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**United States District Court**

**District of Oregon**

**Portland Division**

**AHM**, by and through  
her Guardian *ad litem* and father,  
David Mark Morrison, and  
**David Mark Morrison**, individually,

v.

**Portland Public Schools,**

Defendant.

Civil Action No. 3:11-cv-00739-MO

**Declaration of  
Dr. Magda Havas, B.Sc., Ph.D. -  
Addendum A**

## Addendum 'A': Studies and Reviews

### I. STUDIES: Human Studies, Animal (*in vivo*) Studies, *In vitro* Studies

1. Neurological/Sleep/Learning/Behavior/Electrohypersensitivity [17 studies]
2. Stress-Response/Hormonal-Response/Blood-Brain-Barrier/Immune System/Enzymes [9 studies]
3. Cardiac [8 studies]
4. Reproduction [7 studies]
5. Cancer/DNA Damage/Anti-oxidants/Death [15 studies]

### II. REVIEWS & LETTERS

#### Studies

### I. STUDIES [56]

#### 1. Neurological/Sleep/Learning/Behavior/Electrohypersensitivity [17 studies]

##### *1.1 Human Studies: Neurological . . . [16 studies]*

- 1.1.1 **Abdel-Rassoul et al. 2006.** *Neurobehavioral effects among inhabitants around mobile phone base stations, Neurotoxicology. 2007 Mar;28(2):434-40. Epub 2006 Aug 1, Inhabitants living near mobile phone base stations are at risk for developing neuropsychiatric problems and some changes in the performance of neurobehavioral functions either by facilitation or inhibition.*
- 1.1.2 **Altpeter et al. 2006.** *Effect of Short-Wave (6-22 MHz) Magnetic Fields on Sleep Quality and Melatonin Cycle in Humans: The Schwarzenburg Shut-Down Study. Bioelectromagnetics 27:142-150. Sleep quality improved after transmitter was shut down.*
- 1.1.3 **Altpeter et al. 1995.** *Study of health effects of shortwave transmitter station of Schwarzenburg, Berne, Swizerland, University of Berne, Institute for Social and Preventative Medicine. At exposure means of 0.024 and 0.24  $\mu\text{W}/\text{cm}^2$ , with lowest exposure of 0.0034  $\mu\text{W}/\text{cm}^2$  and highest of 9.06  $\mu\text{W}/\text{cm}^2$ , researchers found significant sleep and concentration disturbance, and general weakness/tiredness. In children there was a slow school promotion rate.*
- 1.1.4 **Aschermann, 2011.** *Electrosensitivity: A Patient with Burn-like Skin Manifestations. Original study in German: ASCHERMANN C (2011) Umwelt-Medizin-Gesellschaft 24(2): 141-146. Patient developed electrohypersensitivity. Symptoms range from skin manifestations, which require treatment, to hypertension and brain-related disorders as well as intestinal bleeding.*

- 1.1.5 **Divan et al. 2008.** *Prenatal and postnatal exposure to cell phone use and behavioral problems in children. Epidemiology 19(4):523-9.* Exposure to cell phones prenatally-and, to a lesser degree, postnatally-was associated with behavioral difficulties such as emotional and hyperactivity problems around the age of school entry. These associations may be noncausal and may be due to unmeasured confounding. If real, they would be of public health concern given the widespread use of this technology.
- 1.1.6 **Eger and Jahn, 2010.** *Specific Health Symptoms and Cell Phone Radiation in Selbitz (Bavaria, Germany)—Evidence of a Dose-Response Relationship. Original German umwelt-medizin-gesellschaft 23 2/2010.* A significant dose-response relationship was observed in relation to objectively determined exposure levels for symptoms, such as sleep problems, depressions, cerebral symptoms, joint problems, infections, skin problems, cardiovascular problems as well as disorders of the visual and auditory systems and the gastrointestinal tract.
- 1.1.7 **Eltiti, et al. 2007.** *Development and Evaluation of the Electromagnetic Hypersensitivity Questionnaire. Bioelectromagnetics 28:137-151 (2007)* This study provides a screening tool for EHS for use by researchers and indicates which symptoms tend to be found together.
- 1.1.8 **Frey, 1998.** *Headaches from Cellular Telephones: Are they Real and What Are the Implications? Environmental Health Perspectives Volume 106, Number 3, pp.101-103.* Headaches as a consequence of exposure to low intensity microwaves were reported in the literature 30 years ago. These were observed during the course of microwave hearing research before there were cellular telephones. The blood-brain barrier appears to be involved in headaches, and low intensity microwave energy exposure affects the barrier. The dopamine-opiate systems of the brain appear to be involved in headaches, and low intensity electromagnetic energy exposure affects those systems. In all three lines of research, the microwave energy used was approximately the same--in frequencies, modulations, and incident energies--as those emitted by present day cellular telephones and WI-FI routers.
- 1.1.9 **Genuis and Lipp. 2011.** *Electromagnetic hypersensitivity: Fact or fiction? A review. Science of the Total Environment xxx (2011): 10 pp.* As well as an assortment of physiological complaints, patients diagnosed with EHS report profound social and personal challenges, impairing their ability to function normally in society. Recommendations are provided to assist health professionals in caring for individuals reporting of EHS.
- 1.1.10 **Huber et al. 2000.** *Exposure to pulsed high-frequency electromagnetic field during waking affects human sleep EEG, Neuroreport. 2000 Oct 20;11(15):3321-5.* The aim of the study was to investigate whether a PM MW affects brain physiology. The present results demonstrate that exposure during waking modifies EEG during subsequent sleep. Thus the

changes of brain function induced by pulsed high-frequency EMF outlast the exposure period, indicating entrainment.

- 1.1.11 **Hung et al. 2007.** *Mobile phone 'talk-mode' signal delays EEG-determined sleep onset, Neurosci Lett. 2007 Jun 21;421(1):82-6. Epub 2007 May 24.* Finding mobile phones signals are pulse-modulated microwaves, and EEG studies suggest that the extremely low-frequency (ELF) pulse modulation affects sleep.
- 1.1.12 **Hutter et al. 2006.** *Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. Occup. Environ. Med.63;307-313.* Despite the influence of confounding variables, including fear of adverse effects from exposure to HF-EMF from the base station, there was a significant relation of some symptoms to measured power density; this was highest for headaches. Perceptual speed increased, while accuracy decreased insignificantly with increasing exposure levels. There was no significant effect on sleep quality.
- 1.1.13 **Kolodynski and Kolodynska, 1996.** *Motor and psychological functions of school children living in the area of the Skrunda Radio Location Station in Latvia, Sci Total Environ.180(1):87-93.* This study found less developed memory and attention, slower reaction time and decreased neuromuscular apparatus endurance in schoolchildren, relative to the control group.
- 1.1.14 **Oberfeld et al. 2004.** *The Microwave Syndrome—Further aspects of the Spanish Study.* Significant exposure-response associations were found between the E-field and fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorder, depressive tendency, feeling of discomfort, difficulty concentrating, loss of memory, visual disorder, dizziness and cardiovascular problems. Ideally levels for radiation should not exceed  $0.0001 \mu\text{W}/\text{cm}^2$  for indoor environments.
- 1.1.15 **Papageorgiou et al. 2011.** *Effects of wi-fi signals on the p300 component of event-related potentials during an auditory hayling task. Journal of Integrative Neuroscience, Vol. 10, No. 2: 189–202.* Wi-Fi exposure may exert gender-related alterations on neural activity associated with the amount of attentional resources engaged during a linguistic test adjusted to induce working memory.
- 1.1.16 **Santini et al. 2002.** *Study of the health of people living in the vicinity of mobile phone base stations: 1. Influences of distance and sex. Pathol Biol 50:369-73.* People should not live within 300 m of cell phone antennas as the number of symptoms increase with proximity to these antennas, especially among women.
- 1.1.17 **Schooneveld and Kuiper, 2007.** *Electrohypersensitivity (EHS) in the Netherlands—A Questionnaire survey.* © Stichting EHS (Dutch EHS Foundation). 70% of respondents suffered from chronic fatigue, headache, concentration problems and other psychosomatic ailments.

Somatic problems included impaired vision, smell and hearing as well as skin problems and pains in joints and muscles. Living in an apartment with several neighbours is a risk factor due to EMFs traveling through wall and floors.

### 1.2 Animal (in vivo) Studies: Neurological . . . [3 studies]

1.2.1 **Loscher and Kas, 1998.** *Extraordinary Behavior Disorders in Cows in Proximity to Transmission Stations. Translated from German language. From the Institute of Pharmacology, Toxicology and Pharmacy of the Veterinary School of Hannover (Director: Prof. Dr. W. Löscher) and the Scientific Design of Electronics and Radar of the University of the German Army, Munchen (Prof. G. Käs).* In addition to reduction of milk yield and increased health problems, behavioral abnormalities were observed over a period of two years in a herd of dairy cows maintained in close proximity to a TV and cell phone transmitting antenna. An experiment in which a cow with abnormal behavior was brought to a stable 20 km away from the antenna resulted in a complete normalization of the cow within five days, whereas symptoms returned when the cow was brought back to the stable nearby the antenna.

1.2.2 **Salford et al, 2003.** *Nerve cell damage in mammalian brain after exposure to microwaves from GSM mobile phones, Environ Health Perspect 2003 Jun;111(7):881-3; discussion A408,* <http://www.ncbi.nlm.nih.gov/pubmed/12782486> . Rats exposed for 2 hours to PM MW radiation at different strengths. Researchers found highly significant ( $P < 0.002$ ) evidence for neuronal damage in the cortex, hippocampus, and basal ganglia in the brains of exposed rats. Such damage may result in reduced brain reserve capacity that might be unveiled by other later neuronal disease.

1.2.3 **Wang and Lai, 2000.** *Acute Exposure to Pulsed 2450-MHz Microwaves Affects Water-Maze Performance of Rats, results show that acute exposure to pulsed microwaves caused a deficit in spatial 'reference' memory in the rat. Bioelectromagnetics 21:52-56.* Rats were exposed to 1.2 W/kg for one hour before each training session. Microwave-exposed rats were slower than sham-exposed and cage control rats in learning to locate the platform. However, there was no significant difference in swim speed among the three groups of animals, indicating that the difference in learning was not due to a change in motor functions or motivation. These results show that acute exposure to pulsed microwaves caused a deficit in spatial "reference" memory in the rat.

## 2. Stress-Response/Hormonal-Response/Blood-Brain-Barrier/Immune System/Enzymes [9 studies]

### 2.1 Human Studies: Stress . . . [3 studies]

- 2.1.1 **Augner et al. 2010.** *Effects of exposure to base station signals on salivary cortisol, alpha-amylase and immunoglobulin A. Biomed Environ Scie 23: 199-207: 2010.* This was a human experimental study with exposure to PM MW radiation wherein immune indicators were monitored after five 50-minute sessions. The researchers found dose-dependent changes in cortisol and alpha-amylase. Salivary alpha-amylase and cortisol are biomarkers for stress. As a part of the body's fight-or-flight response, cortisol also acts to suppress the body's immune system.
- 2.1.2 **Buchner and Eger 2011.** *Changes of Clinically Important Neurotransmitters under the Influence of Modulated RF Fields—A Long-term Study under Real-life Conditions. Original study in German: Umwelt-Medizin-Gesellschaft 24(1): 44-57.* After the activation of the GSM base station, the levels of the stress hormones adrenaline and noradrenalin increased significantly in human subjects during the first six months; the levels of the precursor dopamine decreased substantially. As an indicator of the dysregulated chronic imbalance of the stress system, the phenylethylamine (PEA) levels dropped significantly until the end of the study period. [Abnormally low concentrations of endogenous PEA are found in those with attention-deficit hyperactivity disorder (ADHD) or clinical depression. Abnormally high concentrations are positive correlated with schizophrenia.] The effects showed a dose-response relationship and occurred well below current limits for technical RF radiation exposures. Chronic dysregulation of the catecholamine system has great relevance for health and is well known to damage human health in the long run.
- 2.1.3 **Johansson, 2009.** *Disturbance of the immune system by electromagnetic fields—A potentially underlying cause for cellular damage and tissue repair reduction, which could lead to disease and impairment. Pathophysiology: 21 pp.* EMFs disturb immune function through stimulation of various allergic and inflammatory responses, as well as effects on tissue repair processes. Such disturbances increase the risks for various diseases, including cancer. Existing public safety limits are inadequate to protect public health, and that new public safety limits, as well as limits on further deployment of untested technologies, are warranted.

## 2.2 *Animal (in vivo) Studies: Stress . . . [5 studies]*

- 2.2.1 **Eberhardt et al. 2008.** *Blood-brain barrier permeability and nerve cell damage in rat brain 14 and 28 days after exposure to microwaves from GSM mobile phones. Electromagn Biol Med. 27(3):215-29.* Blood-brain barrier permeability and nerve cell damage was documented in rat brain 14 and 28 days after exposure to PN microwaves.

- 2.2.2 **Eskemaya et al. 2010.** *Pulse modulated 900 MHz radiation induces hypothyroidism and apoptosis in thyroid cells: a light, electron microscope and immunohistochemical study. Int J Radiat Biol.* 2010 86(12)1106-16. Whole-body exposure to PM RF radiation can cause pathological changes in the thyroid gland and enhances pathways of apoptosis (programmed cell death).
- 2.2.3 **Kesari et al. 2011.** *Biomarkers inducing changes due to microwave exposure effect on rat brain. General Assembly and Scientific Symposium, 13-20 Aug. 2011.* Rat brains exposed for 2 h a day for 45 days at 210  $\mu\text{W}/\text{cm}^2$  had a significant decrease in melatonin levels and a significant increase in creatine kinase and caspase 3. The study concludes that the chronic exposure to these radiations may be an indication of possible tumor promotion. Melatonin is responsible for many functions from sleep to immune responses. Creatine kinase is a biomarker for muscle breakdown such as heart attacks or muscular dystrophy. Both creatine kinase and caspase-3 play a role in apoptosis (programmed cell death).
- 2.2.4 **Lin et al. 1998.** Enhancement of anticancer drug delivery to the brain by microwave induced hyperthermia. *Bioelectrochemistry and Bioenergetics* 47:259–264. The blood brain barrier serves a very important function and that is to keep chemicals out of the brain. This makes it difficult to administer certain types of drugs that need to be into the brain. Because microwave radiation increases the permeability of the blood brain barrier this might be one way to help administer drugs to this part of the body.
- 2.2.5 **Sinha 2008.** *Chronic non-thermal exposure of modulated 2450 MHz microwave radiation alters thyroid hormones and behavior of male rats. Int. J. Radiat. Biol., Vol. 84, No. 6, June 2008, pp. 505 – 513.* This study concluded that low energy 2450 MHz microwave radiation can be harmful as it insufficient to alter extravasations of blood-brain barrier permeability, changes in thyroid hormone metabolism and emotional reactivity of the animals.

### 2.3 *In vitro* Studies: Stress . . . [1 study]

- 2.3.1 **Schirmacher et al. 2000.** *Electromagnetic Fields (1.8 GHz) Increase the Permeability to Sucrose of the Blood-Brain Barrier In Vitro. Bioelectromagnetics* 21:338-345. Exposure to EMF increased permeability for  $^{14}\text{C}$ -sucrose significantly compared to unexposed samples.

## 3. Cardiac [8 studies]

### 3.1 *Human Studies: Cardiac* [6 studies]

- 3.1.1 Bortkiewicz et al. 1996.** *Evaluation of selected parameters of circulatory system function in various occupational groups exposed to high frequency electromagnetic fields. II. Electrocardiographic changes. Med Pr 47(3):241-252.* The study indicates that exposure to AM broadcast radiation increases risk for electrographic disturbances (detected by means of resting ECG and a 24-hour Holter recording) by six times ‘(a six-fold increase)’ in comparison with that in radio link station workers who were not exposed.
- 3.1.2 Braune et al. 1998.** *Resting blood pressure increase during exposure to a radio-frequency electromagnetic field. Lancet 351(9119):1857-8.* Subjects exposed to radiation from a cellular phone in a single-blind placebo controlled study experienced statistically significant elevated systolic and diastolic blood pressure and a lower heart rate.
- 3.1.3 Glotova and Sadchikova, 1970.** *Development and clinical course of cardiovascular changes after chronic exposure to microwave irradiation. Institute of Labor Hygiene and Occupational Diseases, USSR Academy of Medical Sciences; Moscow, Gligiyena Truda. Professional'nyve Zabolevaniya, Russian, No 7,1970, June, pp 24-27.*  
[http://www.magdahavas.com/wordpress/wp-content/uploads/2011/03/Development\\_and\\_Clinical\\_Course\\_of\\_Cardiovascular\\_Changes\\_After\\_Chronic\\_Exposure\\_to\\_Microwave\\_Irr.pdf](http://www.magdahavas.com/wordpress/wp-content/uploads/2011/03/Development_and_Clinical_Course_of_Cardiovascular_Changes_After_Chronic_Exposure_to_Microwave_Irr.pdf)  
 The nature and intensity of the cardiovascular reactions to prolonged exposure to microwaves are closely related to neurological changes, especially those in the autonomic nervous system. Some individuals exhibit only mild symptoms with a slow heart rate and low blood pressure. Others develop autonomic-vascular dysfunction, which results in high blood pressure, tachycardia (elevated heart rate), and impaired blood flow to the brain.
- 3.1.4 Havas et al. 2010.** *Provocation Study using Heart Rate Variability shows Microwave. Radiation from cordless phone affects Autonomic Nervous System. European Journal of Oncology-Library Vol. 5.* Some subjects experienced tachycardia or arrhythmia when exposed in a double blind study to radiation from a cordless phone at 2.4 GHz at levels less than 1% of FCC and Health Canada guidelines.
- 3.1.5 Sandstrom et al. 2003.** *Holter ECG monitoring in patients with perceived electrical hypersensitivity. International Journal of Psychophysiology 49 (2003) 227–235.* EHS patients had a disturbed pattern of circadian rhythms of HRV and showed a relatively ‘flat’ representation of hourly-recorded spectral power of the HF (parasympathetic) component of HRV. Authors conclude that HRV should be included as part of the clinical investigation of EHS.



**3.1.6 Wilen et al. 2006.** Psychophysiological Tests and Provocation of Subjects With Mobile Phone Related Symptoms, *Bioelectromagnetics* 27:204-214. The HRV data recorded during the various tests differed significantly between the cases (those with EHS) and the controls. The higher LF activity and the lower HF activity represent a shift in the autonomic regulation towards sympathetic activity. This in turn is often regarded as a sign of an elevated stress level.

**3.2 Animal (in vivo) Studies: Cardiac [1 study]**

**3.2.1 Mohamed et al. 2011.** *Study of the cardiovascular effects of exposure to electromagnetic field. Life Science Journal, Volume 8, Issue 1.* Long-term exposure of rats to cell phone EMF increases the liability for hypertension reflected on the ECG and cardiac weights which is accompanied by histopathological changes in the heart. In addition, EMF altered biological functions of the heart.

**3.3 In vitro Studies: Cardiac [1 study]**

**3.3.1 Schwartz et al. 1990.** *Exposure of frog hearts to CW or amplitude-modulated VHF fields: Selective efflux of calcium ions at 16 Hz. Bioelectromagnetics* 11(4):349-358. Isolated frog hearts were exposed for 30-min periods to continuous or 0.5 and 16 Hz modulated 240 MHz frequency. Calcium efflux increased significantly (approximately 20%) at both 0.3 mW/kg and 0.15 mW/kg. These exposures are well below the FCC guideline for partial body exposure in an uncontrolled exposure (1,600 mW/kg, partial-body).

**4. Reproduction [7 studies]**

**4.1 Human Studies: Reproduction [3 studies]**

**4.1.1 Agarwal et al. 2008.** *Effect of cell phone usage on semen analysis in men attending infertility clinic: an observational study. Fertil Steril.* 2008 Jan;89(1):124-8. Epub 2007 May 4. Use of cell phones decrease the semen quality in men by decreasing the sperm count, motility, viability, and normal morphology. The decrease in sperm parameters was dependent on the duration of daily exposure to cell phones and independent of the initial semen quality.

**4.1.2 Fejes et al. 2005.** *Is there a relationship between cell phone use and semen quality? Arch Androl.* 51(5):385-93. Prolonged use of cell phones affects sperm motility. The low and high transmitter groups differed in the proportion of rapid progressive motile sperm (48.7% vs. 40.6%).

**4.1.3 Ouellet-Hellstrom and Stewart. 1993.** *Miscarriages among female physical therapists who report using radio- and microwave- frequency electromagnetic radiation, American Journal of Epidemiology,* 138(10):775-786. A very large epidemiologic occupational study,

found increased miscarriages from MW radiation at *in utero* exposure levels lower than what the Portland School students and teachers receive from WI-FI. Miscarriages were increased with RF exposure, and occurred more frequently with MW than Shortwave (SW) radiation. MW radiation involves body part-size waves, while SW involves waves many meters in length. This study illustrates the power of the contributing factor of frequency/wavelength and their respective absorption in producing adverse bioeffects. As the study demonstrates, the fetus, which received far less radiation than the mother, is particularly vulnerable to MW radiation, even with the shielding the mother's body provides.

#### 4.2 *Animal (in vivo) Studies: Reproduction [2 studies]*

- 4.2.1 Magras and Xenos, 1997.** *RF Radiation-Induced Changes in the Prenatal Development of Mice. Bioelectromagnetics 18:455-461.* Mice near TV and FM broadcast transmitters, with exposure levels below  $1.053 \mu\text{W}/\text{cm}^2$  experienced testicular damage and decreasing litters. Within a few generations they became irreversible infertile.
- 4.2.2 Yan et al. 2007.** *Effects of cellular phone emissions on sperm motility in rats. Fertil Steril. 88(4):957-64. Epub 2007 Jul 12.* Increase in sperm cell death and clumping of sperms with exposure to 6 hours of daily cellular phone emissions for 18 weeks.

#### 4.3 *In vitro Studies: Reproduction [2 studies]*

- 4.3.1 Avendano et al. 2012.** *Use of laptop computers connected to Internet through WI-FI decreases human sperm motility and increases sperm DNA fragmentation. Fert Steril, 2012, In press.* In this study human sperm were exposed to WI-FI from a laptop, and were found to show reduced motility after a 4-hour exposure. The results are consistent with other publications (Agarwal et al. 2008, reference 4.1.1 above).
- 4.3.2 Eroglu et al. 2006.** *Effects of electromagnetic radiation from a cellular phone on human sperm motility: an in vitro study. Arch Med Res. 37(7):840-3.* Radiation from cellular phones affects human sperm motility and may lead to behavioral and structural changes in sperm cells.

### 5. Cancer/DNA Damage/Anti-oxidants/Death [15 studies]

#### 5.1 *Human Studies: Cancer . . . [9 studies]*

- 5.1.1 Eger et al. 2004.** *The Influence of Being Physically Near to a Cell Phone Transmission Mast on the Incidence of Cancer. Published in Umwelt-Medizin-Gesellschaft 17,4 2004, as: 'Einfluss der räumlichen Nähe von Mobilfunksendeanlagen auf die Krebsinzidenz'.* After five years' operation of the transmitting installation, the relative risk of getting cancer had trebled for the residents of the area in the proximity of the installation compared to the inhabitants of Naila outside the area.

- 5.1.2 Ha et al. 2003.** *Incidence of cancer in the vicinity of Korean AM radio transmitters. Increase in leukemia and brain cancer at high power sites. Arch Environ Health. 58(12):756-62.* Among the 11 high-power sites, there were significantly increased incidences of leukemia in 2 areas and of brain cancer in 1 area
- 5.1.3 Hardell et al. 2008.** *Meta-analysis of long-term mobile phone use and the association with brain, tumours, Int J Oncol. 32(5):1097-103.* This meta-analysis showed an association between mobile phone use and ipsilateral (same-side of the head) glioma and acoustic neuroma for those using a mobile phone for 10 or more years.
- 5.1.4 Hocking et al. 1996.** *Cancer Incidence and Mortality and Proximity to TV Towers, Medical Journal of Australia 165: 601-605.* There was an association between increased childhood leukemia incidence and mortality in the proximity of television towers. The power density ranged from 0.2-8.0  $\mu\text{W}/\text{cm}^2$  nearer and 0.02  $\mu\text{W}/\text{cm}^2$  farther from the towers.
- 5.1.5 Lönn et al. 2004.** Mobile phone use and the risk of acoustic neuroma, *Epidemiology. 2004 Nov;15(6):653-9.* There was an increased risk of developing acoustic neuromas for those who used a mobile phone for at least 10 years.
- 5.1.6 Michelozzi et al. 1998.** *Adult and Childhood Leukemia near a High-Power Radio Station in Rome, Italy. American Journal of Epidemiology Vol. 155, No. 12: 1096-1103.* Vatican Radio is a very powerful station located in a northern suburb of Rome, Italy. In the 10-km area around the station, with 49,656 residents (in 1991), leukemia mortality among adults (aged >14 years; 40 cases) in 1987–1998 and childhood leukemia incidence (eight cases) in 1987–1999 were evaluated. The risk of childhood leukemia was significantly elevated (SIR 2.2) within 6 km of the Vatican Radio station and declined with increasing distance both for male mortality ( $p = 0.03$ ) and for childhood leukemia ( $p = 0.036$ ).
- 5.1.7 Oberfeld 2008.** *Environmental Epidemiological Study of Cancer Incidence in the Municipalities of Hausmannstätten & Vasoldsberg (Austria). Commissioned by Provincial Government of Styria, Department 8B, Provincial Public Health Office, Graz (Austria).* The study showed a significant cancer incidence with regard to timing and location in the area around the transmitter as well as significant exposure-effect relationships between RF radiation exposure and the incidence of breast cancers and brain tumors.
- 5.1.8 Park et al. 2004.** *Ecological study on residences in the vicinity of AM radio broadcasting towers and cancer death: preliminary observations in Korea. Int Arch Occup Environ Health. 77(6):387-94. Epub 2004 Jul 31.* Higher mortality rates were observed for all cancers in some age groups near AM radio broadcasting towers.

**5.1.9 Wolf and Wolf, 2004.** *Increased incidence of cancer near a cell-phone transmitter station. International Journal of Cancer Prevention Vol 1(2): 19 pp.* This study in Israel reported an increased incidence of cancers, especially among women, who lived near cell phone transmitter stations. Measured power density was between 0.3 and 0.5  $\mu\text{W}/\text{cm}^2$ .

**5.2 Animal (in vivo) Studies: Cancer . . . [4 studies]**

**5.2.1 Chou et al. 1992.** *Long-Term, Low-Level Microwave Irradiation of Rats. Bioelectromagnetic 13:469-496.* Study by the U.S. Air Force. This was a \$4.5 million study that showed an increase in both metastatic tumors and primary tumors in rats exposed to 2.45 GHz pulsed radiation at levels below FCC guidelines for 25 months. This was one of the first low-level, long-term exposure of rats to pulsed 2.45 GHz radiation (similar to WI-FI).

**5.2.2 Kesari et al. 2010.** *Mutagenic response of 2.45 GHz radiation exposure on rat brain. Int. J. Radiat. Biol. 86 (4): 334-343.* Significant changes were noted for various enzymes (glutathione peroxidase, superoxide dismutase, catalase and histone kinase) in brain tissue among rats exposed for 2 hours a day for 35 days to 2.45 GHz radiation at 350  $\mu\text{W}/\text{cm}^2$  (note this is less than the 1000  $\mu\text{W}/\text{cm}^2$  FCC guideline). Authors conclude that chronic exposure to this radiation may cause significant damage to the brain and may contribute to tumor promotion. These antioxidants protect the organism from oxidative damage. Oxidative damage may be the mechanism responsible for DNA damage at non-ionizing frequencies that are too weak to break chemical bonds.

**5.2.3 Lai and Singh, 1995.** *Acute Low-Intensity Microwave Exposure Increases DNA Single-Strand Breaks in Rat Brain Cells. Bioelectromagnetics 16:207-210.* Rats exposed to 2.45 GHz frequencies experienced single-strand DNA breaks.

**5.2.4 Polson et al. 1974.** *Mortality in rats exposed to CW microwave radiation at 0.95, 2.45, 4.54, and 7.44 GHz.* See, <http://www.magdahavas.com/2010/09/06/pick-of-the-week-9-0-95-and-2-45-ghz-most-lethal-microwave-frequencies/>. In this study rats were exposed to continuous wave (CW) microwave radiation at four frequencies: 0.95, 2.45, 4.54, and 7.44 GHz. Power density levels ranged from approximately 0.2  $\text{W}/\text{cm}^2$  to 12  $\text{W}/\text{cm}^2$  (note these are very high levels) and lethal exposure durations from approximately 10 sec to 300 sec. Study reported that the most lethal frequencies (at very high intensities) are 0.95 and 2.45 GHz.

**5.3 In vitro Studies: Cancer . . . [2 studies]**

**5.3.1 Diem et al. 2005.** *Non-thermal DNA breakage by mobile-phone radiation (1800 MHz) in human fibroblasts and in transformed GFSH-R17 rat granulosa cells in vitro, Mutat Res. 2005 Jun 6;583(2):178-83,* The

induced DNA damaged in this study by microwave radiation was not due to thermal effects.

- 5.3.2 Markova et al. 2009.** *Microwaves from Mobile Phones inhibit 53BP1 Focus Formation in Human Stem cells strong than in Differentiated Cells: Possible Mechanistic Link to Cancer Risk. Environmental Health Perspectives, ehponline.org.* Stem cells are most sensitive to MW exposure and react to more frequencies than differentiated cells and this may be important for cancer risk assessment.

## II REVIEWS AND LETTERS [10 reports]

- 1. Adams and Williams. 1975.** *Biological Effects of electromagnetic radiation (radiowaves and microwaves)--Eurasian communist countries, prepared by U.S. Army Medical Intelligence and Information Agency Office of the Surgeon General.* <http://www.magdahavas.com/2011/02/24/pick-of-the-week-23-research-on-biological-effects-of-radio-frequency-radiation-in-eurasian-communist-countries-1976> . This study was undertaken to provide a review and evaluation of the current Eurasian Communist country state-of-the-art in the area of the effects of radiowaves and microwaves. There are two disturbing paragraphs in this document that clearly indicate the U.S. military's perspective opposing more stringent guidelines for microwave radiation.

*If the more advanced nations of the West are strict in the enforcement of stringent exposure standards, there could be unfavorable effects on industrial output and military function. The Eurasian Communist countries could, on the other hand, give lip service to strict standards, but allow their military to operate without restriction and thereby gain the advantage in electronic warfare techniques and the development of antipersonnel applications.[page vii]*

*Should subsequent research result in adoption of the Soviet standard by other countries, industries whose practices are based on less stringent safety regulations, could be required to make costly modifications in order to protect workers. Recognition of the 0.01 mW/cm<sup>2</sup> standard could also limit the application of new technology by making the commercial exploitation of some products unattractive because of increased cost, imposed by the need for additional safeguards.[page 24]*

- 2. Balmori, 2009.** *Electromagnetic pollution from phone masts. Effects on wildlife, Pathophysiology 16: 191–199.* This large review of wildlife effects concludes, 'pulsed telephony microwave radiation can produce effects on nervous, cardiovascular, immune and reproductive systems,' including damage to the nervous system by altering EEG and changes to the blood-brain barrier, disruption of the circadian rhythms (sleep-wake) by interfering with the pineal gland and hormonal imbalances, changes in heart rate and blood pressure, impairment of health and immunity towards pathogens, weakness, exhaustion, growth problems, problems in building the nest or impaired fertility, embryonic development,

hatching percentage, genetic and developmental problems, problems of locomotion, promotion of tumors and more.

3. **Cherry, 2002.** *Science has now passed beyond this, positively confirming serious adverse cardiac effects.* Cherry, N., *Cardiac Effects of Natural and Artificial EMR: (2002)*, [http://www.neilcherry.com/documents/90\\_s4\\_EMR\\_Cardiac\\_Effects\\_Review.pdf](http://www.neilcherry.com/documents/90_s4_EMR_Cardiac_Effects_Review.pdf) (reporting significant and dose-response increases in cardiac disease and death rates and radiofrequency and microwave exposure).
4. **Cleary (Editor), 1970.** *Biological Effects and Health Implications of Microwave Radiation, Symposium Proceedings, Richmond Virginia, September 17-19, 1969. Sponsored by Medical College of Virginia, Virginia Commonwealth University with the support of Bureau of Radiological Health, U.S. Department of Health, Education, and Welfare, Public Health Service, Environmental Health Service. 275 pp.*  
[http://www.magdahavas.com/wordpress/wp-content/uploads/2011/02/Biological\\_Effects\\_and\\_Health\\_Implications\\_of\\_Microwave\\_Radiation.pdf](http://www.magdahavas.com/wordpress/wp-content/uploads/2011/02/Biological_Effects_and_Health_Implications_of_Microwave_Radiation.pdf) This documented presented the 'state of the art' of research regarding the biological effects of microwave radiation available up to and including 1970. Although some of the papers deal with very high levels of microwave exposure that did not then, but do now, exceed FCC guidelines and are less useful in our discussion of WI-FI in schools, there are several excellent reports. Notable papers include those by **Frey** on the nervous system with some interesting experiments with frog hearts causing tachycardia and arrhythmia or having no effect based on whether the radiation was synchronized with the ECG; **Dodge** on clinical and hygienic aspects of electromagnetic radiation (Table 2) where he documents hyper- or hypotension; bradycardia and tachycardia, changes in ECG and fainting spells all associated with the autonomic nervous system; **Korbel** on behavioral effects of low intensity RF radiation that include (a) consistent, long-term hypoactivity which may be preceded by a short-term period of hyperactivity, (b) greater emotionality, (c) longer latency of recovery from electroconvulsive shock, (d) longer time to learn to swim a water maze, and (e) a differential stress reaction as determined by weight of adrenal glands. If students in school have a similar response to WI-FI radiation as did the rats to RF radiation in the Korbel study, then we need to be concerned not only about the health effects but also effects on learning.
5. **Goldsmith, 1999.** *Epidemiologic Evidence of Radiofrequency Radiation (Microwave) Effects on Health in Military, Broadcasting, and Occupational Studies*, Goldsmith JR, *Int J Occup Environ Health*.1(1):47-57. This report finds sufficient evidence that MW exposures are associated with all four of the following outcomes (a) blood count changes, (b) evidence of somatic mutation, (c) impairment of reproductive outcomes, especially increased spontaneous abortion, and (d) increase in cancer incidence and mortality. The author concludes that the possible effects and their timings with respect to exposure are qualitatively similar to those of ionizing radiation. A prudent course of action

would be to provide more protection for those exposed than required by present regulations.

6. **Hallberg and Oberfeld, 2006.** *Letter to the Editor: Will we all become Electrosensitive? Electromagnetic Biology and Medicine, 25: 189–191.* Based on studies from Austria, Germany, Ireland, England, Sweden and the United States on the estimated prevalence of electrosensitivity, this paper extrapolates that by 2017, 50% of the population may be electrically hypersensitive.
7. **Johansson, 2006.** *Electrohypersensitivity: State-of-the-Art of a Functional Impairment. A review. Electromagnetic Biology and Medicine, 25: 245–258.* In Sweden electrohypersensitivity is a recognized functional impairment (i.e. it is not regarded as a disease). It affects about 3% of the Swedish population. Changes in the cellular and neuronal systems of a person's skin have been documented that explain the rashes, flushing, itching, burning irritations some experience when they are exposed to electromagnetic energy.
8. **Lai, 1997.** *Neurological Effects of Radiofrequency Electromagnetic Radiation. Relating to Wireless Communication Technology, Paper presentation at the IBC-UK Conference: "Mobile Phones-Is There a Health Risk?" September 16-17, 1997, Brussels, Belgium.* Review includes effects on the blood brain barrier, neurotransmitters, calcium flux, and DNA breaks.
9. **Royal Society of Canada, 1999.** *A Review of the Potential Health Risks of Radiofrequency Fields from Wireless Telecommunication Devices. An Expert Panel Report prepared at the request of the Royal Society of Canada for Health Canada. 155 pp.* This review concludes that biological effects occur below federal guidelines at non-thermal levels and the evidence is particularly strong for calcium flux, increased permeability of the blood-brain-barrier, and changes in enzyme ornithine decarboxylase. Many of the more recent studies have been repeated in independent laboratories. Because these effects occur at exposures not thought to elicit thermal effects, it is likely that these effects, even if they also occur at higher exposure levels, are non-thermal biological effects.

The work of Salford et al (1992,1994) provides evidence that at SAR values below Federal guidelines, causes changes in blood-brain barrier permeability. Further, the work of Oscar and Hawkins (1977), using much lower power densities than recommended as safe limits in Safety Code 6 (1 W/m<sup>2</sup> vs. 10 W/m<sup>2</sup> at 2850 MHz), also showed increases in blood-brain barrier permeability. The changes may be related to the RF frequency or the extremely low frequency modulation of the RF carrier frequency. The possibility exists that the non-thermal effect of RF on ornithine decarboxylase activity or calcium ion concentrations may initiate this small increase in blood-brain barrier permeability (Koenig et al 1989).

Increases in ODC activity have been observed in experiments using RF fields in the frequency range of standard wireless telecommunications devices at exposure levels below those recommended in Safety Code 6. This increased activity occurs only when the amplitude of the radiofrequency field is modulated by ELF. Pulsed

digital telephone fields with a low frequency component also are capable of increasing ODC activity. ODC activity has been shown to increase with increasing RF field strength. The panel noted that while nearly all factors capable of causing cancer lead to elevated ODC activity, not all stimuli capable of increasing ODC activity promote cancer.

Furthermore, the Royal Society concludes that guidelines do not protect the eyes and may result in cataract formation. The eyes and testicles are particularly vulnerable to microwave radiation.

**10. Yakymenko et al. 2011.** *Long-term exposure to microwave radiation provokes cancer growth: Evidences from radar and mobile communication systems. Exp Oncol 33, 2, 62–70.* Review of 95 documents that collectively demonstrate the carcinogenic effects of microwave radiation. These studies include in vivo, in vitro and human exposures to mobile phones, base stations, and radar. Mechanisms contributing to DNA breaks, such as free radical species and ornithine decarboxylase, are discussed. Authors conclude that recent data strongly point to the need for re-evaluation of the current safety limits for non-ionizing radiation using recently obtained knowledge.