# Microwave/Radiowave Exposure Health Studies

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

### 1. Neurological, Blood-Brain-Barrier, Sleep and Melatonin, Electrohypersensitivity

### 2. Endocrine/Reproduction, Immune System/Enzymes

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### 4. DNA, Cellular Stress Response, Cancer, Cell Death, Death

## II. SCIENTIFIC LITERATURE REVIEWS

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# I. STUDIES [86 reports]

## 1. Neurological, Blood Brain Barrier, Sleep/Melatonin, EHS [33 studies]

### 1.1 Human Studies: Neurological . . . [21 studies]

**1.1.01 Altpeter et al. 1995.** STUDY ON HEALTH EFFECTS OF THE SHORTWAVE TRANSMITTER STATION AT SCHWARZENBURG, BERNE, SWITZERLAND. *University of Berne on behalf of the Swiss Federal Office of Energy; BEW Publication Series, Study No. 55.* The purpose of this study was to establish an association between ill health and the emf field of the Shortwave radio transmitter of Schwarzenburg, Switzerland. Our results indicate a higher frequency of disorders of a neurovegetative nature among residents up to about 1000 meters from the transmitter and are highly suggestive of a direct effect of the radio transmitter on sleep quality. The other complaints seem to be mediated by the sleep disorder.

**1.1.1 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 with multiple chemical sensitivity has developed electrohypersensitivity. Symptoms range from skin manifestations, which require treatment, to hypertension and brain-related disorders as well as intestinal bleeding.

**1.1.2 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.

**1.1.3 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.

**1.1.4 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.

**1.1.5 Divan et al. 2010.** Cell phone use and behavioural problems in young children. *J Epidemiol Community Health (2010).* What this study adds:

*"There is an association between prenatal as well as postnatal use and behavioural problems by age 7 years among a general population of mothers who are cell phone users. These results replicate the findings of an association observed among only early technology adopters. These new results also reduce the likelihood that these are chance findings or findings that did not adequately consider the influence of other important factors for behavioural problems."*

**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 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.

**1.1.9 Huber et al. 2002.** Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking. *EEG, J. Sleep Res. (2002) 11, 289–295.* Pulse-modulated electromagnetic fields (EMF) alters waking rCBF and (2) pulse modulation of EMF is necessary to induce waking and sleep EEG-changes.

**1.1.10 Hung et al. 2007.** Mobile phone 'talk-mode' signal delays EEG determined sleep onset. N*eurosci 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.

**1.1.11 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.

**1.1.12 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.

**1.1.13 Kwon et al. 2011.** GSM mobile phone radiation suppresses brain glucose metabolism. *Journal of Cerebral Blood Flow & Metabolism (2011) **31,** 2293–2301; doi:10.1038/jcbfm.2011.128; published online 14 September 2011.* Our results show that short-term mobile phone exposure can locally suppress brain energy metabolism in humans.

**1.1.14 Oberfeld et al. 2004.** "The Microwave Syndrome–Further aspects of the Spanish Study." *Presented at an International Conference in Kos, Greece, May 2004.* 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 μW/cm2 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: I. 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.

**1.1.19 Tombini et al. 2012.** Mobile phone emissions modulate brain excitability in patients with focal epilepsy. B*rain Stimulation xxx (2012) 1-7. http://dx.doi.org/10.1016/j.brs.2012.07.006.* The present study clearly demonstrated that an acute and relatively prolonged exposure to GSM EMFs modulates cortical excitability in patients affected by focal epilepsy; however, in contrast to healthy subjects, these effects were evident only after EMFs exposure over the hemisphere contralateral to the epileptic focus (CH). They were characterized by a significant cortical excitability increase in the exposed hemisphere paired with slight excitability decrease in the other one (IH).

**1.1.18 Tyazhelov et al. 1979.** Some peculiarities of auditory sensation evoked by pulsed microwave fields. *Radio Science Volume 14, Number 6S, pages 259-263, November-December 1979.* The auditory sensations evoked by trains of shorter ( _<50 •) microwave pulses are believed to be due to limited perception of pulsed waves at P RRs above 8000 pps. In summary, our data indicate that additional psychophysical studies of RF hearing are needed. The thermoacoustic model, while very promising and doubtless correct for higher peak densities and shorter pulses of irradiation, is inadequate to explain a number of peculiarities of auditory sensation observed by us near threshold levels.

**1.1.20 Volkow et al. 2011.** Effects of Cell Phone Radiofrequency Signal Exposure on Brain Glucose Metabolism. *JAMA. 2011;305(8): 808-813.* In summary, this study provides evidence that in humans RF-EMF exposure from cell phone use affects brain function, as shown by the regional increases in metabolic activity.

## 1.2 Animal (in vivo) Studies: Neurological . . . [12 studies]

**1.2.1 Aldad et al. 2012.** Fetal Radiofrequency Radiation Exposure From 800-1900 Mhz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice. *SCIENTIFIC REPORTS, 2 : 312,DOI: 10.1038/srep00312.* In summary, we demonstrate that fetal radiofrequency radiation exposure led to neurobehavioral disorders in mice. We anticipate these findings will improve our understanding of the etiology of neurobehavioral disorders. The rise in behavioral disorders in developed countries may be, at least in part, due to a contribution from fetal cellular telephone radiation exposure.

**1.2.2 Cammaerts et al. 2012.** GSM 900 MHz radiation inhibits ants' association between food sites and encountered cues. *Electromagnetic Biology and Medicine, Early Online: 1–15, 2012.* In the present work, we experimentally demonstrate the effect of 900MHz (10 dBm) waves on ant foragers' ability in using olfactory and visual cues, and we reveal an impact on their physiology. We speculate about similar effects on other insects (i.e., bees) and about an impact of EW on the nervous cells functioning. We cautiously advance some economical-ecological application of these results.

**1.2.3 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.

**1.2.4 Fragopoulou et al. 2012.** Brain proteome response following whole body exposure of mice to mobile phone or wireless DECT base radiation. *Electromagnetic Biology and Medicine, Early Online: 1–25.* Three equally divided groups of animals (6 animals/group) were used; the first group was exposed to a typical mobile phone, at a SAR level range of 0.17–0.37 W/kg for 3 h daily for 8 months, the second group was exposed to a wireless DECT base (Digital Enhanced Cordless Telecommunications/ Telephone) at a SAR level range of 0.012–0.028 W/kg for 8 h/day also for 8 months and the third group comprised the sham-exposed animals. Comparative proteomics analysis revealed that long-term irradiation from both EMF sources altered significantly (p , 0.05) the expression of 143 proteins in total (as low as 0.003 fold downregulation up to 114 fold overexpression). Several neural function related proteins (i.e., Glial Fibrillary Acidic Protein (GFAP), Alpha-synuclein, Glia Maturation Factor beta (GMF), and apolipoprotein E (apoE)), heat shock proteins, and cytoskeletal proteins (i.e., Neurofilaments and tropomodulin) are included in this list as well as proteins of the brain metabolism (i.e., Aspartate aminotransferase, Glutamate dehydrogenase) to nearly all brain regions studied.

**1.2.5 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.

**1.2.6 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.

**1.2.7 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 μW/cm2 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).

**1.2.8 Nittby et al. 2009** Increased blood–brain barrier permeability in mammalian brain 7 days after exposure to the radiation from a GSM-900 mobile phone. *Pathophysiology , doi:10.1016/ j.pathophys.2009.01.001.* Our group has earlier shown that the electromagnetic radiation emitted by mobile phones alters the permeability of the blood–brain barrier (BBB), resulting in albumin extravasation immediately and 14 days after 2 h of exposure. Albumin extravasation was enhanced in the mobile phone exposed rats as compared to sham controls after this 7-day recovery period.

**1.2.9 Persson et al. 2005** Effects of Microwaves from GSM Mobile Phones on the Blood-brain Barrier and Neurons in Rat Brain. ***PIERS Online, Vol. 1, No. 6,pp: 638-641.*** In series of more than 1800 Fisher rats, we have proven that sub thermal power levels from both pulse modulated and continuous RF fields - including those from real GSM mobile phones - have the potency to significantly open the BBB for the animals' own albumin (but not fibrinogen) to pass out into the brain and to accumulate in the neurons and glial cells surrounding the capillaries. Albumin extravasations are most prominent at the lower SAR values. This dose-response behaviour suggests some kind of energy or electromagnetic field strength windowing effect. A linear dose-response relationship for dark neurons was found at 50 days after exposure, with most prominent occurrence at SAR 200mW/kg.

**1.2.10 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.

**1.2.11 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 14C-sucrose significantly compared to unexposed samples.

**1.2.12 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. Endocrine/Reproduction, Immune System/Enzymes [21 studies]

### 2.1 Human Studies: Endocrine . . . [8 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 Longterm 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 noradrenaline 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 positively 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 Eskander et al, 2011.** How does long term exposure to base stations and mobile phones affect human hormone profiles?*, Clin Biochem*, doi:10.1016/j.clinbiochem.2011.11.006. This study was conducted for 6 years on volunteers exposed to RFR emitted from base 60 stations (n=34) were selected with age ranges 14–22 years 61 (n=17), and 25–60 years (n=17) and living at distances 20–100 m 62 and 100–500 m apart from the base station. Additional 10 subjects 63 of each age range living at a distance more than 500 m apart from 64 the base station were considered as negative control group. The data showed significant decreases in ACTH, cortisol, thyroid hormones, prolactin (for young females), and testosterone levels of exposed groups compared with the control groups. In conclusion, the present study revealed that high RFR base station exposure has tangible effects on the pituitary–adrenal axis.

**2.1.4 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%).

**2.1.5 Karinen et al. 2008.** Mobile phone radiation might alter protein expression in human skin. *BMC Genomics 2008, 9:77 doi:10.1186/1471-2164-9-77.* This is the first study showing that molecular level changes might take place in human volunteers in response to exposure to RF-EMF. Our study confirms

that proteomics screening approach can identify protein targets of RF-EMF in human volunteers.

**2.1.6 Mortavazi et al. 2009.** Alterations in TSH and Thyroid Hormones following Mobile Phone Use. *Oman Med J. 2009 October; 24(4): 274–278.* The level of thyroid stimulating hormone was increased in the exposed groups compared to the control group. Based on the findings, a higher than normal TSH level, low mean T4 and normal T3 concentrations in mobile users were observed. It seems that minor degrees of thyroid dysfunction with a compensatory rise in TSH may occur following excessive use of mobile phones. It may be concluded that possible deleterious effects of mobile microwaves on hypothalamic-pituitary-thyroid axis affects the levels of these hormones.

**2.1.7 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.

**2.1.8 Vangelova et al. 2005.** Variations of Melatonin and Stress Hormones under Extended Shifts and Radiofrequency Electromagnetic Radiation. *REVIEWS ON ENVIRONMENTAL HEALTH, Volume 20, Number 2, 2005.* A significant EMR exposure-effect relation for stress hormones was found. Our data show higher 24-h cortisol, adrenaline, and noradrenaline excretion with higher radio- frequency EMR exposure (Table 4), with a significantly higher cortisol and noradrenaline 24-h excretion in high-level exposure operators than in the control group ($F = 5.561$, $p = 0.023$ and $F = 4.773$, $p = 0.041$ for cortisol and noradrenaline respectively).

## 2.2 Animal (in vivo) Studies: Endocrine . . . [9 studies]

**2.2.1 Eskemaya et al. 2010.** Pulse modulated 900 MHz radiation induces hypothyroidism and apoptosis in thyroid cells: a light, electron microscope and immunohistochemical study. *Int L 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).

**2.2.2 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 below1.053 μW/cm2 experienced testicular damage and decreasing litters. Within a few generations they became irreversibly infertile.

**2.2.3 Ozguner et al. 2004**. Biological and morphological effects on the reproductive organ of rats after exposure to electromagnetic field. *Saudi Med J 2005; 26 (3): 405 - 410*. The diameter of the seminiferous tubules and the mean height of the germinal epithelium were significantly decreased inexposed animals. There was a significant decrease in serum total testosterone level in exposed rats, but there was an insignificant decrease in plasma luteinizing hormone and follicle stimulating hormone levels in the exposed group compared to the control group.

**2.2.4 Panagopoulos and Margaritis, 2008**. MOBILE TELEPHONY RADIATION EFFECTS ON LIVING ORGANISMS. *2008 Nova Science Publishers, Inc. ISBN: 978-1-60456-436-5* This chapter reviews briefly the most important experimental, clinical and statistical findings and presents more extensively a series of experiments, concerning cell death induction on a model biological system. Mobile telephony radiation is found to decrease significantly and non thermally insect reproduction by up to 60%, after a few minutes daily exposure for only few days. Both sexes were found to be affected. The effect is due to DNA fragmentation in the gonads caused by both types of digital mobile telephony radiation used in Europe, GSM 900MHz, (Global System for Mobile telecommunications), and DCS 1800MHz, (Digital Cellular System). GSM was found to be even more bioactive than DCS, due to its higher intensity under equal conditions. The decrease in reproductive capacity seems to be non-linearly depended on radiation intensity, exhibiting a peak for intensities higher than 200 μW/cm2 and an intensity "window" around 10μW/cm2 where it becomes maximum.

**2.2.5 Panagopoulos, 2012.** Effect of Microwave Exposure on the Ovarian Development of Drosophila melanogaster. *Cell Biochem Biophys (2012) 63:121–132.* Our present experiments showed retardation of ovarian development due to DNA damage and consequent ovarian cell death after exposure to microwave radiation emitted by GSM mobile phones. Fertility disorders due to ovarian cell death induction may be very similar between insects and mammals (including humans).

**2.2.6 Sarookhani et al. 2010.** The influence of 950 MHz magnetic field (mobile phone radiation) on sex organ and adrenal functions of male rabbits. *African Journal of Biochemistry Research Vol. 5(2), pp. 65-68.* Results of this study suggest that testosterone and FSH levels were disturbed as a result of mobile phone EMF exposure which can possibly affect reproductive functions.

**2.2.7 Seyednour and Chekaniazar, 2011.** Effects of Exposure to Cellular Phones 950 MHZ Electromagnetic Fields on Progesterone, Cortisol and Glucose Level in Female Hamsters (*Mesocricetus auratus*). *Asian Journal of Animal and Veterinary Advances, 6: 1084-1088.* It was concluded that short- or long-term exposure to 950 MHZ may cause progesterone suppressing and cortisol releasing but this frequency only in long-term exposure could cause hyperglycemia in hamster as a laboratory model.

**2.2.8 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 sufficient to alter extravasations of blood-brain barrier permeability, changes in thyroid hormone metabolism and emotional reactiveness of the animals. Since, thyroid hormones are also reported to interact with other neurohormones, the involvement of other neurotransmitters and hormonal systems in altered animal behavior following low energy, nonthermal chronic microwave exposure of 2450 MHz cannot be ruled out.

**2.2.9 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.

## 2.3 In vitro Studies: Endocrine . . . [4 studies]

**2.3.1 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.

**2.3.2 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 2.3.1 above).

**2.3.3 Erogul 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.

**2.3.4 Lyle et al. 1983.** Suppression of T-Lymphocyte Cytotoxicity Following Exposure to Sinusoidally Amplitude-Modulated Fields. *Bioelectromagnetics 4:281-292.* Significant inhibition of allogeneic cytotoxicity of the target cell MPC-I 1 by the murine cytotoxic T-lymphocyte line CTLL-I was observed when the 4-h cytotoxicity assay was conducted in the presence of a 450-MHz field sinusoidally amplitude-modulated at 60 Hz. The inhibition was preferentially expressed during the early allogeneic recognition phase. Field exposed cytolytic cells recovered their full cytolytic capacity in 12.5 h.

## 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 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, Glgiyena Truda. Professional'nyve Zabolevaniya, Russian, No 7,1970, June, pp 24-27. 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.

**3.1.3 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.

**3.1.4 Sadchikova, 1973.** Clinical Manifestations of Reactions to Microwave Irradiation in Various Occupational Groups. *Proceedings of an International Symposium, Warsaw, October 15-18, 1973, Polish Medical Publishers. Sponsored by the World Health Organization; the US Dept of Health, Education and Welfare; and the Scientific Council of the Minister of Health and Social Welfare, Poland.* The present communication presents clinical observations on the health status in two groups of workers (1180) exposed to microwaves. The first group was subjected to a power density of up a few milliwatts per cm2; the second were exposed to levels that generally did not exceed several hundredths of a milliwatt per cm2. 200 workers who were not exposed to microwaves served as a control. The data showed that microwave action was characterized by autonomic vascular symptoms of a vagotonic character. ECG revealed minor disturbances on intraventricular conduction, sinus bradycardia and moderate lowering of T deflection. In both groups, the frequency of asthenic and autonomic vascular disturbances of a hyperreactive character depended directly on the duration of employment. Vagotonic reactions occurred mainly in the initial period of work with microwaves. At a certain stage of development of autonomic vascular disturbances, the hypothalamic syndrome appeared, characterized by sudden crisis,predominantly of a sympathico-adrenal character. In a number of patients, the clinical picture of ischemic heart disease and hypertension developed. Changes in catecholamine excretion and in metabolism of glucocorticoid hormones were more marked after epinephrine loading which led to clinical autonomic vascular reactions. Cessation of work involving irradiation frequently resulted in stabilization of the process or recovery if withdrawal took place in the initial stage of the illness.

**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. DNA, Cellular Stress Response, Cancer, Cell Death, Death [25 studies]

### 4.1 Human Studies: DNA Damage . . . [11 studies]

**4.1.1 Dode et al, 2011.** Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil. Science of the Total Environment. 409(2011) 3649-3665. This research showed the existence of a spatial correlation between cases of death by neoplasia and the locations of the BSs, in the Belo Horizonte municipality from 1996 to 2006. Between 1996 and 2006, 7191 deaths by neoplasia occurred and within an area of 500 m from the BS, the mortality rate was 34.76 per 10,000 inhabitants. Outside of this area, a decrease in the number of deaths by neoplasia occurred.

**4.1.2 Dolk et al. 1997.** Cancer Incidence near Radio and Television Transmitters in Great Britain. *Am J Epidemiol Vol. 145, No. 1, 1997.* The main finding was the confirmation of a reported excess of leukemias near the Sutton Coldfield radio and television transmitter, and a decline in risk with distance from the site.

**4.1.3 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.

**4.1.4 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.

**4.1.5 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.

**4.1.6 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 μW/cm2 nearer and 0.02 μW/cm2 farther from the towers.

**4.1.7 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.

**4.1.8 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).

**4.1.9 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.

**4.1.10 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.

**4.1.11 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 μW/cm2.

## 4.2 Animal (in vivo) Studies: DNA Damage . . . [10 studies]

**4.2.1 Adang et al. 2009.** Results of a Long-Term Low-Level Microwave Exposure of Rats. *IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES, VOL. 57, NO. 10.* We exposed four-month-old Wistar albino rats during 21 months to two different microwave frequencies and exposure modes, 2 h a day, seven days a week. After 14 and 18 months of exposure, we observed a significant increase in white blood cells and neutrophils of about 15% and 25%, respectively. Lymphocytes fell down after 18 months of exposure with about 15% compared to the sham-exposed group. The most obvious effect we detected is the increase in mortality rate of the exposed groups with respect to the sham-exposed group after 21 months of exposure at the age of 25 months. This increase even increases when observing rats until the age of 28 months: mortality in exposed groups then reaches almost twice the value observed in the sham-exposed group.

**4.2.2 Alghamdi et al. 2012.** Effects of Exposure to Electromagnetic Field on Some Hematological Parameters in Mice. *Open Journal of Medicinal Chemistry, 2012, 2, 30-42 doi:10.4236/ojmc.2012.22005 Published Online June 2012 .* The present result found a decline in hemoglobin, hematocrit, red blood

cells count, in addition to the platelet count, after short and long exposure to both types of mobile phone (Alcatel, Nokia). It was observed that the average number of white cells and lymphocytes increased significantly, indicating the increase to the body's immune response to radiation. Also, when exposed to both devices (Alcatel, Nokia) for 15 minutes, the red blood cells began to take on a rouleaux formation. Increased duration of exposure to 30-minutes revealed disparities in the sizes of red blood cells with the appearance of a large proportion of cells with pale colors due to lack of hemoglobin. In the group exposed for 45 minutes, the authors observed a variation in the cell sizes with the emergence of abnormal cell. Blood cells exposed for 60 minutes appeared completely different from the natural form and took the form teardrops that appear in the case of anemia. After three months of exposure to both types of mobile phone, red blood cells showed pathological changes in the outer cell membrane.

**4.2.3 Aweda et al. 2010.** Genotoxic effects of low 2.45 GHz microwave radiation exposures on Sprague Dawley rats. *International Journal of Genetics and Molecular Biology Vol. 2(9), pp. 189-197.* Our findings showed that low SARs exposure to 2.45 GHz MW radiation could result in single strand breaks of DNA in blood leukocytes, brain, lung and spleen cells of rats.

**4.2.4 Balmori, 2010.** Mobile phone mast effects on common frog (Rana temporaria) tadpoles: the city turned into a laboratory. *Electromagn Biol Med 2010; 29 (1-2): 31 - 35.* The data showed in the exposed group low coordination of movements, an asynchronous growth (resulting in both big and small tadpoles) and a high mortality (90%). In the control group under the same conditions but inside a Faraday cage, the coordination of movements was normal, the development was synchronous, and the mortality rate was 4.2%. These findings indicate that exposure to mobile phone base stations in a real situation may affect the development and may cause an increase in mortality of exposed tadpoles.

**4.2.5 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 WIFI).

**4.2.6 Jelodar et al. 2010.** Effect of electromagnetic field generated by BTS on hematological parameters and cellular composition of bone marrow in rat. *Comp Clin Pathol DOI 10.1007/s00580-010-1031-4.* Exposure to EMF generated by BTS significantly decreased hematocrit (PCV) and total leukocyte, erythrocyte, and platelet count in the immature–test group. Exposure to EMF generated by BTS had no significant effect on hematological parameters in mature rats. Changes in the mentioned parameters could be due to the effects of EMW on circulating cells or their producing stem cells in the bone marrow. Our results show that exposure to EMF generated by BTS had significant effects on bone marrow composition in mature and immature rats.

**4.2.7 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 μW/cm2 (note this is less than the 1000 μ/W/cm2 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.

**4.2.8 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. Brain cell DNA responded differently to CW and pulsed microwaves.

**4.2.9 Panagopoulos et al. 2006.** Cell death induced by GSM 900-MHz and DCS 1800-MHz mobile telephony radiation. *Mutation Research (2006), doi:10.1016.* Induced cell death is recorded for the first time, in all types of cells constituting an egg chamber (follicle cells, nurse cells and the oocyte) and in all stages of the early and mid-oogenesis, from germarium to stage 10, during which programmed cell death does not physiologically occur. Germarium and stages 7–8 were found to be the most sensitive developmental stages also in response to electromagnetic stress induced by the GSM and DCS fields and, moreover, germarium was found to be even more sensitive than stages 7–8.

**4.2.10 Polson et al. 1974.** Mortality in rats exposed to CW microwave radiation at 0.95, 2.45, 4.54, and 7.44 GHz. *Prepared for: U.S. Army Mobility Equipment Research and Development Center, Fort Belvoir, Virginia.* 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 W/cm2 to 12 W/cm2 (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.

## 4.3 In vitro Studies: DNA Damage . . . [3 studies]

**4.3.1 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.

**4.3.2 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.

**4.3.3 Friedman et al. 2007.** Mechanism of short-term ERK activation by electromagnetic fields at mobile phone frequencies. *Biochem. J. (2007) 405, 559–568.* The exposure to non-thermal microwave electromagnetic fields generated by mobile phones affects the expression of many proteins... We found that the first step is mediated in the plasma membrane by NADH oxidase, which rapidly generates ROS (reactive oxygen species). These ROS then directly stimulate MMPs (matrix metalloproteinases) and allow them to cleave and release Hb-EGF [heparin-binding EGF (epidermal growth factor)]. This secreted factor activates the EGF receptor, which in turn further activates the ERK cascade. Thus this study demonstrates for the first time a detailed molecular mechanism by which electromagnetic irradiation from mobile phones induces the activation of the ERK cascade and thereby induces transcription and other cellular processes.

## II. SCIENTIFIC LITERATURE REVIEWS [21 literature reviews]

**1. Adams and Williams, 1975**. Biological Effects of electromagnetic radiation (radiowaves and microwaves)--Eurasian community countries. *Prepared by U.S. Army Medical Intelligence and Information Agency Office of the Surgeon General.*

**2. Balmori, 2009.** Electromagnetic pollution from phone masts. Effects on wildlife*. Pathophysiology 16: 191–199.*

**3. Blank and Goodman, 2007.** A Mechanism for Stimulation of Biosynthesis by Electromagnetic Fields: Charge Transfer in DNA and Base Pair Separation. *J. Cell. Physiol. 214: 20–26, 2008.*

**4. Bergman, 1965.** The Effect of Micro Waves on the Central Nervous System. *Pub. Research and Scientific Laboratory of Ford Motor Company, 1965.*

**5. Cherry, 2000-2002**.

**A**. Evidence of Health Effects of Electromagnetic Radiation, *To the Australian Senate Inquiry into Electromagnetic Radiation. September 8, 2000.*

**B.** Epidemiological studies of enhanced Brain/CNS Cancer incidence and mortality from EMR and EMF exposures. *Lincoln University Canterbury, New Zealand, June 2002.*

**C.** EMF/EMR Reduces Melatonin in Animals and People. *Lincoln University Canterbury, New Zealand. September 2, 2002.*

**D.** Evidence of Neurological effects of Electromagnetic Radiation: Implications for degenerative disease and brain tumour from residential, occupational, cell site and cellphone exposures. *Lincoln University Canterbury, New Zealand. September 10, 2002.*

**E.** Evidence that EMF/EMR causes Leukaemia/Lymphoma in Adults and Children. *Lincoln University Canterbury, New Zealand. September 12. 2002.*

**F.** Reproductive effects from EMF/EMR exposure. *Lincoln University Canterbury, New Zealand. September 12, 2002.*

**G.** Cardiac Effects of Natural and Artificial EMR. *Lincoln University Canterbury, New Zealand. December 16, 2002.*

**6. Cleary, 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.*

**7. Georgiou, 2010.** Oxidative stress-induced biological damage by low-level EMFs: mechanism of free radical pair electron spinpolarization and biochemical amplification. *Eur. J. Oncol. - Library Vol. 5*

*(2010): pp 63-114.* Low-level EMFs can interact non-thermally with biological systems primarily by spin-polarized chemical steps that can be enhanced by non-linear biological amplification mechanisms that can be triggered with internal and external factors. This evidence strongly suggests the involvement of the free radical pair mechanism on the oxidative stress-inducing effect of EMF and SMF as amplified by various extracellular and intracellular stimulants (fig. 8). This has been shown by indirect evidence that oxygen free radicals are generated in experimental organisms and cells during and/or after exposure to EMFs. Oxygen/nitrogen free radicals uncover their presence by the various biological alterations they cause; serious damage on lipids (lipid peroxidation) and DNA (fragmentation and nicks), decrease in the activity of important enzymes involved in the antioxidant protection of the cell, and alterations in the activity of a variety of other important metabolic enzymes, all of which reflect on the harmful perturbation of the general cell/organism metabolism.

**7. 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.*

**8. 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 (2009). doi:10.1016/j.pathophys.2009.03.004.*

**10. Lai, 1998.** NEUROLOGICAL EFFECTS OF RADIOFREQUENCY ELECTROMAGNETIC RADIATION. *Paper presented at the "Workshop on Possible Biological and Health Effects of RF Electromagnetic Fields", Mobile Phone and Health Symposium, Oct 25-28, 1998, University of Vienna, Vienna, Austria.*

**12. LaVignera, 2012.** Effects of the Exposure to Mobile Phones on Male Reproduction: A Review of the Literature. *J Androl 2012;33:350–356.*

**12. Raines, 1981.** ELECTROMAGNETIC FIELD INTERACTIONS WITH THE HUMAN BODY: OBSERVED EFFECTS AND THEORIES. *NASA Purchase Order No. S-75151B . Report Prepared for: National Aeronautics and Space Administration Goddard Space Flight Center Greenbelt, Maryland 20771. April 9, 1981.*

**13. Salford, 2008.** The Mammalian Brain in the Electromagnetic Fields Designed by Man with Special Reference to Blood-Brain Barrier Function, Neuronal Damage and Possible Physical Mechanisms. *Progress of Theoretical Physics Supplement No. 173, 2008.*

**14. US Fish and Wildlife Report, 2009.** Briefing Paper on the Need for Research into the Cumulative Impacts of Communication Towers on Migratory Birds and Other Wildlife in the United States Division of Migratory Bird Management (DMBM), U.S. Fish & Wildlife Service – for Public release.

**15. 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.*

## III. EXPERT REPORTS & LETTERS [23 items]

**1. American Academy of Environmental Medicine.** Recommendations Regarding Electromagnetic and Radiofrequency Field Exposure. July 12, 2012.

**2. The American Academy of Environmental Medicine.** AAEM Calls for Immediate Caution regarding Smart Meter Installation. April 12, 2012.

**3. American Academy of Pediatrics.** Letter from Robert W. Block, MD FAAP, President of the American Academy of Pediatrics, "*strongly supports the proposal for a formal inquiry into radiation standards for cell phones and other wireless products. The Academy encourages the Federal Communications Commission (FCC) to vote to move forward with this inquiry in an expeditious manner*." July 12, 2012.

**4. Dr. Robert A. Baan, PhD.** Officer in charge of the development of Monograph 102 on Radiofrequency (RF) Electromagnetic Fields for the World Health Organization's International Agency for Research on Cancer. Email to Dr. Hudson. *"The classification 2B, possibly carcinogenic, holds true for all types of radiation within the radiofrequency part of the electromagnetic spectrum, including those emitted by...smart meters."* August 29, 2012. (See also, World Health Organization, item 21 ).

**5. Dr. David O. Carpenter, MD.** Former Dean of the University of Albany's School of Public Health. Article in Quebec-based magazine *La Maison du 21e siecle*. La Maison asked physician David O. Carpenter, former founding dean of the University at Albany (NY)'s School of Public Health, to comment on a letter published in the Montreal daily *Le Devoir* last May 24. *"We, the undersigned are a group of scientists and health professionals who together have coauthored hundreds of peer-reviewed studies on the health effects of electromagnetic fields (EMFs). We wish to correct some of the gross misinformation found in the letter regarding wireless "smart" meters that was published in the Montreal daily Le Devoir on May 24. Submitted by a group Quebec engineers, physicists and chemists, the letter in question reflects an obvious lack of understanding of the science behind the health impacts of the radiofrequency (RF)/microwave EMFs emitted by these meters...Children are especially at risk...According to seven surveys done in six European countries between 2002 and 2004, about 10% of Europeans have become electrosensitive, and experts fear that percentage could reach 50% by 2017...High frequency EMFs such as the microwaves used in cell phones, smart meters, Wi-Fi and cordless ''DECT'' phones, appear to be the most damaging when used commonly. Most of their biological effects, including symptoms of electrohypersensitivity, can be seen in the damage done to cellular membranes by the loss of structurally-important calcium ions. Prolonged exposure to these high frequencies may eventually lead to cellular malfunction and death."* July 12, 2012.

**6. Dr. David O. Carpenter, MD.** Expert Report to Quebec Energy Board, Docket N. R-3770-2011. Carpenter, whose curriculum vitae runs to 32 pages, is the former director of the third-largest public health lab in the U.S., testified about RF and power-line emissions and cancer before the U.S. President's Cancer Panel in 2009 and is among the external reviewers of grant proposals for Quebec's cancer program. April 30, 2011.

**7. Dr. David O. Carpenter, MD.** President's Cancer Panel 2009. *"Many cellular effects of EMFs have been demonstrated, including gene induction, indirect DNA damage through formation of reactive oxygen species, disruption of calcium regulation, and induction of heat shock proteins...Reduction of exposure to other sources of RF can be accomplished by keeping AM, FM, television, and mobile phone towers far from homes, schools, and businesses. Wireless networks should not be used in schools; wired connections should be used instead. There should be resistance to the general trend toward making everything wireless without consideration of negative consequences...Given the growing evidence of adverse human health effects from RF exposure, this issue cannot be ignored. "* January 27, 2009.

**8. Dr. David O. Carpenter, MD.** Report on the review of the California Council on Science and Technology document, "Health Impacts of Radiofrequency from Smart Meters. We rely on statistical significance and weight of evidence when drawing conclusions about health effects. When one uses these definitions there isconclusive scientific evidence for adverse health effects in humans. The evidence for adverse effects of radiofrequency radiation is currently strong and grows stronger with each new study. Wired meters with shielded cable do not increase exposure. The report clearly indicates that "smart meters could conceivably be adapted to non-wireless transmission of data. However, retrofitting millions of smart meters with hard-wired technology could be difficult and costly." Clearly the answer to this dilemma is not to install wireless smartmeters to begin with.

**9. Fragopoulos, 2010.** Selutun Scientific Panel Position and Appeal. *Scientific Panel on Electromagnetic Field Health Risks: Consensus Points, Recommendations, and Rationales. REVIEWS ON ENVIRONMENTAL HEALTH, VOLUME 25, No. 4, 2010.*

**10. Daniel Hirsch, Nuclear Policy Expert.** Comments on the Draft Report by the California Council on Science and Technology "Health Impacts of Radio Frequency from Smart Meters". *"[T])he cumulative whole body exposure from a Smart Meter at 3 feet appears to be approximately two orders of magnitude higher than that of a cell phone, rather than two orders of magnitude lower. It is strongly recommended that CCST revise its Draft Report and conduct actual measurements of cell phone, microwave oven, and SmartMeter RF cumulative whole body power densities. If measurements aren't made, then rigorous calculations correcting for cell phone and microwave oven duty cycles and whole body exposures should be made."* 31 January 2011.

**11. International Commission for Electromagnetic Safety (ICEMS).** ICEMS is a non-profit organization that promotes research to protect public health from electromagnetic fields and develops the scientific basis and strategies for assessment, prevention, management and communication of risk, based on the precautionary principle. The Venice Resolution. *"As stated in the Benevento Resolution of September 2006, we remain concerned about the effects of human exposure to electromagnetic fields on health. At the Venice Workshop, entitled, "Foundations of bioelectromagnetics: towards a new rationale for risk assessment and management," we discussed electrohypersensitivity, blood brain barrier changes, learning and behavioral effects, changes in anti-oxidant enzyme activities, DNA damage, biochemical mechanisms of interaction, biological damage and, experimental approaches to validate these effects. As an outcome, we are compelled to confirm the existence of non-thermal effects of electromagnetic fields on living matter, which seem to occur at every level of investigation from molecular to epidemiological... We, who are at the forefront of this research, encourage an ethical approach in setting of exposure standards which protect the health of all, including those who are more vulnerable...We recognize the growing public health problem known as electrohypersensitivity; that this adverse health condition can be quite disabling; and, that this condition requires further urgent investigation and recognition."* June 6, 2008.

**12. International Doctors´Appeal 2012.** 10 Years after the Freiburg Appeal: Radio-frequency Radiation Poses a Health Risk. Physicians Demand Overdue Precaution. *Ten years ago, physicians of the **Freiburg Appeal** called on their colleagues, the public, and the politicians and health officials in charge because they were deeply concerned about the health of their fellow citizens. This Doctors´Appeal, in which they strongly warned about the dangers of wireless radiation, was translated into many languages and supported by more than 1000 physicians and more than 36,000 people worldwide.* October 2012.

**13. Professor Lukas Margaritis, PhD.** *Department of Cell Biology & Biophysics Electromagnetic Biology Laboratory.* Comment on CCST Report. *"It is not true (as mentioned in the report) that there is no evidence for mechanism on non-thermal. ROS formation is more and more shown to be a key first response cascading all rest effects (DNA damage, tumour formation, memory deficits, fatigue, sleep disorders, etc.) The argument that "more and more wireless devices will be used in daily life" is not and cannot be taken as obligatory. Who can support that the constitution, any constitution of any country should allow installations to take place (as the one with Smart Meters) against the rights for health of the citizens. The safety guidelines by ICNIRP are 12 years old, this by itself, after an enormous accumulation of research data implies that the threshold limits should have been updated, and they have not. In fact NO GUIDELINES FOR CONSTANT EXPOSURE HAVE BEEN ESTABLISHED SO FAR."* January 16, 2011.

**14. Don Maisch, PhD. 2010.** EMFacts Consultancy. Consumers Federation of Australia (CFA) and Consumer Law Centre (CLC). CFA representative on the Consultative committee, ELF powerline standards, The Australian Radiation Protection And Nuclear Safety Agency (ARPANSA). The Procrustean Approach – Setting Exposure Standards for Telecommunications Frequency Electromagnetic Radiation. An examination of the manipulation of telecommunications standards by political, military, and industrial vested interests at the expense of public health protection. This thesis contends that, rather than taking a precautionary approach, Western standard setting organisations have actually followed what can best be described as a Procrustean approach. This approach consists of cutting off from consideration scientific data that does not conform to their bed of knowledge. Such an approach can be considered just as inimical to public health protection as was Procrustes' mythical bed for the public of his time.

**15. Dr. Karl Maret.** Bachelor of Science in Electrical Engineering, a Master of Engineering degree in Biomedical Engineering,Medical Doctor with a four year postdoctoral fellowship in physiology. Commentary on the California Council on Science and Technology Report "Health Impacts of Radio Frequency from Smart Meters" . "*I submit that the CCST report, written in response to health concerns expressed by Assembly Members of the California Legislature, contains inaccuracies and minimizes the biological effects and health impacts of non-thermal radiofrequency radiation, such as those produced by wireless technologies including Smart Meters...In summary, we find that the CCST report is incomplete and misleading giving California State regulators a false sense of security while potentially endangering the future health and well-being of Californians. It is requested that the current Smart Meter deployment be halted pending a more comprehensive scientific investigation of the biological response and health impacts of the non-thermal aspects of this technology. All households should be offered full disclosure about possible exposure levels, modulation patterns, peak power levels and interactions with other parts of the microwave spectrum in their home environments. Additionally, those who are sensitive to this radiation must be given the choice to opt out from having this form of RFR imposed upon their residential dwellings."*

January 30, 2011.

**16. Dr. Samuel Milham. MD, MPH.** Physician /epidemiologist, specializing in occupational medicine and in the health effects of electromagnetic fields**.** Critique of CCST's report, "Health Impacts of Radio Frequency from Smart Meters," written to Lora Lee Martin. *"Dirty electricity levels measured in homes, offices and schools should increase after the meters are deployed. Dirty electricity levels measured in the utility drops and in the earth will also increase as the meters are deployed. Since dirty electricity is a potent carcinogen (see attached paper and pp. 78-80 in my book), and causes numerous health problems, the only way to avoid a public health catastrophe is to send the smart meter information over existing telephone land lines or go back to the analog meters."*

**17. Dr. Poki Stewart Namkung, MD, MPH.** Health Officer, Public Health Division, County of Santa Cruz, California. Report to Santa Cruz County Board of Supervisors on the Health Risks Associated with Smart Meters. *"Currently, research has demonstrated objective evidence to support the EHS diagnosis, defining pathophysiological mechanisms including immune-dysregulation in-vitro with increased production of cytokines and disruption and dysregulation of catecholamine physiology. (Genius, 2011)....evidence is accumulating on the results of exposure to RF at non-thermal levels including increased permeability of the blood-brain barrier in the head (Eberhardt, 2008), harmful effects on sperm, double strand breaks in DNA which could lead to cancer genesis (Phillips, 2011), stress gene activation indicating an exposure to a toxin (Blank, 2011), and alterations in brain glucose metabolism (Volkow, 2011)... There are no current, relevant public safety standards for pulsed RF involving chronic exposure of the public, nor of sensitive populations, nor of people with metal and medical implants that can be affected both by localized heating and by electromagnetic interference (EMI) for medical wireless implanted devices."* January 13, 2012.

**18. Janet Newton.** President, EMR Policy Institute. *"Currently there are three U.S. federal mandates promoting wireless technologies that can adversely affect the health and well being of all Americans, and especially those who require Implanted Medical Devices (IMDs) as well as those who suffer from the functional impairments of EHS and Radiofrequency Sickness. These population subgroups warrant protection by the under Americans with Disabilities Act provisions....Illustrating inadequate protection under the current FCC RF safety policy is the experience of geophysics professor Gary Olhoeft PhD with the critical EMI problems he encounters daily with his Medtronics Deep Brain Stimulator (DBS). Prof. Olhoeft's*
*comment was read at the first Public Comment period at the July 26-27, 2010 FCC FDA combined public meeting on, "Enabling the Convergence of Communications and Medical Systems." Despite Dr. Olhoeft's insightful analysis and account of this one example of EMI between wireless systems and his DBS, neither the FCC moderator nor the FDA moderator of the following day's panel on Electromagnetic Compatibility (EMC) raised one question on this EMI topic so critical to the life, health and well being of millions of Americans" EMR Policy Institute " strongly urges the State of California to broaden #4 of CCST Other Considerations to require Smart Grid / Smart Meter options that employ fiber optic and hard-wired data transmission rather than wireless transmitting Smart Meters."* January 31, 2011.

**19. Dr. Elihu D. Richter, MD, MPH.** Hebrew University-Hadassah School of Public Health and Community Medicine Unit of Occupational and Environmental Medicine. Medical epidemiologist who has assessed source exposure-effect relationships for many chemical and physical agents over the past 40 years. Letter of Comment on Smart Meter Report to Lora Lee Martin, Director Strategic Policy Initiatives and Government Affairs California Council on Science and Technology; and Susan Hackwood, PhD,

Executive Director, California Council on Science and Technology. *"Were these population-wide exposures to smart meters to be part of a project carried out in a medical setting, to test the risks and benefits of a new technology on human health and well being, it would be rejected by a Medical Institutional Review Board on ethical grounds as an unethical exercise in human experimentation...There is a huge body of evidence to refute the claim the so-called "hot muffin theory" that there are no effects from sub-thermal exposures to NIR [non-ionizing radiation], and specifically RF/MW...The effects pertain to ROS- Reactive Oxygen Species, cellular changes, effects on DNA, and neurobehavioral effects--e.g. deficits in memory, mood changes, fatigue, headache, as well as electro hypersensitivity and cancer, and effects on those with electronic medical implants. It is important to note that there are also concerns about the production of dirty electricity, itself a risk factor for many of these outcomes...There is no excuse for avoiding this investment with a permanent enduring protection for the public in avoiding and not introducing fiber optics. For reasons just stated, it will be bad ethics and bad technology and, possibly wanton negligence, recklessness and incompetence to wilfully forego the last option."*

**20. Cindy Sage, MA.** Environmental Consultant, Public Policy Researcher. Associate Member of the Bioelectromagnetics Society. Served on the California Public Utilities Commission EMF Consensus Group (1991-1992), the Keystone Institute Dialogue for Transmission Line Siting (1991-1992), and the International Electric Transmission Perception Project (1993-1994). "Assessment of Radiofrequency Microwave Radiation Emissions from Smart Meters." *"The installation of wireless 'smart meters' in California can produce significantly high levels of radiofrequency radiation (RF) depending on many factors (location of meter(s) in relation to occupied or usable space, duty cycle or frequency of RF transmissions, reflection and re-radiation of RF, multiple meters at one location, collector meters, etc). Power transmitters that will relay information from appliances inside buildings with wireless smart meters produce high, localized RF pulses. Any appliance that contains a power transmitter (for example, dishwashers, washers, dryers, ranges and ovens, convection ovens, microwave ovens, flash water heaters, refrigerators, etc) will create another 'layer of RF signals' that may cumulatively increase RF exposures from the smart meter(s)....**RF levels from the various scenarios depicting normal installation and operation, and possible FCC violations have been determined based on both time-averaged and peak power limits** (Tables 1 – 14). Potential violations of current FCC public safety standards for smart meters and/or collector meters in the manner installed and operated in California are illustrated in this Report, based on computer modeling (Tables 10 – 17)".* January 1, 2011.

**21. Cindy Sage, MA.** Response to EPRI Comment: Sage Report on Radio-Frequency. *"EPRI has presented no evidence of technical errors in the approach or calculations in the Sage Report, so the public and policy makers can rely on our conclusions and recommendations."* February 14, 2011.

**22. Cindy Sage, MA.** An Assessment of the EPRI Technical Report, An Investigation of Radiofrequency Fields Associated with the Itron Smart Meter [as performed by] Richard Tell Associates, Inc, December 2010 by Sage Associates. *"The EPRI report concludes that no violations of current FCC public safety limits are predicted to occur. However, our analysis shows that this conclusion is unsupported and in error...The EPRI report lays a foundation of doubt about whether and when a specific smart meter may or may not place a family home at risk of violations of FCC safety limits...Tell discusses many problems with predicting RF emissions and the need for long-term statistical monitoring of matured (read fully deployed and operational) smart meter networks across regions. He says this testing cannot be done today. So, utilities are hoping for the best, and deploying at full speed, regardless of the clear 'between-the lines' warnings, from their own highly regarded expert...No positive assertion of safety can be made by the parties involved in this issue, nor are any solid answers provided by this EPRI report. What is clear is that the information on RF emissions is highly uncertain, and may not be known*

*unless and until the entire system is up and running, and subjected to long-term testing...Deploying millions of wireless utility meters on such limited testing and questionable assertions of safety is unwise. Given that RF has recently been classified as a Possible Human Carcinogen, and this wireless utility meter initiative imposes the most extensive RF blanket yet created over every living resident that is electrified, ratepayers and the decision-makers will not know what irretrievable commitments of health and resources have been made until it is too late."* November 11, 2011.

**23. World Health Organization.** Press Release No. 208. IARC CLASSIFIES RADIOFREQUENCY ELECTROMAGNETIC FIELDS AS POSSIBLY CARCINOGENIC TO HUMANS. "The WHO/ International Agency for Research on Cancer (IARC) has classified radiofrequency electromagnetic fields as possibly carcinogenic to humans (Group 2B), based on an increased risk for glioma, a malignant type of brain cancer, associated with wireless phone use."