{cm}^2$ . Several studies report sperm damage effects at 'standby model' cell phone emission levels, which are in the low nanowatt to picowatt per square centimeter range.

**F. Electrohypersensitivity (EHS) Studies:** McCarty et al (2011) studied electrohypersensitivity in a patient (a female physician). The patient was unable to detect the presence or absence of EMF exposure, largely ruling out the possibility of bias. In multiple trials with the fields either on or not on, the subject experienced and reported temporal pain, feeling of unease, skipped heartbeats, muscle twitches and/or strong headache when the pulsed field (100 ms, duration at 10 Hz) was on, but no or mild symptoms when it was off. Symptoms from continuous fields were less severe than with pulsed fields. The differences between field on and sham exposure were significant at the  $p < 0.05$  level. The authors conclude that electromagnetic hypersensitivity is a neurological syndrome, and statistically reliable somatic reactions could be provoked in this patient by exposure to 60-Hz electric fields at 300 volts per meter (V/m). They

conclude “*EMF hypersensitivity can occur as a bona fide environmentally inducible neurological syndrome.*” In their response to a letter to the editor of the journal, the authors say: “*(W)e followed an empirical approach and demonstrated a cause-and-effect relationship ( $p < 0.05$ ) under conditions that permitted us to infer the existence of electromagnetic hypersensitivity (EHS), a novel neurological syndrome.*” (Marino et al., 2012)

Further, the authors explain the significance of detecting EHS effects by non-linear methods.

*“The important issue at this point is not whether EMF can produce symptoms (we empirically demonstrated that it can) but rather why this effect historically has been difficult to detect. It occurred to us that EHS has remained elusive because of the way it was studied. The experiments designed to detect EHS had been based on the assumption that if it existed, it was a linear phenomenon, whereas EHS is actually a nonlinear phenomenon.” “Our study was designed to detect whether EHS was a linear or nonlinear phenomenon, and we were successful in showing a link between acute EMF exposure and somatic responses ( $p < 0.05$ ). This finding – taken together with the unfailingly negative results of the linear studies – is good evidence that EHS is a nonlinear phenomenon, as we suspected.”*

With the exception of the McCarty study there have not been clear demonstrations in controlled circumstances showing that persons reporting to be electrophysensitive can distinguish whether or not RFR is being applied. There are, however, multiple reports of symptoms experienced by individuals exposed to EMFs in uncontrolled circumstances.

A. Johansson et al (2010) studied symptoms, personality traits and stress in people with mobile phone-related symptoms and electromagnetic hypersensitivity. They reported there is support for a difference between people with symptoms related to specific EMF sources and people with general EHS. The symptoms are anxiety, depression, somatization, exhaustion and stress. The EHS group reported more neurasthenic symptoms.

Two publications on electrophysensitivity by O. Johansson (2007, 2009) provide an extensive overview of the relevant literature on electrophysensitivity. Both

publications document symptoms and conditions giving rise to increased sensitivity to ELF-EMF and RFR. The need for new, biologically-based public exposure standards is recommended in both publications, in order to address electrohypersensitivity.

Landgrebe et al (2007) reported that their study of electrosensitive patients showed participants had a reduced intracortical facilitation as compared to two control groups. The EHS group of patients showed altered central nervous system function. In a follow-up study, the authors reported that EHS patients but not controls “*demonstrated significant cognitive and neurobiological alterations pointing to a higher genuine individual vulnerability of electromagnetic hypersensitive patients.*” (Landgrebe et al, 2008).

The team of Sandstrom, Hansson Mild and Lyskov produced numerous papers between 1994 and 2003 involving people who are electrosensitive (Lyskov et al, 1995; Lyskov et al, 1998; Sandstrom et al, 1994; Sandstrom et al, 1995; Sandstrom et al, 1997; Sandstrom et al, 2003). Sandstrom et al (2003) presented evidence that heart rate variability is impaired in people with electrical hypersensitivity and showed a dysbalance of the autonomic nervous system. “*EHS patients had a disturbed pattern of circadian rhythms of HRF and showed a relatively ‘flat’ representation of hourly-recorded spectral power of the HF component of HRV*”. This research team also found that “*EHS patients have a dysbalance of the autonomic nervous system (ANS) regulation with a trend to hyper-sympathotonia, as measured by heart rate (HR) and electrodermal activity, and a hyperreactivity to different external physical factors, as measured by brain evoked potentials and sympathetic skin responses to visual and audio stimulation.*” (Lyskov et al, 2001 a,b; Sandstrom et al, 1997). The reports referenced above provide evidence that persons who report being electrosensitive differ from others in having some abnormalities in the autonomic nervous system, reflected in measures such as heart rate variability. At present it remains unclear whether EHS is actually caused by RF/EMF exposure, or rather is a self-identifying syndrome of excessive responsiveness to a variety of stimuli. But given the relatively high percentage of persons reported to be electrosensitive (5% of the general population of Switzerland according to Schreier et al,

2006), with some being severely disabled as a consequence, it is critical that there be more study of this syndrome.

Tuengler and von Klitzing et al (2012) reported EHS people that were tested showed significant changes in regulation of the autonomic nervous system, including changes in capillary blood flow (microcirculation), heart rate variability, and electric skin potentials. The continuous detection of capillary blood flow is an important tool in analyzing the capacity of the autonomic nervous system. In EHS patients, von Klitzing finds that intestinal motility may also be dysregulated and show no activity at all for some time after exposure.

**G. Effects on the Blood-brain Barrier (BBB):** The Lund University (Sweden) team of Leif Salford, Bertil Persson and Henrietta Nittby has done pioneering work on effects of very low level RFR on the human brain's protective lining – the barrier that protects the brain from large molecules and toxins that are in the blood.

#### **THE BLOOD-BRAIN BARRIER IS AT RISK**

*The BBB is a protective barrier that prevents the flow of toxins into sensitive brain tissue. Increased permeability of the BBB caused by cell phone RFR may result in neuronal damage. Many research studies show that very low intensity exposures to RFR can affect the blood-brain barrier (BBB) (mostly animal studies). Summing up the research, it is more probable than unlikely that non-thermal EMF from cell phones and base stations do have effects upon biology. A single 2-hr exposure to cell phone radiation can result in increased leakage of the BBB, and 50 days after exposure, neuronal damage can be seen, and at the later time point also albumin leakage is demonstrated. The levels of RFR needed to affect the BBB have been shown to be as low as 0.001 W/kg, or less than holding a mobile phone at arm's length. The US FCC standard is 1.6 W/kg; the ICNIRP standard is 2 W/kg of energy (SAR) into brain tissue from cell/cordless phone use. Thus, BBB effects occur at about 1000 times lower RFR exposure levels than the US and ICNIRP limits allow. (Salford, 2012)*

The consequence to modern life is that cell and cordless phone use may cause a pathological leakage of the BBB with very short use periods, and the damage may be long-lasting. Harmful substances may enter the brain. If the damage is ongoing (if cell and cordless phone use continues to occur over months and years), the potential for



harmful effects increases. There is already ‘epidemiologically visible’ evidence of increased brain cancer risk in humans (Section 11).

Volkow et al (2011a, b) reported increased glucose metabolism in the brain with cell phone use in humans. This important investigation of 47 human subjects used a randomized crossover design and labeled fluorodeoxyglucose to measure the metabolisms of the brain when the cell phone was activated but muted for 50 minutes as compared to not being activated. *“Our study showed that cell phone activation was associated with metabolic increases in brain regions closest to the antenna and that the increases showed a negative linear correlation with distance from the antenna. While the effect was small, the negative correlation of the effect with distance was statistically significant ( $R = -0.91$ ;  $P < .001$ ).* This study is particularly important in that it demonstrates definitively that an active cell phone, placed on the ear as one would normally be used, alters brain metabolic activity, but only in the region close to the cell phone.

**H. Brain Cancer Studies:** The Orebro University (Sweden) team led by Lennart Hardell, MD, an oncologist and medical researcher, has produced an extraordinary body of work on environmental toxins of several kinds, including the effects of radiofrequency/microwave radiation and cancer. Their 2012 work concludes:

*“Based on epidemiological studies there is a consistent pattern of increased risk for glioma and acoustic neuroma associated with use of mobile phones and cordless phones. The evidence comes mainly from two study centres, the Hardell group in Sweden and the Interphone Study Group. No consistent pattern of an increased risk is seen for meningioma. A systematic bias in the studies that explains the results would also have been the case for meningioma. The different risk pattern for tumor type strengthens the findings regarding glioma and acoustic neuroma. Meta-analyses of the Hardell group and Interphone studies show an increased risk for glioma and acoustic neuroma. Supportive evidence comes also from anatomical localisation of the tumor to the most exposed area of the brain, cumulative exposure in hours and latency time that all add to the biological relevance of an increased risk. In addition risk calculations based on estimated absorbed dose give strength to the findings.*

*In summary:*

- *There is reasonable basis to conclude that RF-EMFs are bioactive and have a potential to cause health impacts.*

- *There is a consistent pattern of increased risk for glioma and acoustic neuroma associated with use of wireless phones (mobile phones and cordless phones) mainly based on results from case-control studies from the Hardell group and Interphone Final Study results.*
- *Epidemiological evidence gives that RF-EMF should be classified as a human carcinogen.*
- *Based on our own research and review of other evidence the existing FCC/IEEE and ICNIRP public safety limits and reference levels are not adequate to protect public health.*
- *New public health standards and limits are needed.* (Hardell et al, 2012)

**I. Genetic Damage (Genotoxicity Studies):** There are at least several hundred published papers that report EMF affects cellular oxidative processes (oxidative damage). Increased free radical activity and changes in enzymes involved in cellular oxidative processes are the most consistent effects observed in cells and animals after EMF exposure. Aging may make an individual more susceptible to the detrimental effects of ELF EMF from oxidative damage, since anti-oxidants may decline with age. Clearly, the preponderance of genetic studies report DNA damage and failure to repair DNA damage.

Eighty six (86) new papers on genotoxic effects of RFR published between 2007 and mid-2012 are profiled. Of these, 54 (63%) showed effects and 32 (37%) showed no effects (Lai, 2012)

Forty three (43) new ELF-EMF papers and two static magnetic field papers that report on genotoxic effects of ELF-EMF published between 2007 and mid-2012 are profiled. Of these, 35 (81%) show effects and 8 (19%) show no effect (Lai, 2012).

**J. Nervous System Damage:** Factors that act directly or indirectly on the nervous system can cause morphological, chemical, or electrical changes in the nervous system that can lead to neurological effects. Both RF and ELF EMF affect neurological functions and behavior in animals and humans.

One hundred fifty five (155) new papers that report on neurological effects of RFR published between 2007 and mid-2012 are profiled. Of these, 98 (63%) showed effects and 57 (37%) showed no effects.

Sixty nine (69) new ELF-EMF papers (including two static field papers) that report on genotoxic effects of ELF-EMF published between 2007 and mid-2012 are profiled. Of these, 64 (93%) show effects and 5 (7%) show no effect. (Lai, 2012)

**L. Children are More Vulnerable:** Many studies demonstrate that children are more sensitive to environmental toxins of various kinds (Barouki et al, 2012; Preston, 2004; WHO, 2002; Gee, 2009; Sly and Carpenter, 2012).

The Presidential Cancer Panel (2010) found that children *'are at special risk due to their smaller body mass and rapid physical development, both of which magnify their vulnerability to known carcinogens, including radiation.'*

The American Academy of Pediatrics, in a letter to Congressman Dennis Kucinich dated 12 December 2012 states *"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."*

## II. ISSUES AND ANSWERS IN THE EMF DEBATE

Much of the emphasis in the 2007 Bioinitiative Report focused on cancer, which is still the best documented disease of concern from exposure to EMF/RF. The evidence that exposure to EMF/RF increases the risk of cancer has only gotten significantly stronger since then, and we have a better, albeit still incomplete, understanding of the mechanisms involved. However, in terms of threshold exposures that result in human disease, new research on male reproduction and neurobehavioral alterations provide evidence for harm at even lower exposure levels. RFR has been shown in this Report to act as an external synchronizer of neural activity, capable of disrupting sleep, circadian rhythms, diurnal hormone fluctuations, brain wave activity and heart rate variability by exposure to artificial electromagnetic signals (as opposed to natural evolutionary frequencies) and to do so at exceedingly low intensities.

Much of the debate over the body of EMF science ignores simple questions that would help to discriminate among studies with apparently conflicting results. Section 15 by Dr. Belyaev is helpful in identifying key factors which must be known and controlled for in experiments (biological variables and physical parameters include bandwidth, frequency, modulation, polarization, intermittence and coherence time of exposure, static

magnetic field, electromagnetic stray fields, sex, age, individual traits, and cell density during exposure). Dr. Andrew Marino emphasizes that detection of EMF/RFR effects require investigation of non-linear phenomena, a critical difference that if ignored, may miss important biological effects (Marino, 2012).

A unifying hypothesis for a plausible biological mechanism to account for very weak field EMF bioeffects other than cancer may lie with weak field interactions of pulsed RFR and ELF-modulated RFR as disrupters of synchronized neural activity. Electrical rhythms in our brains can be influenced by external signals. This is consistent with established weak field effects on coupled biological oscillators in living tissues. Biological systems of the heart, brain and gut are dependent on the cooperative actions of cells that function according to principles of non-linear, coupled biological oscillations for their synchrony, and are dependent on exquisitely timed cues from the environment at vanishingly small levels (Buzsaki, 2006; Strogatz, 2003). The key to synchronization is the joint actions of cells that co-operate electrically - linking populations of biological oscillators that couple together in large arrays and synchronize spontaneously according to the mathematics described for Josephson junctions (Brian Josephson, the 1993 Nobel prize winner for this concept). This concept has been professionally presented in journal articles and also popularized in print by Prof. Steven Strogatz, a mathematician at Cornell University who has written about 'sync' as a fundamental organizing principle for biological systems (Strogatz, 2001; 2003).

*“Organisms are biochemically dynamic. They are continuously subjected to time-varying conditions in the form of both extrinsic driving from the environment and intrinsic rhythms generated by specialized cellular clocks within the organism itself. Relevant examples of the latter are the cardiac pacemaker located at the sinoatrial node in mammalian hearts and the circadian clock residing at the suprachiasmatic nuclei in mammalian brains. These rhythm generators are composed of thousands of clock cells that are intrinsically diverse but nevertheless manage to function in a coherent oscillatory state. This is the case, for instance, of the circadian oscillations exhibited by the suprachiasmatic nuclei, the period of which is known to be determined by the mean period of the individual neurons making up the circadian clock. The mechanisms by which this collective behavior arises remain to be understood.”(Strogatz, 2003)*

Synchronous biological oscillations in cells (pacemaker cells) can be disrupted by artificial, exogenous environmental signals, resulting in desynchronization of neural

activity that regulates critical functions (including metabolism) in the brain, gut and heart and circadian rhythms governing sleep and hormone cycles (Strogatz, 1987). The brain contains a population of oscillators with distributed natural frequencies, which pull one another into synchrony (the circadian pacemaker cells). Strogatz has addressed the unifying mathematics of biological cycles and external factors disrupt these cycles. Buzsaki (2006) says *“rhythms can be altered by a wide variety of agents and that these perturbations must seriously alter brain performance. Rhythms are a robust phenomenon.”*

The heart's natural pacemaker center is the sinoatrial node, a cluster of about 10,000 cells that generate electrical rhythm that commands the rest of the heart to beat. Diseases related to disruption of that synchronization include epilepsy, chronic insomnia, and cardiac arrhythmias (Strogatz, 2003). Some EMF diseases are those where desynchronization of neural activity results in physiological changes that, if chronic, result in chronically disrupted homeostasis, and eventually ill-health and chronic diseases. Such a future burdens health care systems in an irreversible way.

The late Dr. Ross Adey in his last publication in Bioelectromagnetic Medicine (P. Roche and M. Markov, eds. 2004) concluded:

*“There are major unanswered questions about possible health risks that may arise from exposures to various man-made electromagnetic fields where these human exposures are intermittent, recurrent, and may extend over a significant portion of the lifetime of the individual.”*

*“Epidemiological studies have evaluated ELF and radiofrequency fields as possible risk factors for human health, with historical evidence relating rising risks of such factors as progressive rural electrification, and more recently, to methods of electrical power distribution and utilization in commercial buildings. Appropriate models describing these bioeffects are based in nonequilibrium thermodynamics, with nonlinear electrodynamics as an integral feature. Heating models, based in equilibrium thermodynamics, fail to explain an impressive new frontier of much greater significance. Though incompletely understood, tissue free radical interactions with magnetic fields may extend to zero field levels.”*

Our society appears determined to make everything wireless, and the consequence is to increase cumulative exposure to RFR. Many homes and almost every Starbucks or McDonalds has WiFi. Smart phones, tablets, video iPods and other wireless devices are even given to children as playthings. The result is a significant increase in cumulative RFR exposure of the whole population, but particularly of those who have and use wireless devices for prolonged periods of time. No national or international standard of RFR exposure considers cumulative effects, all being developed to avoid local tissue heating from acute exposures.

The issues around exposure of children to RFR is of critical importance. There is overwhelming evidence that children are more vulnerable than adults to many different exposures (Sly and Carpenter, 2012), including RFR, and that the diseases of greatest concern are cancer and effects on neurodevelopment. Yet parents place RFR baby monitors in cribs, provide very young children with wireless toys, and give cell phones to young children, usually without any knowledge of the potential dangers. A growing concern is the movement to make all student computer laboratories in schools wireless. A wired computer laboratory will not increase RFR exposure, and will provide safe access to the internet.

An urgent example for the need to address the lack of adequate public protection from inadequate safety standards for pulsed RFR exposures is the rapid, global rollout of wireless utility meters ('smart' meters for electricity, gas and water meters). Current safety standard calculations that rely on time-averaging of RFR almost entirely dilute out the power density of RFR levels that are delivered in millisecond bursts, but occur at intervals of every second, or multiple times per second when in use within a wireless mesh network. Said differently, the RFR power density levels are usually legal. While there have been no long term studies of adverse effects of smart meters on human health (primarily because they are so new), there are increasing reports from electrosensitive individuals of harm. Added together, these RFR pulses that now appear to be a highly bioactive agent but are essentially erased or made energetically invisible by time-averaging the pulses as current FCC safety rules mandate.

The wireless meters transmit RF signals like a mini-cell tower antennas in the cell phone radiation frequencies. Currently, they are being deployed in the US and are on the drawing boards around the world including many European countries. The 'smart meter' infrastructure represents the largest single commercial saturation of living space with pulsed RFR yet rolled out by industry. This program places a wireless device (like a mini-mobile phone base station) on the wall, replacing the electromechanical (spinning dial) meter. They will be installed on every home and classroom (every building with an electric meter). Utilities from California to Maine have installed tens of millions already, despite health concerns of experts who already are seeing thousands of health complaints. The wireless meters produce spikes of pulsed radiofrequency radiation on a continuous basis (24/7), and in typical operation, will saturate living space at levels that can be much higher than already reported to cause bioeffects and adverse health effects for some people. These meters, depending on where they are placed relative to occupied space in the home or classroom, can produce RFR exposure levels similar to that within the first 100 feet to 600 feet of a mobile phone base station (cell tower). In the not-so-distant future the plan is to have a wireless device implanted in every household appliance, which will communicate with the smart meter whenever electricity is being used. This will likely make the kitchen a major source of exposure to RFR.

The cumulative RFR burden within any community is largely unknown. Both involuntary sources (like cell towers, smart meters and second-hand radiation from the use of wireless devices by others) plus voluntary exposures from ones' personal use of cell and cordless phones, wireless routers, electronic baby surveillance monitors, wireless security systems, wireless hearing aids, and wireless medical devices like implanted insulin pumps all add up. No one is tallying up the combined exposure levels. Billions of new RFR transmitters from a global smart meter rollout will significantly add to the existing RFR body-burden of pulsed RFR for millions of people. The health concerns are the same as with all other sources of EMF/RFR. Cancer is a serious adverse effect, but damage to male reproduction and central nervous system effects may results from even lower levels of exposure. The work by Strogatz (2001, 2003) and Buzsaki (2006) on weak-field effects on non-linear biological oscillators (brain waves and synchronization of neural activities that regulate body processes) is directly relevant to an understanding

of the profound biological disruptions and health symptoms that continued exposures of pulsed RFR may produce.

### **The Commons of the Air**

Turning to questions of social equity and the individuals' choice not to be exposed to harmful levels of environmental toxins, there has been little inclusion of the public in discussions of wireless radiofrequency exposure. Wireless technologies have become infused in daily habits of billions of people; often choices for wired equivalents are lacking (or those that exist are disappearing). Involuntary exposure to EMF and RFR is becoming more the norm, even where it runs counter to individual choice (second-hand radiation, like second-hand smoke is difficult to avoid).

*“Wireless technologies drive electromagnetic energy through our air, into and through virtually all indoor and outdoor living environments. The protective air cushion around our planet holds breathable air, buffers us from space radiation, and supports and sustains life in tandem with the natural electromagnetic signature of the earth itself. We are changing this ‘commons of the air’ in major ways. Wireless signals from broadcast and communications technologies are crowding out and overpowering the natural background. The ‘commons of the air’ is being altered in unprecedented ways that have enormous consequences for life on earth.”(Sage, 2010).*

The rush to ‘buy the airwaves’ and to market them for commercial purposes is loading ‘*the commons of the air*’ with unsustainable levels of exposure (Sage, 2010). Commercial markets for wireless spectrum successfully lobby government regulators to allocate even more spectrum, once the existing frequencies are allocated. Sage (2010) asks:

*“Who owns the ‘commons of the air’? Who should be allowed to pollute it? What are the limits? On what basis should carrying capacity be defined? Who defines the limits? Do these limits conserve the resource for the future? Do they protect public health and welfare, and the health and well-being of other living things on earth? Who bears the burden of proof of safety or of harm? How should the ‘new commons’ be managed for the greater good? Do we know enough to act responsibly? Who decides? When should limits be placed on utilization?”*



With no regard to cumulative harm, this commercial rush to buy up wireless spectrum territorial rights has vast implications for public health and well-being. Environmental protections afforded to other natural resources under the National Environmental Policy Act have been ignored. The cumulative impacts and irretrievable commitments on humans, wildlife, and natural resources have never been assessed.

*“Societies must now define carrying capacity for chronic electromagnetic and wireless exposures. Taking into account the large individual variability to withstand it, new limits must conserve and sustain the ‘commons of the air’ so that is sustainable for all—and this includes sensitive populations, the young, the elderly, and those with existing sensitivity. Some countries of the world already have surpassed sustainable wireless exposure levels as demonstrated by significant percentages that have already become electrosensitive.” (Sage, 2010)*

### **Homeostasis and Human Health Rights**

Chronic exposure to low-intensity RFR and to ELF-modulated RFR at today’s environmental levels in many cities will exceed thresholds for increased risk of many diseases and causes of death (Sage and Huttunen, 2012). RFR exposures in daily life alter homeostasis in human beings. These exposures can alter and damage genes, trigger epigenetic changes to gene expression and cause de novo mutations that prevent genetic recovery and healing mechanisms. These exposures may interfere with normal cardiac and brain function; alter circadian rhythms that regulate sleep, healing, and hormone balance ; impair short-term memory, concentration, learning and behavior; provoke aberrant immune, allergic and inflammatory responses in tissues; alter brain metabolism; increase risks for reproductive failure (damage sperm and increase miscarriage risk); and cause cells to produce stress proteins. Exposures now common in home and school environments are likely to be physiologically addictive and the effects are particularly serious in the young (Sage and Huttunen, 2012). This declaration of human health rights below (Sage and Huttunen, 2012) is based on specific reference to health impacts of EMF and RFR that are reasonably well established to occur (Sage and Carpenter, 2009).

**Human Health Rights Declaration**  
***Fundamental Human Health Rights (Sage and Huttunen, 2012)***

*The right to homeostasis in our own bodies.*  
*The right to normal central nervous system function.*  
*The right to natural environmental cues that synchronize our circadian rhythms.*  
*The right to sleep.*  
*The right to heal.*  
*The right to hear.*  
*The right to reproduce.*  
*The right to learn and retain memories.*  
*The right to an intact genome.*

*If even one of these rights is compromised – placed at risk from involuntary wireless exposures in daily life, it is a breach of human health rights. When many of these human health rights are compromised without the consent of the individual, then the deployment of wireless technologies should be halted and existing exposures reduced or eliminated, in accord with the scientific and public health findings on chronic exposure to low-intensity radiofrequency radiation, and other forms of potentially harmful electromagnetic fields (Sage and Huttunen, 2012)*

## V. CONCLUSIONS FOR PRUDENT PUBLIC HEALTH PLANNING

### **Methodology and Approach for Precautionary Action Limits**

In 2007, the BioInitiative Report chapter on Key Scientific Evidence and Public Health Policy Implications, proposed a specific, interim radiofrequency radiation target level of 0.1  $\mu\text{W}/\text{cm}^2$  for cumulative, outdoor RFR exposure (for AM, FM, TV and wireless). It was based on best-available scientific studies to that date. There were few studies prior to 2006 that reported effects at less than 0.1 to 1  $\mu\text{W}/\text{cm}^2$  chronic RFR exposures.

In 2009, the journal Pathophysiology produced many peer-reviewed articles in a special two-volume edition on EMF (both ELF-EMF and RFR) essentially publishing the contents of the BioInitiative Report and updating some information. One of these 2009 Pathophysiology papers presented a review of mobile phone base station studies (Kundi and Hutter, 2009). It concluded that the overall studies did not detect effects (headache,

fatigue, tinnitus, concentration difficulties, sleep disruption, etc) at levels of RFR exposure below 0.05 to 0.1  $\mu\text{W}/\text{cm}^2$ .

New base station-level RFR studies are available in 2012 that can be analyzed to determine if new (and lower) RFR recommendations are warranted. The approach in this chapter relies on "lowest levels at which effects are not seen" akin to the "no observed effect level (NOEL)" used for chemical exposures, as a sufficient basis to establish scientific benchmarks for harm (or alternately, the lowest observed effects level of exposure). It is the province of the science and public health evaluation we do here to report the evidence regardless of what political or strategic complications it may create. An objective presentation of what the studies reveal for 'effects levels' is our goal; not to pre-judge or dilute the evidence because it may present strategic or political hurdles to achieve consensus on policy and regulatory changes. What this report does not intend to do is take into account "how could we do this" or "what would it mean". The purpose is to lay out the science, and make some defensible reductions for factors that studies cannot or do not yet test for, and compensate with deductions for them (safety margins). As interim targets for precautionary action, they will serve as guides for decision-makers who will take up the issues of health, the quality of the future gene pool, social equity and cost.

There is no one study alone that meets impeccable standards for exposure assessment or totally eliminates all possibility for bias, but the constellation of studies together gives adequate support to delineate a 'lowest observed effects level', that in turn, with added safety margins, can serve as a guideline for precautionary action.

A reduction from the BioInitiative 2007 recommendation of 0.1  $\mu\text{W}/\text{cm}^2$  (or one-tenth of a microwatt per square centimeter which is the same as 100 nanowatts/ $\text{cm}^2$ ) for cumulative outdoor RFR down to something three orders of magnitude lower (in the low nanowatt per square centimeter range) is justified on a public health basis. We use the new scientific evidence documented in this Report to identify 'effect levels' and then apply one or more reduction factors to provide a safety margin. We do note however, even a precautionary action level of several tenths of a nanowatt per square centimeter (or

several hundred picowatts per square centimeter) would still allow for cell phone transmissions (that can operate down to about 0.00003 V/m).

Even so, these levels may need to go lower in the future, as new and better studies are completed. This is what the authors said in 2007 (Carpenter and Sage, 2007, BioInitiative Report) and it remains true today in 2012. We leave room for future studies that may lower today's observed 'effects levels' and should be prepared to accept new information as a guide for new precautionary actions.

### **Establishing A Scientific Benchmark for 'Lowest Observed Effect Levels'**

Studies that provide information at 'new levels of observed effect' have been identified. These serve as scientific benchmarks for possible risk to health and well-being. Next, we identify reduction factors to compensate for sensitive subpopulations and apply them to the scientific benchmarks (lowest observed effect levels).

A ten-fold reduction factor is warranted (or higher) for studies that report effects from only short-term (i.e., acute) rather than chronic (i.e., long-term) exposures. Longer duration of exposure can cause bioeffects at lower exposures where these effects are NOT seen with shorter (acute) exposures (Belyaev, 1997; Belyaev, 2012). Chronic exposures with longer durations of weeks, months or years is what most populations face with respect to wireless classrooms, wireless offices and locations near base stations.

A second ten-fold reduction (or higher) is justified as a buffer for sensitive populations including children, the elderly and other adult groups that may be ill, already sensitized, in remission or suffer from ailments made worse by physiological stress and insomnia.

Studies which contribute together can reasonably contribute to delineating a new RFR lower effects level are primarily mobile phone (cell phone) base station studies of healthy human populations and studies of sperm damage in men who use and/or wear their wireless devices on or around the belt or pants pocket.

## **Power Density Studies (Mobile Phone Base Stations and Sperm/Fertility Studies)**

A scientific benchmark of 0.003 uW/cm<sup>2</sup> or three nanowatts per centimeter squared for 'lowest observed effect level' for RFR is based on mobile phone base station-level studies. The Thomas et al, (2008) study shows effects at a LOEL of 0.005 uW/cm<sup>2</sup> on adults exposed to short-term cell phone radiation only (it is not a chronic exposure study). Other studies that are relevant are Thomas et al (2010) with a LOEL of 0.003 uW/cm<sup>2</sup> and Heinrich et al (2010) with a LOEL of 0.003 uW/cm<sup>2</sup>. Both studied mixed child/adolescent populations of students, but have short-term test periods (are not chronic exposure studies) and have LOELs of 0.003 uW/cm<sup>2</sup>. Buchner et al (2012) shows a 0.006 uW/cm<sup>2</sup> 'effect level' and tests adult populations, but achieves 'chronic' exposure testing criterion (over 18 months). Applying a ten-fold reduction to compensate for the lack of long-term exposure (to provide a safety buffer for chronic exposure) or for children as a sensitive subpopulation yields a 300 to 600 picowatts per square centimeter precautionary action level. This is also equal to a 0.3 nanowatts to 0.6 nanowatts per square centimeter as a reasonable, precautionary action level.

Of the studies that deal with children and base-station level RFR exposures, none studied children exclusively, so the results may dilute out any apparent effects accruing to the younger test subjects. Thomas et al (2010) is a short-term exposure study of children and adolescents 8 to 17 years in age. Heinrich et al (2010) is a further study of the same population of 8 to 17 year olds over the short-term. A 100-fold reduction could be defended as reasonably conservative in this instance.

Behari et al (2006) provides the one sperm study expressed in power density units with a LOEL of 0.00034 uW/cm<sup>2</sup>. It is a chronic exposure study. The majority of sperm studies with good exposure information are expressed in SARs (W/kg). These range from LOELs of 0.014 (Kumar et al, 2012) to 0.091 W/kg (Atasoy et al, 2012) to 0.43 W/kg (Salama et al, 2008) to 0.795 W/kg (Panagopoulous et al, 2012) to 0.9 W/kg (Kesari et al, 2012). All the other sperm damage or ovarian damage studies have SARs

of greater than 1.0 W/kg (7 more studies). All are short-term studies. There are more sperm damage studies but without any measurements or other specific exposure information. These are studies that place sperm, or mice, or give prenatal exposures to animals close to sources of cell phone radiation. Such studies give weight to the argument that low-intensity RFR exposures can cause damage, but do not help in delineating LOELs because they have no specific exposure numbers, just distances.

Most of the sperm studies and base station studies which have exposures expressed power density (microwatts per square centimeter) have 'effect' levels in the nanowatt range (0.34 nanowatt/cm<sup>2</sup> to 100 nanowatt/cm<sup>2</sup>)\*. They include Behari and Kesari, 2006; Buchner and Eger, 2012; Oberfeld et al, 2004; Thomas et al, 2008, 2010; Heinrich et al, 2010; Navarro et al, 2003; and Otitoloju et al 2010. Avendano et al (2012) report that WI-FI exposure from a 4-hr laptop exposure decreased sperm viability and caused DNA fragmentation in human sperm samples (exposure in petri dishes) at 0.5 to 1.0 uW/cm<sup>2</sup>. The Kundi-Hutter 2009 Pathophysiology Journal review paper of base station studies through 2006 reports an overall NOEL below 0.05 to 0.1 uW/cm<sup>2</sup>. Overall, the new 2007-2012 power density studies are reporting 'lowest effects levels' two or three orders of magnitude lower than in 2006, down from the microwatt/cm<sup>2</sup> range to the nanowatt/cm<sup>2</sup> range.

### **SAR Studies (Sperm Studies and Ovarian Damage with Cell Phone Radiation Exposures)**

Studies on male fertility (adverse effects on sperm, on the testes size and morphology, etc) coming from cell phone-in-the-pocket-on-stand-by-mode and wireless laptop studies provide us with a flood of new data showing very low-intensity effects to guide precautionary actions and to educate the public about potential risks to health, fertility and reproduction.

\*The RF Color Charts in this Report are a guide to reported biological effects and those RFR levels reported to cause them.

Sperm and fertility studies with ‘effects levels’ in the 9 microwatt/kg to 80 milliwatt/kg range are Kumar et al (2012) (male infertility) and Aitken et al (2005) (sperm DNA damage). Sperm studies with ‘effect levels’ in the 90 to 900 milliwatt/kg range are De Iuliis et al (2009) (human sperm cell damage), Salama et al (2008) (decrease in sperm mobility and concentration), Panagopoulous et al (2012) (ovarian damage) and Kesari et al (2012) (sperm damage). Studies from 1 W/kg to 1.8 W/kg that report sperm or reproductive damage are Gul et al (2009) (toxic effect on ovaries), Agarwal et al (2008) (sperm damage), Agarwal et al (2009) (sperm damage) and Yan et al (2007) (deformed sperm cells, disabled for swimming).

The WI-FI laptop study by Atasoy et al (2012) reports that exposures to laptops estimated at 0.091 W/kg increase DNA damage and reduce DNA repair in damaged sperm, and *“raise questions about safety of radiofrequency exposure from WI-FI internet access dvices for growing organisms of reproductive age, with a potential effect on fertility and integrity of germ lines.”*

Altered fetal development in mice exposed to RFR at SARs of 0.3 to 60 milliwatt/kg is reported to result in consequent adverse effects on learning and behavior (Aldad et al, 2012). Fragopoulou et al (2009) reported changes at 600 to 900 milliwatts/kg in mouse embryos.

### **General Approach to Delineating a Precautionary Action Level**

As a methodology, is not necessary or wise to use an averaging approach among studies. The technique itself is too vulnerable to weighting problems by the older studies that did not test for effects at the lowest range of exposures to RFR (or did not have the power to assess effects). Averaging also is insensitive in giving proper visibility to important NEW results at the very low-intensity (nanowatt, picowatt and femtowatt/cm<sup>2</sup> range). Even when they are averaged together, these studies contribute vanishingly small influence when averaged together with studies of much higher power density to determine a scientific benchmark for harm.

One limitation of the sperm studies using base station-level RFR exposures is that good estimates of exposure are available if sperm are tested outside the body (in petri dishes), but that does not reflect the more realistic situation of sperm exposed in humans themselves (using or carrying a mobile phone near the testes) where exposure estimates are more difficult to determine. So, it is useful and informative to observe the combined results of both in-vivo and ex-vivo studies as a guide. For base station studies on human populations, the quality of exposure assessments is variable, and in some cases inadequate. Further, very few base station studies are conducted so that test subjects do not know if/when they are subjected to elevated RFR (blinded studies), so that some bias may influence results. People often report more ill effects because they are aware of the exposure (from a nearby base station, for example). These variations in quality across the studies, however, do not offset their usefulness in the aggregate for delineating what the lowest observable effect exposures are, and helping to guide decision-making for public health and precautionary actions.

A further concern is that time-averaging of RFR to give a single numeric recommendation for a precautionary action guideline does not address the critical difference between peak power levels (RFR spikes that occur intermittently) and measurements that hide how high peak power spikes are by dilution. Biological responses can last over seconds of time, or have even longer effects on proteins and enzymes, while the RFR pulses may be in microseconds or milliseconds in duration. It is entirely possible that what causes bioeffects is the high, intermittent RFR spikes that the body perceives and responds to as one continuous, high-power assault. For example, the DECT phone peak power is about 100 times larger than what RFR is measured with time-averaging. A person near a cell tower that produces an RFR measurement of 0.1 microwatts/cm<sup>2</sup> is probably getting RFR power density spikes of eight times higher, if one could measure the spikes individually. None of the studies profiled in this section deal with peak power pulses and biological response times that are longer than the 'intermission' between RFR spikes. Thus, precautionary action levels should err on the side of being conservative.



The planning of base stations, and other site evaluations needs to have a scientific benchmark below which effects have not (not yet) been characterized, published or vetted. Then, a reasonable safety buffer should be added - remembering that the design life of such facilities may be 30-50 years long. This is standard procedure for environmental planning constraints.

### **Health Agencies Should Act Now**

Health agencies and regulatory agencies that set public safety standards for ELF-EMF and RFR should act now to adopt new, biologically-relevant safety limits that key to the lowest scientific benchmarks for harm coming from the recent studies, plus a lower safety margin. Existing public safety limits are too high by several orders of magnitude, if prevention of bioeffects and resulting adverse health effects are to be minimized or eliminated. Most safety standards are a thousand times or more too high for healthy populations, and even less effective in protecting sensitive subpopulations.

New, biologically-based public exposure standards are critically needed now and should key to scientific benchmarks for harm, plus a safety margin below that level.

### **Standard of Evidence for Judging the Science**

The standard of evidence for judging the scientific evidence should be based on good public health principles rather than demanding scientific certainty before actions are taken.

### **Sensitive Populations Require Special Protections**

Safety standards for sensitive populations will need to be set at lower levels than for healthy adult populations to protect the developing fetus, the infant and young child, school-age children, the elderly, those with pre-existing chronic diseases, and those with

developed electrical sensitivity (EHS). Men of child-bearing age should not wear wireless devices on their body in order to protect the integrity of sperm DNA. Sperm should be considered a 'sensitive population'. Scientific benchmarks for lowest effect levels should be identified, and applied with additional safety margin reductions to safeguard populations against excessively high exposure to chronic ELF-EMF and RFR.

### **Protect Children Against Chronic Exposure to Wireless Devices**

Strong precautionary action and clear public health warnings are universally warranted for use of cordless and cell phones to help prevent a global epidemic of brain tumors. This is especially important for children, adolescents and young adults, while new safety standards are established and implemented. Children should not use wireless devices except in the case of emergencies, or be exposed on an involuntary and chronic basis to wireless in their living, sleeping or learning environments.

### **Common Sense Precautionary Measures are Warranted Now**

Common sense measures to limit both ELF-EMF and RFR in the fetus and newborn infant are needed, especially with respect to avoidable exposures like baby monitors in the crib and baby isolettes (incubators) in hospitals that can be modified; and where education of the pregnant mother with respect to laptop computers, mobile phones and other sources of ELF-EMF and RFR are easily instituted.

Wireless laptops and other wireless devices should be strongly discouraged in schools for children of all ages, and wireless systems already installed should be replaced with wired (cable) alternatives. While without question it is important for children to have access to the internet, wired computer laboratories will have no elevated exposure to RFR. What might be lost in flexibility of moving rooms arounds will be more than gained by reducing exposure to RFR if wired connections, rather than wireless, are used. Pregnant women should be strongly cautioned not to use wireless devices during pregnancy. If a school already has wireless facilities, classrooms without wireless should

be made available to students, teachers and staff during the transition if sensitivities to EMF are reported by the individual. Special education classroom teaching environments should offer wired teaching environments (not wireless), nor should they be exposed to off-site wireless radiofrequency radiation from other sources that elevate interior levels for children.

### **Special Protections for the Integrity of the Genome and Reproduction**

Reducing life-long health risks should begin in the earliest stages of embryonic and fetal development. Development pace is accelerated for the infant and very young child compared to adults, and is not complete in young people (as far as brain and nervous system maturation) until the early 20's. Windows of critical development mean that risk factors once laid down in the cells, or in epigenetic changes in the genome may have grave and life-long consequences for health or illness for every individual, and furthermore these genetic and epigenetic changes may be passed to the next generation. All relevant environmental conditions, including biologically active exposures to EMF and RFR that can degrade the human genome, and impair normal health and development of all species including humans - should be given weight in defining and implementing strong precautionary actions now to protect public health. The consequence of ignoring clear evidence of large-scale health risks to global populations, when the risk factors are largely avoidable or preventable is too high a risk to take.

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## **SECTION 25**

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Prepared for the BioInitiative Working Group  
2007-2012

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## **SECTION 26**

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# **Glossary of Terms and Abbreviations**

Prepared for the BioInitiative Working Group

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**Absorption.** In radio wave propagation, attenuation of a radio wave due to dissipation of its energy, i.e., conversion of its energy into another form, such as heat.

**Athermal effect.** Any effect of electromagnetic energy on a body that is not a heat-related effect.

**Blood–brain barrier.** A functional concept developed to explain why many substances that are transported by blood readily enter other tissues but do not enter the brain; the "barrier" functions as if it were a continuous membrane lining the vasculature of the brain. These brain capillary endothelial cells form a nearly continuous barrier to entry of substances into the brain from the vasculature.

**Conductance.** The reciprocal of resistance. Expressed in siemens (S).

**Conductivity:** A property of materials that determines the magnitude of the electric current density when an electric field is impressed on the material.

**Continuous wave.** A wave whose successive oscillations are identical under steady-state conditions.

**Current density.** A vector of which the integral over a given surface is equal to the current flowing through the surface; the mean density in a linear conductor is equal to the current divided by the cross-sectional area of the conductor. Expressed in ampere per square metre ( $\text{A m}^{-2}$ ).

**Depth of penetration.** For a plane wave electromagnetic field (EMF), incident on the boundary of a good conductor, depth of penetration of the wave is the depth at which the field strength of the wave has been reduced to  $1/e$ , or to approximately 37% of its original value.

**Dielectric properties:** In the context of this document the properties of materials conductivity and permeability.

**Dosimetry.** Measurement, or determination by calculation, of internal electric field strength or induced current density, of the specific energy absorption, or specific energy absorption rate distribution, in humans or animals exposed to electromagnetic fields.

**Electric field strength.** The force ( $\mathbf{E}$ ) on a stationary unit positive charge at a point in an electric field; measured in volt per metre ( $\text{V m}^{-1}$ ).

**Electrosensitivity (Electrohypersensitivity):** A working definition of EHS from Bergqvist et al. (1997) is “a phenomenon where individuals experience adverse health effects while using or being in the vicinity of devices emanating electric, magnetic or electromagnetic fields (EMFs)”.

**Electromagnetic energy.** The energy stored in an electromagnetic field. Expressed in joule (J).

**Electric field strength ( $\mathbf{E}$ ):** The magnitude of a field vector at a point that represents the force ( $\mathbf{F}$ ) on a charge ( $q$ ).  $\mathbf{E}$  is defined as  $\mathbf{E} = \mathbf{F}/q$  and is expressed in units of Volt per meter (V/m).

**Electromagnetic field:** Electromagnetic phenomena expressed in vector functions of space and time.

**Electromagnetic radiation:** The propagation of energy in the form of electromagnetic waves through space.

**EMF.** Electric, magnetic, and electromagnetic fields.

**Exposure:** Exposure occurs wherever a person is subjected to electric, magnetic or electromagnetic fields or contact currents other than those originating from physiological processes in the body.

**Extra low frequency (ELF):** Extra low frequency fields include, in this document, electromagnetic fields from 1 to 300 Hz. Alternately, **ELF-** Extremely low frequency where the European convention is extremely low frequency, US is extra-low frequency.

**Frequency modulation (FM):** Frequency Modulation is a type of modulation representing information as variations in the frequency of a carrier wave. FM is often used at VHF frequencies (30 to 300 MHz) for broadcasting music and speech.

**Far field.** The region where the distance from a radiating antenna exceeds the wavelength of the radiated EMF; in the far-field, field components (**E** and **H**) and the direction of propagation are mutually perpendicular, and the shape of the field pattern is independent of the distance from the source at which it is taken.

**Frequency.** The number of sinusoidal cycles completed by electromagnetic waves in 1 second; usually expressed in hertz (Hz).

**Impedance, wave.** The ratio of the complex number (vector) representing the transverse electric field at a point to that representing the transverse magnetic field at that point. Expressed in ohm (S).

**Magnetic flux density (B):** The magnitude of a field vector at a point that results in a force (F) on a charge (q) moving with the velocity (v). The force F is defined by  $F = q*(v \times B)$  and is expressed in units of Tesla (T).

**Magnetic field strength (H):** The magnitude of a field vector that is equal to the magnetic flux density (B) divided by the permeability ( $\mu$ ) of the medium. H is defined as  $H = B/\mu$  and is expressed in units of Ampere per metre (A/m).

**Magnetic permeability.** The scalar or vector quantity which, when multiplied by the magnetic field strength, yields magnetic flux density; expressed in henry per metre ( $H m^{-1}$ ). *Note:* For isotropic media, magnetic permeability is a scalar; for anisotropic media, it is a tensor quantity.

**Microwaves:** Microwaves are defined in the frame of this expertise as electromagnetic waves with wavelengths of approximately 30 cm (1 GHz) to 1 mm (300 GHz).

**Milligauss (mG):** A milligauss is a measure of ELF intensity and is abbreviated mG. This is used to describe electromagnetic fields from appliances, power lines, interior electrical wiring.

**Milliwatt (mW):** A unit of power equal to  $10^{-3}$ .

**Microwatt (uW):** A unit of power equal to  $10^{-6}$ .

**Microwatts per centimeter squared ( $\mu\text{W}/\text{cm}^2$ )**

Radiofrequency radiation in terms of power density is measured in microwatts per centimeter squared and abbreviated ( $\mu\text{W}/\text{cm}^2$ ). It is used when talking about emissions from wireless facilities, and when describing ambient RF in the environment. The amount of allowable RF near a cell tower is  $1000 \mu\text{W}/\text{cm}^2$  for some cell phone frequencies, for example.

**Nanowatt (nW):** A unit of power equal to  $10^{-9}$  Watt.

**Non – thermal effects (or athermal effects):** An effect which can only be explained in terms of mechanisms other than increased molecular motion (i.e. heating), or occurs at absorbed power levels so low, that a thermal mechanism seems unlikely, or displays so unexpected a dependence upon some experimental variable that it is difficult to see how heating could be the cause.

**Near field.** The region where the distance from a radiating antenna is less than the wavelength of the radiated EMF. *Note:* The magnetic field strength (multiplied by the impedance of space) and the electric field strength are unequal and, at distances less than one-tenth of a wavelength from an antenna, vary inversely as the square or cube of the distance if the antenna is small compared with this distance. Near field exposures are unreliable for estimation of exposures by calculation. The can zero out or be additive and nearly infinite, thus creating problems for exposure assessment.

**Non-ionizing electromagnetic radiation (NIER).** Includes all radiations and fields of the electromagnetic spectrum that do not normally have sufficient energy to produce ionization in matter; characterized by energy per photon less than about 12 eV, wavelengths greater than 100 nm, and frequencies lower than  $3 \times 10^{15}$  Hz.

**Occupational exposure.** All exposure to EMF experienced by individuals in the course of performing their work. Safety limits are five times higher for allowable occupational exposures than for general public exposures in the US.

**Permeability ( $\mu$ ):** A property of materials that indicates how much polarisation occurs when an electric field is applied.

**Permittivity.** A constant defining the influence of an isotropic medium on the forces of attraction or repulsion between electrified bodies, and expressed in farad per metre ( $\text{F m}^{-1}$ ); *relative permittivity* is the permittivity of a material or medium divided by the permittivity of vacuum.

**Public Exposure.** All exposure to EMF experienced by the general public excluding exposure during medical procedures and occupational work environments. Public exposure limits in the US are five times lower than for occupational exposures, where informed consent by employees is required.

**Power Density.** The power as measured in free space (ambient) as opposed to measured by SAR or specific absorption rate (within tissues or the body). The unit of measurement can be watts per square meter, milliwatts per square meter or microwatts per centimeter squared. Radiofrequency (RF). Any frequency at which electromagnetic radiation is useful for telecommunications, or broadcasting for radio and television. Frequency range is usually defined as 300 Hz (300 hertz) to 300 GHz (300 gigahertz).

**Radiofrequency (RF):** The frequencies between 100 kHz and 300 GHz of the electromagnetic spectrum.

**Reasonance.** The change in amplitude occurring as the frequency of the wave approaches or coincides with a natural frequency of the medium; whole body absorption of electromagnetic waves presents its highest value, i.e., the reasonance. for frequencies (in MHz or megahertz) corresponding to approximately  $114/L$  where L is the height of the individual in meters. Reasonance can also be applicable to organs, tissues, or other body parts.

**Specific Absorption Rate (SAR is measured in watts per kilogram or W/Kg)**

SAR stands for specific absorption rate. It is a calculation of how much RF energy is absorbed into the body, for example when a cell phone or cordless phone is pressed to the head. SAR is expressed in watts per kilogram of tissue (W/Kg). The amount of allowable energy into 1 gram of brain tissue from a cell phone is 1.6 W/Kg in the US. For whole body exposure, the exposure is 0.8 W/Kg averaged over 30 minutes for the general public. International standards in most countries are similar, but not exactly the same.

**Static electric field:** Static fields produced by fixed potential differences.

**Static magnetic fields:** Static fields established by permanent magnets and by steady currents.

**VDU:** Video display units for computers, videos, TV and some measurement devices using cathode ray tubes

**WI-FI:** Stands for wireless fidelity. WI-FI systems create zones of wireless RF that allow access to wireless internet for computers, internet phone access and other wireless services. Access points that provide WI-FI to access Local Area Networks (LANs) can be installed on streets (for city-wide coverage) or indoors in buildings, Restaurants, hotels, coffee shops, airports, malls and other commercial enterprises are widely installing WI-FI. The range of typical WI-FI systems is about 300 feet.

**WI-MAX:** Stands for “Wireless interoperability for Microwave Access” and is a telecommunications technology aimed at providing wireless data over long distances. Like WI-FI, WI-MAX systems are designed to provide wireless access but over much broader geographic areas, with some systems transmitting signal up to 10 miles. Higher levels of RF are produced at the wireless transmission facilities than for WI-FI.s

## **Section 20    LIST OF ABBREVIATIONS**

<b>μT</b>	microtesla
<b>μW</b>	microwatt
<b>AC</b>	Alternating current
<b>ALS</b>	Amyotrophic Lateral Sclerosis
<b>AM</b>	Amplitude modulation
<b>B</b>	Magnetic flux density
<b>BBB</b>	Blood-Brain-Barrier
<b>CENELEC</b>	European Committee for Electrotechnical Standardization
<b>CI</b>	Confidence Interval
<b>CNS</b>	Central Nervous System
<b>CW</b>	Continuous wave
<b>DC</b>	Direct current
<b>DECT</b>	Digital Enhanced Cordless Telephone
<b>DMBA</b>	7,12-dimethylbenz[a]anthracene
<b>DNA</b>	Deoxyribonucleic acid
<b>EEG</b>	Electroencephalogram
<b>EHS</b>	Electromagnetic hypersensitivity
<b>ELF</b>	Extra low frequency (also ELF-EMF)
<b>EMF</b>	Electromagnetic field
<b>FM</b>	Frequency Modulation
<b>GSM</b>	Global System for Mobile Communication
<b>H</b>	Magnetic field strength
<b>HSP</b>	Heat-shock proteins (stress proteins)
<b>Hz</b>	Frequency in Hertz
<b>IARC</b>	International Agency for Research on Cancer
<b>IL</b>	Interleukin
<b>kg</b>	Kilogram
<b>kHz</b>	Kilohertz
<b>kV</b>	Kilovolt
<b>MF</b>	Magnetic Field (sometimes MF-ELF)
<b>MHz</b>	Megahertz
<b>ms</b>	Milliseconds
<b>mT</b>	Millitesla
<b>mG</b>	Milligauss
<b>mW</b>	Milliwatt
<b>nT</b>	Nanotesla

<b>nW</b>	Nanowatt
<b>NRPB</b>	National Radiation Protection Board (HPA)
<b>OR</b>	Odds Ratio (measure of increased risk of disease)
<b>REFLEX</b>	European Research Program for Radiofrequency Hazards
<b>RF</b>	Radiofrequency Radiation (also written as RFR or RF-EMF)
<b>SCENIHR</b>	Scientific Committee on Emerging and Newly Identified Health Risks
<b>TNO</b>	Nederlandse Onderzoek (Netherlands Organisation Applied Scientific Research
<b>UMTS</b>	Universal Mobile Telephony System
<b>UNEP</b>	United Nations Environmental
<b>VDT</b>	Video display terminal (VDU – for computers, videos, TV, that use cathode ray tubes).
<b>Wi-Fi</b>	Short for wireless fidelity – wireless internet access - works for short- distances for cell phone and laptop computer access without wires.
<b>WLAN</b>	Wireless Local Area Network (wireless internet coverage usually up to 300’ provided by access points that create elevated radiofrequency radiation for that service zone.
<b>WiMAX</b>	Worldwide Interoperability for Microwave Access (wireless service up to 10 miles in comparison to Wi-Fi that may serve 300’ area)
<b>WHO</b>	World Health Organisation
<b>FCC</b>	The Federal Communications Commission (FCC) is an independent United States government agency, created, directed, and empowered by Congressional statute to oversee the regulation of radio and TV broadcasting and wireless technologies. It is not a health agency.
<b>HPA</b>	Health Protection Agency (UK) that was formerly the National Radiation Protection Division Board). The Health Protection Agency (HPA) is an independent body that protects the health and well-being of the population. The Agency plays a critical role in protecting people from infectious diseases and in preventing harm when hazards involving chemicals, poisons or radiation occur.
<b>DNA</b>	Deoxyribonucleic acid, or DNA is a nucleic acid molecule that contains the genetic instructions used in the development and functioning of all living things.
<b>Melatonin</b>	Melatonin is a hormone produced in the brain by the pineal gland, It is a potent anti-oxidant that protects against oxidative damage from free radicals that can cause DNA damage.
<b>Alzheimer’s</b>	Alzheimer’s disease is a progressive brain disorder that gradually destroys a person's memory and ability to learn, reason, make judgments, communicate and carry out daily activities. As Alzheimer’s progresses, individuals may also experience changes in personality and behavior, such as anxiety, suspiciousness or agitation, as well as delusions or hallucinations.

- RFIAWG**      Radiofrequency Interagency Working Group (US) composed of members from federal agencies with some interest in radiofrequency radiation issues. This Working Group was made up of representatives from the US government's National Institute for Occupational Safety and Health (NIOSH), the Federal Communications Commission (FCC), Occupational Health and Safety Administration (OSHA), the Environmental Protection Agency (US EPA), the National Telecommunication and Information Administration, and the US Food and Drug Administration (FDA).
- ICNIRP**      International Commission on Non-Ionizing Radiation. It is a body of independent scientific experts consisting of a main Commission of 14 members, 4 Scientific Standing Committees covering Epidemiology, Biology, Dosimetry and Optical Radiation and a number of consulting experts. This expertise is brought to bear on addressing the important issues of possible adverse effects on human health of exposure to non-ionising radiation.



## **SECTION 27**

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# **Appendix 20-A Average Residential Exposures to ELF (Power Frequency Fields)**

Prepared for the BioInitiative Working Group

July 2007



## **What are Ambient ELF and RF Levels?**

A nation-wide survey in the United States by Zaffanella et al (1993) collected engineering data on sources and levels of 60 Hz electric power magnetic fields that exist inside residences in the United States.

Approximately 1000 residences were randomly selected for the survey. The goals were to 1) identify all significant sources of magnetic field, 2) estimate for each source the percentage of residences where magnetic fields exceeded specified levels, 3) to determine the relation between magnetic field and sources and 4) to characterize the field variations in time.

The median field was identified as 0.5 mG and the average field was 0.9 mG. Thus, this confirms that average residential magnetic fields based on the 1000-home study is less than 1 mG.

Appliances produce magnetic fields but these diminish rapidly with distance (at  $1/R^3$ ),

Power lines generally produce the largest average residential magnetic field when the entire living space of a residence and a 24-hour period are considered. Power line magnetic field exceeds 1 mG in 17%, exceed 2.5 mG in 9.5% and exceed 5 mG in 0.3% of all the residences surveyed.

Zaffanella (1998) conducted measurements to characterize typical EMF exposure levels in persons living in the United States - a study called the 1000-Person Study. Table A-S.2 shows that about half of all people in the US have EMF exposures at home under 0.75 mG; in bed are 0.48 mg; at school 0.60 mG; at work 0.99 mG; and 0.87 mG is the median EMF exposure for an average 24-hour day.

Table A-S.2

**Table S.2 Descriptive Statistics for Different Activity Periods**

Parameter	Home not in Bed	In Bed	Work	School	Travel	24-Hour
Number of Valid Data Sets	1011	996	525	139	765	1012
1 <sup>st</sup> Percentile	0.10 mG	0.01 mG	0.14 mG	0.13 mG	0.13 mG	0.18 mG
5 <sup>th</sup> Percentile	0.20 mG	0.08 mG	0.24 mG	0.18 mG	0.29 mG	0.27 mG
10 <sup>th</sup> Percentile	0.27 mG	0.12 mG	0.30 mG	0.29 mG	0.41 mG	0.35 mG
25 <sup>th</sup> Percentile	0.44 mG	0.24 mG	0.60 mG	0.35 mG	0.66 mG	0.51 mG
<b>50<sup>th</sup> Percentile</b>	<b>0.75 mG</b>	<b>0.48 mG</b>	<b>0.99 mG</b>	<b>0.60 mG</b>	<b>0.98 mG</b>	<b>0.87 mG</b>
75 <sup>th</sup> Percentile	1.39 mG	1.24 mG	1.78 mG	1.01 mG	1.46 mG	1.41 mG
90 <sup>th</sup> Percentile	2.49 mG	2.44 mG	3.32 mG	1.64 mG	2.18 mG	2.38 mG
95 <sup>th</sup> Percentile	3.89 mG	3.63 mG	5.00 mG	1.77 mG	2.73 mG	3.38 mG
99 <sup>th</sup> Percentile	9.50 mG	9.19 mG	13.5 mG	3.55 mG	5.43 mG	6.16 mG
<b>Mean</b>	<b>1.29 mG</b>	<b>1.11 mG</b>	<b>1.73 mG</b>	<b>0.82 mG</b>	<b>1.22 mG</b>	<b>1.25 mG</b>
Standard Deviation	2.54 mG	2.06 mG	3.09 mG	0.70 mG	0.99 mG	1.51 mG
<b>Geometric Mean</b>	0.80 mG	0.52 mG	1.03 mG	0.64 mG	0.96 mG	0.89 mG
Geometric Standard Deviation	2.50	3.52	2.57	2.06	2.03	2.18

In Sweden, Mild et al (1996) report that overall mean residential ELF exposures are 0.4 mG, and in Norway are 0.13 mG.

### **Average Occupational Exposures to ELF**

Average occupational exposures in commercial office buildings are 1-2 mG or less and have been reported fairly consistently across numerous studies of exposure assessment (Table 1). Powerline and electrical workers have higher average occupational exposures from 10 mG to 16.6 mG.

**Table A-2: Average Occupational Exposures to ELF**

EMF RAPID Program – Questions and Answers, NIEHS,  
June 2002

Office buildings (median)	0.6 mG
Support staff	0.5 mG
Professional staff	0.6 mG
Maintenance staff	0.6 mG
Visitors	0.6 mG

EMF RAPID Program Engineering Project #3 Executive  
Summary, May 1996

Office building (average)	0.7 mG
Office building (median)	0.4 mG

Electric and Magnetic Field Fundamentals (EPRI Resource Paper, March 1994)

Typical magnetic fields in offices	1 – 2 mG
Power line workers	10 mG

Occupational EMF Exposure Assessment (EPRI Resource Paper, February 1994)

Office Worker Comparison Group	1.6 mG
All Occupationally Exposed Utility Workers	16.6 mG
Table 7 – Other Studies Cited	
Bracken Study (1990)	1.0 mG
Deadman Study (1988)	1.6 mG
Bowman Study (1992)	0.9 – 1.8 mG

**Limits on Operation of Sensitive Electronic Equipment**

Companies that manufacture or use equipment in nanotechnology and biotechnology and found 1.0 mG is generally the limit for proper operation of electron beam devices (mass spectrometers, scanning electron microscopes, lithography, etc) used in these technologies. Ten (10) milligauss (mG) is the EMF limit for normal computers – above 10 mG can introduce “computer jitter” and other problems.

**What are Ambient Radiofrequency Radiation/Microwave Levels?**

Prior to the rapid development of wireless communications for personal and business usage, RF power density levels were primarily related to AM, FM and television broadcasting signal in both urban and rural areas of the United States. Microwave frequencies used for wireless communications were negligible.

Original extra-planetary sources of microwave radiation were infinitesimally small, on the order of a billionth of a microwatt per centimeter squared ( $10^{-12}$  uW/cm<sup>2</sup>). Human evolution took place without any appreciable exposure to microwave radiation from background sources. The human body has no evolutionary protection against microwave radiation, as it does for ultraviolet radiation from the sun (Johannson, 2000). Wireless voice and communications have introduced unprecedented levels of public exposure in the last decade.

Mantiply (1997) measured and reported common sources and levels of RF in the environment. He identified areas near cellular base stations on the ground near towers to be from 0.003 to 0.3  $\mu$ W/cm<sup>2</sup>. Background level ambient RF exposures in cities and suburbs in the 1990's were generally reported to be below 0.003  $\mu$ W/cm<sup>2</sup>.

Hamnerius (2000) reported that ambient RF power density measurements in twelve (12) large cities in Sweden were roughly ten times higher than in the United States for equivalent measurement locations by Mantiply in 1978 (when no cellular phone service existed in the US). He reported a total mean value of 26 measured sites in the study was 0.05  $\mu$ W/cm<sup>2</sup> and the median value was 40  $\mu$ W/cm<sup>2</sup>. An office location with a base station nearby at about 300 feet distance tested 150  $\mu$ W/cm<sup>2</sup>. A train station with antennas mounted indoors tested at about 3  $\mu$ W/cm<sup>2</sup>. Both indoor and outdoor ambient RF power density measurements showed high variability depending on proximity to transmitting antennas.

Sage Associates reported on microwave frequency RF power density levels at outdoor locations both near and far from wireless antenna sites in the United States (Sage, 2000). Within the first 100-300 feet, power density levels have been measured at 0.01 to 3.0  $\mu$ W/cm<sup>2</sup>. Elevated RF power density levels from a major wireless antenna site can often be detected at 1000 feet or more. Power density levels away from wireless antenna sites measure between 0.001  $\mu$ W/cm<sup>2</sup> to 0.000001  $\mu$ W/cm<sup>2</sup>. Vegetation often reduces signal (and therefore the reach of elevated RF exposures) but dry building materials used to visually screen wireless sites do not appreciably diminish signal transmission. Therefore, many sites that are "out-of-sight" because of stealth design can still produce elevated RF levels in nearby areas where people live, work and go to

school. For purposes of this evaluation, a 10 dB attenuation has been incorporated to take building material shielding effects into account.

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## **APPENDIX 20-B**

### **STANDARDS OF EVIDENCE FOR DECISIONMAKING DIFFERS AMONG PROFESSIONS**

There is a large difference between what constitutes causal evidence for purposes of achieving scientific consensus, what constitutes sufficient evidence for purposes of interim public health policy, and what constitutes "a more likely than not" case. A central confusion in this debate is whether prudent policy and public health decisions necessarily require conclusive scientific evidence first. This is not the case. The state of the science needs to be presented in an understandable and scientifically accurate manner, but prudent public health actions do not and should not require 100% proof of harm. In fact, precautionary and preventative actions are specifically justified at a point in time before scientific proof is established. If the growing weight of evidence is positive (although all studies need not report positive effects) then it may be essential to take preventative actions and implement policies that are protective of public health, safety and welfare rather than wait for absolute certainty. The following discussion is presented to highlight some of the main differences in professional approach and traditional ways of viewing and interpreting scientific evidence. In reality, the basis for taking action (preventative or precautionary action) is a continuum – there are no hard and fast rules. The bar for Public Health Policy may be higher or lower than shown in Figure 2; based on many factors, including how widespread the risk, how dread the disease, the cost of inaction (doing nothing until there is proof, but many may be harmed), etc.

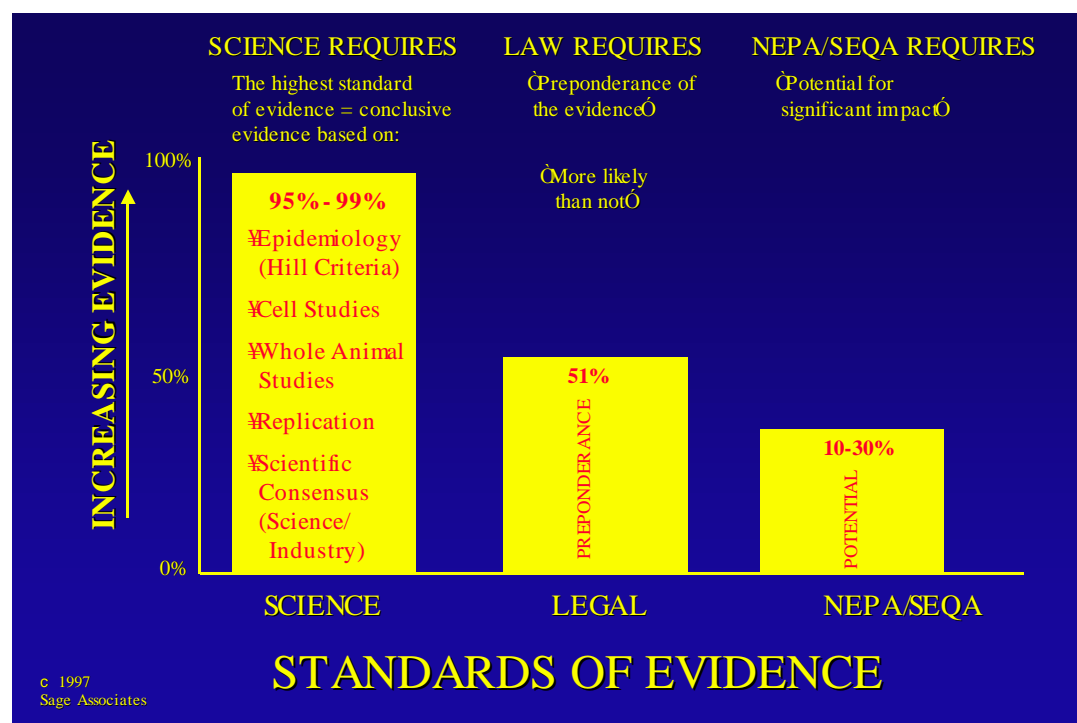
#### **A. Scientific Standard of Evidence**

There are several levels of proof for adverse effects of environmental exposures. The most rigorous is a scientific standard, where virtual proof of causation is typically required by scientists to arrive at consensus about an effect. This approach works best in physics and chemistry. In biological systems this is rarely possible.

In this case, the 'scientific standard' refers to the overall evidence that the science community typically requires before rendering opinions on the strength of evidence, and what evidence they believe is necessary to establish a causal link (proof).

Figure 1 shows Standards of Evidence that are routinely employed by various interest groups in the EMF debate (Sage, 1997). It can be used to focus on various accepted standards for evidence that are legitimately used by scientific and professional groups to determine when an action is appropriate. The varying levels of certainty about an outcome will dictate different decision-making among different groups that may all be appropriate given their professional charge. Even though the evidence required to make a scientific determination about causality has a far higher standard than a legal determination on the 'weight of the evidence' or 'preponderance of evidence' (a legal standard), neither negates the correctness of the other in its proper jurisdiction. Scientists typically want all possible evidence (animal, cell and epidemiological studies, with replications) showing a high degree of consistency. This can generally be described as a 95% to

99% degree of certainty before drawing conclusions (it does not refer to the 95% confidence interval in epidemiology, except as a part of the overall proof).



**Figure 1 Variable Standards of Evidence (By Profession)**

## B. Legal Standard of Evidence

The second level of proof is the standard applied in legal proceedings, which is ‘more likely than not’ or ‘preponderance of the evidence’ (Figure 1). This is to say if there is a 50%+ likelihood of harm, this is taken as evidence for a relationship (Sage, 1997). At least this level of evidence is reached for the studies of adult cancer and neurodegenerative diseases and 50/60 Hz magnetic field exposures. As with childhood leukemia, while we have documented associations, this does not necessarily indicate causation. Failure to meet either the scientific or the legal standard of proof does not mean that there is no relationship between exposure and disease. In the case of EMF exposure, where everyone is exposed, the societal implications may be huge if there is a real risk whose magnitude has simply just not yet been clarified. Public policies are needed to address this issue of decision-making in the face of this scientific uncertainty.

## C. Environmental Protection Standard of Evidence

National and state environmental quality acts (The National Environmental Policy Act) and various state environmental quality acts (SEQA) require that assessments use a standard of “potential for a significant impact on the environment which is a relatively low level of certainty (10% to 30%). The potential for a significant impact requires that mitigation strategies be developed, i.e, require precautionary or preventative actions when only the potential for risk is present (Figure 1).

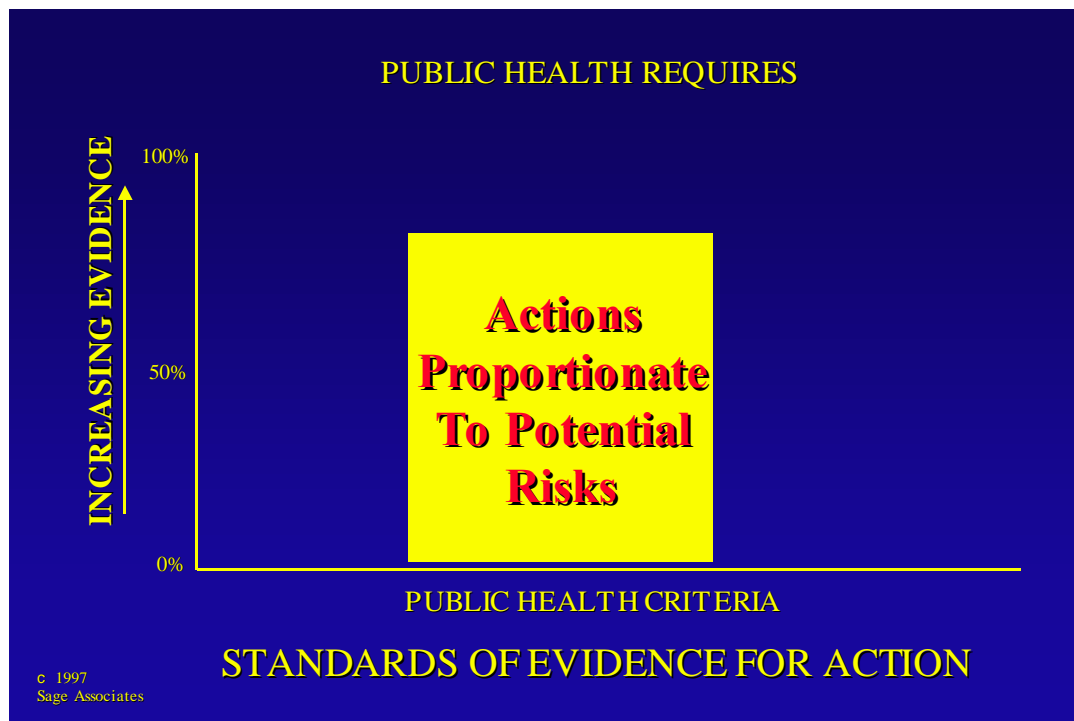
For example, the potential for risk to humans from building on an active earthquake fault will require a finding of potentially significant impact, and will require mitigative action; even when there is no certainty (no causal evidence) that the fault will rupture and cause damage within the design lifetime of the building. Proof of harm is not a pre-condition for taking action, and the level of certainty is low in comparison to a scientific or legal standard of certainty. Nonetheless, each standard has validity, and will have a different level of evidence required to take action. What decision-makers need to address is what standard of evidence is appropriate now to guide them with respect to EMF exposures that are clearly of environmental and public health concern.

#### **D. Public Health Standard of Evidence**

The prudent approach from a public health point of view is to take preventive actions as if causation had been proven, while at the same time to continue to search for mechanisms of action. In the case of childhood leukemia and ELF exposure there is a consistent and statistically significant association in most studies, while for many of the other diseases the results are less consistent although strong associations are found in some studies (Figure 2). This bar graph should be considered illustrative only, since the level of certainty may be higher or lower (above or below 50%) depending on the circumstances of the potential risk, and costs of those risks to society.

Whether magnetic fields actually cause childhood leukemia and the other cancers and neurological diseases documented in this Report; or whether it is some other component in the electromagnetic environment that is responsible for the association is a subject of debate within the scientific community, but from a public health point of view it doesn't matter. The fact that there are unknowns does not negate or override the ultimate public health responsibility, which is to protect the population from exposures which cause disease. Those who make public health decisions, as well as policymakers who rely on them and who approve construction of new schools and homes near power lines, those who provide insurance or financing of new construction, those who must choose siting routes for new electrical facilities all face making decisions with some uncertainty about the potential health risks from EMF exposure. Important social issues must often be decided on the basis of incomplete or uncertain scientific information.





**Figure 2**                      **Public Health Standard of Evidence for Decisions**



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