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

UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

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

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

v.

FEDERAL COMMUNICATIONS COMMISSION;
UNITED STATES OF AMERICA
Respondents

Petition for Review of Order Issued by the
Federal Communications Commission

DEFERRED JOINT APPENDIX

VOLUME 4

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Research Compilation; Abstracts of over 2,100 studies published between 1990-2017; Prof. Henry Lai.
(Tab 7 Part 3)

or degenerate neurons. These findings suggest that no dynamic changes occurred in cerebral microcirculation even during local cortex exposure under these conditions.

Martens AL, Slottje P, Timmermans DRM, Kromhout H, Reedijk M, Vermeulen RCH, Smid T. Modeled and Perceived Exposure to Radiofrequency Electromagnetic Fields From Mobile-Phone Base Stations and the Development of Symptoms Over Time in a General Population Cohort. Am J Epidemiol. 186(2):210-219, 2017.

We assessed associations between modeled and perceived exposure to radiofrequency electromagnetic fields (RF-EMF) from mobile-phone base stations and the development of nonspecific symptoms and sleep disturbances over time. A population-based Dutch cohort study, the Occupational and Environmental Health Cohort Study (AMIGO) (n = 14,829; ages 31-65 years), was established in 2011/2012 (T0), with follow-up of a subgroup (n = 3,992 invited) in 2013 (T1; n = 2,228) and 2014 (T2; n = 1,740). We modeled far-field RF-EMF exposure from mobile-phone base stations at the home addresses of the participants using a 3-dimensional geospatial model (NISMap). Perceived exposure (0 = not at all; 6 = very much), nonspecific symptoms, and sleep disturbances were assessed by questionnaire. We performed cross-sectional and longitudinal analyses, including fixed-effects regression. We found small correlations between modeled and perceived exposure in AMIGO participants at baseline (n = 14,309; rSpearman = 0.10). For 222 follow-up participants, modeled exposure increased substantially (>0.030 mW/m2) between T0 and T1. This increase in modeled exposure was associated with an increase in perceived exposure during the same time period. In contrast to modeled RF-EMF exposure from mobile-phone base stations, perceived exposure was associated with higher symptom reporting scores in both cross-sectional and longitudinal analyses, as well as with sleep disturbances in cross-sectional analyses.

Martinez-Burdalo M, Martin A, Anguiano M, Villar R. Comparison of FDTD-calculated specific absorption rate in adults and children when using a mobile phone at 900 and 1800 MHz. Phys Med Biol. 49(2):345-354, 2004.

In this paper, the specific absorption rate (SAR) in scaled human head models is analysed to study possible differences between SAR in the heads of adults and children and for assessment of compliance with the international safety guidelines, while using a mobile phone. The finite-difference time-domain method (FDTD) has been used for calculating SAR values for models of both children and adults, at 900 and 1800 MHz. Maximum 1 g averaged SAR (SAR1 g) and maximum 10 g averaged SAR (SAR10 g) have been calculated in adults and scaled head models for comparison and assessment of compliance with ANSI/IEEE and European guidelines. Results show that peak SAR1 g and peak SAR10 g all trend downwards with decreasing head size but as head size decreases, the percentage of energy absorbed in the brain increases. So, higher SAR in children's brains can be expected depending on whether the thickness of their skulls and surrounding tissues actually depends on age. The SAR in eyes of different sizes, as a critical organ, has also been studied and very similar distributions for the full size and the scaled models have been obtained. Standard limits can only be exceeded in the

unpractical situation where the antenna is located at a very short distance in front of the eye.

Martinez-Burdalo M, Martin A, Anguiano M, Villar R. On the safety assessment of human exposure in the proximity of cellular communications base-station antennas at 900, 1800 and 2170 MHz. Phys Med Biol. 50(17):4125-4137, 2005.

In this work, the procedures for safety assessment in the close proximity of cellular communications base-station antennas at three different frequencies (900, 1800 and 2170 MHz) are analysed. For each operating frequency, we have obtained and compared the distances to the antenna from the exposure places where electromagnetic fields are below reference levels and the distances where the specific absorption rate (SAR) values in an exposed person are below the basic restrictions, according to the European safety guidelines. A high-resolution human body model has been located, in front of each base-station antenna as a worst case, at different distances, to compute whole body averaged SAR and maximum 10 g averaged SAR inside the exposed body. The finite-difference time-domain method has been used for both electromagnetic fields and SAR calculations. This paper shows that, for antenna-body distances in the near zone of the antenna, the fact that averaged field values be below the reference levels could, at certain frequencies, not guarantee guidelines compliance based on basic restrictions.

Marzook EA, Abd El Moneim AE, Elhadary AA. Prootective role of seame oil against mobile phone base station-induced oxidative stress. J Rad Res Appl Sci 7(1):1-6, 2014.

The present study was undertaken to shed the light on the environmental threats associated with the wireless revolution and the health hazards associated with exposure to mobile base station (MBS). Besides, studying the possible protective role of sesame oil (SO) as an antioxidant against oxidative stress. Therefore, the present work was designed to study the effect of chronic exposure to electromagnetic radiations (EMR), produced by a cellular tower for mobile phone and the possible protective role of sesame oil on glutathione reductase (GSH-Rx), superoxide dismutase (SOD), catalase (CAT), total testosterone and lipid profile (total cholesterol (Tch), triglycerides (TG), low density lipoprotein cholesterol (LDL-c) and high density lipoprotein cholesterol (HDL-c) in male albino rats. Rats were arranged into four groups: the control unexposed, the exposed untreated and the exposed treated groups (1.5 and 3 ml oil). Exposed groups were subjected to electromagnetic field at frequency of 900 MHz, for 24 h/day for 8 weeks, at the same time both treated groups were supplied with oral injection of sesame oil three times per week. At the end of the experiment, blood samples were obtained for determination of the above mentioned variables in serum. The results obtained revealed that TG and testosterone were raised significantly over control in all groups and the significant increase in oil groups occurred in dose dependent manner. SOD and CAT activities were reduced significantly in exposed rats than control and increased significantly in sesame oil groups as the dose of oil increased. Total cholesterol only showed remarkable reduction in the group treated with 3 ml sesame oil. Also, in this latter group, significant elevation of GSH-Rx was recorded. Changes in serum HDL-c and LDL-c followed an opposite trend in exposed and sesame oil groups reflecting their affectation by EMR or sesame oil. In conclusion, all results of the current study proved that sesame

oil can be used as an edible oil to attenuate the oxidative stress which could be yielded as a result of chronic exposure to EMR.

Mashevich M, Folkman D, Kesar A, Barbul A, Korenstein R, Jerby E, Avivi L,Exposure of human peripheral blood lymphocytes to electromagnetic fields associated with cellular phones leads to chromosomal instability. Bioelectromagnetics 24:82-90, 2003.

Whether exposure to radiation emitted from cellular phones poses a health hazard is at the focus of current debate. We have examined whether in vitro exposure of human peripheral blood lymphocytes (PBL) to continuous 830 MHz electromagnetic fields causes losses and gains of chromosomes (aneuploidy), a major "somatic mutation" leading to genomic instability and thereby to cancer. PBL were irradiated at different average absorption rates (SAR) in the range of 1.6-8.8 W/kg for 72 hr in an exposure system based on a parallel plate resonator at temperatures ranging from 34.5-37.5 °C. The averaged SAR and its distribution in the exposed tissue culture flask were determined by combining measurements and numerical analysis based on a finite element simulation code. A linear increase in chromosome 17 aneuploidy was observed as a function of the SAR value, demonstrating that this radiation has a genotoxic effect. The SAR dependent aneuploidy was accompanied by an abnormal mode of replication of the chromosome 17 region engaged in segregation (repetitive DNA arrays associated with the centromere), suggesting that epigenetic alterations are involved in the SAR dependent genetic toxicity. Control experiments (i.e., without any RF radiation) carried out in the temperature range of 34.5-38.5 °C showed that elevated temperature is not associated with either the genetic or epigenetic alterations observed following RF radiation - the increased levels of aneuploidy and the modification in replication of the centromeric DNA arrays. These findings indicate that the genotoxic effect of the electromagnetic radiation is elicited via a non-thermal pathway. Moreover, the fact that aneuploidy is a phenomenon known to increase the risk for cancer, should be taken into consideration in future evaluation of exposure guidelines.

Maskarinec G, Cooper J, Swygert L. Investigation of increased incidence in childhood leukemia near radio towers in Hawaii: preliminary observations. J Environ Pathol Toxicol Oncol. 13(1):33-37, 1994.

Twelve children from the Waianae Coast, Hawaii, were diagnosed with acute leukemia from 1979 to 1990. The standardized incidence ratio (SIR) of 2.09 (95% confidence interval (CI) 1.08 to 3.65) indicates a significant increase. Seven cases occurred between 1982 and 1984 and were unusual in terms of sex, age, and type of leukemia. A case-control study (12 cases, 48 matched controls) explored risk factors, including parents' occupation, X-ray exposure, domestic smoking, family and medical histories, and distance of children's residence locations to low frequency radio towers. The odds ratio (OR) for having lived within 2.6 miles of the radio towers before diagnosis was 2.0 (95% CI 0.06 to 8.3). The clustering may have been a chance event, but because of its peculiar characteristics, we feel it should be noted.

Maskey D, Kim M, Aryal B, Pradhan J, Choi IY, Park KS, Son T, Hong SY, Kim

SB, Kim HG, Kim MJ. Effect of 835 MHz radiofrequency radiation exposure on calcium binding proteins in the hippocampus of the mouse brain. Brain Res.1313:232-241, 2010.

Worldwide expansion of mobile phones and electromagnetic field (EMF) exposure has raised question of their possible biological effects on the brain and nervous system. Radiofrequency (RF) radiation might alter intracellular signaling pathways through changes in calcium (Ca(2+)) permeability across cell membranes. Changes in the expression of calcium binding proteins (CaBP) like calbindin D28-k (CB) and calretinin (CR) could indicate impaired Ca(2+)homeostasis due to EMF exposure. CB and CR expression were measured with immunohistochemistry in the hippocampus of mice after EMF exposure at 835 MHz for different exposure times and absorption rates, 1 h/day for 5 days at a specific absorption rate (SAR)=1.6 W/kg, 1 h/day for 5 days at SAR=4.0 W/kg, 5 h/day for 1 day at SAR=1.6 W/kg, 5 h/day for 1 day at SAR=4.0 W/kg, daily exposure for 1 month at SAR=1.6 W/kg. Body weights did not change significantly. CB immunoreactivity (IR) displayed moderate staining of cells in the cornu ammonis (CA) areas and prominently stained granule cells. CR IR revealed prominently stained pyramidal cells with dendrites running perpendicularly in the CA area. Exposure for 1 month produced almost complete loss of pyramidal cells in the CA1 area. CaBP differences could cause changes in cellular Ca(2+)levels, which could have deleterious effect on normal hippocampal functions concerned with neuronal connectivity and integration..

Maskey D, Pradhan J, Aryal B, Lee CM, Choi IY, Park KS, Kim SB, Kim HG, Kim MJ. Chronic 835 MHz radiofrequency exposure to mice hippocampus alters the distribution of calbindin and GFAP immunoreactivity. Brain Res 1346:237-246, 2010.

Exponential interindividual handling in wireless communication system has raised possible doubts in the biological aspects of radiofrequency (RF) exposure on human brain owing to its close proximity to the mobile phone. In the nervous system, calcium (Ca(2+)) plays a critical role in releasing neurotransmitters, generating action potential and membrane integrity. Alterations in intracellular Ca(2+) concentration trigger aberrant synaptic action or cause neuronal apoptosis, which may exert an influence on the cellular pathology for learning and memory in the hippocampus. Calcium binding proteins like calbindin D28-K (CB) is responsible for the maintaining and controlling Ca(2+) homeostasis. Therefore, in the present study, we investigated the effect of RF exposure on rat hippocampus at 835MHz with low energy (Specific Absorption Rate: SAR=1.6W/kg) for 3months by using both CB and glial fibrillary acidic protein (GFAP) specific antibodies by immunohistochemical method. Decrease in CB immunoreactivity (IR) was noted in exposed (E1.6) group with loss of interneurons and pyramidal cells in CA1 area and loss of granule cells. Also, an overall increase in GFAP IR was observed in the hippocampus of E1.6. By TUNEL assay, apoptotic cells were detected in the CA1, CA3 areas and dentate gyrus of hippocampus, which reflects that chronic RF exposure may affect the cell viability. Additionally, the increase of GFAP IR due to RF exposure could be well suited with the feature of reactive astrocytosis, which is an abnormal increase in the number of astrocytes due to the loss of nearby neurons. Chronic RF exposure to the rat brain

suggested that the decrease of CB IR accompanying apoptosis and increase of GFAP IR might be morphological parameters in the hippocampus damages.

Maskey D, Kim HJ, Kim HG, Kim MJ. Calcium-binding proteins and GFAP immunoreactivity alterations in murine hippocampus after 1 month of exposure to 835MHz radiofrequency at SAR values of 1.6 and 4.0W/kg. Neurosci Lett. 506(2):292-296, 2012.

Abstract. Widespread use of wireless mobile communication has raised concerns of adverse effect to the brain owing to the proximity during use due to the electromagnetic field emitted by mobile phones. Changes in calcium ion concentrations via binding proteins can disturb calcium homeostasis; however, the correlation between calcium-binding protein (CaBP) immunoreactivity (IR) and glial cells has not been determined with different SAR values. Different SAR values [1.6 (E1.6 group) and 4.0 (E4 group) W/kg] were applied to determine the distribution of calbindin D28-k (CB), calretinin (CR), and glial fibrillary acidic protein (GFAP) IR in murine hippocampus. Compared with sham control group, decreased CB and CR IRs, loss of CB and CR immunoreactive cells and increased GFAP IR exhibiting hypertrophic cytoplasmic processes were noted in both experimental groups. E4 group showed a prominent decrement in CB and CR IR than the E1.6 group due to down-regulation of CaBP proteins and neuronal loss. GFAP IR was more prominent in the E4 group than the E1.6 group. Decrement in the CaBPs can affect the calcium-buffering capacity leading to cell death, while increased GFAP IR and changes in astrocyte morphology, may mediate brain injury due to radiofrequency exposure.

Maskey D, Kim MJ. Immunohistochemical Localization of Brain-derived Neurotrophic Factor and Glial Cell Line-derived Neurotrophic Factor in the Superior Olivary Complex of Mice after Radiofrequency Exposure. Neuroscience Letters. 564:78-82, 2014.

Raising health concerns about the biological effects from radiofrequency exposure, even with conflicting results, has prompted calls for formulation of a guideline of the biological safety level. Given the close proximity between a mobile phone and the ear, it has been suggested that the central auditory system may be detrimentally influenced by radiofrequency exposure. In the auditory system, neurotrophins are important in the regulation of neuron survival, especially mammalian cochlear neurons. Neurotrophic factors like brain-derived neurotrophic factor (BDNF) and glial-derived neurotrophic factor (GDNF) present in the auditory system are responsible for the maintenance of auditory neurons. BDNF and GDNF may protect against acoustic trauma and prevent from hearing defect. The present study applied radiofrequency at a specific absorption rate (SAR) of 1.6 W/kg (E1.6) or 0 W/kg group to determine the distribution of BDNF and GDNF in the nuclei of superior olivary complex (SOC). In the E1.6 group, significant decrements of BDNF immunoreactivity (IR) were noted in the lateral superior olive, medial superior olive, superior paraolivary nucleus and medial nucleus of the trapezoid body. GDNF IR was also significantly decreased ($p < 0.001$) in all SOC nuclei of the E1.6 group. The decrease in the IR of these neurotrophic factors in the SOC of the E1.6 group suggests a detrimental effect of RF exposure in the auditory nuclei.

Mason PA, Escarciga R, Doyle JM, Romano WF, Berger RE, Donnellan JP, Amino acid concentrations in hypothalamic and caudate nuclei during microwave-induced thermal stress: analysis by microdialysis. Bioelectromagnetics 18(3):277-283, 1997.

Exposure to radiofrequency radiation (RFR) may produce thermal responses. Extracellular amino acid concentrations in the hypothalamus (Hyp) and caudate nucleus (CN) were measured by using in vivo microdialysis before and during exposure to RFR. Under urethane anesthetic, each rat was implanted stereotaxically with a nonmetallic microdialysis probe and temperature probe guides and then placed in the exposure chamber. The rat laid on its right side with its head and neck placed directly under the wave guide. Temperature probes were placed in the left brain, right brain, face (subcutaneously), left tympanum, and rectum. Each microdialysis sample was collected over a 20 min period. The microdialysis probe was perfused for 2 h before the rat was exposed to 5.02 GHz radiation (10 microseconds pulse width, 1000 pulses/s). The right and left sides of the brain were maintained at approximately 41.2 and 41.7 degrees C, respectively, throughout a 40 min exposure period. Initially when the brain was being heated to these temperatures, the time-averaged specific absorption rates (SARs) for the right and left sides of the brain were 29 and 40 W/kg, respectively. Concentrations of aspartic acid, glutamic acid, serine, glutamine, and glycine in dialysate were determined by using high-pressure liquid chromatography with electrochemical detection. In the Hyp and CN, the concentrations of aspartic acid, serine, and glycine increased significantly during RFR exposure ($P < .05$). These results indicate that RFR-induced thermal stress produces a general change in the amino acid concentrations that is not restricted to thermoregulatory centers. Changes in the concentrations of glutamic acid (Hyp, $P = .16$; CN, $P = .34$) and glutamine (Hyp, $P = .13$; CN, $P = .10$) were not statistically significant. Altered amino acid concentrations may reveal which brain regions are susceptible to damage in response to RFR-induced thermal stress.

Mason PA, Walters TJ, DiGiovanni J, Beason CW, Jauchem JR, Dick EJ Jr, Mahajan K, Dusch SJ, Shields BA, Merritt JH, Murphy MR, Ryan KL. Lack of effect of 94 GHz radio frequency radiation exposure in an animal model of skin carcinogenesis. Carcinogenesis 22(10):1701-1708, 2001.

Although there is no evidence that electromagnetic energy in the radio frequency radiation (RFR) band is mutagenic, there have been suggestions that RFR energy might serve as either a promoter or co-promoter in some animal models of carcinogenesis. Recent developments in electromagnetic technology have resulted in the manufacture of RFR sources capable of generating frequencies in the millimeter wavelength (MMW) range (30-300 GHz). Because absorption of MMW energy occurs in the skin, it is to be expected that long-term detrimental health effects, if any, would most likely be manifest in the skin. In this study we investigated whether a single (1.0 W/cm(2) for 10 s) or repeated (2 exposures/week for 12 weeks, 333 mW/cm(2) for 10 s) exposure to 94 GHz RFR serves as a promoter or co-promoter in the 7,12-dimethylbenz[a]anthracene (DMBA)-induced SENCAR mouse model of skin carcinogenesis. Neither paradigm of MMW exposure significantly affected papilloma development, as evidenced by a lack of effect on tumor incidence and multiplicity. There was also no evidence that MMW exposure served as a co-promoter in DMBA-induced animals repeatedly treated with 12-O-

tetradecanoylphorbol 13-acetate. Therefore, we conclude that exposure to 94 GHz RFR under these conditions does not promote or co-promote papilloma development in this animal model of skin carcinogenesis.

Masuda H, Sanchez S, Dulou PE, Haro E, Anane R, Billaudel B, Leveque P, Veyret B. Effect of GSM-900 and -1800 signals on the skin of hairless rats. I: 2-hour acute exposures. Int J Radiat Biol. 82(9):669-674, 2006.

Purpose: The acute influence on the skin of non-ionizing electromagnetic fields in the radiofrequency (RF) range used in mobile telephony has not been widely studied to date. The purpose of this work was to determine whether the cells of hairless rat skin are affected by acute local exposure to Global System for Mobile Communication: GSM-900 or -1800 RadioFrequency Radiation (RFR).Materials and methods: Hairless female rats were exposed or sham-exposed for 2 h to GSM-900 or -1800 signals, using a loop-antenna located on the right part of the rats' back. The local Specific Absorption rate (SAR) at skin level was ca. 5 W/kg (5.8+/-0.4 and 4.8+/-0.4 W/kg at 900 and 1800 MHz, respectively). A skin biopsy was done at the end of the experiment not only at the location of exposure, but also on the symmetrical part of the back.Results: Analysis of skin sections using Hematoxylin Eosin Saffron (HES) coloration showed no difference in skin thickness or apparent cell toxicity (with no sign of cellular necrosis) among the animal groups. Histological analysis of the epidermis showed that the ratio between cells expressing the antigen Ki-67 (cellular proliferation marker) and the total number of cells remained within the range of normal proliferation ratio for the exposed side of the animal. No Ki-67 labelling was observed at the dermis level. Results on filaggrin, collagen and elastin levels also showed an insignificant influence of RFR.Conclusions: These results do not demonstrate any major physical and histological variations at skin level induced by RFR used in mobile telephony.

Masuda H, Ushiyama A, Hirota S, Wake K, Watanabe S, Yamanaka Y, Taki M, Ohkubo C. Effects of subchronic exposure to a 1439 MHz electromagnetic field on the microcirculatory parameters in rat brain. In Vivo. 21(4):563-570, 2007.

THE AIM of this study was to investigate whether repeated exposure to radio frequency electromagnetic field (RF-EMF) of 1439 MHz affects the cerebral microcirculation, including blood-brain barrier function, in a rat brain. MATERIALS AND METHODS: The head of the rat was exposed for four weeks (60 min/day, 5 days/week) to RF-EMF at 2.4 W/kg of brain averaged specific absorption rate (BASAR). Three microcirculatory parameters: blood-brain barrier permeability, leukocyte behavior and plasma velocity were measured before and after RF-EMF exposure using a closed cranial window method. RESULTS: No extravasation of intravenously injected dyes from pial venules was found at any BASAR level. No significant changes in the number of endothelial-adhering leukocytes after exposure were found. The plasma velocity remained constant within the physiological range through each exposure. CONCLUSION: These findings suggest that there were no effects on the cerebral microcirculation under the given RF-EMF exposure conditions.

Masuda H, Ushiyama A, Hirota S, Wake K, Watanabe S, Yamanaka Y, Taki M, Ohkubo C. Effects of acute exposure to a 1439 MHz electromagnetic field on the

microcirculatory parameters in rat brain. In Vivo. 21(4):555-562, 2007.

THE AIM of this study was to determine the potential of radio-frequency electromagnetic fields (RF-EMF) to affect cerebral microcirculation, including blood-brain barrier function, in rat brain. MATERIALS AND METHODS: The head of the rat was exposed for 10 min to 1439 MHz RF-EMF having three intensity doses: 0.6, 2.4, 4.8 W/kg of brain averaged specific absorption rate (BASAR). Four microcirculatory parameters: blood-brain barrier permeability, leukocyte behavior, plasma velocity, and vessel diameter were measured before and after RF-EMF exposure using a closed cranial window method. RESULTS: No extravasation of intravenously injected dyes from pial venules was found at any BASAR level. No significant changes in the number of endothelial-adhering leukocytes after exposure were found. The hemodynamics indicated that the plasma velocities and vessel diameters remained constant within the physiological range throughout each exposure. CONCLUSION: These findings suggest that there were no effects on the cerebral microcirculation under the given RF-EMF exposure conditions.

Masuda H, Hirata A, Kawai H, Wake K, Watanabe S, Arima T, Poulletier de Gannes F, Lagroye I, Veyret B. Local exposure of the rat cortex to radiofrequency electromagnetic fields increases local cerebral blood flow along with temperature. J Appl Physiol. 110(1):142-148, 2011.

Few studies have shown that local exposure to radiofrequency electromagnetic fields (RF) induces intensity-dependent physiological changes, especially in the brain. The aim of the present study was to detect reproducible responses to local RF exposure in the parietal cortex of anesthetized rats and to determine their dependence on RF intensity. The target cortex tissue was locally exposed to 2-GHz RF using a figure-eight loop antenna within a range of averaged specific absorption rates (10.5, 40.3, 130, and 263 W/kg averaged over 4.04 mg) in the target area. Local cerebral blood flow (CBF) and temperatures in three regions (target area, rectum, and calf hypodermis) were measured using optical fiber blood flow meters and thermometers during RF exposure. All parameters except for the calf hypodermis temperature increased significantly in exposed animals compared with sham-exposed ones during 18-min exposures. Dependence of parameter values on exposure intensity was analyzed using linear regression models. The elevation of local CBF was correlated with temperature rise in both target and rectum at the end of RF exposure. However, the local CBF elevation seemed to be elevated by the rise in target temperature, but not by that of the rectal temperature, in the early part of RF exposure or at low-intensity RF exposure. These findings suggest that local RF exposure of the rat cortex drives a regulation of CBF accompanied by a local temperature rise, and our findings may be helpful for discussing physiological changes in the local cortex region, which is locally exposed to RF.

Mathur R. Effect of chronic intermittent exposure to AM radiofrequency field on responses to various types of noxious stimuli in growing rats. Electromagn Biol Med. 27(3):266-276, 2008.

There are several reports of altered pain sensation after exposure (from a few minutes to hours in single or repeated doses for 2-3 weeks) to electromagnetic fields (EMF) in adults. The commonly utilized noxious stimulus is radiant heat. The nociceptive responses are known to be influenced by characteristics of stimulus, organism, and environment. We studied the pattern of nociceptive responses to various noxious stimuli in growing rats exposed to radiofrequency field (73.5 MHz amplitude modulated, 16 Hz power density 1.33 mw/cm(2), SAR = 0.4 w/kg) for 45 d (2 h/d). Threshold current for stimulation of nociceptive afferents to mediate motor response of tail (TF), vocalization during stimulus (VD), and vocalization after discharge (VA); the withdrawal latency of tail (TFL) and hind paw (HPL) to thermal noxious stimulus and tonic pain responses were recorded in every rat. The TFL was not affected, HPL was decreased ($p < 0.01$), and the thresholds of TF and VD were not affected, while, that of VA was significantly decreased. The tonic pain rating was decreased ($p < 0.01$). A decrease in the threshold of VA ($p < 0.01$) is indicative of an increase in the emotional component of the response to the phasic pain, whereas a decrease in the pain rating indicates analgesia in response to the tonic pain. The results of our study suggest that chronic (45 d), intermittent (2 h/d) amplitude modulated RF field exposure to the peripubertal rat increases the emotional component of phasic pain over a basal eaualgesic state, while late response to tonic pain is decreased. The data suggest that amplitude modulated RF field differentially affects the mechanisms involved in the processing of various noxious stimuli.

Mattei E, Censi F, Triventi M, Calcagnini G. Electromagnetic Immunity of Implantable Pacemakers Exposed to Wi-Fi Devices. Health Phys. 107(4):318-325, 2014.

The purpose of this study is to evaluate the potential for electromagnetic interference (EMI) and to assess the immunity level of implantable pacemakers (PM) when exposed to the radiofrequency (RF) field generated by Wi-Fi devices. Ten PM from five manufacturers, representative of what today is implanted in patients, have been tested in vitro and exposed to the signal generated by a Wi-Fi transmitter. An exposure setup that reproduces the actual IEEE 802.11b/g protocol has been designed and used during the tests. The system is able to amplify the Wi-Fi signal and transmits at power levels higher than those allowed by current international regulation. Such approach allows one to obtain, in case of no EMI, a safety margin for PM exposed to Wi-Fi signals, which otherwise cannot be derived if using commercial Wi-Fi equipment. The results of this study mitigate concerns about using Wi-Fi devices close to PM: none of the PM tested exhibit any degradation of their performance, even when exposed to RF field levels five times higher than those allowed by current international regulation (20 W EIRP). In conclusion, Wi-Fi devices do not pose risks of EMI to implantable PM. The immunity level of modern PM is much higher than the transmitting power of RF devices operating at 2.4 GHz.

Matthews R, Legg S, Charlton S. The effect of cell phone type on drivers subjective workload during concurrent driving and conversing. Accid Anal Prev 35(4):451-457, 2003.

The effect of three types of cell phones (hand held, hands free with an external speaker and personal hands free) on total subjective workload (including its constituent components; mental demand, physical demand, temporal demand, performance, effort and frustration) and intelligibility was measured using the NASA-task load index (TLX) and the modified rhyme test (MRT), respectively in 13 experienced drivers (nine male, four female, age range 28-65 years), whilst driving on a rural highway. The drivers rated all components of workload for each type of cell phone to be significantly higher than for a control condition in which no cell phone was used. The mean (standard deviation) total workload was lowest for the personal hands free cell phone (7.1(3.65)) and highest for the hands free speaker phone (10.8 (3.63)) ($P<0.001$). The mean (standard deviation) intelligibility score was highest for the personal hands free cell phone (74.1 (7.9)) and lowest for the hands free speaker phone (55.0 (10.4)) ($P<0.001$). Frustration was significantly correlated with total workload (0.60, $P<0.001$) and intelligibility was significantly correlated with frustration (-0.35, $P<0.05$). Physical demand was not a high contributor to total workload. It is concluded that a personal hands free cell phone would interfere least with the cognitive demands of driving.

Mausset A, de Seze R, Montpeyroux F, Privat A. Effects of radiofrequency exposure on the GABAergic system in the rat cerebellum: clues from semi-quantitative immunohistochemistry. Brain Res 912(1):33-46, 2001.

The widespread use of cellular phones raises the problem of interaction of electromagnetic fields with the central nervous system (CNS). In order to measure these effects on neurotransmitter content in the CNS, we developed a protocol of neurotransmitter detection based on immunohistochemistry and image analysis. Gamma-vinyl-GABA (GVG), an inhibitor of the GABA-transaminase was injected in rats to increase GABA concentration in the CNS. The cellular GABA contents were then revealed by immunohistochemistry and semi-quantified by image analysis thanks to three parameters: optical density (O.D.), staining area, and number of positive cells. The increase in cerebellar GABA content induced by GVG 1200 mg/kg was reflected in these three parameters in the molecular and the granular layers. Therefore, control of immunohistochemistry parameters, together with appropriate image analysis, allowed both the location and the detection of variations in cellular neurotransmitter content. This protocol was used to investigate the effects of exposure to 900 MHz radiofrequencies on cerebellar GABA content. Both pulsed emission with a specific absorption rate (SAR) of 4 W/kg and continuous emission with high SAR (32 W/kg) were tested. We observed a selective diminution of the stained processes area in the Purkinje cell layer after exposure to pulsed radiofrequency and, in addition, a decrease in O.D. in the three cell layers after exposure to continuous waves. Whether this effect is, at least partly, due to a local heating of the tissues is not known. Overall, it appears that high energetic radiofrequency exposure induces a diminution in cellular GABA content in the cerebellum.

Mausset-Bonnefont AL, Hirbec H, Bonnefont X, Privat A, Vignon J, de Seze R.Acute exposure to GSM 900-MHz electromagnetic fields induces glial reactivity and biochemical modifications in the rat brain. Neurobiol Dis. 17(3):445-454, 2004.

The worldwide proliferation of mobile phones raises the question of the effects of 900-MHz electromagnetic fields (EMF) on the brain. Using a head-only exposure device in the

rat, we showed that a 15-min exposure to 900-MHz pulsed microwaves at a high brain-averaged power of 6 W/kg induced a strong glial reaction in the brain. This effect, which suggests neuronal damage, was particularly pronounced in the striatum. Moreover, we observed significant and immediate effects on the K(d) and B(max) values of N-methyl-d-aspartate (NMDA) and GABA(A) receptors as well as on dopamine transporters. Decrease of the amount of NMDA receptors at the postsynaptic membrane is also reported. Although we showed that the rat general locomotor behavior was not significantly altered on the short term, our results provide the first evidence for rapid cellular and molecular alterations in the rat brain after an acute exposure to high power GSM (Global System for Mobile communication) 900-MHz microwaves.

Mazor R, Korenstein-Ilan A, Barbul A, Eshet Y, Shahadi A, Jerby E, Korenstein R. Increased levels of numerical chromosome aberrations after in vitro exposure of human peripheral blood lymphocytes to radiofrequency electromagnetic fields for 72 hours. Radiat Res 169(1):28-37, 2008.

We investigated the effects of 72 h in vitro exposure of 10 human lymphocyte samples to radiofrequency electromagnetic fields (800 MHz, continuous wave) on genomic instability. The lymphyocytes were exposed in a specially designed waveguide resonator at specific absorption rates (SARs) of 2.9 and 4.1 W/kg in a temperature range of 36-37 degrees C. The induced aneuploidy of chromosomes 1, 10, 11 and 17 was determined by interphase FISH using semi-automated image analysis. We observed increased levels of aneuploidy depending on the chromosome studied as well as on the level of exposure. In chromosomes 1 and 10, there was increased aneuploidy at the higher SAR, while for chromosomes 11 and 17, the increases were observed only for the lower SAR. Multisomy (chromosomal gains) appeared to be the primary contributor to the increased aneuploidy. The effect of temperature on the level of aneuploidy was examined over the range of 33.5-40 degrees C for 72 h with no statistically significant difference in the level of aneuploidy compared to 37 degrees C. These findings suggest the possible existence of an athermal effect of RF radiation that causes increased levels of aneuploidy. These results contribute to the assessment of potential health risks after continuous chronic exposure to RF radiation at SARs close to the current levels set by ICNIRP guidelines.

McEvoy SP, Stevenson MR, McCartt AT, Woodward M, Haworth C, Palamara P, Cercarelli R. Role of mobile phones in motor vehicle crashes resulting in hospital attendance: a case-crossover study. BMJ 331(7514):428, 2005.

OBJECTIVES: To explore the effect of drivers' use of mobile (cell) phones on road safety. DESIGN: A case-crossover study. SETTING: Perth, Western Australia. PARTICIPANTS: 456 drivers aged >/=17 years who owned or used mobile phones and had been involved in road crashes necessitating hospital attendance between April 2002 and July 2004. MAIN OUTCOME MEASURE: Driver's use of mobile phone at estimated time of crash and on trips at the same time of day in the week before the crash. Interviews with drivers in hospital and phone company's records of phone use. RESULTS: Driver's use of a mobile phone up to 10 minutes before a crash was associated with a fourfold increased likelihood of crashing (odds ratio 4.1, 95% confidence interval 2.2 to 7.7, P<0.001). Risk

was raised irrespective of whether or not a hands-free device was used (hands-free: 3.8, 1.8 to 8.0, P<0.001; hand held: 4.9, 1.6 to 15.5, P=0.003). Increased risk was similar in men and women and in drivers aged >/=30 and <30 years. A third (n=21) of calls before crashes and on trips during the previous week were reportedly on hand held phones. CONCLUSIONS: When drivers use a mobile phone there is an increased likelihood of a crash resulting in injury. Using a hands-free phone is not any safer.

McIntosh RL, Deppeler L, Oliva M, Parente J, Tambuwala F, Turner S, Winship D, Wood AW. Comparison of radiofrequency exposure of a mouse dam and foetuses at 900 MHz. Phys Med Biol. 55(4):N111-122, 2010.

In vivo studies involving radiofrequency (RF) exposure of rodents require detailed dosimetric analysis to enable correct interpretation of biological outcomes. Detailed anatomical models of mice--a female, a pregnant female, a male and a foetus--have been developed for analyses using finite difference numerical techniques. The mouse models, consisting of 49 tissues, will be made freely available to the research community. In this note, the pregnant mouse model, which included eight mature foetuses, was utilized specifically to consider (a) the RF dosimetry in a radial cavity exposure system operated at a frequency of 900 MHz and (b) a 900 MHz plane wave exposure. A comparison was made between the exposure of the mouse dam and the foetuses as specified by the specific energy absorption rate (SAR) and the resultant temperature change. In general, the SAR levels in the foetuses were determined to be slightly lower (around 14% lower than the average values of the dam) and the peak temperature increase was significantly lower (45%) than the values in the dam.

McNamee JP, Bellier PV, Gajda GB, Miller SM, Lemay EP, Lavallee BF, Marro L, Thansandote A. DNA damage and micronucleus induction in human leukocytes after acute in vitro exposure to a 1.9 GHz continuous-wave radiofrequency field. Radiat Res 158(4):523-533, 2002.

Human blood cultures were exposed to a 1.9 GHz continuous-wave (CW) radiofrequency (RF) field for 2 h using a series of six circularly polarized, cylindrical waveguides. Mean specific absorption rates (SARs) of 0.0, 0.1, 0.26, 0.92, 2.4 and 10 W/kg were achieved, and the temperature within the cultures during a 2-h exposure was maintained at 37.0 +/- 0.5 degrees C. Concurrent negative (incubator) and positive (1.5 Gy (137)Cs gamma radiation) control cultures were run for each experiment. DNA damage was quantified immediately after RF-field exposure using the alkaline comet assay, and four parameters (tail ratio, tail moment, comet length and tail length) were used to assess DNA damage for each comet. No evidence of increased primary DNA damage was detected by any parameter for RF-field-exposed cultures at any SAR tested. The formation of micronuclei in the RF-field-exposed blood cell cultures was assessed using the cytokinesis-block micronucleus assay. There was no significant difference in the binucleated cell frequency, incidence of micronucleated binucleated cells, or total incidence of micronuclei between any of the RF-field-exposed cultures and the sham-exposed controls at any SAR tested. These results do not support the hypothesis that acute, nonthermalizing 1.9 GHz CW RF-field exposure causes DNA damage in cultured human leukocytes.

McNamee JP, Bellier PV, Gajda GB, Lavallee BF, Lemay EP, Marro L, Thansandote A. DNA Damage in human leukocytes after acute in vitro exposure to a 1.9 GHz

pulse-modulated radiofrequency field. Radiat Res 158(4):534-537, 2002.

Blood cultures from human volunteers were exposed to an acute 1.9 GHz pulse-modulated radiofrequency (RF) field for 2 h using a series of six circularly polarized, cylindrical waveguides. Mean specific absorption rates (SARs) ranged from 0 to 10 W/kg, and the temperature within the cultures during the exposure was maintained at 37.0 +/- 0.5 degrees C. DNA damage was quantified in leukocytes by the alkaline comet assay and the cytokinesis-block micronucleus assay. When compared to the sham-treated controls, no evidence of increased primary DNA damage was detected by any parameter for any of the RF-field-exposed cultures when evaluated using the alkaline comet assay. Furthermore, no significant differences in the frequency of binucleated cells, incidence of micronucleated binucleated cells, or total incidence of micronuclei were detected between any of the RF-field-exposed cultures and the sham-treated control at any SAR tested. These results do not support the hypothesis that acute, nonthermalizing 1.9 GHz pulse-modulated RF-field exposure causes DNA damage in cultured human leukocytes.

McNamee, J. P., Bellier, P. V., Gajda, G. B., Lavallee, B. F., Marro, L., Lemay, E. and Thansandote, A. No Evidence for Genotoxic Effects from 24 h Exposure of Human Leukocytes to 1.9 GHz Radiofrequency Fields. Radiat Res 159:693-697, 2003.

The current study extends our previous investigations of 2-h radiofrequency (RF)-field exposures on genotoxicity in human blood cell cultures by examining the effect of 24-h continuous-wave (CW) and pulsed-wave (PW) 1.9 GHz RF-field exposures on both primary DNA damage and micronucleus induction in human leukocyte cultures. Mean specific absorption rates (SARs) ranged from 0 to 10 W/kg, and the temperature within the cultures was maintained at 37.0 +/- 1.0 degrees C for the duration of the 24-h exposure period. No significant differences in primary DNA damage were observed between the sham-treated controls and any of the CW or PW 1.9 GHz RF-field-exposed cultures when processed immediately after the exposure period by the alkaline comet assay. Similarly, no significant differences were observed in the incidence of micronuclei, incidence of micronucleated binucleated cells, frequency of binucleated cells, or proliferation index between the sham-treated controls and any of the CW or PW 1.9 GHz RF-field-exposed cultures. In conclusion, the current study found no evidence of 1.9 GHz RF-field-induced genotoxicity in human blood cell cultures after a 24-h exposure period.

McNamee JP, Bellier PV, Konkle AT, Thomas R, Wasoontarajaroen S, Lemay E, Gajda GB. Analysis of gene expression in mouse brain regions after exposure to 1.9 GHz radiofrequency fields. Int J Radiat Biol. 2016 Mar 30:1-13. [Epub ahead of print]

PURPOSE: To assess 1.9 GHz radiofrequency (RF) field exposure on gene expression within a variety of discrete mouse brain regions using whole genome microarray analysis MATERIALS AND METHODS: Adult male C57BL/6 mice were exposed to 1.9 GHz pulse-modulated or continuous-wave RF fields for 4 h/day for 5 consecutive days at whole body average (WBA) specific absorption rates of 0 (sham), ~0.2 W/kg and ~1.4 W/kg. Total RNA was isolated from the auditory cortex, amygdala, caudate, cerebellum, hippocampus, hypothalamus, and medial prefrontal cortex and differential gene expression was assessed using Illumina MouseWG-6 (v2) BeadChip arrays. Validation of potentially responding genes was conducted by RT-PCR. RESULTS: When analysis of

gene expression was conducted within individual brain regions when controlling the false discovery rate (FDR), no differentially expressed genes were identified relative to the sham control. However, it must be noted that most fold changes among groups were observed to be less than 1.5-fold and this study had limited ability to detect such small changes. While some genes were differentially expressed without correction for multiple-comparisons testing, no consistent pattern of response was observed among different RF-exposure levels or among different RF-modulations. CONCLUSIONS: The current study provides the most comprehensive analysis of potential gene expression changes in the rodent brain in response to RF field exposure conducted to date. Within the exposure conditions and limitations of this study, no convincing evidence of consistent changes in gene expression was found in response to 1.9 GHz RF field exposure.

Medeiros LN, Sanchez TG. Tinnitus and cell phones: the role of electromagnetic radiofrequency radiation. Brazilian Journal of Otorhinolaryngology. 82(1):97-104.January–February 2016. doi:10.1016/j.bjorl.2015.04.013

Introduction Tinnitus is a multifactorial condition and its prevalence has increased on the past decades. The worldwide progressive increase of the use of cell phones has exposed the peripheral auditory pathways to a higher dose of electromagnetic radiofrequency radiation (EMRFR). Some tinnitus patients report that the abusive use of mobiles, especially when repeated in the same ear, might worsen ipsilateral tinnitus. Objective The aim of this study was to evaluate the available evidence about the possible causal association between tinnitus and exposure to electromagnetic waves. Methods A literature review was performed searching for the following keywords: tinnitus, electromagnetic field, mobile phones, radio frequency, and electromagnetic hypersensitivity. We selected 165 articles that were considered clinically relevant in at least one of the subjects. Results EMRFR can penetrate exposed tissues and safety exposure levels have been established. These waves provoke proved thermogenic effects and potential biological and genotoxic effects. Some individuals are more sensitive to electromagnetic exposure (electrosensitivity), and thus, present earlier symptoms. There may be a common pathophysiology between this electrosensitivity and tinnitus. Conclusion There are already reasonable evidences to suggest caution for using mobile phones to prevent auditory damage and the onset or worsening of tinnitus.

Meena R, Kumari K, Kumar J, Rajamani P, Verma HN, Kesari KK. Therapeutic approaches of melatonin in microwave radiations-induced oxidative stress-mediated toxicity on male fertility pattern of Wistar rats. Electromagn Biol Med. 2013 May 15. [Epub ahead of print]

Abstract Microwave (MW) radiation produced by wireless telecommunications and a number of electrical devices used in household or in healthcare institutions may adversely affects the reproductive pattern. Present study aimed to investigate the protective effects of melatonin (is well known antioxidant that protects DNA, lipids and proteins from free radical damage) against oxidative stress-mediated testicular impairment due to long-term exposure of MWs. For this, 70-day-old male Wistar rats

were divided into four groups (n = 6/group): Sham exposed, Melatonin (Mel) treated (2 mg/kg), 2.45 GHz MWs exposed and MWs + Mel treated. Exposure took place in Plexiglas cages for 2 h a day for 45 days where, power density (0.21 mW/cm^2) and specific absorption rate (SAR 0.14 W/Kg) were estimated. After the completion of exposure period, rats were sacrificed and various stress related parameters, that is LDH-X (lactate dehydrogenase isoenzyme) activity, xanthine oxidase (XO), ROS (reactive oxygen species), protein carbonyl content, DNA damage and MDA (malondialdehyde) were performed. Result shows that melatonin prevent oxidative damage biochemically by significant increase ($p < 0.001$) in the levels of testicular LDH-X, decreased ($p < 0.001$) levels of MDA and ROS in testis ($p < 0.01$). Meanwhile, it reversed the effects of MWs on XO, protein carbonyl content, sperm count, testosterone level and DNA fragmentation in testicular cells. These results concluded that the melatonin has strong antioxidative potential against MW induced oxidative stress mediated DNA damage in testicular cells.

Megha K, Deshmukh PS, Banerjee BD, Tripathi AK, Abegaonkar MP. Microwave radiation induced oxidative stress, cognitive impairment and inflammation in brain of Fischer rats. Indian J Exp Biol. 50(12):889-896, 2012.

Public concerns over possible adverse effects of microwave radiation emitted by mobile phones on health are increasing. To evaluate the intensity of oxidative stress, cognitive impairment and inflammation in brain of Fischer rats exposed to microwave radiation, male Fischer-344 rats were exposed to 900 MHz microwave radiation (SAR = 5.953 x 10(-4) W/kg) and 1800 MHz microwave radiation (SAR = 5.835 x 10(-4) W/kg) for 30 days (2 h/day). Significant impairment in cognitive function and induction of oxidative stress in brain tissues of microwave exposed rats were observed in comparison with sham exposed groups. Further, significant increase in level of cytokines (IL-6 and TNF-alpha) was also observed following microwave exposure. Results of the present study indicated that increased oxidative stress due to microwave exposure may contribute to cognitive impairment and inflammation in brain.

Megha K, Deshmukh PS, Ravi AK, Tripathi AK, Abegaonkar MP, Banerjee BD. Effect of Low-Intensity Microwave Radiation on Monoamine Neurotransmitters and Their Key Regulating Enzymes in Rat Brain. Cell Biochem Biophys. 2015 Feb 12. [Epub ahead of print]

The increasing use of wireless communication devices has raised major concerns towards deleterious effects of microwave radiation on human health. The aim of the study was to demonstrate the effect of low-intensity microwave radiation on levels of monoamine neurotransmitters and gene expression of their key regulating enzymes in brain of Fischer rats. Animals were exposed to 900 MHz and 1800 MHz microwave radiation for 30 days (2 h/day, 5 days/week) with respective specific absorption rates as 5.953×10^{-4} and 5.835×10^{-4} W/kg. The levels of monoamine neurotransmitters viz. dopamine (DA), norepinephrine (NE), epinephrine (E) and serotonin (5-HT) were detected using LC-MS/MS in hippocampus of all experimental animals. In addition, mRNA expression of key regulating enzymes for these neurotransmitters viz. tyrosine

hydroxylase (TH) (for DA, NE and E) and tryptophan hydroxylase (TPH1 and TPH2) (for serotonin) was also estimated. Results showed significant reduction in levels of DA, NE, E and 5-HT in hippocampus of microwave-exposed animals in comparison with sham-exposed (control) animals. In addition, significant downregulation in mRNA expression of TH, TPH1 and TPH2 was also observed in microwave-exposed animals ($p < 0.05$). In conclusion, the results indicate that low-intensity microwave radiation may cause learning and memory disturbances by altering levels of brain monoamine neurotransmitters at mRNA and protein levels.

Meo SA, Al-Drees AM, Husain S, Khan MM, Imran MB. Effects of mobile phone radiation on serum testosterone in Wistar albino rats. Saudi Med J. 31(8):869-873, 2010.

OBJECTIVE: To investigate the effects of electromagnetic field radiation generated by mobile phones on serum testosterone levels in Wistar albino rats. METHODS: This experimental interventional control study was conducted in the Department of Physiology, College of Medicine, King Saud University, Riyadh, Saudi Arabia during the period December 2006 to April 2008. A total of 34 male Albino rats [Wistar strain], 2 months of age, weighing 150-160 gm were used for the experiment. These animals were divided into 3 groups. The first group containing 6 rats was assigned as a control group. The second group containing 14 rats was exposed to mobile phone radiation for 30 minutes daily and the third group containing 14 rats was exposed to mobile phone radiation for 60 minutes daily for the total period of 3 months. At the end of experimental period, blood was collected into the container, and serum testosterone was analyzed using double-antibody radioimmunoassay method by Coat-A-Count. RESULTS: Exposure to mobile phone radiation for 60 minutes/day for the total period of 3 months significantly decrease the serum testosterone level [p=0.028] in Wistar Albino rats compared to their matched control. CONCLUSION: Long-term exposure to mobile phone radiation leads to reduction in serum testosterone levels. Testosterone is a primary male gender hormone and any change in the normal levels may be devastating for reproductive and general health.

Meo SA, Arif M, Rashied S, Khan MM, Vohra MS, Usmani AM, Imran MB, Al-Drees AM. Hypospermatogenesis and spermatozoa maturation arrest in rats induced by mobile phone radiation. J Coll Physicians Surg Pak. 21(5):262-265, 2011.

OBJECTIVE: To determine the morphological changes induced by mobile phone radiation in the testis of Wistar albino rats. STUDY DESIGN: Cohort study. Place and Duration of Study: Department of Physiology, College of Medicine, King Saud University, Riyadh, Saudi Arabia, from April 2007 to June 2008. METHODOLOGY: Forty male Wistar albino rats were divided in three groups. First group of eight served as the control. The second group [group B, n=16] was exposed to mobile phone radiation for 30 minutes/day and the third group [group C, n=16] was exposed to mobile phone radiation for 60 minutes/day for a total period of 3 months. Morphological changes in the testes induced by mobile phone radiations were observed under a light microscope. RESULTS: Exposure to mobile phone radiation for 60 minutes/day caused 18.75% hypospermatogenesis and 18.75% maturation arrest in the testis of albino rats compared to matched controls. However, no abnormal findings were observed in albino rats that

were exposed to mobile phone radiation for 30 minutes/day for a total period of 3 months. CONCLUSION: Long-term exposure to mobile phone radiation can cause hypospermatogenesis and maturation arrest in the spermatozoa in the testis of Wistar albino rats.

Meo SA, Al Rubeaan K. Effects of exposure to electromagnetic field radiation (EMFR) generated by activated mobile phones on fasting blood glucose. Int J Occup Med Environ Health. 26(2):235-241, 2013.

OBJECTIVE: Extensive use of mobile phones has been accompanied by a common public debate about possible adverse effects on human health. No study has been published so far to establish any association between the fastest growing innovation of mobile phone and fasting blood glucose. The aim was to determine the effects of exposure to electromagnetic field radiation generated by mobile phones on fasting blood glucose in Wistar Albino rats. **MATERIALS AND METHODS:** 40 Male Albino rats (Wistar Strain) were divided into 5 equally numerous groups. Group A served as the control one, group B received mobile phone radiation for less than 15 min/day, group C: 15-30 min/day, group D: 31-45 min/day, and group E: 46-60 min/day for a total period of 3 months. Fasting blood glucose was determined by using Spectrophotometer and serum insulin by Enzyme-linked Immunosorbent Assay (ELISA). The Homeostatic Model (HOMA-B) was applied for the assessment of β-cell function and (HOMA-IR) for resistance to insulin. **RESULTS:** Wister Albino rats exposed to mobile phone radiation for longer than 15 min a day for a total period of 3 months had significantly higher fasting blood glucose ($p < 0.015$) and serum insulin ($p < 0.01$) compared to the control group. HOMA-IR for insulin resistance was significantly increased ($p < 0.003$) in the groups that were exposed for 15-30 and 46-60 min/day compared to the control rats. **CONCLUSION:** The results of the present study show an association between long-term exposure to activated mobile phones and increase in fasting blood glucose and serum insulin in Albino rats.

Meltz ML, Eagan P, Erwin DN, Proflavin and microwave radiation: absence of a mutagenic interaction. Bioelectromagnetics 11(2):149-157, 1990.

The potential ability of radiofrequency electromagnetic radiation (RFR) in the microwave range to induce mutagenesis, chromosomal aberrations, and sister chromatid exchanges in mammalian cells is being explored in our laboratories. In addition, we have also been examining the ability of simultaneous exposure to RFR and chemical mutagens to alter the genotoxic damage induced by chemical mutagens acting alone. We have performed experiments to determine whether there is an interaction between 2.45-GHz, pulsed-wave, RFR and proflavin, a DNA-intercalating drug. The endpoint studied was forward mutation at the thymidine kinase locus in L5178Y mouse leukemic cells. Any effect on the size distribution of the resulting colonies of mutated cells was also examined. The exposures were performed at net forward powers of 500 or 600 W, resulting in a specific absorption rate (SAR) of approximately 40 W/kg. The culture-medium temperature reached a 3 degrees C maximal increase during the 4-h exposure; appropriate 37 degrees C and convection-heating temperature controls (TC) were performed. In no case

was there any indication of a statistically significant increase in the induced mutant frequency due to the simultaneous exposure to RFR and proflavin, as compared with the proflavin exposures alone. There was also no indication of any change in the colony-size distribution of the resulting mutant colonies, neither, and there was no evidence in these experiments of any mutagenic action by the RFR exposure alone.

Meo SA, Al-Drees AM. Mobile phone related-hazards and subjective hearing and vision symptoms in the Saudi population. Int J Occup Med Environ Health. 18(1):53-57, 2005

OBJECTIVES: Over the past decade utilization of mobile phones has dramatically increased. They are now an essential part of business, commerce, and communication, however, their use may lead to health problems. Therefore, the present study was designed to investigate a link between the use of mobile phones and hearing and vision symptoms in the Saudi population and also to contribute to the increase in social awareness of health problems associated with the use of these devices. MATERIALS AND METHODS: A total of 873 (57.04% of males and 39.86% of females) subjects using mobile phones were invited to participate in the presented study. A structured questionnaire was distributed among them to collect a detailed medical history. The Chi-square test was employed to observe the relationship between duration of calls and hearing and vision complaints. RESULTS: The present study showed an association between the use of mobile phones and hearing and vision complaints. About 34.59% of problems were related with impaired hearing, ear ache and/or warmth on the ear, and 5.04% of complaints with the decreased and/or blurred vision. CONCLUSIONS: It is concluded that the use of mobile phone is a health risk factor, and thus it is suggested that excessive use of mobile phones should be avoided and social awareness increased through health promotion activities, such as group discussions or public presentations and via electronic and printed media sources.

Meo SA, Arif M, Rashied S, Khan MM, Vohra MS, Usmani AM, Imran MB, Al-Drees AM. Hypospermatogenesis and spermatozoa maturation arrest in rats induced by mobile phone radiation. J Coll Physicians Surg Pak. 21(5):262-265, 2011.

Abstract. Objective: To determine the morphological changes induced by mobile phone radiation in the testis of Wistar albino rats. Study Design: Cohort study. Place and Duration of Study: Department of Physiology, College of Medicine, King Saud University, Riyadh, Saudi Arabia, from April 2007 to June 2008. Methodology: Forty male Wistar albino rats were divided in three groups. First group of eight served as the control. The second group [group B, n=16] was exposed to mobile phone radiation for 30 minutes/day and the third group [group C, n=16] was exposed to mobile phone radiation for 60 minutes/day for a total period of 3 months. Morphological changes in the testes induced by mobile phone radiations were observed under a light microscope. Results: Exposure to mobile phone radiation for 60 minutes/day caused 18.75% hypospermatogenesis and 18.75% maturation arrest in the testis of albino rats compared to matched controls. However, no abnormal findings were observed in albino rats that were exposed to mobile phone radiation for 30 minutes/day for a total period of 3 months. Conclusion: Long-term exposure to mobile phone radiation can cause hypospermatogenesis and maturation arrest in the

spermatozoa in the testis of Wistar albino rats.

Meral I, Mert H, Mert N, Deger Y, Yoruk I, Yetkin A, Keskin S. Effects of 900-MHz electromagnetic field emitted from cellular phone on brain oxidative stress and some vitamin levels of guinea pigs. Brain Res1169:120-124, 2007.

This study was designed to demonstrate the effects of 900-MHz electromagnetic field (EMF) emitted from cellular phone on brain tissue and also blood malondialdehyde (MDA), glutathione (GSH), retinol (vitamin A), vitamin D(3) and tocopherol (vitamin E) levels, and catalase (CAT) enzyme activity of guinea pigs. Fourteen male guinea pigs, weighing 500-800 g were randomly divided into one of two experimental groups: control and treatment (EMF-exposed), each containing seven animals. Animals in treatment group were exposed to 890- to 915-MHz EMF (217-Hz pulse rate, 2-W maximum peak power, SAR 0.95 w/kg) of a cellular phone for 12 h/day (11-h 45-min stand-by and 15-min spiking mode) for 30 days. Control guinea pigs were housed in a separate room without exposing EMF of a cellular phone. Blood samples were collected through a cardiac puncture and brains were removed after decapitation for the biochemical analysis at the end of the 30 days of experimental period. It was found that the MDA level increased ($P<0.05$), GSH level and CAT enzyme activity decreased ($P<0.05$), and vitamins A, E and D(3) levels did not change ($P>0.05$) in the brain tissues of EMF-exposed guinea pigs. In addition, MDA, vitamins A, D(3) and E levels, and CAT enzyme activity increased ($P<0.05$), and GSH level decreased ($P<0.05$) in the blood of EMF-exposed guinea pigs. It was concluded that electromagnetic field emitted from cellular phone might produce oxidative stress in brain tissue of guinea pigs. However, more studies are needed to demonstrate whether these effects are harmful or/and affect the neural functions.

Meral I, Tekintangac Y, Demir H. Effects of 900 MHz electromagnetic field emitted by cellular phones on electrocardiograms of guinea pigs. Hum Exp Toxicol. 2013 Nov 12. [Epub ahead of print]

This study was carried out to determine the effects of electromagnetic field (EMF) emitted by cellular phones (CPs) on electrocardiograms (ECGs) of guinea pigs. A total of 30 healthy guinea pigs weighing 500-800 g were used. After 1 week of adaptation period, animals were randomly divided into two groups: control group ($n = 10$) and EMF-exposed group ($n = 20$). Control guinea pigs were housed in a separate room without exposing them to EMFs of CPs. Animals in second group were exposed to 890-915 MHz EMF (217 Hz of pulse rate, 2 W of maximum peak power and 0.95 wt kg^{-1} of specific absorption rate) for 12 h day^{-1} (11 h 45 min stand-by and 15 min speaking mode) for 30 days. ECGs of guinea pigs in both the groups were recorded by a direct writing electrocardiograph at the beginning and 10th, 20th and 30th days of the experiment. All ECGs were standardized at 1 mV = 10 mm and with a chart speed of 50 mm sec^{-1}. Leads I, II, III, lead augmented vector right (aVR), lead augmented vector left (aVL) and lead augmented vector foot (aVF) were recorded. The durations and amplitudes of waves on the trace were measured in lead II. The data were expressed as mean with SEM. It was found that 12 h day^{-1} EMF exposure for 30 days did not have any significant effects on ECG findings of guinea pigs. However, this issue needed to be further investigated in a variety of

perspectives, such as longer duration of exposure to be able to elucidate the effects of mobile phone-induced EMFs on cardiovascular functions.

Merola P, Marino C, Lovisolo GA, Pinto R, Laconi C, Negroni A. Proliferation and apoptosis in a neuroblastoma cell line exposed to 900 MHz modulated radiofrequency field. Bioelectromagnetics.27(3):164-71, 2006.

The aim of this study was to examine whether a modulated radiofrequency of the type used in cellular phone communications at a specific absorption rate (SAR) higher than International Commission on Non-ionizing Radiation Protection (ICNIRP) reference level for occupational exposure, could elicit alterations on proliferation, differentiation, and apoptosis processes in a neuroblastoma cell line. The cell line was exposed for 24, 48, and 72 h to 900 MHz radiofrequency and proliferation and differentiation were tested by WST-I assay and by a molecular analysis of specific markers, two oncogenes and a cytoskeleton protein, in exponential growth phase and in synchronized cell cultures. Apoptosis was evaluated by caspase activation analysis and by molecular detection of Poly (ADP-ribose) polimerase (PARP) cleavage. Combined exposures to radiofrequency and to the differentiative agent retinoic acid or to the apoptotic inducer camptothecin were carried out to test possible interference between electromagnetic field and chemical agents. Overall our data suggest that 900 MHz radiofrequency exposure up to 72 h does not induce significant alterations in the three principal cell activities in a neuroblastoma cell line.

Mezhevikina LM, Khramov RN, Lepikhov KA , [The simulation of the cooperative effect of development in a culture of early mouse embryos after irradiation with electromagnetic waves in the millimeter range]. Ontogenez 31(1):27-31, 2000.
[Article in Russian]

We have found that two-cell mouse embryos cultured in vitro can be stimulated by electromagnetic irradiation in the millimeter range. After 30 min of exposure, they acquire the ability to develop in culture on their own and can reach the stage of blastocyst in a relatively large volume of Whitten cultural medium (150 microliters) without serum or growth factors. It is proposed that millimeter range electromagnetic waves activate metabolic processes and specifically the synthesis of factors controlling early embryonic development in culture.

Michelozzi P, Ancona C, Fusco D, Forastiere F, Perucci CA, Risk of leukemia and residence near a radio transmitter in Italy. Epidemiology 9 (Suppl) 354p, 1998.

We conducted a small area study to investigate a cluster of leukemia near a high power radio-transmitter in a peripheral area of Rome. The leukemia mortality within 3.5 km (5,863 inhabitants) was higher than expected (SMR=2.5, 95% confident interval 1.07-4.83); the excess was due to a significant higher mortality among men (7 cases observed, SMR=3.5). The results of the Stone's test, after adjusting for socio-economic confounding, showed a significant decline in risk with distance from the transmitter only among men (p=0.005), whereas the p-value for both sexes was p=0.07.

Michelozzi P, Capon A, Kirchmayer U, Forastiere F, Biggeri A, Barca A, Perucci CA. Adult and childhood leukemia near a high-power radio station in Rome, Italy. Am J

Epidemiol 155(12):1096-1103, 2002.

Some recent epidemiologic studies suggest an association between lymphatic and hematopoietic cancers and residential exposure to high-frequency electromagnetic fields (100 kHz to 300 GHz) generated by radio and television transmitters. 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 higher than expected for the distance up to 6 km from the radio station (standardized incidence rate = 2.2, 95% confidence interval: 1.0, 4.1), and there was a significant decline in risk with increasing distance both for male mortality (p = 0.03) and for childhood leukemia (p = 0.036). The study has limitations because of the small number of cases and the lack of exposure data. Although the study adds evidence of an excess of leukemia in a population living near high-power radio transmitters, no causal implication can be drawn. There is still insufficient scientific knowledge, and new epidemiologic studies are needed to clarify a possible leukemogenic effect of residential exposure to radio frequency radiation.

Mickley GA, Cobb BL, Mason PA, Farrell S, Disruption of a putative working memory task and selective expression of brain c-fos following microwave-induced hyperthermia. Physiol Behav 55(6):1029-1038, 1994.

To discern the effects of hyperthermia on working memory, we recorded the ability of rats to discriminate between objects following microwave radiation exposure. Memory changes were evaluated by measuring relative exploration time of a familiar vs. a new stimulus object. A subject that extensively reexplores a stimulus with which it has previous experience is presumed to exhibit memory loss associated with that object. Between training and testing, rats were exposed to various doses of microwave radiation, were sham irradiated, or remained in their home cage. Brain (dural) and rectal temperatures were recorded. To discern brain regions activated or possibly damaged by microwave exposure, we also used immunocytochemistry techniques to identify sites of c-fos protein expression in the brains of several irradiated/sham-irradiated subjects. Rats exposed to > 5 W/kg exhibited hyperthermia when compared to nonirradiated controls. Normothermic control subjects (sham-irradiated rats and rats exposed to 0.1 W/kg) showed a distinct preference for the new object although other microwave-exposed rats (1, 5, 8.5, 9.3, 10 W/kg) did not. Microwave hyperthermia evoked prominent c-fos expression in periventricular strata, hypothalamic nuclei, amygdala, and several areas of the cortex. These data suggest that performance on a putative working memory task may be disrupted by a sufficiently intense microwave-induced hyperthermia. The pattern of expression of the early proto-oncogene c-fos may suggest candidate brain nuclei that mediate the behavioral changes we observed.

Mickley GA, Cobb BL, Thermal tolerance reduces hyperthermia-induced disruption of working memory: a role for endogenous opiates? Physiol Behav 63(5):855-865, 1998.

Previous reports indicate that microwave-induced hyperthermia can impair learning and memory. Here, we report that preexposure to a single 20-min period of hyperthermia can produce thermal tolerance and, thereby, attenuate future

physiological and behavioral reactions to heating. Because endogenous opioids have been implicated in thermoregulation and reactions to microwave exposure, we also determined how opioid receptor antagonism might modulate these effects. In an initial experiment, rats were exposed daily, over 5 successive days, to 600-MHz microwaves (at a whole-body specific absorption rate of 9.3 W/kg) or sham exposed. In animals exposed to microwaves, thermal tolerance was evidenced by declining rectal temperatures over time. Temperature reductions following microwave exposure were prominent after a single previous exposure. Therefore, in a second study, a single hyperthermic episode was used to induce thermal tolerance. On Day 1, rats were either exposed, over a 20-min period, to 600-MHz microwaves (at a whole-body specific absorption rate of 9.3 W/kg) or sham exposed. Just prior to radiation/sham-radiation treatment, rats received either saline or naltrexone (0.1 or 10 mg/kg, intraperitoneally (i.p.)). The following day (Day 2), rats were either microwave or sham exposed and tested on a task which measures the relative time subjects explore a familiar versus a novel stimulus object. Normothermic rats spend significantly more time in contact with new environmental components and less time with familiar objects. Brain (dura) and rectal temperatures were recorded on both days of the study. Microwave exposure produced a reliable hyperthermia which was significantly lower (on Day 2) in rats receiving repeated treatments (tolerant group). On the behavioral test, rats exposed only once to microwave-induced hyperthermia (nontolerant group) exhibited significantly different patterns of object discrimination than did tolerant or sham-exposed animals. Sham-exposed and tolerant animals showed a distinct preference for the new object whereas the nontolerant animals did not. Naltrexone (10 mg/kg) antagonized the hyperthermia-induced disruption of the object discrimination task (in nontolerant rats) and produced patterns of object exploration that were similar to those of sham-irradiated and thermal-tolerant rats, suggesting that endogenous opioids play a role in the organism's response to heating. Taken together, these data are consistent with the conclusions that 1) microwave-induced hyperthermia can cause a dose-dependent disruption of the normal discrimination between new and familiar objects, 2) physiological reactions to a single hyperthermic episode can produce a thermotolerance that expresses itself in both reduced levels of hyperthermia and attenuated behavioral disruptions following microwave exposure, and 3) opioid antagonism can partially reverse some of the behavioral effects of microwave-induced hyperthermia.

Mild KH, Andersen JB, Pedersen GF. Is there any exposure from a mobile phone in stand-by mode? Electromagn Biol Med. 31(1):52-56, 2012.

Several studies have been using a GSM mobile phone in stand-by mode as the source for exposure, and they claimed that this caused effects on for instance sleep and testicular function. In stand-by mode the phone is only active in periodic location updates, and this occurs with a frequency set by the net operator. Typical updates occur with 2-5 h in between, and between these updates the phone is to be considered as a passive radio receiver with no microwave emission. Thus, the exposure in stand-by mode can be considered negligible.

Millenbaugh NJ, Roth C, Sypniewska R, Chan V, Eggers JS, Kiel JL, Blystone RV, Mason PA. gene expression changes in the skin of rats induced by prolonged 35 GHz millimeter-wave exposure. Radiat Res 169(3):288-300, 2008.

To better understand the cellular and molecular responses to overexposure to millimeter waves, alterations in the gene expression profile and histology of skin after exposure to 35 GHz radiofrequency radiation were investigated. Rats were subjected to sham exposure, to 42 degrees C environmental heat, or to 35 GHz millimeter waves at 75 mW/cm(2). Skin samples were collected at 6 and 24 h after exposure for Affymetrix GeneChip analysis. The skin was harvested from a separate group of rats at 3-6 h or 24-48 h after exposure for histopathology analysis. Microscopic findings observed in the dermis of rats exposed to 35 GHz millimeter waves included aggregation of neutrophils in vessels, degeneration of stromal cells, and breakdown of collagen. Changes were detected in 56 genes at 6 h and 58 genes at 24 h in the millimeter-wave-exposed rats. Genes associated with regulation of transcription, protein folding, oxidative stress, immune response, and tissue matrix turnover were affected at both times. At 24 h, more genes related to extracellular matrix structure and chemokine activity were altered. Up-regulation of Hspa1a, Timp1, S100a9, Ccl2 and Angptl4 at 24 h by 35 GHz millimeter-wave exposure was confirmed by real-time RT-PCR. These results obtained from histopathology, microarrays and RT-PCR indicate that prolonged exposure to 35 GHz millimeter waves causes thermally related stress and injury in skin while triggering repair processes involving inflammation and tissue matrix recovery.

Miller G, Zhu G, Wright MJ, Hansell NK, Martin, NG. The Heritability and Genetic Correlates of Mobile Phone Use: A Twin Study of Consumer Behavior. Twin Research and Human Genetics / Volume 15 / Issue 01 / February 2012, pp 97-106.

There has been almost no overlap between behavior genetics and consumer behavior research, despite each field's importance in understanding society. In particular, both have neglected to study genetic influences on consumer adoption and usage of new technologies — even technologies as important as the mobile phone, now used by 5.8 out of 7.0 billion people on earth. To start filling this gap, we analyzed self-reported mobile phone use, intelligence, and personality traits in two samples of Australian teenaged twins (mean ages 14.2 and 15.6 years), totaling 1,036 individuals.

ACE modeling using Mx software showed substantial heritabilities for how often teens make voice calls (.60 and .34 in samples 1 and 2, respectively) and for how often they send text messages (.53 and. 50). Shared family environment – including neighborhood, social class, parental education, and parental income (i.e., the generosity of calling plans that parents can afford for their teens) — had much weaker effects. Multivariate modeling based on cross-twin, cross-trait correlations showed negative genetic correlations between talking/texting frequency and intelligence (around –.17), and positive genetic correlations between talking/texting frequency and extraversion (about .20 to .40).

Our results have implications for assessing the risks of mobile phone use such as

radiofrequency field (RF) exposure and driving accidents, for studying adoption and use of other emerging technologies, for understanding the genetic architecture of the cognitive and personality traits that predict consumer behavior, and for challenging the common assumption that consumer behavior is shaped entirely by culture, media, and family environment.

Miller SA, Bronson ME, Murphy MR, Ultrawideband radiation and pentylenetetrazol-induced convulsions in rats. Bioelectromagnetics 20(5):327-329, 1999.

New non-ionizing pulsed systems using ultrawideband (UWB) require safety assessment before they can be used by either military or civilian communities.

The development of directed energy weaponry intended for use against electronically vulnerable targets, as well as ground-probing radar systems, have used fast-rise-time high-peak-power electromagnetic pulses characteristic of UWB emitters. It has been postulated that these ultrashort pulses might produce electromagnetic transients resulting in tissue damage. Several challenges to this notion have been posed, however. One report found that rats exposed to UWB after receiving a convulsant drug tended toward longer latency to the onset of convulsions than the no-exposure group. Although not statistically significant, the presence of this trend prompted the present study. An ED99 dose of the convulsant pentylenetetrazol (PTZ) or saline was given just before UWB or sham exposure and resultant seizure activity was recorded. The data from the current study show no effect of UWB exposure on PTZ-induced seizure activity, thereby not supporting the tissue damage concerns, at least for the exposure parameters used here.

Min ST, Redelmeier DA, Car phones and car crashes: an ecologic analysis. Can J Public Health 89(3):157-161, 1998.

OBJECTIVE: Some countries have regulations against using a cellular Telephone while driving. We used ecologic analysis to evaluate cellular telephone use and motor vehicle collisions in a city without such regulations. METHODS: We studied locations in Toronto, Ontario (n = 75) that were hazardous (total collisions = 3,234) and tested whether increases in collision rates from 1984 to 1993 correlated with increases in telephone usage over the same time interval. RESULTS: Locations with the largest increases in collision rates tended to have the smallest increases in estimated cellular telephone usage. Yet extreme assumptions about potential protective effects from cellular telephones failed to explain the magnitude observed. CONCLUSIONS: The effects of cellular telephones on driving ability are small relative to the biases in ecologic analysis. Claims from industry, which argue that cellular telephones are not dangerous based on ecologic analysis, can be misleading in the policy debate about whether to regulate cellular telephone use while driving.

Mina D, Sagonas K, Fragopoulou AF, Pafilis P, Skouroliakou A, Margaritis LH, Tsitsilonis OE, Valakos ED. Immune responses of a wall lizard to whole-body exposure to radiofrequency electromagnetic radiation. Int J Radiat Biol. 92(3):162-168, 2016.

PURPOSE: During the last three decades, the number of devices that emit non-ionizing electromagnetic radiation (EMR) at the wireless communication spectrum has rapidly increased and possible effects on living organisms have become a major concern. The purpose of this study was to investigate the effects of radiofrequency EMR emitted by a widely used wireless communication device, namely the Digital Enhanced Communication Telephony (DECT) base, on the immune responses of the Aegean wall lizard (Podarcis erhardii).MATERIALS AND METHODS: Adult male lizards were exposed 24 h/day for 8 weeks to 1880-1900 MHz DECT base radiation at average electric field intensity of 3.2 V/m. Immune reactivity was assessed using the phytohemagglutinin (PHA) skin swelling and mixed lymphocyte reaction (MLR) tests.RESULTS: Our results revealed a noticeable suppression (approximately 45%) of inflammatory responses in EMR-exposed lizards compared to sham-exposed animals. T cell-mediated responses were marginally affected.CONCLUSION: Daily radiofrequency EMR exposure seems to affect, at least partially, the immunocompetence of the Aegean wall lizard.

Mineta M, Katada R, Yamada T, Nagasawa K, Takahashi K, Aburano T, Yoshida I, [Bacterial mutation in high magnetic fields and radiofrequency radiation]. Nippon Igaku Hoshasen Gakkai Zasshi 59(9):467-469, 1999. [Article in Japanese]

Epidemiological studies recently have indicated that magnetic fields and radiofrequency (RF) radiation have an adverse influence on the living body. The purpose of this study was to examine the safety of magnetic resonance imaging (MRI) by observing whether bacterial mutation occurs in an approximate MRI environment. We employed a GX-270 FT-NMR unit (JEOL, Ltd.) with a magnetic field strength of 6.3 Tesla. The Salmonella typhimurium tester strains used in the AMES test were exposed, and the incidence of point and frameshift mutations was evaluated. TA98 and TA7001-7006 mixed strains were used to detect frameshift and point mutations, respectively. Tester strains were exposed to the 6.3 Tesla magnetic field with RF radiation (90 degrees and 180 degrees refocusing pulses were repeated using the hydrogen Lamor frequency at 2-second intervals) for 15, 30, 45, and 60 minutes. After each exposure, the rate of revertant mutation was counted. The rates of revertant mutation in mixed strains and the TA98 strain were not statistically significant. Therefore, it was concluded that bacterial mutation is not increased by RF radiation under a 6.3 Tesla magnetic field.

Misa Agustiño MJ, Leiro JM, Jorge Mora MT, Rodríguez-González JA, Jorge Barreiro FJ, Ares-Pena FJ, López-Martín E. Electromagnetic fields at 2.45 GHz trigger changes in heat shock proteins 90 and 70 without altering apoptotic activity in rat thyroid gland. Biol Open. 1(9):831-838, 2012.

Non-ionizing radiation at 2.45 GHz may modify the expression of genes that codify heat shock proteins (HSP) in the thyroid gland. Using the enzyme-linked immunosorbent assay (ELISA) technique, we studied levels of HSP-90 and HSP-70. We also used hematoxilin eosin to look for evidence of lesions in the gland and applied the DAPI technique of fluorescence to search for evidence of chromatin condensation and nuclear fragmentation in the thyroid cells of adult female Sprague-Dawley rats. Fifty-four rats were individually exposed for 30 min to 2.45 GHz radiation in a Gigahertz transverse electromagnetic (GTEM) cell at different levels of non-thermal specific absorption rate

(SAR), which was calculated using the finite difference time domain (FDTD) technique. Ninety minutes after radiation, HSP-90 and HSP-70 had decreased significantly (P<0.01) after applying a SAR of 0.046±1.10 W/Kg or 0.104±5.10(-3) W/Kg. Twenty-four hours after radiation, HSP-90 had partially recovered and HSP-70 had recovered completely. There were few indications of lesions in the glandular structure and signs of apoptosis were negative in all radiated animals. The results suggest that acute sub-thermal radiation at 2.45 GHz may alter levels of cellular stress in rat thyroid gland without initially altering their anti-apoptotic capacity.

Misa-Agustiño MJ, Leiro-Vidal JM, Gomez-Amoza JL, Jorge-Mora MT, Jorge-Barreiro FJ, Salas-Sánchez AA, Ares-Pena FJ, López-Martín E. EMF radiation at 2450MHz triggers changes in the morphology and expression of heat shock proteins and glucocorticoid receptors in rat thymus. Life Sci. 127:1-11, 2015.

Aims. Electromagnetic fields (EMFs) can act as inducers or mediators of stress response through the production of heat shock proteins (HSPs) that modulate immune response and thymus functions. In this study, we analyzed cellular stress levels in rat thymus after exposure of the rats to a 2.45 GHz radio frequency (RF) using an experimental diathermic model in a Gigahertz Transverse Electromagnetic (GTEM) chamber. Main methods. In this experiment, we used H&E staining, the ELISA test and immunohistochemistry to examine Hsp70 and Hsp90 expression in the thymus and glucocorticoid receptors (GR) of 64 female Sprague–Dawley rats exposed individually to 2.45 GHz (at 0, 1.5, 3.0 or 12.0 W power). The 1 g averaged peak and mean SAR values in the thymus and whole body of each rat to ensure that sub-thermal levels of radiation were being reached. Key findings. The thymus tissue presented several morphological changes, including increased distribution of blood vessels along with the appearance of red blood cells and hemorrhagic reticuloepithelial cells. Levels of Hsp90 decreased in the thymus when animals were exposed to the highest power level (12 W), but only one group did not show recovery after 24 h. Hsp70 presented no significant modifications in any of the groups. The glucocorticoid receptors presented greater immunomarking on the thymic cortex in exposed animals.Significance. Our results indicate that non-ionizing sub-thermal radiation causes changes in the endothelial permeability and vascularization of the thymus, and is a tissue-modulating agent for Hsp90 and GR**.**

Misa-Agustiño MJ, Jorge-Mora T, Jorge-Barreiro FJ, Suarez-Quintanilla J, Moreno-Piquero E, Ares-Pena FJ, López-Martín E. Exposure to non-ionizing radiation provokes changes in rat thyroid morphology and expression of HSP-90. Exp Biol Med (Maywood). 2015 Feb 2. pii: 1535370214567611. [Epub ahead of print]

Non-ionizing radiation at 2.45 GHz may modify the morphology and expression of genes that codify heat shock proteins (HSP) in the thyroid gland. Diathermy is the therapeutic application of non-ionizing radiation to humans for its beneficial effects in rheumatological and musculo-skeletal pain processes.
We used a diathermy model on laboratory rats subjected to maximum exposure in the left front leg, in order to study the effects of radiation on the nearby thyroid tissue. Fifty-six rats were individually exposed once or repeatedly (10 times in two weeks) for 30 min to

2.45 GHz radiation in a commercial chamber at different non-thermal specific absorption rates (SARs), which were calculated using the finite difference time domain technique. We used immunohistochemistry methods to study the expression of HSP-90 and morphological changes in thyroid gland tissues. Ninety minutes after radiation with the highest SAR, the central and peripheral follicles presented increased size and the thickness of the peripheral septa had decreased. Twenty-four hours after radiation, only peripheral follicles radiated at 12 W were found to be smaller. Peripheral follicles increased in size with repeated exposure at 3 W power. Morphological changes in the thyroid tissue may indicate a glandular response to acute or repeated stress from radiation in the hypothalamic-pituitary-thyroid axis. Further research is needed to determine if the effect of this physical agent over time may cause disease in the human thyroid gland.

Miyakoshi J, Takemasa K, Takashima Y, Ding GR, Hirose H, Koyama S. Effects of exposure to a 1950 MHz radio frequency field on expression of Hsp70 and Hsp27 in human glioma cells. Bioelectromagnetics. 26(4):251-257, 2005.

Human glioma MO54 cells were used to investigate whether radio frequency (RF) field exposure could activate stress response genes. Cells were exposed to continuous wave 1950 MHz or sham conditions for up to 2 h. Specific absorption rates (SARs) were 1, 2, and 10 W/kg. For the cell growth experiment, cell numbers were counted at 0-4 days after exposure. Expression of Hsp27 and Hsp70, as well as the level of phosphorylated Hsp27 (78Ser) protein, was determined by Western blotting. It was found that sham exposed and RF exposed cells demonstrated a similar growth pattern up to 4 days after RFfield exposure. RFfield exposure at both 2 and 10 W/kg did not affect the growth of MO54 cells. In addition, there were no significant differences in protein expression of Hsp27 and Hsp70 between sham exposed and RF exposed cells at a SAR of 1, 2, or 10 W/kg for 1 and 2 h. However, exposure to RFfield at a SAR of 10 W/kg for 1 and 2 h decreased the protein level of phosphorylated Hsp27 (78Ser) significantly. Our results suggest that although exposure to a 1950 MHz RFfield has no effect on cell proliferation and expression of Hsp 27 and Hsp70, it may inhibit the phosphorylation of Hsp27 at Serine 78 in MO54 cells.

Mizuno Y, Moriguchi Y, Hikage T, Terao Y, Ohnishi T, Nojima T, Ugawa Y. Effects of W-CDMA 1950 MHz EMF emitted by mobile phones on regional cerebral blood flow in humans. Bioelectromagnetics.30(7):536-544,2009.

Use of the third generation mobile phone system is increasing worldwide. This is the first study to investigate the effects of the third generation system on regional cerebral blood flow (rCBF) in humans. We compared effects of the electromagnetic field (EMF) emitted from the Wideband Code Division Multiple Access (W-CDMA) cellular system versus sham control exposure on rCBF in humans. Nine healthy male volunteers participated in this study. Positron emission tomography (PET) scans were obtained before, during, and after unilateral 30 min EMF exposure. The subtraction analysis revealed no significant rCBF changes caused by the EMF conditions compared with the sham exposure, suggesting that EMF emitted by a third generation mobile phone does not affect rCBF in

humans.

Mjøen G, Saetre DO, Lie RT, Tynes T, Blaasaas KG, Hannevik M, Irgens LM. Paternal occupational exposure to radiofrequency electromagnetic fields and risk of adverse pregnancy outcome. Eur J Epidemiol. 21(7):529-535, 2006

BACKGROUND: During the last decades, public concern that radiofrequency radiation (RFR) may be related to adverse reproductive outcomes has been emerging. Our objective was to assess associations between paternal occupational exposure to RFR and adverse pregnancy outcomes including birth defects using population-based data from Norway. METHODS: Data on reproductive outcomes derived from the Medical Birth Registry of Norway were linked with data on paternal occupation derived from the general population censuses. An expert panel categorized occupations according to exposure. Using logistic regression, we analyzed 24 categories of birth defects as well as other adverse outcomes. RESULTS: In the offspring of fathers most likely to have been exposed, increased risk was observed for preterm birth (odds ratio (OR): 1.08, 95% confidence interval (CI): 1.03, 1.15). In this group we also observed a decreased risk of cleft lip (OR: 0.63, 95% CI: 0.41, 0.97). In the medium exposed group, we observed increased risk for a category of "other defects" (OR: 2.40, 95% CI: 1.22, 4.70), and a decreased risk for a category of "other syndromes" (OR: 0.75, 95% CI: 0.56, 0.99) and upper gastrointestinal defects (OR: 0.61, 95% CI: 0.40, 0.93). CONCLUSION: The study is partly reassuring for occupationally exposed fathers.

Mohammed HS, Fahmy HM, Radwah NM, Elsayed AA. Non-thermal continuous and modulated electromagnetic radiation fields effects on sleep EEG of rats. J Adv Res 4(2) 181-187, 2013.

In the present study, the alteration in the sleep EEG in rats due to chronic exposure to low-level non-thermal electromagnetic radiation was investigated. Two types of radiation fields were used; 900 MHz unmodulated wave and 900 MHz modulated at 8 and 16 Hz waves. Animals has exposed to radiation fields for 1 month (1 h/day). EEG power spectral analyses of exposed and control animals during slow wave sleep (SWS) and rapid eye movement sleep (REM sleep) revealed that the REM sleep is more susceptible to modulated radiofrequency radiation fields (RFR) than the SWS. The latency of REM sleep increased due to radiation exposure indicating a change in the ultradian rhythm of normal sleep cycles. The cumulative and irreversible effect of radiation exposure was proposed and the interaction of the extremely low frequency radiation with the similar EEG frequencies was suggested.

Mohler E, Frei P, Braun-Fahrländer C, Fröhlich J, Neubauer G, Röösli M; Qualifex Team. Effects of everyday radiofrequency electromagnetic-field exposure on sleep quality: a cross-sectional study.Radiat Res. 174(3):347-356, 2010.

The aim of this cross-sectional study was to investigate the association between exposure to various sources of radiofrequency electromagnetic fields (RF EMFs) in the everyday environment and sleep quality, which is a common public health concern. We

assessed self-reported sleep disturbances and daytime sleepiness in a random population sample of 1,375 inhabitants from the area of Basel, Switzerland. Exposure to environmental far-field RF EMFs was predicted for each individual using a prediction model that had been developed and validated previously. Self-reported cordless and mobile phone use as well as objective mobile phone operator data for the previous 6 months were also considered in the analyses. In multivariable regression models, adjusted for relevant confounders, no associations between environmental far-field RF EMF exposure and sleep disturbances or excessive daytime sleepiness were observed. The 10% most exposed participants had an estimated risk for sleep disturbances of 1.11 (95% CI: 0.50 to 2.44) and for excessive daytime sleepiness of 0.58 (95% CI: 0.31 to 1.05). Neither mobile phone use nor cordless phone use was associated with decreased sleep quality. The results of this large cross-sectional study did not indicate an impairment of subjective sleep quality due to exposure from various sources of RF EMFs in everyday life.

Mohler E, Frei P, Fröhlich J, Braun-Fahrländer C, Röösli M; QUALIFEX-team. Exposure to radiofrequency electromagnetic fields and sleep quality: a prospective cohort study.PLoS One. 7(5):e37455, 2012.

BACKGROUND: There is persistent public concern about sleep disturbances due to radiofrequency electromagnetic field (RF-EMF) exposure. The aim of this prospective cohort study was to investigate whether sleep quality is affected by mobile phone use or by other RF-EMF sources in the everyday environment. METHODS: We conducted a prospective cohort study with 955 study participants aged between 30 and 60 years. Sleep quality and daytime sleepiness was assessed by means of standardized questionnaires in May 2008 (baseline) and May 2009 (follow-up). We also asked about mobile and cordless phone use and asked study participants for consent to obtain their mobile phone connection data from the mobile phone operators. Exposure to environmental RF-EMF was computed for each study participant using a previously developed and validated prediction model. In a nested sample of 119 study participants, RF-EMF exposure was measured in the bedroom and data on sleep behavior was collected by means of actigraphy during two weeks. Data were analyzed using multivariable regression models adjusted for relevant confounders. RESULTS: In the longitudinal analyses neither operator-recorded nor self-reported mobile phone use was associated with sleep disturbances or daytime sleepiness. Also, exposure to environmental RF-EMF did not affect self-reported sleep quality. The results from the longitudinal analyses were confirmed in the nested sleep study with objectively recorded exposure and measured sleep behavior data. CONCLUSIONS: We did not find evidence for adverse effects on sleep quality from RF-EMF exposure in our everyday environment.

Moisescu MG, Leveque P, Bertrand JR, Kovacs E, Mir LM. Microscopic observation of living cells during their exposure to modulated electromagnetic fields.Bioelectrochemistry. 74(1):9-15, 2008.

Studying cell behaviour under irradiation with radiofrequency electromagnetic fields (RF-EMF) is often impeded by the difficulty to monitor cell characteristics during irradiation. Here we report the design and the application of a complete device for continuous

microscopic observation of cells exposed to modulated EMF similar to mobile phones signals. The system allows the follow up of cell progression into mitosis under controlled temperature and CO(2) environment. Protocols are proposed in which the same cells are the controls before and after the EMF exposure and we demonstrate the interest of the "before exposure" controls. The exposure system was validated by cell endocytosis measurements. While the endocytosis rate was increased, no alteration of mitosis progression and mitosis duration was observed in cells exposed to 900 MHz modulated EMF for 1 h, at 30 degrees C and at a Specific Absorption Rate of 2.2 W/kg.

Moisescu MG, Leveque P, Verjus MA, Kovacs E, Mir LM. 900 MHz modulated electromagnetic fields accelerate the clathrin-mediated endocytosis pathway. Bioelectromagnetics30(3):222-230,2009.

We report new data regarding the molecular mechanisms of GSM-induced increase of cell endocytosis rate. Even though endocytosis represents an important physical and biological event for cell physiology, studies on modulated electromagnetic fields (EMF) effects on this process are scarce. In a previous article, we showed that fluid phase endocytosis rate increases when cultured cells are exposed to 900 MHz EMF similar to mobile phones' modulated GSM signals (217 Hz repetition frequency, 576 micros pulse width) and to electric pulses similar to the GSM electrical component. Trying to distinguish the mechanisms sustaining this endocytosis stimulation, we exposed murine melanoma cells to Lucifer Yellow (LY) or to GSM-EMF/electric pulses in the presence of drugs inhibiting the clathrin- or the caveolin-dependent endocytosis. Experiments were performed at a specific absorption rate (SAR) of 3.2 W/kg in a wire patch cell under homogeneously distributed EMF field and controlled temperature (in the range of 28.5-29.5 degrees C). Thus, the observed increase in LY uptake was not a thermal effect. Chlorpromazine and ethanol, but not Filipin, inhibited this increase. Therefore, the clathrin-dependent endocytosis is stimulated by the GSM-EMF, suggesting that the cellular mechanism affected by the modulated EMF involves vesicles that detach from the cell membrane, mainly clathrin-coated vesicles.

Moisescu MG, Leveque P, Bertrand JR, Kovacs E, Mir LM. Microscopic observation of living cells during their exposure to modulated electromagnetic fields. Bioelectrochemistry 74(1) 9-15, 2008.

Studying cell behaviour under irradiation with radiofrequency electromagnetic fields (RF-EMF) is often impeded by the difficulty to monitor cell characteristics during irradiation. Here we report the design and the application of a complete device for continuous microscopic observation of cells exposed to modulated EMF similar to mobile phones signals. The system allows the follow up of cell progression into mitosis under controlled temperature and CO(2) environment. Protocols are proposed in which the same cells are the controls before and after the EMF exposure and we demonstrate the interest of the "before exposure" controls. The exposure system was validated by cell endocytosis measurements. While the endocytosis rate was increased, no alteration of mitosis progression and mitosis duration was observed in cells exposed to 900 MHz modulated EMF for 1 h, at 30 degrees C and at a Specific Absorption Rate of 2.2 W/kg.

Mokarram P, Sheikhi M, Mortazavi SMJ, Saeb S, Shokrpour N. Effect of Exposure to 900 MHz GSM Mobile Phone Radiofrequency Radiation on Estrogen Receptor Methylation Status in Colon Cells of Male Sprague Dawley Rats. J Biomed Phys Eng. 7(1):79-86, 2017.

BACKGROUND: Over the past several years, the rapidly increasing use of mobile phones has raised global concerns about the biological effects of exposure to radiofrequency (RF) radiation. Numerous studies have shown that exposure to electromagnetic fields (EMFs) can be associated with effects on the nervous, endocrine, immune, cardiovascular, hematopoietic and ocular systems. In spite of genetic diversity, the onset and progression of cancer can be controlled by epigenetic mechanisms such as gene promoter methylation. There are extensive studies on the epigenetic changes of the tumor suppressor genes as well as the identification of methylation biomarkers in colorectal cancer. Some studies have revealed that genetic changes can be induced by exposure to RF radiation. However, whether or not RF radiation is capable of inducing epigenetic alteration has not been clarified yet. To date, no study has been conducted on the effect of radiation on epigenetic alterations in colorectal cancer (CRC). Several studies have also shown that methylation of estrogen receptor α (ERα), MYOD, MGMT, SFRP2 and P16 play an important role in CRC. It can be hypothesized that RF exposure can be a reason for the high incidence of CRC in Iran. This study aimed to investigate whether epigenetic pattern of ERα is susceptible to RF radiation and if RF radiation can induce radioadaptive response as epigenetic changes after receiving the challenge dose (γ-ray). MATERIAL AND METHOD: 40 male Sprague-Dawley rats were divided into 4 equal groups (Group I: exposure to RF radiation of a GSM cell phone for 4 hours and sacrificed after 24 hours; Group II: RF exposure for 4 hours, exposure to Co-60 gamma radiation (3 Gy) after 24 hours and sacrificed after 72 hrs; Group III: only 3Gy gamma radiation; Group 4: control group). DNA from colon tissues was extracted to evaluate the methylation status by methylation specific PCR. RESULTS: Our finding showed that exposure to GSM cell phone RF radiation was capable of altering the pattern of ERα gene methylation compared to that of non-exposed controls. Furthermore, no adaptive response phenomenon was induced in the pattern of ERα gene methylation after exposure to the challenging dose of Co-60 γ-rays. CONCLUSION: It can be concluded that exposure to RF radiation emitted by GSM mobile phones can lead to epigenetic detrimental changes in ERα promoter methylation pattern.

Momoli F, Siemiatycki J, McBride ML, Parent MÉ, Richardson L, Bedard D, Platt R, Vrijheid M, Cardis E, Krewski D. Probabilistic Multiple-Bias Modeling Applied to the Canadian Data From the Interphone Study of Mobile Phone Use and Risk of Glioma, Meningioma, Acoustic Neuroma, and Parotid Gland Tumors. Am J Epidemiol. 186(7):885-893, 2017.

We undertook a re-analysis of the Canadian data from the 13-country case-control Interphone Study (2001-2004), in which researchers evaluated the associations of mobile phone use with the risks of brain, acoustic neuroma, and parotid gland tumors. In the main publication of the multinational Interphone Study, investigators concluded that biases and errors prevented a causal interpretation. We applied a probabilistic multiple-

bias model to address possible biases simultaneously, using validation data from billing records and nonparticipant questionnaires as information on recall error and selective participation. In our modeling, we sought to adjust for these sources of uncertainty and to facilitate interpretation. For glioma, when comparing those in the highest quartile of use (>558 lifetime hours) to those who were not regular users, the odds ratio was 2.0 (95% confidence interval: 1.2, 3.4). After adjustment for selection and recall biases, the odds ratio was 2.2 (95% limits: 1.3, 4.1). There was little evidence of an increase in the risk of meningioma, acoustic neuroma, or parotid gland tumors in relation to mobile phone use. Adjustments for selection and recall biases did not materially affect interpretation in our results from Canadian data.

Moneda AP, Ioannidou MP, Chrissoulidis DP. Radio-wave exposure of the human head: analytical study based on a versatile eccentric spheres model including a brain core and a pair of eyeballs. IEEE Trans Biomed Eng. 50(6):667-676, 2003.

A versatile eccentric-spheres model of the human head is used in this paper to investigate radio-wave absorption. Numerical results, obtained by use of an exact analytical solution, are presented for the total, percentage, and gram-specific absorption. Interest is mainly in the brain and in the eyes of an adult or an infant head. Our model comprises a host sphere and several spherical inclusions, all concentrically stratified with respect to their own center. Any number of inclusions and any number of concentric layers for the host sphere and each one of the inclusions can be considered. Excitation is provided either by a plane-wave or by a nearby electric dipole. The analytical solution is obtained by use of the indirect-mode matching method. The theory of this paper and the accompanying computer code constitute a versatile tool for analytical studies of cellular-phone interactions with the human head. Specific absorption rate maps in a horizontal cross section of the head model manifest the existence of hot spots in the eyes and near the center of the brain.

Mortazavi SM, Daiee E, Yazdi A, Khiabani K, Kavousi A, Vazirinejad R, Behnejad B, Ghasemi M, Mood MB. Mercury release from dental amalgam restorations after magnetic resonance imaging and following mobile phone use. Pak J Biol Sci. 11(8):1142-1146, 2008.

In the 1st phase of this study, thirty patients were investigated. Five milliliter stimulated saliva was collected just before and after MRI. The magnetic flux density was 0.23 T and the duration of exposure of patients to magnetic field was 30 minutes. In the 2nd phase, fourteen female healthy University students who had not used mobile phones before the study and did not have any previous amalgam restorations were investigated. Dental amalgam restoration was performed for all 14 students. Their urine samples were collected before amalgam restoration and at days 1, 2, 3 and 4 after restoration. The mean +/- SD saliva Hg concentrations of the patients before and after MRI were 8.6 +/- 3.0 and 11.3 +/- 5.3 microg L(-1), respectively ($p < 0.01$). A statistical significant ($p < 0.05$) higher concentration was observed in the students used mobile phone. The mean +/- SE urinary Hg concentrations of the students who used mobile phones were 2.43 +/- 0.25, 2.71 +/- 0.27, 3.79 +/- 0.25, 4.8 +/- 0.27 and 4.5 +/- 0.32 microg L(-1) before the amalgam restoration and at days 1, 2, 3 and 4, respectively. Whereas the respective Hg concentrations in the controls, were 2.07 +/- 0.22, 2.34 +/- 0.30, 2.51 +/- 0.25, 2.66 +/-

0.24 and 2.76 +/- 0.32 microg L(-1). It appears that MRI and microwave radiation emitted from mobile phones significantly release mercury from dental amalgam restoration. Further research is needed to clarify whether other common sources of electromagnetic field exposure may cause alterations in dental amalgam and accelerate the release of mercury.

Mortazavi SM, Mahbudi A, Atefi M, Bagheri Sh, Bahaedini N, Besharati A. An old issue and a new look: Electromagnetic hypersensitivity caused by radiations emitted by GSM mobile phones. Technol Health Care. 19(6):435-443, 2011.

Abstract. University students use mobile phones frequently. We previously showed that there was no association between mobile phone use and EMF health hazards among university students. As our previous study was based only on self-reported symptoms this double-blind study was designed to answer two basic questions. Firstly, are self-reported hypersensitive individuals capable of sensing whether there is a real/sham microwave exposure? Secondly, do hypersensitive patients show alterations in their biological parameters such as heart rate, respiration, and blood pressure during microwave exposure? The study consisted of a preliminary screening phase and two subsequent complementary phases. In the 1st phase, 700 students were screened for EMF hypersensitivity. Fifty two participants were hypersensitive individuals but after applying the exclusion criteria only 28 students were invited to take part in the 2nd and 3rd phase of the study, but only 20 students (71.4%) declared their informed consent. In the 2nd phase, these self reported hypersensitive participants, were exposed/sham exposed to microwave radiation emitted from a mobile phone for 10 minutes and they were asked if they could sense the existence of microwave radiation. In the 3rd phase, all students were connected to ICU monitoring devices and their basic physiological parameters were recorded precisely. Among self-reported symptoms reported in our previous study, in this study only problem in concentration ($P< 0.05$) and low back pain ($P< 0.05$) were associated with mobile phone use. Furthermore, there was a significant association between the location of mobile phone during talk and the overall score of the severity of the symptoms ($P< 0.001$). When the participants were asked to report their perception about the real and sham exposures, only 5 students (25%) could discriminate the real exposure/sham exposure phases. This relative frequency can be only due to chance. In the 3rd phase all of the 20 participants were connected to intensive care unit monitors and the changes in their heart rate, respiration, and blood pressure during real/sham exposure were recorded. No statistically significant changes between the means of these parameters in real/sham exposure were observed. Our findings clearly confirm the results obtained inother provocative studies. These data also indicate the possible role of psychological factors in electromagnetic hypersensitivity.

Mortazavi SMJ, Mosleh-Shirazi MA, Tavassoli AR, Taheri M, Bagheri Z, Ghalandari R, Bonyadi S, Shafie M , Haghani M. A comparative study on the increased radioresistance to lethal doses of gamma rays after exposure to microwave radiation and oral intake of flaxseed oil. Iran. J. Radiat. Res. 9(1): 9-14, 2011.

Background: Mobile phones, use electromagnetic radiation in the microwave range. On the other hand, there is only one report on radioprotective effects of flaxseed oil. The aim of this study was to investigate the effect of irradiation of rats with microwaves and/or treatment with flaxseed oil on the induction of adaptive response to a subsequent lethal dose (LD) of gamma rays. **Materials and Methods:** Eighty male rats were randomly divided into 6 groups of 13-15 animals. The animals in the 1st to 5th groups received microwave exposure, microwave+flaxseed oil (dissolved in olive oil), flaxseed (continued after LD), flaxseed, and olive oil. At day 5, all animals were whole-body irradiated with a previously reported LD 50/30 of 8 Gy gamma radiation. The 6th group (controls) received the same LD 50/30, but there was not any other treatment before or after the LD. **Results:** No death event was observed during days 1-9 after LD irradiation in either group. At day 10, death events started in the 4th group. Thirty days after irradiation of the animals, the survival fractions for the control group, as expected, was 53.3% while there was no death event in the 1st group (survival rate of 100% in microwave-pretreated animals). The survival fractions for the 2nd to 5th groups were 69.2%, 92.3%, 46.1%, and 61.5%, respectively. **Conclusion:** While these findings open new horizons in radiation protection, the radioresistance induced by microwave radiations emitted by a mobile phone may interfere with the outcome of any subsequent therapeutic application of photons or radioisotopes.

Mortazavi S, Mosleh-Shirazi M, Tavassoli A, Taheri M, Mehdizadeh A, Namazi S, Jamali A, Ghalandari R, Bonyadi S, Haghani M, Shafie M. Increased Radioresistance to Lethal Doses of Gamma Rays in Mice and Rats after Exposure to Microwave Radiation Emitted by a GSM Mobile Phone Simulator. Dose Response. 11(2):281-292, 2012.

The aim of this study was to investigate the effect of pre-irradiation with microwaves on the induction of radioadaptive response. In the 1(st) phase of the study, 110 male mice were divided into 8 groups. The animals in these groups were exposed/sham-exposed to microwave, low dose rate gamma or both for 5 days. On day six, the animals were exposed to a lethal dose (LD). In the 2(nd) phase, 30 male rats were divided into 2 groups of 15 animals. The 1(st) group received microwave exposure. The 2(nd) group (controls) received the same LD but there was no treatment before the LD. On day 5, all animals were whole-body irradiated with the LD. Statistically significant differences between the survival rate of the mice only exposed to lethal dose of gamma radiation before irradiation with a lethal dose of gamma radiation with those of the animals pre-exposed to either microwave ($p=0.02$), low dose rate gamma ($p=0.001$) or both of these physical adapting doses ($p=0.003$) were observed. Likewise, a statistically significant difference between survival rates of the rats in control and test groups was observed. Altogether, these experiments showed that exposure to microwave radiation may induce a significant survival adaptive response.

Mortazavi SM, Vazife-Doost S, Yaghooti M, Mehdizadeh S, Rajaie-Far A. Occupational exposure of dentists to electromagnetic fields produced by magnetostrictive cavitrons alters the serum cortisol level. J Nat Sci Biol Med. 3(1):60-64, 2012.

OBJECTIVES: Some studies indicate that dentistry is one of the job categories with high potential exposure to elevated levels of extremely low frequency magnetic fields. In spite of this, information on occupational exposure of dentists to these fields is scarce. Studies on other common sources of electromagnetic fields (EMFs) such as mobile base stations have shown alterations in the cortisol level following exposure of humans to these sources. The aim of this study is to compare the level of cortisol among dentists and dentistry students who are being occupationally exposed to EMFs emitted by magnetostrictive cavitrons (case group) and among their counterparts who are not being exposed to these fields (control group). MATERIALS AND METHODS: In this case-control study, blood samples were collected from 41 dentists and dentistry students, 21 of whom were exposed to EMFs emitted by cavitrons as the case group and 20 who were not exposed as the control group, twice; i.e. before work (at 8:30-9:30 a.m.) and after work (11:30-12:30 a.m.). The samples were coded and the serum cortisol level was investigated using the ELISA method (Cortisol AccuBind ELISA Kits). RESULTS: The serum cortisol level of dentists and dental students in the morning (before starting the work) in the control group was 189.15 ± 110.70 (mean ± SD) whereas it was 157.77 ± 112.03 in those who were occupationally exposed to EMFs produced by the use of cavitrons. This difference was not statistically significant (P = 0.373). In contrast, the serum cortisol level of the participants in the noon (after stopping the work) in the control group was 136.25 ± 67.91 (mean ± SD) while it was 88.58 ± 52.83 in those who were occupationally exposed to EMFs produced by the use of cavitrons. This time, the observed difference was statistically significant (P = 0.016). In this light, while the difference between serum cortisol levels of dentists and dental students in the morning and after stopping the work was not statistically significant (P = 0.06), in the EMF-exposed group the cortisol level decreased significantly from 157.77 ± 112.03 in the morning to 88.58 ± 52.83 in the noon (P = 0.001).CONCLUSIONS: As far as we know, this is the first study that evaluated the effect of occupational exposure of dentists to EMFs on their serum cortisol level. The EMFs produced by magnetostrictive cavitrons can decrease the serum cortisol level in dentists. As cortisol plays an important role in blood pressure regulation, cardiovascular, and immune system function, a low cortisol level may threaten health. More studies are needed to clearly understand the effects of EMFs emitted by magnetostrictive cavitron on the level of stress hormones. As some studies have shown that exposure to EMFs has no effect on the cortisol level, whereas other studies reported either an increase or a decrease in the cortisol level, it can be concluded that the effects of exposure to EMFs may occur only at specific absorbed energies or energy absorption rates (usually known as window) similar to that exists in the case of exposure to the low doses of ionizing radiations.

Mortazavi SM, Rouintan MS, Taeb S, Dehghan N, Ghaffarpanah AA, Sadeghi Z, Ghafouri F. Human short-term exposure to electromagnetic fields emitted by

mobile phones decreases computer-assisted visual reaction time. Acta Neurol Belg. 112(2):171-175, 2012.

The worldwide dramatic increase in mobile phone use has generated great concerns about the detrimental effects of microwave radiations emitted by these communication devices. Reaction time plays a critical role in performing tasks necessary to avoid hazards. As far as we know, this study is the first survey that reports decreased reaction time after exposure to electromagnetic fields generated by a high specific absorption rate mobile phone. It is also the first study in which previous history of mobile phone use is taken into account. The aim of this study was to assess both the acute and chronic effects of electromagnetic fields emitted by mobile phones on reaction time in university students. Visual reaction time (VRT) of young university students was recorded with a simple blind computer-assisted-VRT test, before and after a 10 min real/sham exposure to electromagnetic fields of mobile phones. Participants were 160 right-handed university students aged 18-31. To assess the effect of chronic exposures, the reaction time in sham-exposed phases were compared among low level, moderate and frequent users of mobile phones. The mean ± SD reaction time after real exposure and sham exposure were 286.78 ± 31.35 ms and 295.86 ± 32.17 ms (P < 0.001), respectively. The age of students did not significantly alter the reaction time either in talk or in standby mode. The reaction time either in talk or in standby mode was shorter in male students. The students' VRT was significantly affected by exposure to electromagnetic fields emitted by a mobile phone. It can be concluded that these exposures cause decreased reaction time, which may lead to a better response to different hazards. In this light, this phenomenon might decrease the chances of human errors and fatal accidents.

Mortazavi SM, Taeb S, Dehghan N. Alterations of visual reaction time and short term memory in military radar personnel. Iran J Public Health. 42(4):428-435, 2013.

BACKGROUND: Radar transmitters emit high-power radiofrequency radiation by creation of a high-voltage and high-frequency alternating electrical current. METHODS: Health effects of occupational exposure to military radar were investigated. Visual reaction time was recorded with a simple blind computer-assisted-visual reaction time test. To assess the short-term memory, modified Wechsler Memory Scale test was performed. RESULTS: The mean +/- SD reaction time in radar works (N=100) and the control group (N=57) were 238.58 +/- 23.47 milliseconds and 291.86 +/- 28.26 milliseconds (P<0.0001), respectively. The scores of forward digit span in radar works and the control group were 3.56 +/- 0.77 and 4.29 +/- 1.06 (P<0.0001), while the scores of backward digit span in radar works and the control group were 2.70 +/- 0.69 and 3.62 +/- 0.95 (P<0.0001). The scores of word recognition in radar works and the control group were 3.37 +/- 1.13 and 5.86 +/- 1.11 (P<0.0001). Finally, the scores of paired words in radar works and the control group were 13.56 +/- 1.78 and 15.21 +/- 2.20 (P<0.0001). It can be concluded that occupational exposures to radar radiations decreases reaction time, which may lead to a better response to different hazards. CONCLUSION: To the best of our knowledge, this is the first study to show that occupational exposure to radar microwave radiation leads to decreased reaction time and the lower performance of short-term memory. Altogether,

these results indicate that occupational exposure to radar microwave radiations may be linked to some non-detrimental and detrimental health effects.

Mohler E, Frei P, Braun-Fahrländer C, Fröhlich J, Neubauer G, Röösli M. Effects of everyday radiofrequency electromagnetic-field exposure on sleep quality: a cross-sectional study. Radiat Res. 174(3):347-356, 2010.

The aim of this cross-sectional study was to investigate the association between exposure to various sources of radiofrequency electromagnetic fields (RF EMFs) in the everyday environment and sleep quality, which is a common public health concern. We assessed self-reported sleep disturbances and daytime sleepiness in a random population sample of 1,375 inhabitants from the area of Basel, Switzerland. Exposure to environmental far-field RF EMFs was predicted for each individual using a prediction model that had been developed and validated previously. Self-reported cordless and mobile phone use as well as objective mobile phone operator data for the previous 6 months were also considered in the analyses. In multivariable regression models, adjusted for relevant confounders, no associations between environmental far-field RF EMF exposure and sleep disturbances or excessive daytime sleepiness were observed. The 10% most exposed participants had an estimated risk for sleep disturbances of 1.11 (95% CI: 0.50 to 2.44) and for excessive daytime sleepiness of 0.58 (95% CI: 0.31 to 1.05). Neither mobile phone use nor cordless phone use was associated with decreased sleep quality. The results of this large cross-sectional study did not indicate an impairment of subjective sleep quality due to exposure from various sources of RF EMFs in everyday life.

Momoli F, Siemiatycki J, McBride ML, Parent MÉ, Richardson L, Bedard D, Platt R, Vrijheid M, Cardis E, Krewski D. Probabilistic Multiple-Bias Modeling Applied to the Canadian Data From the Interphone Study of Mobile Phone Use and Risk of Glioma, Meningioma, Acoustic Neuroma, and Parotid Gland Tumors. Am J Epidemiol. 186(7):885-893, 2017.

We undertook a re-analysis of the Canadian data from the 13-country case-control Interphone Study (2001-2004), in which researchers evaluated the associations of mobile phone use with the risks of brain, acoustic neuroma, and parotid gland tumors. In the main publication of the multinational Interphone Study, investigators concluded that biases and errors prevented a causal interpretation. We applied a probabilistic multiple-bias model to address possible biases simultaneously, using validation data from billing records and nonparticipant questionnaires as information on recall error and selective participation. In our modeling, we sought to adjust for these sources of uncertainty and to facilitate interpretation. For glioma, when comparing those in the highest quartile of use (>558 lifetime hours) to those who were not regular users, the odds ratio was 2.0 (95% confidence interval: 1.2, 3.4). After adjustment for selection and recall biases, the odds ratio was 2.2 (95% limits: 1.3, 4.1). There was little evidence of an increase in the risk of meningioma, acoustic neuroma, or parotid gland tumors in relation to mobile phone use. Adjustments for selection and recall biases did not materially affect interpretation in our results from Canadian data.

Monfrecola G, Moffa G, Procaccini EM. Non-ionizing electromagnetic radiations, emitted by a cellular phone, modify cutaneous blood flow. Dermatology. 207(1):10-14, 2003.

BACKGROUND: Our surroundings are full of non-ionizing electromagnetic radiation (EMR) of different frequency and power. The non-ionizing EMRs emitted by television, computer and cellular phone (CF) sets have been increasing over the past few years. OBJECTIVE: The aim of our study was to assess the effects of non-ionizing EMRs (frequency 3 x 10(8) to 3 x 10(11) Hz), emitted by CFs, on cutaneous blood flow in healthy volunteers. METHODS: Thirty healthy volunteers (14 male and 16 female; age: 18-53 years) entered the study. Measurements of cutaneous blood flow were taken under standard conditions (temperature and humidity), using a laser Doppler He-Ne flowmeter that was applied to the ear skin by an optical fibre probe. Microflow values were recorded without CF contact with the skin (T0), with the CF turned off but in contact with the ear skin (T1), with CF contact and turned on (T2), with CF contact, turned on and receiving (T3). The microflow values were also recorded backwards: with CF contact and set turned on (T4), with CF contact and turned off (T5), without CF contact (T6). RESULTS: The mean value of basal microflow (T0), expressed as perfusion units (PU), was 51.26+/-11.93 PU. During the T1 phase, the microflow increase was 61.38%; in T2 it was 131.74%, in T3 157.67%, in T4 139.21% and in T5 122.90%; in T6, the microflow value was 57.58+/-10 PU (similar to the basal microflow). Statistically significant cutaneous microflow values ($p<0.050$) were observed comparing the T1 to T5 values with basal microflow (T0). Furthermore, in comparison with T1 values (CF turned off in contact with the ear skin), the T2, T3 and T4 data were statistically significant (T2 vs. T1: $t=7.763$ with $p<0.050$; T3 vs. T1: $t=9.834$ with $p<0.050$; T4 vs. T1: $t=8.885$ with $p<0.050$).

Monnery PM, Srouji EI, Bartlett J. Is cochlear outer hair cell function affected by mobile telephone radiation? Clin Otolaryngol 29(6):747-749, 2004.

Mobile telephones emit high-frequency pulsed electromagnetic fields (PEMF). These are known to have measurable biological effects, and possible effects on the auditory system. Otoacoustic emissions give an indication of the functional state of the auditory system. Otoacoustics are known to be highly specific for the individual when the test pulse is identical. In this way, subtle changes in the ear can be detected. We investigated whether there is a measurable effect on Otoacoustic emissions from PEMF radiation. A total of 12 volunteers were recruited who had normal hearing; confirmed by pure tone audiometry. An Otoacoustic emission trace was obtained. The test subjects were exposed to a mobile telephone that was placed over the test ears mastoid process. The subjects had Otoacoustic emissions measured without the telephone and again on receive and transmit. There was no change in the trace signature during the test. There was no statistically significant change in the trace figures. This would indicate that PEMF from commonly available hand held mobile telephones have no measurable effect on the outer hair cell function during the time of use.

Monselise EB, Levkovitz A, Gottlieb HE, Kost D. Bioassay for assessing cell stress in the vicinity of radio-frequency irradiating antennas. J Environ Monit. 13(7):1890-1896, 2011.

The 24 h exposure of water plants (etiolated duckweed) to RF-EMF between 7.8 V m(-1) and 1.8 V m(-1), generated by AM 1.287 MHz transmitting antennas, resulted in alanine accumulation in the plant cells, a phenomenon we have previously shown to be a universal stress signal. The magnitude of the effect corresponds qualitatively to the level of RF-EMF exposure. In the presence of 10 mM vitamin C, alanine accumulation is completely suppressed, suggesting the involvement of free radicals in the process. A unique biological connection has thus been made between exposure to RF-EMF and cell stress, in the vicinity of RF transmitting antennas. This simple test, which lasts only 24 h, constitutes a useful bioassay for the quick detection of biological cell stress caused in the vicinity of RF irradiating antennas.

Mora R, Crippa B, Mora F, Dellepiane M. A study of the effects of cellular telephone microwave radiation on the auditory system in healthy men. Ear Nose Throat J. 85(3):160, 162-163, 2006.

We conducted a study of the effects of mobile cellular telephone microwave radiation on the auditory system in 20 healthy men. After the subjects underwent baseline measurements of transient evoked otoacoustic emission (TEOAE) and auditory brainstem response (ABR), they participated in three sessions of exposure to an electromagnetic field of 900 to 1,800 MHz produced by a cellular phone. Sessions ranged from 15 to 30 minutes in length. TEOAE and ABR were again measured after or during each exposure. Throughout the study, no significant changes in either measurement were noted. We conclude that the use of cellular phones does not alter the auditory system in the short-term.

Moretti D, Garenne A, Haro E, Poulletier de Gannes F, Lagroye I, Lévêque P, Veyret B, Lewis N. In-vitro exposure of neuronal networks to the GSM-1800 signal. Bioelectromagnetics. 2013 Aug 1. doi: 10.1002/bem.21805. [Epub ahead of print]

The central nervous system is the most likely target of mobile telephony radiofrequency (RF) field exposure in terms of biological effects. Several electroencephalography (EEG) studies have reported variations in the alpha-band power spectrum during and/or after RF exposure, in resting EEG and during sleep. In this context, the observation of the spontaneous electrical activity of neuronal networks under RF exposure can be an efficient tool to detect the occurrence of low-level RF effects on the nervous system. Our research group has developed a dedicated experimental setup in the GHz range for the simultaneous exposure of neuronal networks and monitoring of electrical activity. A transverse electromagnetic (TEM) cell was used to expose the neuronal networks to GSM-1800 signals at a SAR level of 3.2 W/kg. Recording of the neuronal electrical activity and detection of the extracellular spikes and bursts under exposure were performed using microelectrode arrays (MEAs). This work provides the proof of feasibility and preliminary results of the integrated investigation regarding exposure setup, culture of the neuronal network, recording of the electrical activity, and analysis of the signals obtained under RF exposure. In this pilot study on 16 cultures, there was a 30% reversible decrease in firing rate (FR) and bursting rate (BR) during a 3 min exposure to RF. Additional experiments are needed to further characterize this effect.

Morgan RW, Kelsh MA, Zhao K, Exuzides KA, Heringer S, Negrete W, Radiofrequency exposure and mortality from cancer of the brain and lymphatic/hematopoietic systems. Epidemiology 11(2):118-127, 2000.

The proliferation of wireless communication technologies has raised public concern regarding potential health effects of radiofrequency (RF) exposures. This is the first report of findings from a large-cohort mortality study among employees of Motorola, a manufacturer of wireless communication products. We examined all major causes of mortality, with brain cancers, lymphomas, and leukemias as a priori outcomes of interest. Using job titles, we classified workers into high, moderate, low, and background RF exposure groups. A total of 195,775 workers contributed 2.7 million person-years during the 1976-1996 period. Using external comparisons, the standardized mortality ratios for RF-exposed workers were 0.53 [95% confidence interval (CI) = 0.21-1.09] and 0.54 (95% CI = 0.33-0.83) for central nervous system/brain cancers and all lymphomas/leukemias. Rate ratios calculated from Poisson regression models based on internal comparisons were near 1.0 for brain cancers and below 1.0 for all lymphomas and leukemias. These findings were consistent across cumulative, peak, and usual exposure classifications. We did not observe higher risk with increased exposure duration or latency. Although this study is limited by the use of a qualitative exposure matrix and the relatively young age of the cohort, our findings do not support an association between occupational RF exposure and brain cancers or lymphoma/leukemia.

Morimoto S, Takahashi T, Shimizu K, Kanda T, Okaishi K, Okuro M, Murai H, Nishimura Y, Nomura K, Tsuchiya H, Ohashi I, Matsumoto M. Electromagnetic fields inhibit endothelin-1 production stimulated by thrombin in endothelial cells. J Int Med Res. 33(5):545-554, 2005.

Electromagnetic field (EMF) radiation has been found to induce arteriolar dilatation, but the mechanism of action remains largely unknown. This study investigated the effect of EMF radiation on the production of endothelin-1 (ET-1), a potent vasoconstrictor, by cultured endothelial cells. EMF radiation reduced ET-1 basal levels in human umbilical vein and microvascular endothelial cells, but failed to reduce ET-1 basal levels in bovine and human aortic endothelial cells. EMF radiation significantly inhibited thrombin-stimulated ET-1 production in all four endothelial cell types in a dose-dependent manner. EMF radiation significantly inhibited thrombin-induced endothelin-1 mRNA expression in all four cell types. The inhibitory effect of EMF radiation on ET-1 production was abolished by the nitric oxide synthase inhibitor NG-monomethyl-L-arginine (10(-3) mol/1). These results demonstrate that EMF radiation modulates ET-1 production in cultured vascular endothelial cells and the inhibitory effect of EMF radiation is, at least partly, mediated through a nitric oxide-related pathway.

Morrissey JJ, Raney S, Heasley E, Rathinavelu P, Dauphinee M, Fallon JH, IRIDIUM exposure increases c-fos expression in the mouse brain only at levels which likely result in tissue heating. Neuroscience 92(4):1539-1546, 1999.

With the rapid development of wireless communication technology over the last 20 years, there has been some public concern over possible health effects of long-term, low-level radiofrequency exposure from cellular telephones. As an initial step in compiling a database for risk analysis by government agencies, the effects of 1-h exposure of mice to a 1.6-GHz radiofrequency signal, given as either a continuous wave or pulse modulated at 11 Hz with a duty cycle of 4:1 and a pulse duration of 9.2 ms IRIDIUM), on c-fos gene expression in the brain was investigated. The IRIDIUM signal is the operating frequency for a ground-to-satellite-to-ground cellular communications web which has recently become fully operational, and was named as such due to the original designed employment of the same number of low orbiting satellites as there are electrons orbiting the nucleus of an iridium atom. The expression of c-fos was not significantly elevated in the brains of mice until exposure levels exceeded six times the peak dose and 30 times the whole body average dose as maximal cellular telephone exposure limits in humans. Higher level exposure using either continuous wave (analog) or IRIDIUM signals elevated c-fos to a similar extent, suggesting no obvious pulsed modulation-specific effects. The pattern of c-fos elevation in limbic cortex and subcortex areas at higher exposure levels is most consistent with a stress response due to thermal perception coupled with restraint and/or neuron activity near thermoregulatory regions, and not consistent with any direct interaction of IRIDIUM energy with brain tissue.

Morrissey JJ, Swicord M, Balzano Q. Characterization of electromagnetic interference of medical devices in the hospital due to cell phones. Health Phys 82(1):45-51, 2002.

Concern over electromagnetic interference with medical devices due to cell phone emissions has stemmed from anecdotal reports and unpublished observations of hospital staff. In an effort to characterize electromagnetic interference concerns, representative medical devices from four large teaching hospitals were exposed to standard North American and European communication signal emissions. Of 33 medical devices tested, only 4 showed disruption of critical function due to cell phone emissions at a distance of 25 cm or greater. Although other cases of electromagnetic interference were observed, these were not critically disruptive and mainly occurred when the transmitters were at full power and placed 5 cm or closer to the medical device. Overall, no cell phone signal was exempt from producing electromagnetic interference effects. While sensitive medical devices were often affected by more than one signal type, the effects were not entirely predictable based upon the results of other signals or related medical device units or models. Because a comprehensive analysis of all medical devices in all possible electromagnetic environments was not performed, the data presented here are only intended to provide a general idea of the magnitude of electromagnetic interference effects that might be encountered in a hospital environment, as well as a standard protocol for clinical engineering groups to perform ad hoc electromagnetic interference surveys and methods to manage and/or eliminate electromagnetic interference with appropriate system engineering design including supplementary communication infrastructure, medical device shielding and positioning, and appropriate cell phone user guidelines.

Mortazavi SM, Shirazi KR, Mortazavi G. The study of the effects of ionizing and non-ionizing radiations on birth weight of newborns to exposed mothers. J Nat Sci Biol Med. 4(1):213-217, 2013.

OBJECTIVES: Life evolved in an environment filled with a wide variety of ionizing and non-ionizing radiation. It was previously reported that medical exposures to pregnant women increases the risk of low birth weight. This study intends to investigate the relationship between exposure to ionizing and non-ionizing radiation and the risk of low birth weight. MATERIALS AND METHODS: One thousand two hundred mothers with their first-term labor (vaginal or cesarean) whose newborns' history had been registered in neonates' screening program in Shiraz were interviewed and surveyed. Data collection was performed by the assessment of mother's history of radiography before and during pregnancy, physical examination of the mother for height and weight and weighing and examining the newborn for any diagnosis of disease and anomalies. RESULTS: There were no statistical significant differences between the mean weight of newborns whose mothers had been exposed to some common sources of ionizing and non-ionizing radiations such as dental or non dental radiographies, mobile phone, cordless phone and cathode ray tube (CRT) and those of non-exposed mothers. CONCLUSIONS: The findings of this study cast doubt on previous reports, which indicated that exposure to ionizing radiation during pregnancy increased the risk of low birth weight.

Mortazavi S, Parsanezhad M, Kazempour M, Ghahramani P, Mortazavi A, Davari M. Male reproductive health under threat: Short term exposure to radiofrequency radiations emitted by common mobile jammers. J Hum Reprod Sci. 2013 Apr;6(2):124-8. doi: 10.4103/0974-1208.117178.

BACKGROUND: Modern life prompted man to increasingly generate, transmit and use electricity that leads to exposure to different levels of electromagnetic fields (EMFs). Substantial evidence indicates that exposure to common sources of EMF such as mobile phones, laptops or wireless internet-connected laptops decreases human semen quality. In some countries, mobile jammers are occasionally used in offices, shrines, conference rooms and cinemas to block the signal. AIMS: To the best of our knowledge, this is the first study to investigate the effect of short term exposure of human sperm samples to radiofrequency (RF) radiations emitted by common mobile jammers. SUBJECTS AND METHODS: Fresh semen samples were collected by masturbation from 30 healthy donors who had referred to Infertility Treatment Center at the Mother and Child Hospital with their wives. Female problem was diagnosed as the reason for infertility in these couples. STATISTICAL ANALYSIS: T-test and analysis of variance were used to show statistical significance. RESULTS: The motility of sperm samples exposed to jammer RF radiation for 2 or 4 h were significantly lower than those of sham-exposed samples. These findings lead us to the conclusion that mobile jammers may significantly decrease sperm motility and the couples' chances of conception. CONCLUSION: Based on these results, it can be suggested that in countries that have not banned mobile jammer use, legislations should be urgently passed to restrict the use of these signal blocking devices in public or private places.

Mortazavi SM, Motamedifar M, Namdari G, Taheri M, Mortazavi AR, Shokrpour N. Non-linear adaptive phenomena which decrease the risk of infection after pre-exposure to radiofrequency radiation. Dose Response. 12(2):233-245, 2014.

Substantial evidence indicates that adaptive response induced by low doses of ionizing radiation can result in resistance to the damage caused by a subsequently high-dose radiation or cause cross-resistance to other non-radiation stressors. Adaptive response contradicts the linear-non-threshold (LNT) dose-response model for ionizing radiation. We have previously reported that exposure of laboratory animals to radiofrequency radiation can induce a survival adaptive response. Furthermore, we have indicated that pre-exposure of mice to radiofrequency radiation emitted by a GSM mobile phone increased their resistance to a subsequent Escherichia coli infection. In this study, the survival rates in animals receiving both adapting (radiofrequency) and challenge dose (bacteria) and the animals receiving only the challenge dose (bacteria) were 56% and 20%, respectively. In this light, our findings contribute to the assumption that radiofrequency-induced adaptive response can be used as an efficient method for decreasing the risk of infection in immunosuppressed irradiated individuals. The implication of this phenomenon in human's long term stay in the space is also discussed.

Mortazavi SM, Owji SM, Shojaei-Fard MB, Ghader-Panah M, Mortazavi SA, Tavakoli-Golpayegani A, Haghani M, Taeb S, Shokrpour N, Koohi O. GSM 900 MHz Microwave Radiation-Induced Alterations of Insulin Level and Histopathological Changes of Liver and Pancreas in Rat. J Biomed Phys Eng. 6(4):235-242, 2016.

BACKGROUND: The rapidly increasing use of **mobile phones** has led to public concerns about possible health effects of these popular communication devices. This study is an attempt to investigate the effects of radiofrequency (RF) radiation produced by GSM **mobile phones** on the insulin release in rats. METHODS: Forty two female adult Sprague Dawley rats were randomly divided into 4 groups. Group1 were exposed to RF radiation 6 hours per day for 7 days. Group 2 received sham exposure (6 hours per day for 7 days). Groups 3 and 4 received RF radiation 3 hours per day for 7 days and sham exposure (3 hours per day), respectively. The specific absorption rate (SAR) of RF was 2.0 W/kg. RESULTS: Our results showed that RF radiations emitted from **mobile phone** could not alter insulin release in rats. However, mild to severe inflammatory changes in the portal spaces of the liver of rats as well as damage in the cells of islet of Langerhans were observed. These changes were linked with the duration of the exposures. CONCLUSION: RF exposure can induce inflammatory changes in the liver as well causing damage in the cells of islet of Langerhans.

Mortazavi SMJ, Mostafavi-Pour Z, Daneshmand M, Zal F, Zare R, Mosleh-Shirazi MA. Adaptive Response Induced by Pre-Exposure to 915 MHz Radiofrequency: A Possible Role for Antioxidant Enzyme Activity. J Biomed Phys Eng. 7(2):137-142, 2017.

BACKGROUND: Over the past few years, the rapid use of high frequency electromagnetic fields like **mobile phones** has raised global concerns about the negative health effects of its use. Adaptive response is the ability of a **cell** or tissue to better resist stress damage by prior exposure to a lesser amount of stress. This study aimed to assess whether radiofrequency radiation can induce adaptive response by changing the antioxidant balance.MATERIALS AND METHODS: In order to assess RF-induced adaptive response in tissues, we evaluated the level of GSH and the activity of GR in liver. 50 rats were divided into 5 groups. Three groups were pre-exposed to 915 MHz RF radiation, 4 hours per day for one week at different powers, as low, medium and high. 24 hours after the last exposure to radiation, they were exposed to 4 Gy sublethal dose of gamma radiation and then sacrificed after 5 hours. Their livers were removed, washed and were kept at -80o C until used.RESULTS: Our finding showed that pre-exposure to 915 MHz radiofrequency radiation with specific power could induce adaptive response in liver by inducing changes in the activity and level of antioxidant enzymes.CONCLUSION: It can be concluded that pre-exposure to microwave radiation could increase the level of GSH and the activity of GR enzyme, although these increases were seen just in low power group, and the GR activity was indicated in medium power group. This increase protects tissue from oxidative damage induced by sublethal dose of gamma radiation.

Moszczynski P, Lisiewicz J, Dmoch A, Zabinski Z, Bergier L, Rucinska M, Sasiadek U, [The effect of various occupational exposures to microwave radiation on the concentrations of immunoglobulins and T lymphocyte subsets]. Wiad Lek 52(1-2):30-34, 1999. [Article in Polish]

The immunoglobulins' concentrations and T lymphocyte subsets during occupational exposures to microwave radiation were assessed. In the workers of retransmission TV center and center of satellite communications on increased IgG and IgA concentration and decreased count of lymphocytes and T8 cells was found. However, in the radar operators IgM concentration was elevated and a decrease in the total T8 cell count was observed. The different behaviour of examined immunological parameters indicate that the effect of microwave radiation on immune system depends on character of an exposure. Disorders in the immunoglobulins' concentrations and in the T8 cell count did not cause any clinical consequences.

Motawi TK, Darwish HA, Moustafa YM, Labib MM. Biochemical Modifications and Neuronal Damage in Brain of Young and Adult Rats After Long-Term Exposure to Mobile Phone Radiations. Cell Biochem Biophys. 2014 May 7. [Epub ahead of print]

This study investigated the effect of exposure to mobile phone radiations on oxidative stress and apoptosis in brain of rats. Rats were allocated into six groups (three young and three adult). Groups 1 and 4 were not subjected to the radiation source and served as control groups. In groups 2 and 5, the mobile phones were only connected to the global system for mobile communication, while in groups 3 and 6, the option of calling was in use. Microwaves were generated by a mobile test phone (SAR = 1.13 W/kg) during 60 days (2 h/day). Significant increments in conjugated dienes, protein carbonyls, total oxidant status, and oxidative stress index along with a significant reduction of total antioxidant capacity levels were evident after exposure. Bax/Bcl-2 ratio, caspase-3

activity, and tumor necrosis factor-alpha level were enhanced, whereas no DNA fragmentation was detected. The relative brain weight of young rats was greatly affected, and histopathological examination reinforced the neuronal damage. The study highlights the detrimental effects of mobile phone radiations on brain during young and adult ages. The interaction of these radiations with brain is via dissipating its antioxidant status and/or triggering apoptotic cell death.

Mouradi R, Desai N, Erdemir A, Agarwal A.The use of FDTD in establishing in vitro experimentation conditions representative of lifelike cell phone radiation on the spermatozoa.Health Phys. 102(1):54-62, 2012.

Recent studies have shown that exposing human semen samples to cell phone radiation leads to a significant decline in sperm parameters. In daily living, a cell phone is usually kept in proximity to the groin, such as in a trouser pocket, separated from the testes by multiple layers of tissue. The aim of this study was to calculate the distance between cell phone and semen sample to set up an in vitro experiment that can mimic real life conditions (cell phone in trouser pocket separated by multiple tissue layers). For this reason, a computational model of scrotal tissues was designed by considering these separating layers, the results of which were used in a series of simulations using the Finite Difference Time Domain (FDTD) method. To provide an equivalent effect of multiple tissue layers, these results showed that the distance between a cell phone and semen sample should be 0.8 cm to 1.8 cm greater than the anticipated distance between a cell phone and the testes.

Mousavy SJ, Riazi GH, Kamarei M, Aliakbarian H, Sattarahmady N, Sharifizadeh A, Safarian S, Ahmad F, Moosavi-Movahedi AA. Effects of mobile phone radiofrequency on the structure and function of the normal human hemoglobin. Int J Biol Macromol. 44(3):278-285, 2009

Widespread use of mobile phones has increased the human exposure to electromagnetic fields (EMFs). It is required to investigate the effect of EMFs on the biological systems. In this paper the effect of mobile phone RF (910MHz and 940 MHz) on structure and function of HbA was investigated. Oxygen affinity was measured by sodium dithionite with UV-vis spectrophotometer. Structural changes were studied by circular dichroism and fluorescence spectroscopy. The results indicated that mobile phone EMFs altered oxygen affinity and tertiary structure of HbA. Furthermore, the decrease of oxygen affinity of HbA corresponded to the EMFs intensity and time of exposure.

Moustafa YM, Moustafa RM, Belacy A, Abou-El-Ela SH, Ali FM.Effects of acute exposure to the radiofrequency fields of cellular phones on plasma lipid peroxide and antioxidase activities in human erythrocytes. J Pharm Biomed Anal 26(4):605-608, 2001.

Radiofrequency fields of cellular phones may affect biological systems by increasing free radicals, which appear mainly to enhance lipid peroxidation, and by changing the antioxidase activities of human blood thus leading to oxidative stress. To test this, we

have investigated the effect of acute exposure to radiofrequency fields of commercially available cellular phones on some parameters indicative of oxidative stress in 12 healthy adult male volunteers. Each volunteer put the phone in his pocket in standby position with the keypad facing the body. The parameters measured were lipid peroxide and the activities of superoxide dismutase (SOD), total glutathione peroxidase (GSH-Px) and catalase. The results obtained showed that the plasma level of lipid peroxide was significantly increased after 1, 2 and 4 h of exposure to radiofrequency fields of the cellular phone in standby position. Moreover, the activities of SOD and GSH-Px in human erythrocytes showed significant reduction while the activity of catalase in human erythrocytes did not decrease significantly. These results indicate that acute exposure to radiofrequency fields of commercially available cellular phones may modulate the oxidative stress of free radicals by enhancing lipid peroxidation and reducing the activation of SOD and GSH-Px, which are free radical scavengers. Therefore, these results support the interaction of radiofrequency fields of cellular phones with biological systems.

Movvahedi MM, Tavakkoli-Golpayegani A, Mortazavi SA, Haghani M, Razi Z, Shojaie-Fard MB, Zare M, Mina E, Mansourabadi L, Nazari-Jahromi, Safari A, Shokrpour N, Mortazavi SM. Does exposure to GSM 900 MHz mobile phone radiation affect short-term memory of elementary school students? J Pediatr Neurosci. 9(2):121-124, 2014.

BACKGROUND: Now-a-days, children are exposed to mobile phone radiation at a very early age. We have previously shown that a large proportion of children in the city of Shiraz, Iran use mobile phones. Furthermore, we have indicated that the visual reaction time (VRT) of university students was significantly affected by a 10 min real/sham exposure to electromagnetic fields emitted by mobile phone. We found that these exposures decreased the reaction time which might lead to a better response to different hazards. We have also revealed that occupational exposures to radar radiations decreased the reaction time in radar workers. The purpose of this study was to investigate whether short-term exposure of elementary school students to radiofrequency (RF) radiation leads to changes in their reaction time and short-term memory. MATERIALS AND METHODS: A total of 60 elementary school children ages ranging from 8 to 10 years studying at a public elementary school in Shiraz, Iran were enrolled in this study. Standardized computer-based tests of VRT and short-term memory (modified for children) were administered. The students were asked to perform some preliminary tests for orientation with the VRT test. After orientation, to reduce the random variation of measurements, each test was repeated ten times in both real and sham exposure phases. The time interval between the two subsequent sham and real exposure phases was 30 min. RESULTS: The mean ± standard deviation reaction times after a 10 min talk period and after a 10 min sham exposure (switched off mobile) period were 249.0 ± 82.3 ms and 252.9 ± 68.2 ms (P = 0.629), respectively. On the other hand, the mean short-term memory scores after the talk and sham exposure periods were 1062.60 ± 305.39, and 1003.84 ± 339.68 (P = 0.030), respectively. Conclusion: To the best of our knowledge, this is the first study to show that short-term exposure of elementary school students to RF radiation leads to the better performance of their short-term memory.

Mugunthan N, Anbalagan J, Meenachi S, Samy AS. EXPOSURE OF MICE TO 900 - 1900 MHZ RADIATIONS FROM CELL PHONE RESULTING IN MICROSCOPIC CHANGES IN THE KIDNEY. IJCRR. 6(16): 44-49, 2014

Objective: The study was to evaluate possible effects of chronic exposure to 900 - 1900 MHz radiations emitted from 2G cell phone on kidney of mice at the histological level. Methods: Mice were exposed to 2G ultra-high frequency radiation, 48 minutes per day for a period of 30 to 180 days. The amount of electromagnetic field (EMF) exposed was measured by radiation frequency meter. The sham control mice were subject to similar conditions without 2G exposure. Six animals each were sacrificed at the end of 30, 60, 90,120,150 and 180 days of exposure in the experimental group after 24 hours of last exposure. Same numbers of control animals were sacrificed on similar period. Both kidneys were harvested and processed for histomorphometric study. Kidneys size, weight and volume were measured and analysed. Kidney sections were analysed under the light microscope and structural changes were studied. Results: In 2G exposed group the kidney weight and volume was significantly reduced in the first month. Kidney weight alone was significantly increased in the fifth month. Glomerulus showed dilated capillaries and increased urinary space. Proximal convoluted tubule showed wider lumen with reduced cell size. Brush border interrupted at places and vacuolated cytoplasm and pyknotic nuclei. Wider lumen with decreased cell size and marked basal striations were found in the distal convoluted tubule. Conclusion: Chronic exposure to ultra-high frequency radiation from 2G cell phone could cause microscopic changes in glomerulus, proximal and distal convoluted tubules of the kidney.

Mugunthan N, Anbalagan J, Samy AS, Rajanarayanan S, Meenachi S. EFFECTS OF CHRONIC EXPOSURE TO 2G AND 3G CELL PHONE RADIATION ON MICE TESTIS – A RANDOMIZED CONTROLLED TRIAL. IJCRR. 7(4): 36-47, 2015.

Objective: The aim of our study is to evaluate possible effects of chronic exposure to 900 - 1800 MHz radiation emitted from 2G cell phone and 1900 -2200 MHz from 3G cell phone on the testis of mice and to compare the effects of 2G and 3G radiation on testis at the histological level. Methods: Mice were exposed to 2G and 3G ultra-high frequency radiation, 48 minutes per day for a period of 30 to 180 days. The sham control mice were exposed to similar conditions without 2G or 3G exposure. Animal's weight of 2G and 3G cell phone exposed group were recorded before sacrificing at the end of 30, 60, 90,120,150 and 180 days. Same numbers of control animals were sacrificed on the same period. Blood samples were collected to measure plasma testosterone. Both the testes were dissected and its size, weight and volume were measured. The testes were processed for histomorphometric study. Results: Following chronic exposure of 2G and 3G cell phone radiation in mice, there was significant reduction of animal weight at first, second and fourth month. The mean testis weight and volume of 2G and 3G radiation exposed mice were significantly reduced in the first three months. The comparison between 2G and 3G exposed groups, showed no significant changes in mean body weight, mean testis weight and mean testis volume. The mean density of seminiferous tubule, mean seminiferous tubule diameter, mean number of Sertoli and Leydig cells of 2G and 3G exposed groups had significantly lower value than the control. The following

microscopic changes were observed in the 2G and 3G radiation exposed mice testis over control. 1. Wide interstitium 2. Detachment of Sertoli cells and spermatogonia from the basal lamina. 3. Vacuolar degeneration and desquamation of seminiferous epithelium. 4. Peripheral tubules showed reduced thickness of seminiferous epithelium and maturation arrest in the spermatogenesis. 5. Seminiferous tubules scored 7 to 9 using Johnson testicular biopsy score count. The mean total serum testosterone level of first, second, third, fourth and sixth month 2G and 3G exposed mice had significantly lower serum testosterone level than control. However, comparison between 2G and 3G showed no significant difference in the mean serum testosterone level. Conclusion: Chronic exposure to ultra-high frequency radiation emitted from 2G and 3G cell phone could cause microscopic changes in the seminiferous epithelium, reduction of serum testosterone level, reduction in the number of Sertoli cells and Leydig cells.

Mugunthan N, Shanmugasamy K, Anbalagan J, Rajanarayanan S, Meenachi S. Effects of Long Term Exposure of 900-1800 MHz Radiation Emitted from 2G Mobile Phone on Mice Hippocampus- A Histomorphometric Study. J Clin Diagn Res. 2016 Aug;10(8):AF01-6.

INTRODUCTION: The advancement in the telecommunications technology with multi-functional added features in mobile phone, attracts more users of all age group. It is alarming to note that, the mobile phone use has increased amongst children and they are exposed to potentially harmful radiofrequency radiation in their lifetime. AIM: To investigate the long term exposure of 900 to 1800 MHz radiations emitted from 2G mobile phone in mice hippocampus at histomorphometric level. MATERIALS AND METHODS: With due approval from institutional animal ethics committee, 36 mice were exposed to 2G mobile phone radiation, 48 minutes per day for a period of 30-180 days. The control group was kept under similar conditions without 2G exposure. Mice were sacrificed and the brain was removed from the first month to six months period. Brain was removed from the cranial cavity and hippocampus region was dissected out carefully and processed for routine histological study. Random serial sections were analysed under microscope for histomorphometric changes. For statistical analysis, independent t-test was used for comparing control and 2G exposed groups.RESULTS: The mean density of neurons in the hippocampus regions CA1, CA2 and DGDB from first to sixth month was significantly lower in the 2G exposed groups; however, in CA3 and DGVB, the 2G exposed mice showed significantly higher density of neurons. The mean nuclear diameter of neurons in the hippocampus region of CA1, CA2, CA3, DGDB and DGVB from first to sixth months showed lower nuclear diameter in 2G exposed mice. CONCLUSION: The long term exposure to 900-1800 MHz frequency radiations emitted from 2G mobile phone could cause significantly reduced neuron density and decreased nuclear diameter in the hippocampus neurons of mice.

Munoz S, Sebastian JL, Sancho M, Miranda JM. Transmembrane voltage induced on altered erythrocyte shapes exposed to RF fields. Bioelectromagnetics. 25(8):631-633, 2004.

In this article, the transmembrane voltage induced on erythrocyte, codocyte, ovalocyte and spherocyte cell models exposed to a linearly polarised electromagnetic plane wave of

frequency 1800 MHz is calculated. For this purpose, a finite element (FE) numerical technique with adaptive meshing is used. The results show that the value of the induced voltage on the original erythrocyte shape is higher than the one observed on the rest of the altered cell geometries studied. The erythrocyte shape and the membrane electric permittivity are shown to play a fundamental role on the values of the induced transmembrane voltage.

Murbach, M., Neufeld, E., Christopoulou, M., Achermann, P. and Kuster, N. (2014), Modeling of EEG electrode artifacts and thermal ripples in human radiofrequency exposure studies. Bioelectromagnetics. doi: 10.1002/bem.21837.

The effects of radiofrequency (RF) exposure on wake and sleep electroencephalogram (EEG) have been in focus since mobile phone usage became pervasive. It has been hypothesized that effects may be explained by (1) enhanced induced fields due to RF coupling with the electrode assembly, (2) the subsequent temperature increase around the electrodes, or (3) RF induced thermal pulsing caused by localized exposure in the head. We evaluated these three hypotheses by means of both numerical and experimental assessments made with appropriate phantoms and anatomical human models. Typical and worst-case electrode placements were examined at 900 and 2140 MHz. Our results indicate that hypothesis 1 can be rejected, as the induced fields cause <20% increase in the 10 g-averaged specific absorption rate (SAR). Simulations with an anatomical model indicate that hypothesis 2 is also not supported, as the realistic worst-case electrode placement results in a maximum skin temperature increase of 0.31 °C while brain temperature elevations remained <0.1 °C. These local short-term temperature elevations are unlikely to change brain physiology during the time period from minutes to several hours after exposure. The maximum observed temperature ripple due to RF pulses is <0.001 °C for GSM-like signals and <0.004 °C for 20-fold higher pulse energy, and offers no support for hypothesis 3. Thus, the mechanism of interaction between RF and changes in the EEG power spectrum remains unknown.

Musaev AV, Ismailova LF, Gadzhiev AM. [Influence of (460 MHz) electromagnetic fields on the induced lipid peroxidation in the structures of visual analyzer and hypothalamus in experimental animals] Vopr Kurortol Fizioter Lech Fiz Kult. (5):17-20, 2005. [Article in Russian]

Changes in the intensity of ascorbate- and NADPN2-dependent induced lipid peroxidation (LPO) were studied in exposure of the visual analyzer and hypothalamus of 3- and 12-month-old rats to radiation with microwaves of high and low intensity. The exposure to microwaves of high intensity stimulated basal LPO but suppressed activity of LPO-inducing systems. This suggests disturbances in the activity of different sources of active oxygen forms. Microwaves of low intensity activated systems of induced LPO. This is accompanied with synchronous activity of the antioxidant defense system maintaining a normal oxidation-reduction balance of the cell. The conclusion is that, depending on their intensity, microwaves can be either beneficial to health or be a factor of oxidative stress.

Muscat JE, Malkin MG, Thompson S, Shore RE, Stellman SD, McRee D, Neugut AI, Wynder EL, Handheld cellular telephone use and risk of brain cancer. JAMA

284(23):3001-3007, 2000.

CONTEXT: A relative paucity of data exist on the possible health effects of using cellular telephones. OBJECTIVE: To test the hypothesis that using handheld cellular telephones is related to the risk of primary brain cancer. DESIGN AND SETTING: Case-control study conducted in 5 US academic medical centers between 1994 and 1998 using a structured questionnaire. PATIENTS: A total of 469 men and women aged 18 to 80 years with primary brain cancer and 422 matched controls without brain cancer. MAIN OUTCOME MEASURE: Risk of brain cancer compared by use of handheld cellular telephones, in hours per month and years of use. RESULTS: The median monthly hours of use were 2.5 for cases and 2.2 for controls. Compared with patients who never used handheld cellular telephones, the multivariate odds ratio (OR) associated with regular past or current use was 0.85 (95% confidence interval [CI], 0.6-1.2). The OR for infrequent users (<0. 72 h/mo) was 1.0 (95% CI, 0.5-2.0) and for frequent users (>10.1 h/mo) was 0.7 (95% CI, 0.3-1.4). The mean duration of use was 2.8 years for cases and 2.7 years for controls; no association with brain cancer was observed according to duration of use (P =.54). In cases, cerebral tumors occurred more frequently on the same side of the head where cellular telephones had been used (26 vs 15 cases; P =.06), but in the cases with temporal lobe cancer a greater proportion of tumors occurred in the contralateral than ipsilateral side (9 vs 5 cases; P =.33). The OR was less than 1.0 for all histologic categories of brain cancer except for uncommon neuroepitheliomatous cancers (OR, 2.1; 95% CI, 0.9-4.7). CONCLUSIONS: Our data suggest that use of handheld cellular telephones is not associated with risk of brain cancer, but further studies are needed to account for longer induction periods, especially for slow-growing tumors with neuronal features.

Muscat JE, Malkin MG, Shore RE,. Thompson S, Neugut AL, Stellman SD, Bruce J. Handheld cellular telephones and risk of acoustic neuroma. Neurology 58:1304-1306, 2002.

The hypothesis that intracranial energy deposition from handheldcellular telephones causes acoustic neuroma was tested in anepidemiologic study of 90 patients and 86 control subjects.The relative risk was 0.9 (p = 0.07) and did not vary significantlyby the frequency, duration, and lifetime hours of use. In patientswho used cellular telephones, the tumor occurred more oftenon the contralateral than ipsilateral side of the head. Furtherefforts should focus on potentially longer induction periods.

Muscat JE, Hinsvark M, Malkin M. Mobile telephones and rates of brain cancer. Neuroepidemiology.27(1):55-56, 2006.

The risk of most primary brain cancers including gliomas and acoustic neuromas is unrelated to the use of mobile telephones in several studies. The long-term effects of mobile phones remain to be determined. An increased risk caused by short-term mobile phone use was reported for neuroepithelial tumors, a rare histologic subgroup of brain cancers that are characterized by neuronal features.We analyzed time trends in the age-adjusted incidence rate of adult neuronal cancers in the Surveillance, Epidemiology and End Results program from 1973 to 2002. The rates did not change during this period, despite the exponential increase in mobile phone subscriptions starting in 1984. These results indicate that mobile phone use is unrelated to the risk of neuronal cancers.

Myung SK, Ju W, McDonnell DD, Lee YJ, Kazinets G, Cheng CT, Moskowitz JM. Mobile Phone Use and Risk of Tumors: A Meta-Analysis. J Clin Oncol. 27:5565-5572, 2009.

PURPOSE: Case-control studies have reported inconsistent findings regarding the association between mobile phone use and tumor risk. We investigated these associations using a meta-analysis. METHODS: We searched MEDLINE (PubMed), EMBASE, and the Cochrane Library in August 2008. Two evaluators independently reviewed and selected articles based on predetermined selection criteria. RESULTS: Of 465 articles meeting our initial criteria, 23 case-control studies, which involved 37,916 participants (12,344 patient cases and 25,572 controls), were included in the final analyses. Compared with never or rarely having used a mobile phone, the odds ratio for overall use was 0.98 for malignant and benign tumors (95% CI, 0.89 to 1.07) in a random-effects meta-analysis of all 23 studies. However, a significant positive association (harmful effect) was observed in a random-effects meta-analysis of eight studies using blinding, whereas a significant negative association (protective effect) was observed in a fixed-effects meta-analysis of 15 studies not using blinding. Mobile phone use of 10 years or longer was associated with a risk of tumors in 13 studies reporting this association (odds ratio = 1.18; 95% CI, 1.04 to 1.34). Further, these findings were also observed in the subgroup analyses by methodologic quality of study. Blinding and methodologic quality of study were strongly associated with the research group. CONCLUSION: The current study found that there is possible evidence linking mobile phone use to an increased risk of tumors from a meta-analysis of low-biased case-control studies. Prospective cohort studies providing a higher level of evidence are needed.

Naegeli B, Osswald S, Deola M, Burkart F, Intermittent pacemaker dysfunction caused by digital mobile telephones. J Am Coll Cardiol 27(6):1471-1477, 1996.

OBJECTIVES: This study was designed to evaluate possible interactions between digital mobile telephones and implanted pacemakers. BACKGROUND: Electromagnetic fields may interfere with normal pacemaker function. Development of bipolar sensing leads and modern noise filtering techniques have lessened this problem. However, it remains unclear whether these features also protect from high frequency noise arising from digital cellular phones. METHODS: In 39 patients with an implanted pacemaker (14 dual-chamber [DDD], 8 atrial-synchronized ventricular-inhibited [VDD(R)] and 17 ventricular-inhibited [VVI(R)] pacemakers), four mobile phones with different levels of power output (2 and 8 W) were tested in the standby, dialing and operating mode. During continuous electrocardiographic monitoring, 672 tests were performed in each mode with the phones positioned over the pulse generator, the atrial and the ventricular electrode tip. The tests were carried out at different sensitivity settings and, where possible, in the unipolar and bipolar pacing modes as well. RESULTS: In 7 (18%) of 39 patients, a reproducible interference was induced during 26 (3.9%) of 672 tests with the operating phones in close proximity (<10 cm) to the pacemaker. In 22 dual-chamber (14 DDD, 8 VDD) pacemakers, atrial triggering occurred in 7 (2.8%) of 248 and ventricular inhibition in 5 (2.8%) of 176 tests. In 17 VVI(R) systems, pacemaker inhibition was induced in 14 (5.6%) of 248 tests. Interference was more likely to occur at higher power output of the phone and at maximal sensitivity of the pacemakers (maximal vs. nominal sensitivity, 6% vs. 1.8% positive test results, p = 0.009). When the bipolar and unipolar pacing modes were compared in the

same patients, ventricular inhibition was induced only in the unipolar mode (12.5% positive test results, p = 0.0003). CONCLUSION: Digital mobile phones in close proximity to implanted pacemakers may cause intermittent pacemaker dysfunction with inappropriate ventricular tracking and potentially dangerous pacemaker inhibition.

Nagaoka T, Watanabe S, Sakurai K, Kunieda E, Watanabe S, Taki M, Yamanaka Y. Development of realistic high-resolution whole-body voxel models of Japanese adult males and females of average height and weight, and application of models to radio-frequency electromagnetic-field dosimetry.Phys Med Biol. 49(1):1-15, 2004.

With advances in computer performance, the use of high-resolution voxel models of the entire human body has become more frequent in numerical dosimetries of electromagnetic waves. Using magnetic resonance imaging, we have developed realistic high-resolution whole-body voxel models for Japanese adult males and females of average height and weight. The developed models consist of cubic voxels of 2 mm on each side; the models are segmented into 51 anatomic regions. The adult female model is the first of its kind in the world and both are the first Asian voxel models (representing average Japanese) that enable numerical evaluation of electromagnetic dosimetry at high frequencies of up to 3 GHz. In this paper, we will also describe the basic SAR characteristics of the developed models for the VHF/UHF bands, calculated using the finite-difference time-domain method.

Nagaoka T, Togashi T, Saito K, Takahashi M, Ito K, Ueda T, Osada H, Ito H, Watanabe S. An anatomically realistic voxel model of the pregnant woman and numerical dosimetry for a whole-body exposure to RF electromagnetic fields.Conf Proc IEEE Eng Med Biol Soc. 1:5463-5467, 2006.

The numerical dosimetry of pregnant women is one of the most important issues in electromagnetic-field safety. We have recently developed a whole-body numerical female model of an adult Japanese (non-pregnant) average figure. Therefore, a new fetus model including inherent tissues of pregnant women was constructed based on abdominal MRI data of a 7-month pregnant woman. A whole-body pregnant woman model was developed by combining the new fetus and the female models. The anatomical details of the developed pregnant woman model and basic SAR characteristics for whole-body exposure to RF electromagnetic fields are demonstrated.

Nagaoka T, Watanabe S. Estimation of variability of specific absorption rate with physical description of children exposed to electromagnetic field in the VHF band.Conf Proc IEEE Eng Med Biol Soc. 2009:942-945, 2009.

Recently, there has been an increasing concern regarding the effects of electromagnetic waves on the health of humans. The safety of radio frequency electromagnetic fields (RF-EMFs) is evaluated by the specific absorption rate (SAR). In recent years, SAR has been estimated by numerical simulation using fine-resolution and anatomically realistic reference whole-body voxel models of people of various ages. The variation in SAR with a change in the physical features of a real person is hardly studied, although every person has different physical features. In this study, in order to estimate the individual

variability in SAR of persons, we obtained considerable 3D body shape data from actual three-year-old children and developed several homogeneous models of these children. The variability in SAR of the homogeneous models of three-year-old children for whole-body exposure to RF electromagnetic fields in the very high frequency (VHF) band calculated using the finite-difference time-domain method has been described.

Nagaoka T, Saito K, Takahashi M, Ito K, Watanabe S. Anatomically realistic reference models of pregnant women for gestation ages of 13, 18, and 26 weeks.Conf Proc IEEE Eng Med Biol Soc. 2008:2817-2820, 2008.

The safety of a human body exposed to radio-frequency (RF) electromagnetic fields (EMFs) has become important today. In recent times, conducting numerical dosimetry on the mother and the fetus during pregnancy has become a particularly important issue. This paper outlines the development of pregnant woman models that were adjusted to the reference values of physiological characteristics of maternal tissues in pregnant women for gestation ages of 13, 18, and 26 weeks The models are composed of voxels of 2 x 2 x 2 mm(3), and there are 56 tissue types. The basic specific absorption rate (SAR) characteristics in the pregnant woman models for whole-body exposure to RF electromagnetic fields that were calculated using the finite-difference time-domain (FDTD) method are described here.

Nagaoka T, Kunieda E, Watanabe S. Proportion-corrected scaled voxel models for Japanese children and their application to the numerical dosimetry of specific absorption rate for frequencies from 30 MHz to 3 GHz.Phys Med Biol. 53(23):6695-6711, 2008.

The development of high-resolution anatomical voxel models of children is difficult given, inter alia, the ethical limitations on subjecting children to medical imaging. We instead used an existing voxel model of a Japanese adult and three-dimensional deformation to develop three voxel models that match the average body proportions of Japanese children at 3, 5 and 7 years old. The adult model was deformed to match the proportions of a child by using the measured dimensions of various body parts of children at 3, 5 and 7 years old and a free-form deformation technique. The three developed models represent average-size Japanese children of the respective ages. They consist of cubic voxels (2 mm on each side) and are segmented into 51 tissues and organs. We calculated the whole-body-averaged specific absorption rates (WBA-SARs) and tissue-averaged SARs for the child models for exposures to plane waves from 30 MHz to 3 GHz; these results were then compared with those for scaled down adult models. We also determined the incident electric-field strength required to produce the exposure equivalent to the ICNIRP basic restriction for general public exposure, i.e., a WBA-SAR of 0.08 W kg(-1).

Nageswari KS, Sarma KR, Rajvanshi VS, Sharan R, Sharma M, Barathwal V, Singh V, Effect of chronic microwave radiation on T cell-mediated immunity in the rabbit. Int J Biometeorol 35(2):92-97, 1991.

Experiments were conducted to elucidate the effects of chronic low power-level

microwave radiation on the immunological systems of rabbits. Fourteen male Belgian white rabbits were exposed to microwave radiation at 5 mW/cm2, 2.1 GHz, 3 h daily, 6 days/week for 3 months in two batches of 7 each in specially designed miniature anechoic chambers. Seven rabbits were subjected to sham exposure for identical duration. The microwave energy was provided through S band standard gain horns connected to a 4K3SJ2 Klystron power amplifier. The first batch of animals were assessed for T lymphocyte-mediated cellular immune response mechanisms and the second batch of animals for B lymphocyte-mediated humoral immune response mechanisms. The peripheral blood samples collected monthly during microwave/sham exposure and during follow-up (5/14 days after termination of exposures, in the second batch animals only) were analysed for T lymphocyte numbers and their mitogen responsiveness to ConA and PHA. Significant suppression of T lymphocyte numbers was noted in the microwave group at 2 months (P less than 0.01, delta % 21.5%) and during follow-up (P less than 0.01, delta % 30.2%). The first batch animals were initially sensitised with BCG and challenged with tuberculin (0.03 ml) at the termination of microwave irradiation/sham exposure and the increase in foot pad thickness (delta mm), which is a measure of T cell-mediated immunity (delayed type hypersensitivity response, DTH) was noted in both the groups. The microwave group revealed a better response than the control group (delta % +12.4 vs. +7.54). The animals were sacrificed and the tissue T lymphocyte counts (spleen and lymph node) were analysed.

Nakamura, H, Seto, T, Nagase, H, Yoshida, M, Dan, S, Ogino, K, Effects of exposure to microwaves on cellular immunity and placental steroids in pregnant rats. Occup Environ Med 54(9):676-680, 1997.

OBJECTIVES: Microwaves produce various detrimental changes based on actions of heat or non-specific stress, although the effects of microwaves on pregnant organisms has not been uniform. This study was designed to clarify the effect of exposure to microwaves during pregnancy on endocrine and immune functions. METHODS: Natural killer cell activity and natural killer cell subsets in the spleen were measured, as well as some endocrine indicators in blood--corticosterone and adrenocorticotrophic hormone (ACTH) as indices of the hypothalamic-pituitary-adrenal axis--beta-endorphin, oestradiol, and progesterone in six female virgin rats and six pregnant rats (nine to 11 days gestation) exposed to microwaves at 10 mW/cm2 incident power density at 2450 MHz for 90 minutes. The same measurements were performed in control rats (six virgin and six pregnant rats). RESULTS: Skin temperature in virgin and pregnant rats increased immediately after exposure to microwaves. Although splenic activity of natural killer cells and any of the subset populations identified by the monoclonal antibodies CD16 and CD57 did not differ in virgin rats with or without exposure to microwaves, pregnant rats exposed to microwaves showed a significant reduction of splenic activity of natural killer cells and CD16+CD57-. Although corticosterone and ACTH increased, and oestradiol decreased in exposed virgin and pregnant rats, microwaves produced significant increases in beta-endorphin and progesterone only in pregnant rats. CONCLUSIONS: Microwaves at the power of 10 mW/cm2 produced activation of the hypothalamic-pituitary-adrenal axis and increased oestradiol in both virgin and pregnant rats, suggesting that microwaves greatly stress pregnant organisms. These findings in pregnant rats suggest that--with exposure to microwaves--pregnancy induces

immunosuppression, which could result in successful maintainance of pregnancy. This enhancement of adaptability to heat stress with pregnancy may be mediated by activation of placental progesterone and placental or pituitary beta-endorphin.

Nakamura, H, Seto, T, Hatta, K, Matsuzaki, I, Nagase, H, Yoshida, M, Ogino, K, Natural killer cell activity reduced by microwave exposure during pregnancy is mediated by opioid systems. Environ Res 79(2):106-113, 1998.

We have previously demonstrated immunosuppression including reduced splenic natural killer cell activity (NKCA) in pregnant rats exposed to microwaves produced mainly by their thermal action. To examine the involvement of opioid systems in reduced NKCA in pregnant rats exposed to microwaves at a relatively low level (2 mW/cm2 incident power density at 2450 MHz for 90 min), we assayed beta-endorphin (betaEP) in blood, pituitary lobes, and placenta as well as splenic NKCA in virgin and/or pregnant rats. Although microwaves elevated colonic temperatures by 0.8 degreesC for virgin and 0.9 degreesC for pregnant rats, and betaEP in blood and anterior pituitary lobes (AP) significantly, it did not change blood corticosterone as an index of hypothalamic-pituitary adrenal axis. There were significant interactions between pregnancy and microwave exposure on splenic NKCA, betaEP in both blood and AP, and blood progesterone. Intra-peritoneal administration of opioid receptor antagonist naloxone prior to microwave exposure increased NKCA, blood, and placental betaEP in pregnant rats. Alterations in splenic NKCA, betaEP and progesterone in pregnant rats exposed to microwaves may be due to both thermal and nonthermal actions. These results suggest that NKCA reduced by microwaves during pregnancy is mediated by the pituitary opioid system.

Nakamura H, Nagase H, Ogino K, Hatta K, Matsuzaki I, Uteroplacental circulatory disturbance mediated by prostaglandin F(2alpha) in rats exposed to microwaves. Reprod Toxicol 14(3):235-240, 2000.

To clarify the effects of microwaves on pregnancy, uterine or uteroplacental blood flow and endocrine and biochemical mediators, including corticosterone, estradiol, prostaglandin E(2) (PGE(2)), and prostaglandin F(2)alpha (PGF(2)alpha), were measured in rats exposed to continuous-wave (CW) microwave at 2 mW/cm(2) incident power density at 2450 MHz for 90 min. Colonic temperature in virgin and pregnant rats was not significantly altered by microwave treatment. Microwaves decreased uteroplacental blood flow and increased progesterone and PGF(2)alpha in pregnant, but not in virgin rats. Intraperitoneal (i.p.) administration of angiotensin II, a uteroplacental vasodilator, before microwave exposure prevented the reduction in uteroplacental blood flow and the increased progesterone and PGF(2)alpha in pregnant rats. Increased corticosterone and decreased estradiol during microwave exposure were observed independent of pregnancy and pretreatment with angiotensin II. These results suggest that microwaves (CW, 2 mW/cm(2), 2450 MHz) produce uteroplacental circulatory disturbances and ovarian and placental dysfunction during pregnancy, probably through nonthermal actions. The uteroplacental disturbances appear to be due to actions of PGF(2)alpha and may pose some risk for pregnancy.

Nakamura H, Matsuzaki I, Hatta K, Nobukuni Y, Kambayashi Y, Ogino K. Nonthermal effects of mobile-phone frequency microwaves on uteroplacental functions in pregnant rats. Reprod Toxicol 2003 17(3):321-326, 2003.

Exposure to high-density microwaves can cause detrimental effects on the testis, eye, and other tissues, and induce significant biologic changes through thermal actions. To examine nonthermal effect of continuous wave (CW) 915MHz microwaves used in cellular phones, we compared the effects of microwaves with those of heat. Thirty-six pregnant rats were assigned to six groups: rats exposed to microwaves at 0.6 or 3mW/cm(2) incident power density at 915MHz for 90min, rats immersed in water at 38 or 40 degrees C, which induces about the same increase in colonic temperature of 1.0 or 3.5 degrees C as 0.6 or 3mW/cm(2) microwaves, respectively; rats immersed in water at 34 degrees C, which is considered to be thermoneutral; and control rats. We identified significant differences in the uteroplacental circulation, and in placental endocrine and immune functions between pregnant rats immersed in water at 34 and 38 degrees C, but not between rats immersed at 38 degrees C and those exposed to microwaves at 0.6mW/cm(2). By contrast, we observed significant decreases in uteroplacental blood flow and estradiol in rats exposed to microwaves at 3mW/cm(2) as compared with those immersed in water at 40 degrees C. These results suggest microwaves at 0.6mW/cm(2) at 915MHz, equal to a specific absorption rate (SAR) of 0.4W/kg, which is the maximum permissible exposure level recommended by the American National Standards Institute (ANSI), do not exert nonthermal effects on blood estradiol and progesterone, on splenic natural killer cell activity, on the uteroplacental circulation.

Nakatani-Enomoto S, Furubayashi T, Ushiyama A, Groiss SJ, Ueshima K, Sokejima S, Simba AY, Wake K, Watanabe SI, Nishikawa M, Miyawaki K, Taki M, Ugawa Y. Effects of electromagnetic fields emitted from W-CDMA-like mobile phones on sleep in humans. Bioelectromagnetics. 2013 Aug 22. doi: 10.1002/bem.21809. [Epub ahead of print]

In this study, we investigated subjective and objective effects of mobile phones using a Wideband Code Division Multiple Access (W-CDMA)-like system on human sleep. Subjects were 19 volunteers. Real or sham electromagnetic field (EMF) exposures for 3 h were performed before their usual sleep time on 3 consecutive days. They were exposed to real EMF on the second or third experimental day in a double-blind design. Sleepiness and sleep insufficiency were evaluated the next morning. Polysomnograms were recorded for analyses of the sleep variables and power spectra of electroencephalograms (EEG). No significant differences were observed between the two conditions in subjective feelings. Sleep parameters including sleep stage percentages and EEG power spectra did not differ significantly between real and sham exposures. We conclude that continuous wave EMF exposure for 3 h from a W-CDMA-like system has no detectable effects on human sleep.

Nakatani-Enomoto S, Okutsu M, Suzuki S, Suganuma R, Groiss SJ, Kadowaki S, Enomoto H, Fujimori K, Ugawa Y. Effects of 1950 MHz W-CDMA-like signal on human spermatozoa. Bioelectromagnetics. 2016 Jun 11. doi: 10.1002/bem.21985. [Epub ahead of print]

There are growing concerns about how electromagnetic waves (EMW) emitted from mobile phones affect human spermatozoa. Several experiments have suggested harmful effects of EMW on human sperm quality, motility, velocity, or the deoxyribonucleic acid

(DNA) of spermatozoa. In this study, we analyzed the effects on human spermatozoa (sperm motility and kinetic variables) induced by 1 h of exposure to 1950 MHz Wideband Code Division Multiple Access (W-CDMA)-like EMW with specific absorption rates of either 2.0 or 6.0 W/kg, using a computer-assisted sperm analyzer system. We also measured the percentage of 8-hydroxy-2'-deoxyguanosine (8-OHdG) positive spermatozoa with flow cytometry to evaluate damage to DNA. No significant differences were observed between the EMW exposure and the sham exposure in sperm motility, kinetic variables, or 8-OHdG levels. We conclude that W-CDMA-like exposure for 1 h under temperature-controlled conditions has no detectable effect on normal human spermatozoa. Differences in exposure conditions, humidity, temperature control, baseline sperm characteristics, and age of donors may explain inconsistency of our results with several previous studies.

Nam KC, Kim SW, Kim SC, Kim DW. Effects of RF exposure of teenagers and adults by CDMA cellular phones. Bioelectromagnetics. 27(7):509-514, 2006.

Many cellular phone provocation studies have been conducted since the question of increased health risk from extended usage of cellular phones became a social issue. Internationally, most studies have been conducted regarding the effects of GSM cellular phones on blood pressure and heart rate of adult volunteers. On the other hand, very few provocation studies have been conducted regarding the physiological effects of CDMA phones on teenagers. In this study, two volunteer groups consisting of 21 teenagers and 21 adults were exposed to 300 mW of radio frequency (RF) electromagnetic field emitted by a CDMA cellular phone for half an hour. Physiological parameters such as systolic and diastolic blood pressures, heart rate, respiration rate, and skin resistance were simultaneously measured. All the parameters for both groups were unaffected during the exposure except for decreased skin resistance of the teenager group ($P < .0001$). For the regrouped 23 male and 19 female subjects, all the parameters for both groups were unaffected during the exposure except for decreased skin resistance of the male subjects ($P = .0026$). Those resistances at 10 min after the terminated exposure returned to the resistances at rest regardless of the different groups of age and sex.

Nam KC, Lee JH, Noh HW, Cha EJ, Kim NH, Kim DW. Hypersensitivity to RF fields emitted from CDMA cellular phones: a provocation study. Bioelectromagnetics. 30(8):641-650, 2009.

With the number of cellular phone users rapidly increasing, there is a considerable amount of public concern regarding the effects that electromagnetic fields (EMFs) from cellular phones have on health. People with self-attributed electromagnetic hypersensitivity (EHS) complain of subjective symptoms such as headaches, insomnia, and memory loss, and attribute these symptoms to radio frequency (RF) radiation from cellular phones and/or base stations. However, EHS is difficult to diagnose because it relies on a person's subjective judgment. Various provocation studies have been conducted on EHS caused by Global System for Mobile Communications (GSM) phones in which heart rate and blood pressure or subjective symptoms were investigated. However, there have been few sham-controlled provocation studies on EHS with Code Division Multiple Access (CDMA) phones

where physiological parameters, subjective symptoms, and perception of RF radiation for EHS and non-EHS groups were simultaneously investigated. In this study, two volunteer groups of 18 self-reported EHS and 19 non-EHS persons were tested for both sham and real RF exposure from CDMA cellular phones with a 300 mW maximum exposure that lasted half an hour. We investigated not only the physiological parameters such as heart rate, respiration rate, and heart rate variability (HRV), but also various subjective symptoms and the perception of EMF. In conclusion, RF exposure did not have any effects on physiological parameters or subjective symptoms in either group. As for EMF perception, there was no evidence that the EHS group better perceived EMF than the non-EHS group.

Narasimhan V, Huh WK, Altered restriction patterns of microwave irradiated lambdaphage DNA. Biochem Int 25(2):363-370, 1991.

Samples of lambdaphage DNA exposed to short pulses of microwave irradiation were subjected to restriction fragmentation by Eco RI and Bam HI. Eco RI digests of microwaved DNA samples yielded three additional fragments ranging in base pair lengths between 24,226 and 7,421 besides the six expected fragments. While Bam HI digests of the microwaved samples did not yield any additional fragments, mobilities of the Bam HI fragments from the microwaved DNA samples were slower and the bands were broader in comparison to those from native samples. We attribute these altered restriction patterns to the conformational anomolies in DNA resulting from single strand breaks and localized strand separations induced by microwave irradiation.

Narayanan SN, Kumar RS, Potu BK, Nayak S, Mailankot M. Spatial memory performance of Wistar rats exposed to mobile phone. Clinics. 64(3):231-234, 2009.

INTRODUCTION: With the tremendous increase in number of mobile phone users world wide, the possible risks of this technology have become a serious concern. OBJECTIVE: We tested the effects of mobile phone exposure on spatial memory performance. MATERIALS AND METHODS: Male Wistar rats (10-12 weeks old) were exposed to 50 missed calls/day for 4 weeks from a GSM (900/1800 MHz) mobile phone in vibratory mode (no ring tone). After the experimental period, the animals were tested for spatial memory performance using the Morris water maze test. RESULTS: Both phone exposed and control animals showed a significant decrease in escape time with training. Phone exposed animals had significantly (approximately 3 times) higher mean latency to reach the target quadrant and spent significantly (approximately 2 times) less time in the target quadrant than age- and sex-matched controls. CONCLUSION: Mobile phone exposure affected the acquisition of learned responses in Wistar rats. This in turn points to the poor spatial navigation and the object place configurations of the phone-exposed animals.

Narayanan SN, Kumar RS, Potu BK, Nayak S, Bhat PG, Mailankot M. Effect of radio-frequency electromagnetic radiations (RF-EMR) on passive avoidance behaviour and hippocampal morphology in Wistar rats. Ups J Med Sci.115(2):91-96, 2010.

Abstract Introduction. The interaction of mobile phone radio-frequency electromagnetic radiation (RF-EMR) with the brain is a serious concern of our

society. Objective. We evaluated the effect of RF-EMR from mobile phones on passive avoidance behaviour and hippocampal morphology in rats. Materials and methods. Healthy male albino Wistar rats were exposed to RF-EMR by giving 50 missed calls (within 1 hour) per day for 4 weeks, keeping a GSM (0.9 GHz/1.8 GHz) mobile phone in vibratory mode (no ring tone) in the cage. After the experimental period, passive avoidance behaviour and hippocampal morphology were studied. Results. Passive avoidance behaviour was significantly affected in mobile phone RF-EMR-exposed rats demonstrated as shorter entrance latency to the dark compartment when compared to the control rats. Marked morphological changes were also observed in the CA(3) region of the hippocampus of the mobile phone-exposed rats in comparison to the control rats. Conclusion. Mobile phone RF-EMR exposure significantly altered the passive avoidance behaviour and hippocampal morphology in rats.

Narayanan SN, Kumar RS, Paval J, Kedage V, Bhat MS, Nayak S, Bhat PG. Analysis of emotionality and locomotion in radio-frequency electromagnetic radiation exposed rats.Neurol Sci. 34(7):1117-1124, 2013.

In the current study the modulatory role of mobile phone radio-frequency electromagnetic radiation (RF-EMR) on emotionality and locomotion was evaluated in adolescent rats. Male albino Wistar rats (6-8 weeks old) were randomly assigned into the following groups having 12 animals in each group. Group I (Control): they remained in the home cage throughout the experimental period. Group II (Sham exposed): they were exposed to mobile phone in switch-off mode for 28 days, and Group III (RF-EMR exposed): they were exposed to RF-EMR (900 MHz) from an active GSM (Global system for mobile communications) mobile phone with a peak power density of 146.60 μW/cm(2) for 28 days. On 29th day, the animals were tested for emotionality and locomotion. Elevated plus maze (EPM) test revealed that, percentage of entries into the open arm, percentage of time spent on the open arm and distance travelled on the open arm were significantly reduced in the RF-EMR exposed rats. Rearing frequency and grooming frequency were also decreased in the RF-EMR exposed rats. Defecation boli count during the EPM test was more with the RF-EMR group. No statistically significant difference was found in total distance travelled, total arm entries, percentage of closed arm entries and parallelism index in the RF-EMR exposed rats compared to controls. Results indicate that mobile phone radiation could affect the emotionality of rats without affecting the general locomotion.

Narayanan SN, Kumar RS, Kedage V, Nalini K, Nayak S, Bhat PG. Evaluation of oxidant stress and antioxidant defense in discrete brain regions of rats exposed to 900 MHz radiation. Bratisl Lek Listy. 115(5):260-266, 2014.

AIM: In the current study, the effects of 900 MHz radio-frequency electromagnetic radiation (RF-EMR) on levels of thiobarbituric acid-reactive substances (TBARS), total antioxidants (TA), and glutathione S-transferase (GST) activity in discrete brain regions were studied in adolescent rats. MATERIALS AND METHODS: Thirty-six male Wistar rats (6-8 weeks old) were allotted into three groups (n = 12 in each group). Control group (1) remained undisturbed in their home cage; sham group (2) was exposed to mobile

phone in switch off mode for four weeks; RF-EMR-exposed group (3) was exposed to 900 MHz of RF-EMR (1 hr/day with peak power density of 146.60 µW/cm2) from an activated Global System for Mobile communication (GSM) mobile phone (kept in silent mode; no ring tone and no vibration) for four weeks. On 29th day, behavioral analysis was done. Followed by this, six animals from each group were sacrificed and biochemical parameters were studied in amygdala, hippocampus, frontal cortex, and cerebellum. RESULTS: Altered behavioral performances were found in RF-EMR-exposed rats. Additionally, elevated TBARS level was found with all brain regions studied. RF-EMR exposure significantly decreased TA in the amygdala and cerebellum but its level was not significantly changed in other brain regions. GST activity was significantly decreased in the hippocampus but, its activity was unaltered in other brain regions studied. CONCLUSION: RF-EMR exposure for a month induced oxidative stress in rat brain, but its magnitude was different in different regions studied. RF-EMR-induced oxidative stress could be one of the underlying causes for the behavioral deficits seen in rats after RF-EMR exposure (Fig. 5, Ref. 37).

Narayanan SN, Kumar RS, Karun KM, Nayak SB, Bhat PG. Possible cause for altered spatial cognition of prepubescent rats exposed to chronic radiofrequency electromagnetic radiation. Metab Brain Dis. 2015 Jun 3. [Epub ahead of print]

The effects of chronic and repeated radiofrequency electromagnetic radiation (RFEMR) exposure on spatial cognition and hippocampal architecture were investigated in prepubescent rats. Four weeks old male Wistar rats were exposed to RF-EMR (900 MHz; SAR-1.15 W/kg with peak power density of 146.60 µW/cm^2) for 1 h/day, for 28 days. Followed by this, spatial cognition was evaluated by Morris water maze test. To evaluate the hippocampal morphology; H&E staining, cresyl violet staining, and Golgi-Cox staining were performed on hippocampal sections. CA3 pyramidal neuron morphology and surviving neuron count (in CA3 region) were studied using H&E and cresyl violet stained sections. Dendritic arborization pattern of CA3 pyramidal neuron was investigated by concentric circle method. Progressive learning abilities were found to be decreased in RF-EMR exposed rats. Memory retention test performed 24 h after the last training revealed minor spatial memory deficit in RF-EMR exposed group. However, RF-EMR exposed rats exhibited poor spatial memory retention when tested 48 h after the final trial. Hirano bodies and Granulovacuolar bodies were absent in the CA3 pyramidal neurons of different groups studied. Nevertheless, RF-EMR exposure affected the viable cell count in dorsal hippocampal CA3 region. RF-EMR exposure influenced dendritic arborization pattern of both apical and basal dendritic trees in RF-EMR exposed rats. Structural changes found in the hippocampus of RF-EMR exposed rats could be one of the possible reasons for altered cognition.

Nasri K, Daghfous D, Landoulsi A. Effects of microwave (2.45 GHz) irradiation on some biological characters of Salmonella typhimurium. C R Biol. 2013 Apr;336(4):194-202.

The present study was carried out to evaluate the effects of sub-lethal doses of microwave radiation on some biological characteristics in Salmonella typhimurium. The aim was to show the relationship between this treatment and the development of radiotolerance in this pathogen because there is a need for more information on physiological responses of pathogens to sub-lethal doses of microwave radiation. So, the bacterial strain was treated with a dose of 3600J (40-s exposure with power P=90 W) to cause cellular damage. The results have shown that the exposure of bacteria to microwaves resulted in a significant inhibition of cellular growth. This treatment has notably increased the effectiveness of the most tested antibiotics by the amelioration or the appearance of sensitivity in exposed bacteria. Gas chromatography (GC) analysis was performed to demonstrate the modification of the fatty acids (FA) composition. Results obtained have shown that this treatment had a significant effect on the FA content with an increase of unsaturated FA percentage. The acquisition of sensitivity to the sodium deoxycholate and the significant increase in the amount of extracellular proteins in exposed bacteria has confirmed the weakening of the bacterial membrane by microwaves. This study represents one of the few demonstrating the modifications on the bacterial membrane as a cellular response to survive the non-ionising radiation stress.

Nasseri S, Monazzam M, Beheshti M, Zare S, Mahvi A. The vertical pattern of microwave radiation around BTS (Base Transceiver Station) antennae in Hashtgerd township. J Environ Health Sci Eng. 2013 Dec 20;11(1):40. doi: 10.1186/2052-336X-11-40.

New environmental pollutants interfere with the environment and human life along with technology development. One of these pollutants is electromagnetic field. This study determines the vertical microwave radiation pattern of different types of Base Transceiver Station (BTS) antennae in the Hashtgerd city as the capital of Savojbolagh County, Alborz Province of Iran. The basic data including the geographical location of the BTS antennae in the city, brand, operator type, installation and its height was collected from radio communication office, and then the measurements were carried out according to IEEE STD 95. 1 by the SPECTRAN 4060. The statistical analyses were carried out by SPSS16 using Kolmogorov Smirnov test and multiple regression method. Results indicated that in both operators of Irancell and Hamrah-e-Aval (First Operator), the power density rose with an increase in measurement height or decrease in the vertical distance of broadcaster antenna. With mix model test, a significant statistical relationship was observed between measurement height and the average power density in both types of the operators. With increasing measuring height, power density increased in both operators. The study showed installing antennae in a crowded area needs more care because of higher radiation emission. More rigid surfaces and mobile users are two important factors in crowded area that can increase wave density and hence raise public microwave exposure.

Nasta F, Prisco MG, Pinto R, Lovisolo GA, Marino C, Pioli C. Effects of GSM-modulated radiofrequency electromagnetic fields on B-cell peripheral differentiation and antibody production. Radiat Res. 165(6):664-670, 2006.

We examined the effects of in vivo exposure to a GSM-modulated 900 MHz RF field on B-cell peripheral differentiation and antibody production in mice. Our results show that exposure to a whole-body average specific absorption rate (SAR) of 2 W/kg, 2 h/day for 4 consecutive weeks does not affect the frequencies of differentiating transitional 1 (T1) and T2 B cells or those of mature follicular B and marginal zone B cells in the spleen. IgM and IgG serum levels are also not significantly different among exposed, sham-exposed and control mice. B cells from these mice, challenged in vitro with LPS, produce comparable amounts of IgM and IgG. Moreover, exposure of immunized mice to RF fields does not change the antigen-specific antibody serum level. Interestingly, not only the production of antigen-specific IgM but also that of IgG (which requires T-B-cell interaction) is not affected by RF-field exposure. This indicates that the exposure does not alter an ongoing in vivo antigen-specific immune response. In conclusion, our results do not indicate any effects of GSM-modulated RF radiation on the B-cell peripheral compartment and antibody production and thus provide no support for health-threatening effects.

Natarajan M, Vijayalaxmi , Szilagyi M, Roldan FN, Meltz ML. NF-□B DNA-binding activity after high peak power pulsed microwave (8.2 GHz) exposure of normal human monocytes. Bioelectromagnetics 23:271-277, 2002.

The hypothesis investigated is that exposure of a mammalian cell to high peak power pulsed RF, at the frequency of 8.2 GHz, can result in the activation of an important eukaryotic transcriptional regulator, nuclear factor kappa B (NF-□B). This DNA-binding protein controls genes involved in long term cellular regulation. The selection of 8.2 GHz was based on the availability of a high peak power pulsed RF transmitter. In these studies, triplicate cultures of human monocytes (Mono Mac-6) were exposed to the pulsed wave radiation. The peak to average power ratio was 455:1 (2.2 μs pulse width and pulse repetition rate of 1000 pulses/s). The average power density at the position of exposure was 50 W/m^2, and the mean SAR at the bottom of the culture flask was 10.8 ± 7.1 W/kg. The FDTD analysis indicated that 10% of the cells had an SAR of 22-29 W/kg. The cells were exposed continuously for 90 min at 37 °C, reincubated at this temperature, and harvested 4 h postexposure. The nuclear extracts were analyzed by electrophoretic mobility shift assay. The results showed a profound increase (3.6-fold) in the DNA binding activity of NF-κB in monocytes at 4 h after the pulsed RF exposure compared to sham irradiated controls. Competition experiments with cold NF-κB- specific oligonucleotides confirmed the specificity of the DNA binding activity. These results provide evidence that high peak power pulsed radiofrequency radiation can perturb the cell and initiate cell signaling pathways. However, at this point, we are not prepared to advocate that the cause is a nonthermal mechanism. Because of the broad distribution of SAR's in the flask, experiments need to be performed to determine if the changes observed are associated with cells exposed to high or low SARs.

Natarajan M, Nayak BK, Galindo C, Mathur SP, Roldan FN, Meltz ML. Nuclear translocation and DNA-binding activity of NFKB (NF-kappaB) after exposure of human monocytes to pulsed ultra-wideband electromagnetic fields (1 kV/cm) fails to transactivate kappaB-dependent gene expression. Radiat Res. 165(6):645-654, 2006.

The objective of this study was to investigate whether exposure of human monocytes to a pulsed ultra-wideband electromagnetic field (EMF) of 1 kV/cm average peak power triggers a signaling pathway responsible for the transcriptional regulation of NFKB (NF-kappaB)-dependent gene expression. Human Mono Mac 6 (MM6) cells were exposed intermittently to EMF pulses for a total of 90 min. The pulse width was 0.79+/-0.01 ns and the pulse repetition rate was 250 pps. The temperature of the medium was maintained at 37 degrees C in both sham- and EMF-exposed flasks. Total NFKB DNA-binding activity was measured in the nuclear extracts by the electrophoretic mobility shift assay. Cells exposed to the EMFs and incubated for 24 h postexposure showed a 3.5+/-0.2-fold increase in the NFKB DNA-binding activity. Since activation of NFKB was observed, the possibility of kappaB-dependent gene expression in response to exposure to the EMFs was investigated using NFKB signal-specific gene arrays. The results revealed no difference in the NFKB-dependent gene expression profiles at 8 or 24 h postexposure, indicating that activated NFKB does not lead to the differential expression of kappaB-dependent target genes. To determine whether the absence of the kappaB-dependent gene expression was due to compromised transcriptional regulation of NFKB, the functional activity of NFKB was examined in cells transiently transfected with Mercury Pathway constructs containing 4x NFKB binding sites associated either with the luciferase reporter system or a control vector. Pulsed EMF exposure did not induce NFKB-driven luciferase activity in these cells, indicating that the activation of NFKB at 24 h after the 1 kV/cm EMF exposure is functionally inactive. From these results, it is clear that the EMF-induced NFKB activation is only a transient response, with minimal or no downstream effect.

Navakatikian MA, Tomashevskaya LA, Phasic behavioral and endocrine effects of microwaves of nonthermal intensity. In “Biological Effects of Electric and Magnetic Fields, Volume 1," D.O. Carpenter (ed) Academic Press, San Diego, CA, 1994, pp.333-342.

Microwaves at nonthermal levels are able to induce behavioral and endocrine changes at low power densities (0.01-0.1 mW/cm2). Our studies have demonstrated several phases of inhibition and activation. We suggest that inhibition of behavior by microwaves has many mechanisms depending on the strength and duration of exposure, and most inhibitory effects from direct actions on the nervous system. Activation, on the other hand, is correlated well with decreases in serum concentrations of testosterone and insulin. CW microwaves, however, have no influence on the secretion of insulin.

Navarro EA, Sequra J, Portoles M, Gomez-Perretta de Mateo C. The Microwave Syndrome: A Preliminary Study in Spain. Electromag Biol Med 22:161-169, 2003.

A health survey was carried out in Murcia, Spain, in the vicinity of a Cellular Phone Base Station working in DCS-1800 MHz. This survey contained health items related to “microwave sickness” or “RF syndrome.” The microwave power density was measured at the respondents' homes. Statistical analysis showed significant correlation between the declared severity of the symptoms and the measured power density. The separation of respondents into two different exposure groups also showed an increase of the declared severity in the group with the higher exposure.

Nayyeri V, Hashemi SM, Borna M, Jalilian HR, Soleimani M. ASSESSMENT OF RF RADIATION LEVELS IN THE VICINITY OF 60 GSM MOBILE PHONE BASE STATIONS IN IRAN. Radiat Prot Dosimetry. 155 (2):241-244, 2013.

Increasing development of mobile communication infrastructure while enhancing availability of the technology raises concerns among the public, who see more cell towers erected each day, about possible health effects of electromagnetic radiations. Thereon, a survey of radio-frequency radiation from 60 GSM base stations was carried out in Tehran, Iran at several places mostly located in major medical and educational centres. Measurements were performed at 15 locations near each base station site, i.e. 900 locations in total. Since there are other RF radiation sources such as broadcasting services whose carrier frequencies are <3 GHz, the whole band of 27 MHz to 3 GHz has been assessed for hazardous exposures as well. The results were compared with the relevant guideline of International Commission on Non-Ionising Radiation Protection and that of Iran, confirming radiation exposure levels being satisfactorily below defined limits and non-detrimental.

Naziroğlu M, Gümral N. Modulator effects of L-carnitine and selenium on wireless devices (2.45 GHz)-induced oxidative stress and electroencephalography records in brain of rat. Int J Radiat Biol. 85(8):680-689, 2009.
PURPOSE: Electromagnetic radiation (EMR) from wireless devices may affect biological systems by increasing free radicals. The present study was designed to determine the effects of 2.45 GHz EMR on the brain antioxidant redox system and electroencephalography (EEG) records in rat. The possible protective effects of selenium and L-carnitine were also tested and compared to untreated controls. MATERIALS AND METHODS: Thirty rats were equally divided into five different groups, namely Group A(1): Cage control, Group A(2): Sham control, group B: 2.45 GHz EMR, group C: 2.45 GHz EMR + selenium, group D: 2.45 GHz EMR + L-carnitine. Groups B, C and D were exposed to 2.45 GHz EMR during 60 min/day for 28 days. End of the experiments, EEG records and the brain cortex samples were taken. RESULTS: The cortex brain vitamin A ($p < 0.05$), vitamin C ($p < 0.01$) and vitamin E ($p < 0.05$) concentrations values were lower in group B than in group A1 and A2 although their concentrations were increased by selenium and L-carnitine supplementation. Lipid peroxidation, levels were lower in group C ($p < 0.05$) and D ($p < 0.01$) than in group B where as reduced glutathione levels were higher in group C ($p < 0.05$) than in group A1, A2 and B. However, B-carotene levels did not change in the five groups. CONCLUSIONS: L-carnitine and selenium seem to have protective effects on the 2.45 GHz-induced decrease of the vitamins by supporting antioxidant redox system. L-carnitine on the vitamin concentrations seems to more protective affect than in selenium.

Nazıroğlu M, Ciğ B, Doğan S, Uğuz AC, Dilek S, Faouzi D. 2.45-Gz wireless devices induce oxidative stress and proliferation through cytosolic Ca^{2+} influx in human leukemia cancer cells. Int J Radiat Biol. 88(6):449-456, 2012.

PURPOSE: Electromagnetic radiation from wireless devices may affect biological systems by increasing free radicals. The present study was designed to determine the

effects of 2.45 GHz radiation on the antioxidant redox system, calcium ion signaling, cell count and viability in human leukemia 60 cells. MATERIALS AND METHODS: Twelve cell cultures were equally divided into two main groups as controls (n = 6) and irradiated (n = 6) and then subdivided into four different subgroups depending on the duration of exposure, namely 1, 2, 12 and 24 hours. The samples were analyzed immediately after the experimental period. RESULTS: The extent of lipid peroxidation, cytosolic free Ca^{2+} and cell numbers were higher in 2.45 GHz groups than in the controls. The increase of cytosolic free Ca^{2+} concentrations was radiation time-dependent and was highest at 24-h exposure. The reduced glutathione, glutathione peroxidase, vitamin C and cell viability values did not show any changes in any of the experimental groups. 2-aminoethyl diphenylborinate inhibits Ca^{2+} ions influx by blockage of the transient receptor potential melastatin 2. CONCLUSIONS: 2.45 GHz electromagnetic radiation appears to induce proliferative effects through oxidative stress and Ca^{2+} influx although blocking of transient receptor potential melastatin 2 channels by 2-aminoethyl diphenylborinate seems to counteract the effects on Ca^{2+} ions influx.

Nazıroğlu M, Çelik Ö, Özgül C, Çiğ B, Doğan S, Bal R, Gümral N, Rodríguez AB, Pariente JA. Melatonin modulates wireless (2.45 GHz)-induced oxidative injury through TRPM2 and voltage gated Ca(2+) channels in brain and dorsal root ganglion in rat. Physiol Behav. 105(3):683-692, 2012.

We aimed to investigate the protective effects of melatonin and 2.45 GHz electromagnetic radiation (EMR) on brain and dorsal root ganglion (DRG) neuron antioxidant redox system, Ca(2+) influx, cell viability and electroencephalography (EEG) records in the rat. Thirty two rats were equally divided into four different groups namely group A1: Cage control, group A2: Sham control, group B: 2.45 GHz EMR, group C: 2.45 GHz EMR+melatonin. Groups B and C were exposed to 2.45 GHz EMR during 60 min/day for 30 days. End of the experiments, EEG records and the brain cortex and DRG samples were taken. Lipid peroxidation (LP), cell viability and cytosolic Ca(2+) values in DRG neurons were higher in group B than in groups A1 and A2 although their concentrations were increased by melatonin, 2-aminoethyldiphenyl borinate (2-APB), diltiazem and verapamil supplementation. Spike numbers of EEG records in group C were lower than in group B. Brain cortex vitamin E concentration was higher in group C than in group B. In conclusion, Melatonin supplementation in DRG neurons and brain seems to have protective effects on the 2.45 GHz-induced increase Ca(2+) influx, EEG records and cell viability of the hormone through TRPM2 and voltage gated Ca(2+) channels.

Nazıroğlu M, Yüksel M, Köse SA, Özkaya MO. Recent reports of Wi-Fi and mobile phone-induced radiation on oxidative stress and reproductive signaling pathways in females and males. J Membr Biol. 246(12):869-875, 2013.

Environmental exposure to electromagnetic radiation (EMR) has been increasing with the increasing demand for communication devices. The aim of the study was to discuss the mechanisms and risk factors of EMR changes on reproductive functions and membrane oxidative biology in females and males. It was reported that even chronic exposure to EMR did not increase the risk of reproductive functions such as increased levels of

neoantigens abort. However, the results of some studies indicate that EMR induced endometriosis and inflammation and decreased the number of follicles in the ovarium or uterus of rats. In studies with male rats, exposure caused degeneration in the seminiferous tubules, reduction in the number of Leydig cells and testosterone production as well as increases in luteinizing hormone levels and apoptotic cells. In some cases of male and female infertility, increased levels of oxidative stress and lipid peroxidation and decreased values of antioxidants such as melatonin, vitamin E and glutathione peroxidase were reported in animals exposed to EMR. In conclusion, the results of current studies indicate that oxidative stress from exposure to Wi-Fi and mobile phone-induced EMR is a significant mechanism affecting female and male reproductive systems. However, there is no evidence to this date to support an increased risk of female and male infertility related to EMR exposure.

Nazıroğlu M, Özkan FF, Hapil SR, Ghazizadeh V, Çiğ B. Epilepsy but not mobile phone frequency (900 MHz) induces apoptosis and calcium entry in hippocampus of epileptic rat: involvement of TRPV1 channels. J Membr Biol. 248(1):83-91, 2015.

Electromagnetic radiation (EMR) and epilepsy are reported to mediate the regulation of apoptosis and oxidative stress through Ca(2+) influx. Results of recent reports indicated that EMR can increase temperature and oxidative stress of body cells, and TRPV1 channel is activated by noxious heat, oxidative stress, and capsaicin (CAP). We investigated the effects of mobile phone (900 MHz) EMR exposure on Ca(2+) influx, apoptosis, oxidative stress, and TRPV1 channel activations in the hippocampus of pentylenetetrazol (PTZ)-induced epileptic rats. Freshly isolated hippocampal neurons of twenty-one rats were used in study within three groups namely control, PTZ, and PTZ + EMR. The neurons in the three groups were stimulated by CAP. Epilepsy was induced by PTZ administration. The neurons in PTZ + EMR group were exposed to the 900 MHz EMR for 1 h. The apoptosis, mitochondrial membrane depolarization, intracellular reactive oxygen species (ROS), and caspase-3 and caspase-9 values were higher in PTZ and PTZ + EMR groups than in control. However, EMR did not add additional increase effects on the values in the hippocampal neurons. Intracellular-free Ca(2+) concentrations in fura-2 analyses were also higher in PTZ + CAP group than in control although their concentrations were decreased by TRPV1 channel blocker, capsazepine. However, there were no statistical changes on the Ca(2+) concentrations between epilepsy and EMR groups. In conclusion, apoptosis, mitochondrial, ROS, and Ca(2+) influx via TRPV1 channel were increased in the hippocampal neurons by epilepsy induction although the mobile phone did not change the values. The results indicated that TRPV1 channels in hippocampus may possibly be a novel target for effective target of epilepsy.

Nelson BK, Conover DL, Brightwell WS, Shaw PB, Werren D, Edwards RM, Lary JM, Marked increase in the teratogenicity of the combined administration of the industrial solvent 2-methoxyethanol and radiofrequency radiation in rats. Teratology 43(6):621-634, 1991.

Limited published animal research reports synergistic teratogenic effects following combined hyperthermia (induced by elevated ambient temperature) and

administration of chemical teratogens. Radiofrequency (RF) radiation is widely used in occupational environments. Since RF radiation also elevates the body temperature of, and is teratogenic to, exposed animals, concurrent RF radiation and chemical agent administration may enhance teratogenicity. The present exploratory study, consisting of preliminary dose-finding studies and the primary study, was designed to investigate whether concurrent exposure of rats to RF radiation and the industrial solvent 2-methoxyethanol (2ME) can enhance the developmental toxicity of either agent acting alone. Preliminary dose-finding studies using small numbers of rats investigated the ability of various RF radiation conditions and doses of 2ME to produce external malformations (primarily of the paws) when administered on gestation day 13. Based on these preliminary studies, RF radiation exposure [sufficient to elevate rectal temperature to 42.0 degrees C (4 degrees C above normal for rats) for 30 min] and 2ME administration (150 mg/kg) were selected for the primary study. In the primary study, groups of 18 to 27 pregnant rats were administered RF radiation exposure and distilled water gavage, 2ME gavage and sham RF exposure, RF radiation exposure and 2ME gavage concurrently, or sham RF exposure and distilled water gavage. Pregnant rats were sacrificed on gestation day 20, and the offspring were examined for external malformations. Combined exposures enhanced the adverse effects produced by either experimental agent alone (no malformations were detected in the double sham group). Mean fetal malformations/litter increased from 14% after 2ME and sham RF (15/26 litters affected, with an average of 2 fetuses/litter malformed) and 30% after RF radiation and water gavage (10/18 litters affected, with an average of 4 fetuses/litter malformed), to 76% after the combined treatment (18/18 litters affected, with an average of 12 fetuses/litter malformed). In addition to a significant increase in the frequency of malformations, the severity of malformations also was enhanced by the combination treatment (on a relative severity ranking scale, the 2ME severity score was less than 1, the RF score was 3, and the combination score was 6). This study provided evidence of synergism between RF radiation and 2ME administration, but additional research will be required to characterize the extent of synergism between these two agents. Potential interactive effects between chemical and physical agents need to be investigated to determine the extent to which such interactions should impact occupational exposure standards.

Nelson BK, Conover DL, Shaw PB, Werren DM, Edwards RM, Hoberman AM, Interactive developmental toxicity of radiofrequency radiation and 2-methoxyethanol in rats. Teratology 50(4):275-293, 1994.

Concurrent exposures to chemical and physical agents occur in the workplace; exposed workers include those involved with the microelectronics industry, plastic sealers, and electrosurgical units. Previous animal research indicates that hyperthermia induced by an elevation in ambient temperature can potentiate the toxicity and teratogenicity of some chemical agents. We previously demonstrated that combined exposure to radiofrequency (RF; 10 MHz) radiation, which also induces hyperthermia and is teratogenic to exposed animals, and the industrial solvent, 2-methoxyethanol (2ME), produces enhanced teratogenicity in rats. The present study replicates and extends the previous research investigating the enhanced teratogenicity of combined RF radiation and 2ME exposures.

The interactive dose-related teratogenicity of RF radiation (sham exposure or maintaining colonic temperatures at 42.0 degrees C for 0, 10, 20, or 30 min) and 2ME (0, 75, 100, 125, or 150 mg/kg) was investigated by administering various combinations of RF radiation and 2ME to groups of rats on gestation days 9 or 13; gestation-day 20 fetuses were examined for external, skeletal, and visceral malformations. The results are consistent with and extend our previous research findings. Synergism was observed between RF radiation and 2ME for some treatment combinations, but not for others. The study also clarified which gestational periods, RF radiation exposure durations, and 2ME doses would be most informative in future interaction studies to determine the lowest interactive effect level. Day 9 exposures generally evidenced little effect by 2ME, either by itself or in combination with RF radiation. In contrast, day 13 exposures resulted in highly significant effects from 2ME and RF radiation. The structures showing strong evidence of effects from both 2ME and RF radiation after exposure on gestation day 13 were the forepaw digits, forepaw phalanges, hindpaw digits, hindpaw phalanges, hind limbs, metacarpals, and metatarsals. Statistical analyses did not show a global synergistic effect, but did show evidence for a synergistic effect at intermediate levels of the dose ranges. Future research will address potential interactions at lower doses.

Nelson BK, Conover DL, Krieg EF Jr, Snyder DL, Edwards RM, Interactions of radiofrequency radiation-induced hyperthermia and 2-methoxyethanol teratogenicity in rats. Bioelectromagnetics. 18(5):349-359, 1997.

Radiofrequency (RF) radiation is used in a variety of workplaces. In addition to RF radiation, many workers are concurrently exposed to numerous chemicals; exposed workers include those involved with the microelectronics industry, plastic sealers, and electrosurgical units. The developmental toxicity of RF radiation is associated with the degree and duration of hyperthermia induced by the exposure. Previous animal research indicates that hyperthermia induced by an elevation in ambient temperature can potentiate the toxicity and teratogenicity of some chemical agents. We previously demonstrated that combined exposure to RF radiation (10 MHz) and the industrial solvent, 2-methoxyethanol (2ME), produces enhanced teratogenicity in rats. The purpose of the present research is to determine the effects of varying the degree and duration of hyperthermia induced by RF radiation (sufficient to maintain colonic temperatures at control [38.5], 39.0, 40.0, or 41.0 degrees C for up to 6 h) and 2ME (100 mg/kg) administered on gestation day 13 of rats. Focusing on characterizing the dose-response pattern of interactions, this research seeks to determine the lowest interactive effect level. Day 20 fetuses were examined for external and skeletal malformations. The results are consistent with previous observations. Significant interactions were observed between 2MEand RF radiation sufficient to maintain colonic temperatures at 41 degrees C for 1 h, but no consistent interactions were seen at lower temperatures even with longer durations. These data indicate that combined exposure effects should be considered when developing both RF radiation and chemical exposure guidelines and intervention strategies.

Nelson BK, Conover DL, Shaw PB, Snyder DL, Edwards RM, Interactions of radiofrequency radiation on 2-methoxyethanol teratogenicity in rats. J Appl Toxicol 17(1):31-39, 1997.

Concurrent exposures to chemical and physical agents occur in the workplace; exposed workers include those involved with microelectronics industry, plastic sealers and electrosurgical units. Previous animal research indicates that hyperthermia induced by an elevation in ambient temperature can potentiate the toxicity and teratogenicity of some chemical agents. We previously demonstrated that combined exposure to radiofrequency (r.f.; 10 MHz) radiation, which also induces hyperthermia and is teratogenic to exposed animals, and the industrial solvent 2-methoxyethanol (2ME) produces enhanced teratogenicity in rats. A subsequent study replicated and extended that research by investigating the interactive dose-related teratogenicity of r.f. radiation (sham exposure or maintaining colonic temperatures at 42.0 degrees C for 0, 10, 20 or 30 min by r.f. radiation absorption) and 2ME (0, 75, 100, 125 or 150 mg/kg) on gestation days 9 or 13 of rats. The purpose of the present research is to determine the effects of r.f. radiation (sufficient to maintain colonic temperatures at 42.0 degrees C for 10 min) on a range of doses of 2ME (0, 20, 40, 60, 80, 100, 120 and 140 mg kg-1) administered on gestation day 13of rats. Focusing on characterizing the dose-response pattern of interactions, this research seeks to determine the lowest interactive effect level. Day 20 fetuses were examined for external and skeletal malformations. The results are consistent with previous observations. Dose-related developmental toxicity was observed for 2ME both in the presence and absence of r.f. radiation. However, concurrent RF radiation exposure changed the shape of the dose-effect curve of 2ME. These data indicate that combined exposure effects should be considered when developing exposure guidelines and intervention strategies.

Nelson BK, Conover DL, Krieg EF Jr, Snyder DL, Edwards RM, Effect of environmental temperature on the interactive developmental toxicity of radiofrequency radiation and 2-methoxyethanol in rats. Int Arch Occup Environ Health 71(6):413-423, 1998.

OBJECTIVE: This research was conducted to determine if altered environmental temperatures would affect the interactive developmental toxicity of radiofrequency (RF) radiation and the industrial solvent, 2-methoxyethanol (2ME). This is important because RF radiation is used in a variety of workplaces that have poorly controlled environmental temperatures, and many workers are concurrently exposed to various chemicals. Furthermore, we have previously demonstrated that combined exposure to RF radiation (10 MHz) and 2ME produces enhanced teratogenicity in rats. METHODS: RF radiation sufficient to maintain colonic temperatures at the control value (38degrees), 39.0degrees or 40.0 degrees C for 2 or 4 h combined with either 0 or 100 mg/ kg 2ME at environmental temperatures of 18 degrees , 24 degrees and 30 degrees C (65 degrees , 75 degrees , and 85 degrees F) were given on gestation day 13 to Sprague-Dawley rats. Dams were killed on gestation day 20, and the fetuses were examined for external malformations. RESULTS AND CONCLUSIONS: Environmental temperature does affect the specific absorption rate (SAR) necessary to maintain a specific colonic temperature but does not affect the interactive developmental toxicity of RF radiation and 2ME in rats. These results, consistent with the literature, add to the evidence that the developmental toxicity of RF radiation (combined or alone) is associated with colonic temperature, not with SAR.

Nelson BK, Snyder DL, Shaw PB, Developmental toxicity interactions of salicylic

acid and radiofrequency radiation or 2-methoxyethanol in rats. Reprod Toxicol 13(2):137-145, 1999.

Radiofrequency (RF) radiation is used in a variety of workplaces where workers are concurrently exposed to chemicals. Combined exposure to RF radiation (10 MHz) and the industrial solvent, 2-methoxyethanol (2ME), produces enhanced teratogenicity in rats. The purpose of the present research was to determine if the synergistic effects noted for RF radiation and 2ME are generalizable to other chemicals. Since salicylic acid (SA) is widely used as an analgesic and is teratogenic in animals, SA was selected to address generalizability. Based on the literature and our pilot studies, 0, 250, or 350 mg/kg SA were administered by gavage on gestation Day 9 or 13 to rats. Concurrently rats given SA on Day 9 were exposed to RF radiation sufficient to maintain colonic temperature at 41 degrees C for 60 min (or sham). Those given SA on Day 13 were also given 0 or 100 mg/kg 2ME (gavage). Dams were sacrificed on gestation Day 20, and the fetuses were examined for external malformations. The data provide no evidence of synergistic interactions between RF radiation and salicylic acid (resorptions and malformations). Limited evidence of antagonism was observed between 2ME and salicylic acid (fetal weights). This investigation highlights the importance of additional research on interactions in developmental toxicology, and emphasizes the need to consider combined exposure effects when developing both physical agent and chemical agent exposure guidelines and intervention strategies.

Nelson BK, Snyder DL, Shaw PB, Developmental toxicity interactions of methanol and radiofrequency radiation or 2-methoxyethanol in rats. Int J Toxicol 20(2):89-100, 2001.

This research was undertaken to determine potential interactions among chemical and physical agents. Radiofrequency (RF) radiation is used in numerous workplaces, and many workers are concurrently exposed to RF radiation and various chemicals. The developmental toxicity of RF radiation is associated with the degree and duration of hyperthermia induced by the exposure. Previous animal research indicates that hyperthermia induced by an elevation in ambient temperature can potentiate the toxicity and teratogenicity of some chemical agents. We previously demonstrated that combined exposure to RF radiation (10 MHz) and the industrial solvent, 2-methoxyethanol (2ME), enhanced teratogenicity in rats. Interactions were noted at even the lowest levels of 2ME tested, but only at hyperthermic levels of RF radiation. The purpose of the present research is to investigate if the interactive effects noted for RF radiation and 2ME are unique to these agents, or if similar interactions might be seen with other chemicals. Because methanol is widely used as a solvent as well as fuel additive, and, at high levels, is teratogenic in animals, we selected methanol as a chemical to address generalizability. Based on the literature and our pilot studies, 0, 2, or 3 g/kg methanol (twice, at 6-hour intervals) were administered on gestation day 9 or 13 to groups of 10 Sprague-Dawley rats. Dams treated on day 9 were given methanol and exposed to RF radiation sufficient to maintain colonic temperature at 41 degrees C for 60 minutes (or sham). Those treated on day 13 were given methanol plus either 0 or 100 mg/kg 2ME. Because we observed that methanol produced hypothermia, some groups were given the initial dose of methanol concurrently with the RF or 2ME, and others were given the first dose of methanol 1.5 hours prior to RF or 2ME. Dams were sacrificed on gestation day 20, and

the fetuses were examined for external malformations. The results indicate that RF radiation or methanol on day 9 increased the incidence of resorbed fetuses, but no interactive effects were observed. The resorptions were highest in groups given the experimental treatments 1.5 hours apart. The higher dose of methanol also reduced fetal weights. Administration of 2ME or methanol on day 13 increased the rate of malformations, and there was evidence of a positive interaction between 2ME and methanol. Fetal weights were reduced by 2ME and methanol alone, but no interaction was observed. Also, separation of the dosing with the teratogens did not affect the results. These results point out that interactions in developmental toxicology, such as those of RF radiation, 2ME, and methanol that we have studied, are complex, and such interactions cannot be fully understood or predicted without more research. It is important that combined exposure effects be considered when developing both physical agent and chemical agent exposure guidelines and intervention strategies.

Neshev NN, Kirilova EI, Environmental-health aspects of pulse-modulated microwaves. Rev Environ Health 11(1-2):85-88, 1996.

Our theoretical model describes the potential influence of irradiation with pulse-modulated microwaves on the conformational oscillations of enzymes in living organisms. Certain values of pulse-repetition time, determined by the period of conformational oscillations of the corresponding type of enzyme, can produce the effect at extremely low power levels. Synchronized oscillations in identical enzyme molecules produce in turn large-scale oscillations within living cells. Thus, short periods of exposure to pulse-modulated microwaves could be beneficial to cellular function, whereas maintaining the amplitude of such oscillations at a maximum for long periods may have a stressful effect on biochemical processes. The model discloses the possible environmental-health risks of long-term exposure in ambient fields that are created by radar, navigation, and communication systems.

Neubauer C, Phelan AM, Kues H, Lange DG, Microwave irradiation of rats at 2.45 GHz activates pinocytotic-like uptake of tracer by capillary endothelial cells of cerebral cortex. Bioelectromagnetics 11(4):261-268, 1990.

Far-field exposures of male albino rats to 2.45-GHz microwaves (10-microseconds pulses, 100 pps) at a low average power density (10 mW/cm2; SAR approximately 2 W/kg) and short durations (30-120 min) resulted in increased uptakes of tracer through the blood-brain barrier (BBB). The uptake of systemically administered rhodamine-ferritin complex by capillary endothelial cells (CECs) of the cerebral cortex was dependent on power density and on duration of exposure. At 5 mW/cm2, for example, a 15-min exposure had no effect. Near-complete blockade of uptake resulted when rats were treated before exposure to microwaves with a single dose of colchicine, which inhibits microtubular function. A pinocytotic-like mechanism is presumed responsible for the microwave-induced increase in BBB permeability.

Nieto-Hernandez R, Rubin GJ, Cleare AJ, Weinman JA, Wessely S. Can evidence change belief? Reported mobile phone sensitivity following individual feedback of an inability to discriminate active from sham signals. J Psychosom Res. 65(5):453-460, 2008.

OBJECTIVE: In this study, we tested whether providing individuals, who described being sensitive to mobile phone signals, with accurate feedback about their ability to discriminate an active mobile phone signal from a sham signal had any impact on their subsequent symptom levels or their perceived sensitivity to mobile phones. METHODS: Sixty-nine participants who reported sensitivity to mobile phones took part in a double-blind, placebo-controlled provocation study. Perceived sensitivity to mobile phones was assessed using a version of the Sensitive Soma Assessment Scale (SSAS) and the severity of any symptoms attributed to mobile phones was recorded. Both the overall ("negative") findings of the provocation study and the participant's own individual results ("correct" or "incorrect" at detecting a mobile phone signal) were then described to them. Six months later, perceived sensitivity and symptom severity were measured again. RESULTS: Fifty-eight participants (84%) received feedback and participated in the 6-month follow-up. No significant differences in SSAS scores or in symptom severity scores were found between individuals told that they were correct (n=31) or incorrect (n=27) in their ability to detect mobile phone signals in the provocation study. CONCLUSION: The provision of accurate feedback was insufficient to change attributions or reduce symptoms in this study. However, an overtly negative reaction to feedback was not observed among most participants, and some participants were willing to consider that factors other than electromagnetic field may be relevant in causing or exacerbating their symptoms. Discussing possible psychological factors with electromagnetic hypersensitivity patients may be beneficial for some.

Nikolova T, Czyz J, Rolletschek A, Blyszczuk P, Fuchs J, Jovtchev G, Schuderer J, Kuster N, Wobus AM. Electromagnetic fields affect transcript levels of apoptosis-related genes in embryonic stem cell-derived neural progenitor cells. ASEB J. 19(12):1686-1688, 2005.

Mouse embryonic stem (ES) cells were used as an experimental model to study the effects of electromagnetic fields (EMF). ES-derived nestin-positive neural progenitor cells were exposed to extremely low frequency EMF simulating power line magnetic fields at 50 Hz (ELF-EMF) and to radiofrequency EMF simulating the Global System for Mobile Communication (GSM) signals at 1.71 GHz (RF-EMF). Following EMF exposure, cells were analyzed for transcript levels of cell cycle regulatory, apoptosis-related, and neural-specific genes and proteins; changes in proliferation; apoptosis; and cytogenetic effects. Quantitative RT-PCR analysis revealed that ELF-EMF exposure to ES-derived neural cells significantly affected transcript levels of the apoptosis-related bcl-2, bax, and cell cycle regulatory "growth arrest DNA damage inducible" GADD45 genes, whereas mRNA levels of neural-specific genes were not affected. RF-EMF exposure of neural progenitor cells resulted in down-regulation of neural-specific Nurr1 and in up-regulation of bax and GADD45 mRNA levels. Short-term RF-EMF exposure for 6 h, but not for 48 h, resulted in a low and transient increase of DNA double-strand breaks. No effects of ELF- and RF-EMF on mitochondrial function, nuclear apoptosis, cell proliferation, and chromosomal alterations were observed. We may conclude that EMF exposure of ES-derived neural progenitor cells transiently affects the transcript level of genes related to apoptosis and cell cycle control. However, these responses are not associated with detectable changes of cell physiology, suggesting compensatory mechanisms at the translational and

posttranslational level.

Ning W, Xu SJ, Chiang H, Xu ZP, Zhou SY, Yang W, Luo JH. Effects of GSM 1800 MHz on dendritic development of cultured hippocampal neurons.Acta Pharmacol Sin.28(12):1873-1880, 2007.

AIM: To evaluate the effects of global system for mobile communications (GSM) 1800 MHz microwaves on dendritic filopodia, dendritic arborization, and spine maturation during development in cultured hippocampal neurons in rats.**METHODS:** The cultured hippocampal neurons were exposed to GSM 1800 MHz microwaves with 2.4 and 0.8 W/kg, respectively, for 15 min each day from 6 days in vitro (DIV6) to DIV14. The subtle structures of dendrites were displayed by transfection with farnesylated enhanced green fluorescent protein (F-GFP) and GFP-actin on DIV5 into the hippocampal neurons.**RESULTS:** There was a significant decrease in the density and mobility of dendritic filopodia at DIV8 and in the density of mature spines at DIV14 in the neurons exposed to GSM 1800 MHz microwaves with 2.4 W/kg. In addition, the average length of dendrites per neuron at DIV10 and DIV14 was decreased, while the dendritic arborization was unaltered in these neurons. However, there were no significant changes found in the neurons exposed to the GSM 1800 MHz microwaves with 0.8 W/kg.**CONCLUSION:** These data indicate that the chronic exposure to 2.4 W/kg GSM 1800 MHz microwaves during the early developmental stage may affect dendritic development and the formation of excitatory synapses of hippocampal neurons in culture.

Nirwane A, Sridhar V, Majumdar A. Neurobehavioural Changes and Brain Oxidative Stress Induced by Acute Exposure to GSM900 Mobile Phone Radiations in Zebrafish (Danio rerio). Toxicol Res. 2016 Apr;32(2):123-32. doi: 10.5487/TR.2016.32.2.123. Epub 2016 Apr 30.

The impact of mobile phone (MP) radiation on the brain is of specific interest to the scientific community and warrants investigations, as MP is held close to the head. Studies on humans and rodents revealed hazards MP radiation associated such as brain tumors, impairment in cognition, hearing etc. Melatonin (MT) is an important modulator of CNS functioning and is a neural antioxidant hormone. Zebrafish has emerged as a popular model organism for CNS studies. Herein, we evaluated the impact of GSM900MP (GSM900MP) radiation exposure daily for 1 hr for 14 days with the SAR of 1.34W/Kg on neurobehavioral and oxidative stress parameters in zebrafish. Our study revealed that, GSM900MP radiation exposure, significantly decreased time spent near social stimulus zone and increased total distance travelled, in social interaction test. In the novel tank dive test, the GSM900MP radiation exposure elicited anxiety as revealed by significantly increased time spent in bottom half; freezing bouts and duration and decreased distance travelled, average velocity, and number of entries to upper half of the tank. Exposed zebrafish spent less time in the novel arm of the Y-Maze, corroborating significant impairment in learning as compared to the control group. Exposure decreased superoxide dismutase (SOD), catalase (CAT) activities whereas, increased levels of reduced glutathione (GSH) and lipid peroxidation (LPO) was encountered showing compromised antioxidant defense. Treatment with MT significantly reversed the above neurobehavioral and oxidative derangements induced by GSM900MP radiation

exposure. This study traced GSM900MP radiation exposure induced neurobehavioral aberrations and alterations in brain oxidative status. Furthermore, MT proved to be a promising therapeutic candidate in ameliorating such outcomes in zebrafish.

Nittby H, Widegren B, Krogh M, Grafström G, Berlin H, Rehn G, Eberhardt JL, Malmgren L, Persson BRR, Salford L. Exposure to radiation from global system for mobile communications at 1,800 MHz significantly changes gene expression in rat hippocampus and cortex. Environmentalist 28(4), 458-465, 2008.

We have earlier shown that radio frequency electromagnetic fields can cause significant leakage of albumin through the blood–brain barrier of exposed rats as compared to non-exposed rats, and also significant neuronal damage in rat brains several weeks after a 2 h exposure to a mobile phone, at 915 MHz with a global system for mobile communications (GSM) frequency modulation, at whole-body specific absorption rate values (SAR) of 200, 20, 2, and 0.2 mW/kg. We have now studied whether 6 h of exposure to the radiation from a GSM mobile test phone at 1,800 MHz (at a whole-body SAR-value of 13 mW/kg, corresponding to a brain SAR-value of 30 mW/kg) has an effect upon the gene expression pattern in rat brain cortex and hippocampus—areas where we have observed albumin leakage from capillaries into neurons and neuronal damage. Microarray analysis of 31,099 rat genes, including splicing variants, was performed in cortex and hippocampus of 8 Fischer 344 rats, 4 animals exposed to global system for mobile communications electromagnetic fields for 6 h in an anechoic chamber, one rat at a time, and 4 controls kept as long in the same anechoic chamber without exposure, also in this case one rat at a time. Gene ontology analysis (using the gene ontology categories biological processes, molecular functions, and cell components) of the differentially expressed genes of the exposed animals versus the control group revealed the following highly significant altered gene categories in both cortex and hippocampus: extracellular region, signal transducer activity, intrinsic to membrane, and integral to membrane. The fact that most of these categories are connected with membrane functions may have a relation to our earlier observation of albumin transport through brain capillaries.

Nittby H, Grafström G, Tian DP, Malmgren L, Brun A, Persson BR, Salford LG, Eberhardt J. Cognitive impairment in rats after long-term exposure to GSM-900 mobile phone radiation. Bioelectromagnetics. 29:219-232, 2008.

Considering the frequent use of mobile phones, we have directed attention to possible implications on cognitive functions. In this study we investigated in a rat model the long-term effects of protracted exposure to Global System for Mobile Communication-900 MHz (GSM-900) radiation. Out of a total of 56 rats, 32 were exposed for 2 h each week for 55 weeks to radio-frequency electromagnetic radiation at different SAR levels (0.6 and 60 mW/kg at the initiation of the experimental period) emitted by a (GSM-900) test phone. Sixteen animals were sham exposed and eight animals were cage controls, which never left the animal house. After this protracted exposure, GSM-900 exposed rats were compared to sham exposed controls. Effects on exploratory behaviour were evaluated in the open-field test, in which no difference was seen. Effects on cognitive functions were evaluated in the episodic-like memory

test. In our study, GSM exposed rats had impaired memory for objects and their temporal order of presentation, compared to sham exposed controls (P = 0.02). Detecting the place in which an object was presented was not affected by GSM exposure. Our results suggest significantly reduced memory functions in rats after GSM microwave exposure (P = 0.02).

Nittby H, Brun A, Eberhardt J, Malmgren L, Persson BR, Salford LG. Increased blood-brain barrier permeability in mammalian brain 7 days after exposure to the radiation from a GSM-900 mobile phone. Pathophysiology6(2-3):103-112, 2009.

Microwaves were for the first time produced by humans in 1886 when radio waves were broadcasted and received. Until then microwaves had only existed as a part of the cosmic background radiation since the birth of universe. By the following utilization of microwaves in telegraph communication, radars, television and above all, in the modern mobile phone technology, mankind is today exposed to microwaves at a level up to 10(20) times the original background radiation since the birth of universe. 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 2h of exposure. In the background section of this report, we present a thorough review of the literature on the demonstrated effects (or lack of effects) of microwave exposure upon the BBB. Furthermore, we have continued our own studies by investigating the effects of GSM mobile phone radiation upon the blood-brain barrier permeability of rats 7 days after one occasion of 2h of exposure. Forty-eight rats were exposed in TEM-cells for 2h at non-thermal specific absorption rates (SARs) of 0mW/kg, 0.12mW/kg, 1.2mW/kg, 12mW/kg and 120mW/kg. Albumin extravasation over the BBB, neuronal albumin uptake and neuronal damage were assessed. Albumin extravasation was enhanced in the mobile phone exposed rats as compared to sham controls after this 7-day recovery period (Fisher's exact probability test, p=0.04 and Kruskal-Wallis, p=0.012), at the SAR-value of 12mW/kg (Mann-Whitney, p=0.007) and with a trend of increased albumin extravasation also at the SAR-values of 0.12mW/kg and 120mW/kg. There was a low, but significant correlation between the exposure level (SAR-value) and occurrence of focal albumin extravasation (r(s)=0.33; p=0.04). The present findings are in agreement with our earlier studies where we have seen increased BBB permeability immediately and 14 days after exposure. We here discuss the present findings as well as the previous results of altered BBB permeability from our and other laboratories.

Nittby H, Moghadam MK, Sun W, Malmgren L, Eberhardt J, Persson BR, Salford LG. Analgetic effects of non-thermal GSM-1900 radiofrequency electromagnetic fields in the land snail Helix pomatia. Int J Radiat Biol. ;88(3):245-252, 2012

Abstract. Abstract Purpose: To investigate whether mobile phone radiation might affect snail nociception, employing radiofrequency (RF) electromagnetic fields (EMF) which, to our knowledge, have hitherto not been studied in a snail model. Exposure to extremely low frequency (ELF) magnetic fields has however been shown to significantly affect nociceptive responses. Materials and methods: In the present study, we exposed 29 land snails of the strain Helix pomatia to global system for mobile communications (GSM) EMF at 1900 MHz at the non-thermal level 48 mW/kg for 1 hour each and 29 snails were sham controls. The experiments took place during

the onset of summer, with all snails being well out of hibernation. Before and after GSM or sham exposure, the snails were subjected to thermal pain by being placed on a hot plate. The reaction time for retraction from the hot plate was measured by two blinded observers. Results: Comparing the reaction pattern of each snail before and after exposure, the GSM exposed snails were less sensitive to thermal pain as compared to the sham controls, indicating that RF exposure induces a significant analgesia (Mann-Whitney $p < 0.001$). Conclusion: This study might support earlier findings, describing beneficial effects of EMF exposure upon nociception.

Noor NA, Mohammed HS, Ahmed NA, Radwan NM. Variations in amino acid neurotransmitters in some brain areas of adult and young male albino rats due to exposure to mobile phone radiation.Eur Rev Med Pharmacol Sci. 15(7):729-742, 2011.

BACKGROUND AND OBJECTIVES: Mobile phone radiation and health concerns have been raised, especially following the enormous increase in the use of wireless mobile telephony throughout the world. The present study aims to investigate the effect of one hour daily exposure to electromagnetic radiation (EMR) with frequency of 900 Mz (SAR 1.165 w/kg, power density 0.02 mW/cm2) on the levels of amino acid neurotransmitters in the midbrain, cerebellum and medulla of adult and young male albino rats. **MATERIALS AND METHODS:** Adult and young rats were divided into two main groups (treated and control). The treated group of both adult and young rats was exposed to EMR for 1 hour daily. The other group of both adult and young animals was served as control. The determination of amino acid levels was carried out after 1 hour, 1 month, 2 months and 4 months of EMR exposure as well as after stopping radiation. **RESULTS:** Data of the present study showed a significant increase in both excitatory and inhibitory amino acids in the cerebellum of adult and young rats and midbrain of adult animals after 1 hour of EMR exposure. In the midbrain of adult animals, there was a significant increase in glycine level after 1 month followed by significant increase in GABA after 4 months. Young rats showed significant decreases in the midbrain excitatory amino acids. In the medulla, the equilibrium ratio percent (ER%) calculations showed a state of neurochemical inhibition after 4 months in case of adult animals, whereas in young animals, the neurochemical inhibitory state was observed after 1 month of exposure due to significant decrease in glutamate and aspartate levels. This state was converted to excitation after 4 months due to the increase in glutamate level. **CONCLUSION:** The present changes in amino acid concentrations may underlie the reported adverse effects of using mobile phones.

Nordin S, Neely G, Olsson D, Sandström M. Odor and Noise Intolerance in Persons with Self-Reported Electromagnetic Hypersensitivity. Int J Environ Res Public Health. 11(9):8794-8805, 2014.

Lack of confirmation of symptoms attributed to electromagnetic fields (EMF) and triggered by EMF exposure has highlighted the role of individual factors. Prior observations indicate intolerance to other types of environmental exposures among persons with electromagnetic hypersensitivity (EHS). This study assessed differences in odor and noise intolerance between persons with EHS and healthy controls by use of subscales and global measures of the Chemical Sensitivity Scale (CSS) and the Noise Sensitivity

Scale (NSS). The EHS group scored significantly higher than the controls on all CSS and NSS scales. Correlation coefficients between CSS and NSS scores ranged from 0.60 to 0.65 across measures. The findings suggest an association between EHS and odor and noise intolerance, encouraging further investigation of individual factors for understanding EMF-related symptoms.

Novoselova ET, Fesenko EE, [[Stimulation of production of tumor necrosis factor by murine macrophages when exposed in vio and in vitro to weak electromagnetic waves in the centimeter range]]. Biofizika 43(6):1132-1333, 1998. [Article in Russian]

Whole-body microwave sinusoidal irradiation of male NMRI mice, exposure of macrophages in vitro, and preliminary irradiation of culture medium with 8.15-18 GHz (1 Hz within) at a power density of 1 microW/cm2 caused a significant enhancement of tumor necrosis factor production in peritoneal macrophages. The role of microwaves as a factor interfering with the process of cell immunity is discussed.

Novoselova, EG, Fesenko, EE, Makar, VR, Sadovnikov, VB, Microwaves and cellular immunity. II. Immunostimulating effects of microwaves and naturally occurring antioxidant nutrients. Bioelectrochem Bioenerg 49(1):37-41, 1999.

The effect of 8.15-18 GHz (1 Hz within) microwave radiation at a power density of 1 microW/cm2 on the tumor necrosis factor (TNF) production and immune response was tested. A single 5 h whole-body exposure induced a significant increase in TNF production in peritoneal macrophages and splenic T cells. The mitogenic response in T lymphocytes increased after microwave exposure. The activation of cellular immunity was observed within 3 days after exposure. The diet containing lipid-soluble nutrients (beta-carotene, alpha-tocopherol and ubiquinone Q9) increased the activity of macrophages and T cells from irradiated mice. These results demonstrate that irradiation with low-power density microwaves stimulates the immune potential of macrophages and T cells, and the antioxidant treatment enhances the effect of microwaves, in particular at later terms, when the effect of irradiation is reduced.

Novoselova EG, Ogai VB, Sorokina OV, Novikov VV, Fesenko EE., [Effect of centimeter microwaves and the combined magnetic field on the tumor necrosis factor production in cells of mice with experimental tumors]. Biofizika 46(1):131-135, 2001. [Article in Russian]

The effect of fractionated exposure to low-intensity microwaves (8.15-18 GHz, 1 microW/cm2, 1.5 h daily for 7 days) and combined weak magnetic field (constant 65 1 microT; alternating--100 nT, 3-10 Hz) on the production of tumor necrosis factor in macrophages of mice with experimental solid tumors produced by transplantation of Ehrlich ascites carcinoma was studied. It was found that exposure of mice to both microwaves and magnetic field enhanced the adaptive response of the organism to the onset of tumor growth: the production of tumor necrosis factor in peritoneal macrophages of tumor-bearing mice was higher than in unexposed mice.

Novoselova EG, Ogay VB, Sorokina OV, Glushkova OV, Sinotova OA, Fesenko EE.The production of tumor necrosis factor in cells of tumor-bearing mice after total-body microwave irradiation and antioxidant diet. Electromag Biol Med

23:167-180, 2004.

The effects of repeated treatment with weak microwaves (MW) (8.15–18 GHz, 1 μW/cm^2, 1.5 h daily) and diet with antioxidants (AO) (-carotene, -tocopherol, and ubiquinone Q_9) on production of tumor necrosis factor (TNF) in macrophages and T lymphocytes of healthy and tumor-bearing mice (TBM) were studied. Tumor size and mortality of TBM were also followed. Microwave radiation and antioxidant diet stimulated production of TNF in cells from healthy mice. At early stages, tumor growth induced TNF production in mouse cells; however, this effect decreased as tumors grew. In TBM exposed to MW, TNF production was higher than in unirradiated TBM. Oppositely, AO diet induced TNF production in healthy mice but did not affect TNF secretion in TBM. Accordingly, prolonged treatment of TBM to MW, but not to AO diet, decreased tumor growth rate and increased overall animal longevity. These results suggest that diminished tumor growth rate due to extremely low-level MW exposure of mice carrying tumors, at least in part, was caused by enhancement in TNF production and accumulation of plasma TNF.

Nowak B, Rosocha S, Zellerhoff C, Liebrich A, Himmrich E, Voigtlander T, Meyer J, Is there a risk for interaction between mobile phones and single lead VDD pacemakers? Pacing Clin Electrophysiol 19(10):1447-1450, 1996.

Mobile phones may cause pacemaker interference. Patients with a single lead VDD pacemaker might be at special risk, since the atrial sensitivity is often programmed to low (high sensitivity) threshold values and the majority of patients are pacemaker dependent due to the underlying high degree AV block. We evaluated 31 patients with three types of single lead VDD pacemakers: 12 Unity, 292-07 (Intermedics, Inc.); 10 Thera VDD, 8948 or 8968i (Medtronic, Inc.); and 9 Saphir 600 (Vitatron, Inc.) for interference from a cellular mobile phone with a power of 2 W (D-net). For this purpose, atrial and ventricular sensitivity settings were programmed to their most sensitive values (A: 0.1-0.25 mV; V: 1.0 mV) and ventricular sensing was programmed to unipolar. With the ECG continuously monitored, the phone's extendable antenna was brought in direct contact with the patient's skin at the right sternal border, with the tip of the antenna in skin contact just below the clavicle, within 5 cm of the pacemaker connector. Then multiple phases of phone calls were performed, and the effects on the pacemakers recorded. In our group of patients with three different types of single lead VDD pacemakers, no interference could be detected using a 2-W mobile phone in the digital D-net. The programmed values remained unchanged after the interference test. Therefore, the risk of interference seems to be low for the VDD pacemakers tested, although our study design does not allow to entirely exclude the possibility of interference from a mobile phone.

Ntzouni MP, Stamatakis A, Stylianopoulou F, Margaritis LH. Short-term memory in mice is affected by mobile phone radiation. Pathophysiology. 18(3):193-199, 2011.

Abstract. The effects of mobile phone electromagnetic fields (EMFs) were studied on a non-spatial memory task (Object Recognition Task - ORT) that requires entorhinal cortex function. The task was applied to three groups of mice Mus musculus C57BL/6 (exposed, sham-exposed and control) combined with 3 different radiation exposure protocols. In the first protocol designated "acute exposure", mice 45 days old (PND45

- postnatal day 45) were exposed to mobile phone (MP) radiation (SAR value 0.22W/kg) during the habituation, the training and the test sessions of the ORT, but not during the 10min inter-trial interval (ITI) where consolidation of stored object information takes place. On the second protocol designated "chronic exposure-I", the same mice were exposed for 17 days for 90min/per day starting at PND55 to the same MP radiation. ORT recognition memory was performed at PND72 with radiation present only during the ITI phase. In the third protocol designated "chronic exposure-II", mice continued to be exposed daily under the same conditions up to PND86 having received radiation for 31 days. One day later the ORT test was performed without irradiation present in any of the sessions. The ORT-derived discrimination indices in all three exposure protocols revealed a major effect on the "chronic exposure-I" suggesting a possible severe interaction of EMF with the consolidation phase of recognition memory processes. This may imply that the primary EMF target may be the information transfer pathway connecting the entorhinal-parahippocampal regions which participate in the ORT memory task.

Ntzouni MP, Skouroliakou A, Kostomitsopoulos N, Margaritis LH. Transient and cumulative memory impairments induced by GSM 1.8 GHz cell phone signal in a mouse model. Electromagn Biol Med. 32(1):95-120, 2013.

This study was designed to investigate the transient and cumulative impairments in spatial and non-spatial memory of C57Bl/6J mice exposed to GSM 1.8 GHz signal for 90 min daily by a typical cellular (mobile) phone at a specific absorption rate value of 0.11 W/kg. Free-moving male mice 2 months old were irradiated in two experimental protocols, lasting for 66 and for 148 days respectively. Each protocol used three groups of animals (n = 8 each for exposed, sham exposed and controls) in combination with two behavioural paradigms, the object recognition task and the object location task sequentially applied at different time points. One-way analysis of variance revealed statistically significant impairments of both types of memory gradually accumulating, with more pronounced effects on the spatial memory. The impairments persisted even 2 weeks after interruption of the 8 weeks daily exposure, whereas the memory of mice as detected by both tasks showed a full recovery approximately 1 month later. Intermittent every other day exposure for 1 month had no effect on both types of memory. The data suggest that visual information processing mechanisms in hippocampus, perirhinal and entorhinal cortex are gradually malfunctioning upon long-term daily exposure, a phenotype that persists for at least 2 weeks after interruption of radiation, returning to normal memory performance levels 4 weeks later. It is postulated that cellular repair mechanisms are operating to eliminate the memory affecting molecules. The overall contribution of several possible mechanisms to the observed cumulative and transient impairments in spatial and non-spatial memory is discussed.

Nyakyi CP, Mrutu SI, Sam A, Anatory J, Safety Zone Determination for Wireless Cellular Tower - A Case Study for Tanzania. IJRET: International Journal of Research in Engineering and Technology. 2(9). Sep 2013. eISSN: 2319-1163 | pISSN: 2321-7308

Safety zone determination for wireless cellular towers has attracted attention from many

researchers in the last decade. This is caused by the rapid growth of the wireless cellular industry which has led to the installation of towers even in the residential areas. There are many reports and ongoing researches regarding the biological and thermal effects of wireless cellular electromagnetic fields exposures to people. Cancer, hyperthermia, neural and behaviour effects of people exposed to these electromagnetic fields have been reported. This motivates the research to determine safety zones from wireless cellular towers to assure safety to those living in the vicinity of these towers. A model for safety zone determination is developed. The model takes the received power at the object, power transmitted by the transmitter and gain of the transmitter as inputs to determine the safe distance from the radiation of a wireless cellular transmitter. The power density received by the object and its geographical location from the radiation source are measured using the selective radiation meter. Transmitted power and the gain of the transmitter together with the height of the tower were obtained from the respective wireless cellular network operator. Based on the geographical location of the object, the distance from the radiation source was calculated using the haversine formula. These inputs are then used to determine the safety zone based on the standards and guidelines developed by WHO and ICNIRP.

Nylund R, Leszczynski D. Proteomics analysis of human endothelial cell line EA.hy926 after exposure to GSM 900 radiation. Proteomics 4:1359-1365, 2004.

The human endothelial cell line EA.hy926 was exposed to mobile phone radiation and the effect on protein expression was examined using two-dimensional electrophoresis (2-DE). Up to 38 various proteins have statistically significantly altered their expression levels following the irradiation. Four proteins were identified with matrix-assisted laser desorption/ionization-mass spectrometry (MALDI-MS). Two of the affected proteins were determined to be isoforms of cytoskeletal vimentin. This finding supports our earlier presented working hypothesis which indicated that the mobile phone radiation might affect the cytoskeleton and might have an effect on the physiological functions that are regulated by the cytoskeleton.

Nylund R, Leszczynski D.Mobile phone radiation causes changes in gene and protein expression in human endothelial cell lines and the response seems to be genome- and proteome-dependent. Proteomics.6(17):4769-4780, 2006.

We have examined in vitro cell response to mobile phone radiation (900 MHz GSM signal) using two variants of human endothelial cell line: EA.hy926 and EA.hy926v1. Gene expression changes were examined in three experiments using cDNA Expression Arrays and protein expression changes were examined in ten experiments using 2-DE and PDQuest software. Obtained results show that gene and protein expression were altered, in both examined cell lines, in response to one hour mobile phone radiation exposure at an average specific absorption rate of 2.8 W/kg. However, the same genes and proteins were differently affected by the exposure in each of the cell lines. This suggests that the cell response to mobile phone radiation might be genome- and proteome-dependent. Therefore, it is likely that different types of cells and from different species might respond differently to mobile phone radiation or might have different sensitivity to this weak stimulus. Our findings might also explain, at least in part, the origin of discrepancies in replication studies between different laboratories.

Nylund R, Kuster N, Leszczynski D. Analysis of proteome response to the mobile phone radiation in two types of human primary endothelial cells. Proteome Sci 8(1):52, 2010.

ABSTRACT: Background Use of mobile phones has widely increased over the past decade. However, in spite of the extensive research, the question of potential health effects of the mobile phone radiation remains unanswered. We have earlier proposed, and applied, proteomics as a tool to study biological effects of the mobile phone radiation, using as a model human endothelial cell line EA.hy926. Exposure of EA.hy926 cells to 900 MHz GSM radiation has caused statistically significant changes in expression of numerous proteins. However, exposure of EA.hy926 cells to 1800 MHz GSM signal had only very small effect on cell proteome, as compared with 900 MHz GSM exposure. In the present study, using as model human primary endothelial cells, we have examined whether exposure to 1800 MHz GSM mobile phone radiation can affect cell proteome. Results Primary human umbilical vein endothelial cells and primary human brain microvascular endothelial cells were exposed for 1 hour to 1800 MHz GSM mobile phone radiation at an average specific absorption rate of 2.0 W/kg. The cells were harvested immediately after the exposure and protein expression patterns of the sham-exposed and radiation-exposed cells were examined using two dimensional difference gel electrophoresis-based proteomics (2DE-DIGE). There were observed numerous differences between the proteomes of human umbilical vein endothelial cells and human brain microvascular endothelial cells (both sham-exposed). These differences are most likely representing physiological differences between endothelia in different vascular beds. However, the exposure of both types of primary endothelial cells to mobile phone radiation did not cause any statistically significant changes in protein expression. Conclusions Exposure of primary human endothelial cells to the mobile phone radiation, 1800 MHz GSM signal for 1 hour at an average specific absorption rate of 2.0 W/kg, does not affect protein expression, when the proteomes were examined immediately after the end of the exposure and when the false discovery rate correction was applied to analysis. This observation agrees with our earlier study showing that the 1800 MHz GSM radiation exposure had only very limited effect on the proteome of human endothelial cell line EA.hy926, as compared with the effect of 900 MHz GSM radiation.

Oberto G, Rolfo K, Yu P, Carbonatto M, Peano S, Kuster N, Ebert S, Tofani S. Carcinogenicity Study of 217 Hz Pulsed 900 MHz electromagnetic fields in pim1 transgenic mice. Radiat Res 168(3):316-326, 2007.

In an 18-month carcinogenicity study, Pim1 transgenic mice were exposed to pulsed 900 MHz (pulse width: 0.577 ms; pulse repetition rate: 217 Hz) radiofrequency (RF) radiation at a whole-body specific absorption rate (SAR) of 0.5, 1.4 or 4.0 W/kg [uncertainty (k = 2): 2.6 dB; lifetime variation (k = 1): 1.2 dB]. A total of 500 mice, 50 per sex per group, were exposed, sham-exposed or used as cage controls. The experiment was an extension of a previously published study in female Pim1 transgenic mice conducted by Repacholi et al. (Radiat. Res. 147, 631-640, 1997) that reported a significant increase in lymphomas after exposure to the same 900 MHz RF signal. Animals were exposed for 1 h/day, 7 days/week in plastic tubes similar to

those used in inhalation studies to obtain well-defined uniform exposure. The study was conducted blind. The highest exposure level (4 W/kg) used in this study resulted in organ-averaged SARs that are above the peak spatial SAR limits allowed by the ICNIRP (International Commission on Non-ionizing Radiation Protection) standard for environmental exposures. The whole-body average was about three times greater than the highest average SAR reported in the earlier study by Repacholi et al. The results of this study do not suggest any effect of 217 Hz-pulsed RF-radiation exposure (pulse width: 0.577 ms) on the incidence of tumors at any site, and thus the findings of Repacholi et al. were not confirmed. Overall, the study shows no effect of RF radiation under the conditions used on the incidence of any neoplastic or non-neoplastic lesion, and thus the study does not provide evidence that RF radiation possesses carcinogenic potential.

Obukhan KI, [The effect of ultrahigh-frequency radiation on adaptation thresholds and the damages to blood system cells]. Lik Sprava (7):71-73, 1998. [Article in Ukrainian]

Cytologic investigations designed to study bone marrow, peripheral blood, spleen, and thymus of albino rats irradiated by an electromagnetic field, 2375, 2450, and 3000 MEGS, revealed structural and functional changes in populations of megakaryocytes, immunocompetent cells as well as of undifferentiated cells, and of other types of cells that are dependent on the intensity of irradiation and permit establishing the probability-threshold levels of exposure taking account of reactions of perception and physiologic adaptation together with compensatory and regenerative processes and the injury sustained. It is shown that changes in bone marrow cells differentiation and reproduction rather than integral shifts in the peripheral blood that acquire the utmost significance. Subjected to a particular scrutiny in the paper are blast cells, which cells' repopulation was noted to be getting increased in low-intensity exposure as were disturbances in their mitosis pattern.

Occhetta E, Plebani L, Bortnik M, Sacchetti G, Trevi G, Implantable cardioverter defibrillators and cellular telephones: is there any interference? Pacing Clin Electrophysiol 22(7):983-989, 1999.

The aim of our study was to consider cellular telephone interference using different cellular telephones and implantable cardioverter defibrillator (ICD) models. Thirty (26 men, 4 women) patients with ICDs were considered during follow-up. The ICD models were: Telectronics (7), CPI (7), Medtronic (7), Ventritex (5), and Ela Medical (4). All patients were monitored with surface ECG; permanent telemetric endo-ECG monitoring was activated. Then, the effect of two different European telephone systems were tested: TACS system (Sony CM-R111, 2W power) and GSM system (Motorola MG1-4A11, 2 W power). For both systems, the effect during call, reception, active conversation (dialogue), and passive conversation (listening) were observed. Cellular telephones were located first in contact with the programming head, then near the leads system, and lastly, in the hands of the patient. At the end of the evaluations, memories were interrogated again to check for false arrhythmia detections. In five of these patients during arrhythmia induction at device implant (first implant or ICD replacement), we also evaluated possible interference between cellular telephones in the reception phase and the ventricular

fibrillation detection phase of the ICD. All evaluated models showed significant noise in the telemetric transmission when the cellular telephone (both TACS and GSM) was located near the ICD and the programming head; noise was particularly significant during call and reception, in most cases leading to loss of telemetry. No false arrhythmia detections have been observed during tests with cellular telephones located on the ICDs. During tests performed with cellular telephones located near the leads or in the hands of patients, no telemetric noises orfalse arrhythmia detections were observed. During induced ventricularfibrillation and cellular telephones in reception mode near the device, the arrhythmia recognition was always correct and not delayed. In conclusion, present ICD models seem to be well protected from electromagnetic interference caused by European cellular telephones (TACS and GSM), without under-/oversensing of ventricular arrhythmias. However, cellular telephones disturb telemetry when located near the programming head. ICD patients should not be advised against the use of cellular telephones, but it has to be avoided during ICD interrogation and programming.

O'Connor RP, Madison SD, Leveque P, Roderick HL, Bootman MD. Exposure to GSM RF fields does not affect calcium homeostasis in human endothelial cells, rat pheocromocytoma cells or rat hippocampal neurons. PLoS One. 5(7):e11828, 2010.

In the course of modern daily life, individuals are exposed to numerous sources of electromagnetic radiation that are not present in the natural environment. The strength of the electromagnetic fields from sources such as hairdryers, computer display units and other electrical devices is modest. However, in many home and office environments, individuals can experience perpetual exposure to an "electromagnetic smog", with occasional peaks of relatively high electromagnetic field intensity. This has led to concerns that such radiation can affect health. In particular, emissions from mobile phones or mobile phone masts have been invoked as a potential source of pathological electromagnetic radiation. Previous reports have suggested that cellular calcium (Ca(2+)) homeostasis is affected by the types of radiofrequency fields emitted by mobile phones. In the present study, we used a high-throughput imaging platform to monitor putative changes in cellular Ca(2+) during exposure of cells to 900 MHz GSM fields of differing power (specific absorption rate 0.012-2 W/Kg), thus mimicking the type of radiation emitted by current mobile phone handsets. Data from cells experiencing the 900 Mhz GSM fields were compared with data obtained from paired experiments using continuous wave fields or no field. We employed three cell types (human endothelial cells, PC-12 neuroblastoma and primary hippocampal neurons) that have previously been suggested to be sensitive to radiofrequency fields. Experiments were designed to examine putative effects of radiofrequency fields on resting Ca(2+), in addition to Ca(2+) signals evoked by an InsP(3)-generating agonist. Furthermore, we examined putative effects of radiofrequency field exposure on Ca(2+) store emptying and store-operated Ca(2+) entry following application of the Ca(2+)ATPase inhibitor thapsigargin. Multiple parameters (e.g., peak amplitude, integrated Ca(2+) signal, recovery rates) were analysed to explore potential impact of radiofrequency field exposure on Ca(2+) signals. Our data indicate that 900 MHz GSM fields do not affect either basal Ca(2+) homeostasis or provoked Ca(2+) signals. Even at the highest field strengths applied,

which exceed typical phone exposure levels, we did not observe any changes in cellular Ca(2+) signals. We conclude that under the conditions employed in our experiments, and using a highly-sensitive assay, we could not detect any consequence of RF exposure.

Odaci E, Bas O, Kaplan S. Effects of prenatal exposure to a 900 MHz electromagnetic field on the dentate gyrus of rats: a stereological and histopathological study.Brain Res. 1238:224-229, 2008.

Electromagnetic fields (EMFs) inhibit the formation and differentiation of neural stem cells during embryonic development. In this study, the effects of prenatal exposure to EMF on the number of granule cells in the dentate gyrus of 4-week-old rats were investigated. This experiment used a control (Cont) group and an EMF exposed (EMF) group (three pregnant rats each group). The EMF group consisted of six offspring (n=6) of pregnant rats that were exposed to an EMF of up to 900 megahertz (MHz) for 60 min/day between the first and last days of gestation. The control group consisted of five offspring (n=5) of pregnant rats that were not treated at all. The offspring were sacrificed when they were 4 weeks old. The numbers of granule cells in the dentate gyrus were analyzed using the optical fractionator technique. The results showed that prenatal EMF exposure caused a decrease in the number of granule cells in the dentate gyrus of the rats ($P<0.01$). This suggests that prenatal exposure to a 900 MHz EMF affects the development of the dentate gyrus granule cells in the rat hippocampus. Cell loss might be caused by an inhibition of granule cell neurogenesis in the dentate gyrus.

Odacı E, Unal D, Mercantepe T, Topal Z, Hancı H, Türedi S, Erol H, Mungan S, Kaya H, Colakoğlu S.Pathological effects of prenatal exposure to a 900 MHz electromagnetic field on the 21-day-old male rat kidney. Biotech Histochem. 2014 Aug 27:1-9. [Epub ahead of print]

We investigated the effects on kidney tissue of 900 megahertz (MHz) EMF applied during the prenatal period. Pregnant rats were exposed to 900 MHz EMF, 1 h/day, on days 13-21 of pregnancy; no procedure was performed on control group pregnant rats or on mothers or newborns after birth. On postnatal day 21, kidney tissues of male rat pups from both groups were examined by light and electron microscopy. Malondialdehyde (MDA), superoxide dismutase (SOD), catalase (CAT) and glutathione levels also were investigated. Light microscopy revealed some degenerative changes in the tubule epithelium, small cystic formations in the primitive tubules and large cysts in the cortico-medullary or medullary regions in the experimental group. Electron microscopy revealed a loss of peritubular capillaries and atypical parietal layer epithelial cells in the experimental group. Biochemical analysis showed significantly increased MDA levels in the experimental group and decreased SOD and CAT levels. EMF applied during the prenatal period can caused pathological changes in kidney tissue in 21-day-old male rats owing to oxidative stress and decreased antioxidant enzyme levels.

Odacı E, Özyılmaz C. Exposure to a 900 MHz electromagnetic field for one hour a day over 30 days does change the histopathology and biochemistry of the rat testis. Int J Radiat Biol. 2015 Mar 19:1-20. [Epub ahead of print]

PURPOSE: This study investigated the effect of exposure to a 900-megahertz (MHz) electromagnetic field (EMF) on the rat testicle. MATERIALS AND METHODS: Twenty-four adult male rats were divided into control, sham and EMF groups. The EMF group rats were exposed to 900-MHz EMF (1 h / 30 day), and testicles were extracted at the end of the experiment. Malondialdehyde, superoxide dismutase, catalase and glutathione levels and apoptotic index and histopathological damage scores were compared. RESULTS: Histopathologically, EMF group rats exhibited vacuoles in seminiferous tubules basal membrane and edema in the intertubular space. Seminiferous tubule diameters and germinal epithelium thickness were both smaller, and apoptotic index was higher, in the EMF group than in the other groups. Malondialdehyde, superoxide dismutase, catalase and glutathione values in the EMF group decreased significantly compared to those of the control group. CONCLUSIONS: The results show that exposure to 900-MHz EMF causes alterations in adult rat testicular morphology and biochemistry.

Odacı E, Hancı H, Yuluğ E, Türedi S, Aliyazıcıoğlu Y, Kaya H, Çolakoğlu S. Effects of prenatal exposure to a 900 MHz electromagnetic field on 60-day-old rat testis and epididymal sperm quality. Biotech Histochem. 91(1):9-19, 2016.

We investigated the effects of exposure in utero to a 900 megahertz (MHz) electromagnetic field (EMF) on 60-day-old rat testis and epididymis. Pregnant rats were divided into control (CG; no treatment) and EMF (EMFG) groups. The EMFG was exposed to 900 MHz EMF for 1 h each day during days 13 - 21 of pregnancy. Newborn rats were either newborn CG (NCG) or newborn EMF groups (NEMFG). On postnatal day 60, a testis and epididymis were removed from each animal. Epididymal semen quality, and lipid and DNA oxidation levels, apoptotic index and histopathological damage to the testis were compared. We found a higher apoptotic index, greater DNA oxidation levels and lower sperm motility and vitality in the NEMFG compared to controls. Immature germ cells in the seminiferous tubule lumen, and altered seminiferous tubule epithelium and seminiferous tubule structure also were observed in hematoxylin and eosin stained sections of NEMFG testis. Nuclear changes that indicated apoptosis were identified in TUNEL stained sections and large numbers of apoptotic cells were observed in most of the seminiferous tubule epithelium in the NEMFG. Sixty-day-old rat testes exposed to 900 MHz EMF exhibited altered sperm quality and biochemical characteristics.

Oftedal G, Wilen J, Sandstrom M, Mild KH, Symptoms experienced in connection with mobile phone use. Occup Med (Lond) 50(4):237-245, 2000.

Many people in Norway and Sweden reported headaches, fatigue, and other symptoms experienced in connection with the use of a mobile phone (MP). Therefore, we initiated a cross-sectional epidemiological study among 17,000 people, all using an MP in their job. Thirty-one percent of the respondents in Norway and 13% of those in Sweden had experienced at least one symptom in connection with MP use. Next to the sensations of warmth on the ear and behind/around the ear, burning sensations in the facial skin and headaches were most commonly reported. Most symptoms usually began during or within half an hour after the call and lasted for up to 2 h. Relatively few had consulted a

physician or been on sick leave because of the symptoms, but about 45% among those with an MP attributed symptom had taken steps to reduce the symptom. These results suggest an awareness of the symptoms, but not necessarily a serious health problem.

Oftedal G, Straume A, Johnsson A, Stovner L. Mobile phone headache: a double blind, sham-controlled provocation study. Cephalalgia.27(5):447-55, 2007.

The objective was to test whether exposure to radio frequency (RF) fields from mobile phones may cause head pain or discomfort and whether it may influence physiological variables in individuals attributing symptoms to mobile phones, but not to electromagnetic fields in general. Seventeen eligible individuals, who experienced these symptoms in an open provocation test, took part in a double-blind, randomized provocation study with cross-over design. Sixty-five pairs of sham and mobile phone RF exposures were conducted. The increase in pain or discomfort (visual analogue scales) in RF sessions was 10.1 and in sham sessions 12.6 (P = 0.30). Changes in heart rate or blood pressure were not related to the type of exposure (P: 0.30-0.88). The study gave no evidence that RF fields from mobile phones may cause head pain or discomfort or influence physiological variables. The most likely reason for the symptoms is a nocebo effect.

Ogawa K, Nabae K, Wang J, Wake K, Watanabe S, Kawabe M, Fujiwara O, Takahashi S, Ichihara T, Tamano S, Shirai T. Effects of gestational exposure to 1.95-GHz W-CDMA signals for IMT-2000 cellular phones: Lack of embryotoxicity and teratogenicity in rats. Bioelectromagnetics. 30(3):205-212, 2009.

The present study was designed to evaluate whether gestational exposure to an EMF targeting the head region, similar to that from cellular phones, might affect embryogenesis in rats. A 1.95-GHz wide-band code division multiple access (W-CDMA) signal, which is one applied for the International Mobile Telecommunication 2000 (IMT-2000) system and used for the freedom of mobile multimedia access (FOMA), was employed for exposure to the heads of four groups of pregnant CD(SD) IGS rats (20 per group) for gestational days 7-17. The exposure was performed for 90 min/day in the morning. The spatial average specific absorption rate (SAR) for individual brains was designed to be 0.67 and 2.0 W/kg with peak brain SARs of 3.1 and 7.0 W/kg for low (group 3) and high (group 4) exposures, respectively, and a whole-body average SAR less than 0.4 W/kg so as not to cause thermal effects due to temperature elevation. Control and sham exposure groups were also included. At gestational day 20, all dams were killed and fetuses were taken out by cesarean section. There were no differences in maternal body weight gain. No adverse effects of EMF exposure were observed on any reproductive and embryotoxic parameters such as number of live (243-271 fetuses), dead or resorbed embryos, placental weights, sex ratios, weights or external, visceral or skeletal abnormalities of live fetuses.

Ohmoto Y, Fujisawa H, Ishikawa T, Koizumi H, Matsuda T, Ito H, Sequential changes in cerebral blood flow, early neuropathological consequences and blood-brain barrier disruption following radiofrequency-induced localized hyperthermia in the rat. Int J Hyperthermia 12(3):321-334, 1996.

We investigated the temperature distribution, early histological changes, blood brain barrier (BBB) disruption and sequential changes in cerebral blood flow (CBF) following hyperthermia ranging from 37 to 45 degrees C in a new rat model of radiofrequency-induced localized cerebral hyperthermia. Significant histological changes and BBB disruption were observed in brain regions heated to 43 degrees C and above. In the cortex heated to 41 degrees C, the CBF doubled 20 min after hyperthermia induction, and then returned gradually to the pre-hyperthermic level. In the cortex heated to 43 degrees C, the CBF increased to 134% of the baseline level 10 min after hyperthermia induction, and then fell gradually to reach its minimum level (31% of the baseline level). In the cortex heated to 45 degrees C, the CBF decreased immediately after hyperthermia induction to reach 10% of the baseline level. The results indicate that hyperthermia-induced cellular injury in the central nervous system is associated with cerebral ischaemia and the threshold temperature for such injury is 43 degrees C. This model is useful for investigating the effects of hyperthermia on various cerebral functions and the CBF changes demonstrated in the present study may provide key information for the analysis of other cerebral functions.

Okano T, Terao Y, Furubayashi T, Yugeta A, Hanajima R, Ugawa Y. The effect of electromagnetic field emitted by a mobile phone on the inhibitory control of saccades. Clin Neurophysiol.121(4):603-611, 2010.

OBJECTIVE: To investigate whether exposure to a pulsed high-frequency electromagnetic field (pulsed EMF) emitted by a mobile phone has short-term effects on the inhibitory control of saccades. METHODS: A double-blind, counterbalanced crossover study design was employed. We assessed the performance of 10 normal subjects on antisaccade (AS) and cued saccade (CUED) tasks as well as two types of overlap saccade (OL1, OL2) task before and after 30min of exposure to EMF emitted by a mobile phone or sham exposure. RESULTS: After EMF or sham exposure, we observed a slight but significant shortening of latency in the CUED and OL2 tasks. AS amplitude decreased as well as the saccade velocities in the AS, CUED, and OL1 tasks after exposure. These changes occurred regardless of whether exposure was real or sham. The frequencies of prosaccades in the AS task, saccades to cue in the CUED task, and prematurely initiated saccades in the overlap (OL2) task did not change significantly after real or sham EMF exposure. CONCLUSIONS: Thirtyminutes of mobile phone exposure has no significant short-term effect on the inhibitory control of saccades. SIGNIFICANCE: The cortical processing responsible for saccade inhibition is not affected by exposure to EMF emitted by a mobile phone.

Oksay T, Naziroğlu M, Doğan S, Güzel A, Gümral N, Koşar PA. Protective effects of melatonin against oxidative injury in rat testis induced by wireless (2.45 GHz) devices. Andrologia. 2012 Nov 12. doi: 10.1111/and.12044. [Epub ahead of print]

Wireless devices have become part of everyday life and mostly located near reproductive organs while they are in use. The present study was designed to determine the possible protective effects of melatonin on oxidative stress-dependent testis injury induced by 2.45-GHz electromagnetic radiation (EMR). Thirty-two rats were equally divided into four different groups, namely cage control (A1), sham

control (A2), 2.45-GHz EMR (B) and 2.45-GHz EMR+melatonin (C). Group B and C were exposed to 2.45-GHz EMR during 60 min day(-1) for 30 days. Lipid peroxidation levels were higher in Group B than in Group A1 and A2. Melatonin treatment prevented the increase in the lipid peroxidation induced by EMR. Also reduced glutathione (GSH) and glutathione peroxidase (GSH-Px) levels in Group D were higher than that of exposure group. Vitamin A and E concentrations decreased in exposure group, and melatonin prevented the decrease in vitamin E levels. In conclusion, wireless (2.45 GHz) EMR caused oxidative damage in testis by increasing the levels of lipid peroxidation and decreasing in vitamin A and E levels. Melatonin supplementation prevented oxidative damage induced by EMR and also supported the antioxidant redox system in the testis.

Oktay MF, **Dasdag S**. **Effects of intensive and moderate cellular phone use on hearing function. Electromagn Biol Med. 25(1):13-21, 2006.**

The purpose of this study is to investigate the effects of radiation emitted by mobile phones on the hearing of users. The study was carried out on three groups: 1) 20 men who have used a cellular phone frequently and spoken approximately 2 h per day for four years; 2) 20 men who have used a cellular phone for 10-20 min per day for four years; and 3) 20 healthy men who have never used a cellular phone (the control group). Brainstem evoked response audiometric (BERA) and pure tone audiometric (PTA) methods were used to measure the effects of exposure on hearing function of the subjects. In BERA measurements, I-III, III-V, and I-V interpeak latencies were evaluated. Interpeak latency of subjects in two experimental groups was compared to that of subjects in the control group. The BERA results showed no differences among the groups ($p > 0.05$).In PTA measurements, detection thresholds at 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz frequencies were measured in all three groups. No differences were observed between moderate mobile phone users (10-20 min. per day) and control subjects. However, detection thresholds in those who talked approximately 2 h per day were found to be higher than those in either moderate users or control subjects. Differences at 4000 Hz for both bone and air conduction for right ears, and 500 Hz, and 4000 Hz bone and air conduction for left ears were significant for mean hearing threshold. This study shows that a higher degree of hearing loss is associated with long-term exposure to electromagnetic (EM) field generated by cellular phones.

Oktem F, Ozguner F, Mollaoglu H, Koyu A, Uz E. Oxidative damage in the kidney induced by 900-MHz-emitted mobile phone: protection by melatonin. Arch Med Res.36(4):350-355, 2005.

BACKGROUND: The mobile phones emitting 900-MHz electromagnetic radiation (EMR) may be mainly absorbed by kidneys because they are often carried in belts. Melatonin, the chief secretory product of the pineal gland, was recently found to be a potent free radical scavenger and antioxidant. The aim of this study was to examine 900-MHz mobile phone-induced oxidative stress that promotes production of reactive oxygen species (ROS) on renal tubular damage and the role of melatonin on kidney tissue against possible oxidative damage in rats. METHODS: The animals were randomly grouped as follows: 1) sham-operated control group and 2) study groups: i) 900-MHz EMR exposed (30 min/day for 10 days) group and ii) 900-MHz EMR exposed+melatonin (100 mug kg(-

1) s.c. before the daily EMR exposure) treated group. Malondialdehyde (MDA), an index of lipid peroxidation), and urine N-acetyl-beta-d-glucosaminidase (NAG), a marker of renal tubular damage were used as markers of oxidative stress-induced renal impairment. Superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px) activities were studied to evaluate the changes of antioxidant status. RESULTS: In the EMR-exposed group, while tissue MDA and urine NAG levels increased, SOD, CAT, and GSH-Px activities were reduced. Melatonin treatment reversed these effects as well. In this study, the increase in MDA levels of renal tissue and in urine NAG and also the decrease in renal SOD, CAT, GSH-Px activities demonstrated the role of oxidative mechanism induced by 900-MHz mobile phone exposure, and melatonin, via its free radical scavenging and antioxidant properties, ameliorated oxidative tissue injury in rat kidney. CONCLUSIONS: These results show that melatonin may exhibit a protective effect on mobile phone-induced renal impairment in rats.

Olchowik G, [Evaluation of bone density in rats after hydrocortisone and microwave radiation]. Chir Narzadow Ruchu Ortop Pol 62(2):163-167, 1997. [Article in Polish]

The influence of hydrocortisone and microwave radiation on bone in rats have been investigated. Hydrocortisone hemisuccinate has been administered intraperitoneally for 12 weeks with concomitant microwave irradiation of two power densities. The results achieved indicate protective effect of electromagnetic microwave radiation on bone tissue exposed to corticotherapy.

Olchowik G, Maj JG, Inhibitory action of microwave radiation on gamma-glutamyl transpeptidase activity in liver of rats treated with hydrocortisone. Folia Histochem Cytobiol 38(4):189-191, 2000.

The influence of microwave irradiation on the activity of gamma-glutamyl transpeptidase (GGT) induced by hydrocortisone (HC) in the liver of rats was investigated. Animals were subjected to microwave irradiation (frequency 53.57 GHz, power density 10 mW/cm2 and 1 mW/cm2) during and after hydrocortisone (HC) treatment (20 mg/kg for 60 days). The results indicate that microwave radiation may block an inducible effect of HC on GGT activity in the liver of rats. This effect depends on the power density of millimetre microwaves.

Olchowik G. Influence of hydrocortisone and microwave radiation on the mechanical characteristics of rat bone tissue. Cytobios 105(410):147-152, 2001.

This work deals with the mutual action of hydrocortisone and low intensity microwave radiation (MWR) on the bone tissue of rats. The bone density and velocity of ultrasound was measured in order to evaluate the Young's modulus of the femur. The results show a stimulating effect of the low-intensity MWR field on regeneration of the bone tissue of rats. The MWR, during a long application of hydrocortisone, may be a characteristic protective factor for the bone tissue.

Olgar Y, Hidisoglu E, Celen MC, Yamasan BE, Yargicoglu P, Ozdemir S. 2.1 GHz electromagnetic field does not change contractility and intracellular Ca2+ transients but decreases β-adrenergic responsiveness through nitric oxide

signaling in rat ventricular myocytes. Int J Radiat Biol. 2015 Jul 1:1-23. [Epub ahead of print]

PURPOSE: Due to the increasing use of wireless technology in developing countries, particularly mobile phones, the influence of electromagnetic fields (EMF) on biologic systems has become the subject of an intense debate. Therefore, in this study we investigated the effect of 2.1 GHz EMF on contractility and beta-adrenergic (β-AR) responsiveness of ventricular myocytes. MATERIALS AND METHODS: Rats were randomized to the following groups: sham rats (SHAM) and rats exposed to 2.1 GHz EMF for 2 hours/day for 10 weeks (EM-10). Sarcomere shortening and Ca^{2+} transients were recorded in isolated myocytes loaded with Fura2-AM and electrically stimulated at 1 Hz, while L-type Ca^{2+} currents (I_{CaL}) were measured using whole-cell patch clamping at 36±1°C. Cardiac nitric oxide (NO) levels were measured in tissue samples using a colorimetric assay kit. RESULTS: Fractional shortening and amplitude of the matched Ca^{2+} transients were not changed in EM-10 rats. Although the isoproterenol-induced (10^{-6} M) I_{CaL} response was reduced in rats exposed to EMF, basal I_{CaL} density in myocytes was similar between the two groups ($p<0.01$). Moreover, EMF exposure led to a significant increase in nitric oxide levels in rat heart ($p<0.02$). CONCLUSIONS: Long-term exposure to 2.1 GHz EMF decreases β-AR responsiveness of ventricular myocytes through NO signaling.

Ono T, Saito Y, Komura J, Ikehata H, Tarusawa Y, Nojima T, Goukon K, Ohba Y, Wang J, Fujiwara O, Sato R. Absence of mutagenic effects of 2.45 GHz radiofrequency exposure in spleen, liver, brain, and testis of lacZ-transgenic mouse exposed in utero. Tohoku J Exp Med 202(2):93-103, 2004.

A possible mutagenic effect of 2.45 GHz radiofrequency exposure was examined using lacZ-transgenic Muta mice. Pregnant animals were exposed intermittently at a whole-body averaged specific absorption rate of 0.71 W/kg (10 seconds on, 50 seconds off which is 4.3 W/kg during the 10 seconds exposure). Offspring that were exposed in utero for 16 hours a day, from the embryonic age of 0 to 15 days, were examined at 10 weeks of age. To minimize thermal effects, the exposure was given in repeated bursts of 10 seconds of exposure followed by 50 seconds of no exposure. Mutation frequencies at the lacZ gene in spleen, liver, brain, and testis were similar to those observed in non-exposed mice. Quality of mutation assessed by sequencing the nucleotides of mutant DNAs revealed no appreciable difference between exposed and non-exposed samples. The data suggest that the level of radiofrequency exposure studied is not mutagenic when administered in utero in short repeated bursts.

Oommen BS, Stahl JS. Inhibited head movements: A risk of combining phoning with other activities? Neurology 65(5):754-756, 2005.

Abstract-- Studies of cellular phone use while driving have attributed impaired performance to the distractions of conversation. We determined that holding an inactive phone to the ear reduces the probability of eccentric head positions, potentially indicating reduced ability to monitor the visual surround. This effect may constitute a risk of cellular phone use independent of conversation and peculiar to handheld models.

Oral B, Guney M, Ozguner F, Karahan N, Mungan T, Comlekci S, Cesur G. Endometrial Apoptosis Induced by a 900-MHz Mobile Phone: Preventive Effects of Vitamins E and C. Adv Ther. 23(6):957-973, 2006.

Numerous reports have described the effects induced by an electromagnetic field (EMF) in various cellular systems. The purposes of this study were to examine oxidative stress that promotes production of reactive oxygen species induced by a 900-megahertz (MHz) mobile phone and the possible ameliorating effects of vitamins E and C on endometrial tissue against EMF-induced endometrial impairment and apoptosis in rats. Animals were randomly grouped as follows: (1) sham-operated control group (n=8), (2) 900 MHz EMF-exposed group (n=8; 30 min/d for 30 d), and (3) 900 MHz EMF-exposed group, treated with vitamins E and C (n=8; 50 mg/kg intramuscularly and 20 mg/kg body weight intraperitoneally before daily EMF exposure). Malondialdehyde (an index of lipid peroxidation) was used as a marker of oxidative stress-induced endometrial impairment; Bcl-2, Bax, caspase-3, and caspase-8 were assessed immunohistochemically. In this study, increased malondialdehyde levels in endometrial tissue and apoptosis illustrated the role of the oxidative mechanism induced by exposure to a 900-MHz mobile phone-like device and vitamins E and C; via free radical scavenging and antioxidant properties, oxidative tissue injury and apoptosis were ameliorated in rat endometrium. In conclusion, exposure to 900-MHz radiation emitted by mobile phones may cause endometrial apoptosis and oxidative stress, but treatment with vitamins E and C can diminish these changes and may have a beneficial effect in preventing endometrial changes in rats.

Orhan Baş, Osman Fikret Sönmez, Ali Aslan, Ayşe İkinci, Hatice Hancı, Mehmet Yıldırım, Haydar Kaya, Metehan Akça, Ersan Odacı. Pyramidal Cell Loss in the Cornu Ammonis of 32-day-old Female Rats Following Exposure to a 900 Megahertz Electromagnetic Field During Prenatal Days 13–21. NeuroQuantology 11:591-599, 2013.

The number of studies reporting that the electromagnetic field (EMF) emitted by mobile phones affects human health is increasing by the day. In previous studies we reported that a 900 megahertz (MHz) EMF applied throughout the prenatal period reduced the number of pyramidal cells in the cornu ammonis of rat pups in the postnatal period. In this study we investigated the effect of a 900 MHz EMF applied on days 13-21 of the prenatal period on the number of pyramidal cells in the cornu ammonis of rat pups in the postnatal period. For that purpose, pregnant rats were divided into experimental and control groups. Experimental group pregnant rats were exposed to the effect of a 900 MHz EMF on days 13-21 of pregnancy. No procedure was applied to the control group. Newborn female rat pups were added to the study, and no procedure was performed on these after birth. Five newborn female rats were obtained from the experimental group and six from the control group. All female rat pups were decapitated on the postnatal 32nd day, and histological procedures were performed on the brain tissues. Sections were stained with Cresyl fast violet. The optical dissector technique was used to estimate the total number of pyramidal cells in the cornu ammonis. Sections of cornu ammonis were subjected to

histopathological evaluations. Our results showed that exposure to 900 MHz EMF during prenatal days 13-21 led to a significant decrease in the number of pyramidal cells in the cornu ammonis of the experimental group female rat pups ($P<0.05$). Histopathological examination revealed picnotic cells in the cornu ammonis in experimental female rat pups. The pyramidal cell loss in the cornu ammonis may therefore be attributed to exposure to 900 MHz EMF in days 13-21 of the prenatal period.

Oster S, Daus AW, Erbes C, Goldhammer M, Bochtler U, Thielemann C. Long-term electromagnetic exposure of developing neuronal networks: A flexible experimental setup. Bioelectromagnetics. 37(4):264-278, 2016

Neuronal networks in vitro are considered one of the most promising targets of research to assess potential electromagnetic field induced effects on neuronal functionality. A few exposure studies revealed there is currently no evidence of any adverse health effects caused by weak electromagnetic fields. Nevertheless, some published results are inconsistent. Particularly, doubts have been raised regarding possible athermal biological effects in the young brain during neuronal development. Therefore, we developed and characterized a flexible experimental setup based on a transverse electromagnetic waveguide, allowing controlled, reproducible exposure of developing neuronal networks in vitro. Measurement of S-parameters confirmed very good performance of the Stripline in the band of 800-1000 MHz. Simulations suggested a flexible positioning of cell culture dishes throughout a large exposure area, as specific absorption rate values were quite independent of their position (361.7 ± 11.4 mW/kg) at 1 W, 900 MHz. During exposure, thermal drift inside cellular medium did not exceed 0.1 K. Embryonic rat cortical neurons were cultivated on microelectrode array chips to non-invasively assess electrophysiological properties of electrogenic networks. Measurements were taken for several weeks, which attest to the experimental setup being a reliable system for long-term studies on developing neuronal tissue.

Othman H, Ammari M, Sakly M, Abdelmelek H. Effects of prenatal exposure to WIFI signal (2.45GHz) on postnatal development and behavior in rat: Influence of maternal restraint. Behav Brain Res. 326:291-302, 2017.

The present study was carried out to investigate the potential combined influence of maternal restraint stress and 2.45GHz WiFi signal exposure on postnatal development and behavior in the offspring of exposed rats. 24 pregnant albino Wistar rats were randomly assigned to four groups: Control, WiFi-exposed, restrained and both WiFi-exposed and restrained groups. Each of WiFi exposure and restraint occurred 2h/day along gestation till parturition. The pups were evaluated for physical development and neuromotor maturation. Moreover, elevated plus maze test, open field activity and stationary beam test were also determined on postnatal days 28, 30 and 31, respectively. After behavioral tests, the rats were anesthetized and their brains were removed for biochemical analysis. Our main findings showed no detrimental effects on gestation progress and outcomes at delivery in all groups. Subsequently, WiFi and restraint, per se and mainly in concert altered physical development of pups with slight differences between genders. Behaviorally, the gestational WiFi irradiation, restraint and especially

the associated treatment affected the neuromotor maturation mainly in male progeny. At adult age, we noticed anxiety, motor deficit and exploratory behavior impairment in male offspring co-exposed to WiFi radiation and restraint, and in female progeny subjected to three treatments. The biochemical investigation showed that, all three treatments produced global oxidative stress in brain of both sexes. As for serum biochemistry, phosphorus, magnesium, glucose, triglycerides and calcium levels were disrupted. Taken together, prenatal WiFi radiation and restraint, alone and combined, provoked several behavioral and biochemical impairments at both juvenile and adult age of the offspring.

Ouellet-Hellstrom R, Stewart WF, Miscarriages among female physical therapists who report using radio- and microwave-frequency electromagnetic radiation. Am J Epidemiol 138(10):775-786, 1993.

Physical therapists are exposed to radio- and microwave-frequency electromagnetic radiation by operating shortwave and microwave diathermy units. Recent studies suggest that use of shortwave diathermy is associated with an excess risk of birth defects, perinatal deaths, and late spontaneous abortions among the offspring of exposed female therapists. To assess the impact of occupational use of microwave and shortwave diathermy at the time of conception, the authors mailed questionnaires to 42,403 physical therapists in 1989. Both occupational and reproductive histories were obtained. Exposures to shortwave and microwave diathermy were both assessed in the same fashion and were examined in relation to early recognized fetal loss in a nested case-control design. A total of 1,753 case pregnancies (miscarriages) were matched to 1,753 incidence density control pregnancies (other pregnancies except ectopic pregnancies). A pregnancy was considered "exposed" if the mother reported using microwave or shortwave diathermy anytime during the 6 months prior to the first trimester or during the first trimester. Pregnancies of mothers reporting microwave use 6 months prior to the pregnancy or during the first trimester were more likely to result in miscarriage (odds ratio (OR) = 1.28, 95% confidence interval (CI) 1.02-1.59). The odds ratio increased with increasing level of exposure (chi 2 = 7.25, $p < 0.005$). The odds ratio in the highest exposure group (20 or more exposures/month) was 1.59. The overall odds ratio was slightly lower after it was controlled for prior fetal loss (OR = 1.26, 95% CI 1.00-1.59), but the exposure-response effect remained (chi 2 = 5.17, $p < 0.01$). The risk of miscarriage was not associated with reported use of shortwave diathermy equipment (OR = 1.07, 95% CI 0.91-1.24). The odds ratio in the highest exposure group was 0.87.

Ozguner F, Aydin G, Mollaoglu H, Gokalp O, Koyu A, Cesur G. Prevention of mobile phone induced skin tissue changes by melatonin in rat: an experimental study. Toxicol Ind Health. 20(6-10):133-139, 2004.

Most of the mobile phones in Turkey emit 900 MHz radiation which is mainly absorbed by the skin and, to a lesser extent, muscle. The aim of this study was to investigate the effects the 900 MHz electromagnetic irradiation emitted by these devices on the induction of histopathologic changes in skin and the effect of melatonin (Mel) on any of these changes. Thirty male Wistar-Albino rats were used in the study. The experimental groups were composed of: a nontreated control group, an irradiated group (IR) without Mel and an irradiated with Mel treatment group (IR + Mel). 900 MHz radiation was applied to IR group for 10 days (30 min/day). The IR + Mel group received 10 mg/kg per day melatonin

in tap water for 10 days before irradiation. At the end of the tenth day, the skin graft was excized from the thoraco-abdominal area. Histopathologic changes in skin were analyzed. In the IR group, increased thickness of stratum corneum, atrophy of epidermis, papillamatosis, basal cell proliferation, increased granular cell layer (hypergranulosis) in epidermis and capillary proliferation, impairment in collagen tissue distribution and separation of collagen bundles in dermis were all observed compared to the control group. Most of these changes, except hypergranulosis, were prevented with melatonin treatment. In conclusion, exposure to 900 MHz radiation emitted by mobile phones caused mild skin changes. Furthermore, melatonin treatment can reduce these changes and may have a beneficial effect to prevent 900 MHz mobile phone-induced rat skin changes.

Ozguner M, Koyu A, Cesur G, Ural M, Ozguner F, Gokcimen A, Delibas N. Biological and morphological effects on the reproductive organ of rats after exposure to electromagnetic field. Saudi Med J. 26(3):405-410, 2005.

OBJECTIVE: The biological effect of electromagnetic field (EMF) emitted from mobile phones is a current debate and still a controversial issue. Therefore, little is known on the possible adverse effects on reproduction as mobile phone bio-effects are only a very recent concern. The aim of this experimental study was to determine the biological and morphological effects of 900 MHz radiofrequency (RF) EMF on rat testes. METHODS: The study was performed in the Physiology and Histology Research Laboratories of Suleyman Demirel University, Faculty of Medicine, Isparta, Turkey in May 2004. Twenty adult male Sprague-Dawley rats weighing 270 - 320 gm were randomized into 2 groups of 10 animals: Group I (control group) was not exposed to EMF and Group II (EMF group) was exposed to 30 minutes per day, 5 days a week for 4 weeks to 900 MHz EMF. Testes tissues were submitted for histologic and morphologic examination. Testicular biopsy score count and the percentage of interstitial tissue to the entire testicular tissue were registered. Serum testosterone, plasma luteinizing hormone (LH) and follicle stimulating hormone (FSH) levels were assayed biochemically. RESULTS: The weight of testes, testicular biopsy score count and the percentage of interstitial tissue to the entire testicular tissue were not significantly different in EMF group compared to the control group. However, the diameter of the seminiferous tubules and the mean height of the germinal epithelium were significantly decreased in EMF group ($p<0.05$). There was a significant decrease in serum total testosterone level in EMF group ($p<0.05$). Therefore, there was an insignificant decrease in plasma LH and FSH levels in EMF group compared to the control group ($p>0.05$). CONCLUSION: The biological and morphological effects resulting from 900 MHz RF EMF exposure lends no support to suggestions of adverse effect on spermatogenesis, and on germinal epithelium. Therefore, testicular morphologic alterations may possibly be due to hormonal changes.

Ozguner F, Oktem F, Ayata A, Koyu A, Yilmaz HR. A novel antioxidant agent caffeic acid phenethyl ester prevents long-term mobile phone exposure-induced renal impairment in rat. Prognostic value of malondialdehyde, N-acetyl-beta-D-glucosaminidase and nitric oxide determination.Mol Cell Biochem. 277(1-2):73-80, 2005.

Caffeic acid phenethyl ester (CAPE), a flavonoid like compound, is one of the major

components of honeybee propolis. It has been used in folk medicine for many years in Middle East countries. It was found to be a potent free radical scavenger and antioxidant recently. The aim of this study was to examine long-term applied 900 MHz emitting mobile phone-induced oxidative stress that promotes production of reactive oxygen species (ROS) and, was to investigate the role of CAPE on kidney tissue against the possible electromagnetic radiation (EMR)-induced renal impairment in rats. In particular, the ROS such as superoxide and nitric oxide (NO) may contribute to the pathophysiology of EMR-induced renal impairment. Malondialdehyde (MDA, an index of lipid peroxidation) levels, urinary N-acetyl-beta-D: -glucosaminidase (NAG, a marker of renal tubular injury) and nitric oxide (NO, an oxidant product) levels were used as markers of oxidative stress-induced renal impairment and the success of CAPE treatment. The activities of superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px) in renal tissue were determined to evaluate the changes of antioxidant status. The rats used in the study were randomly grouped (10 each) as follows: i) Control group (without stress and EMR), ii) Sham-operated rats stayed without exposure to EMR (exposure device off), iii) Rats exposed to 900 MHz EMR (EMR group), and iv) A 900 MHz EMR exposed + CAPE treated group (EMR + CAPE group). In the EMR exposed group, while tissue MDA, NO levels and urinary NAG levels increased ($p < 0.0001$), the activities of SOD, CAT, and GSH-Px in renal tissue were reduced ($p < 0.001$). CAPE treatment reversed these effects as well ($p < 0.0001$, $p < 0.001$ respectively). In conclusion, the increase in NO and MDA levels of renal tissue, and in urinary NAG with the decrease in renal SOD, CAT, GSH-Px activities demonstrate the role of oxidative mechanisms in 900 MHz mobile phone-induced renal tissue damage, and CAPE, via its free radical scavenging and antioxidant properties, ameliorates oxidative renal damage. These results strongly suggest that CAPE exhibits a protective effect on mobile phone-induced and free radical mediated oxidative renal impairment in rats.

Ozguner F, Oktem F, Armagan A, Yilmaz R, Koyu A, Demirel R, Vural H, Uz E. Comparative analysis of the protective effects of melatonin and caffeic acid phenethyl ester (CAPE) on mobile phone-induced renal impairment in rat. Mol Cell Biochem. 276(1-2):31-37, 2005.

Melatonin and caffeic acid phenethyl ester (CAPE), a component of honeybee propolis, were recently found to be potent free radical scavengers and antioxidants. There are a number of reports on the effects induced by electromagnetic radiation (EMR) in various cellular systems. Mechanisms of adverse effects of EMR indicate that reactive oxygen species may play a role in the biological effects of this radiation. The present study was carried out to compare the protective effects of melatonin and CAPE against 900 MHz EMR emitted mobile phone-induced renal tubular injury. Melatonin was administered whereas CAPE was given for 10 days before the exposure. Urinary N-acetyl-beta-D-glucosaminidase (NAG, a marker of renal tubular injury) and malondialdehyde (MDA, an index of lipid peroxidation), were used as markers of oxidative stress-induced renal impairment in rats exposed to EMR. Superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px) activities were studied to evaluate the changes of antioxidant status in renal tissue. Urinary NAG and renal MDA were increased in EMR exposed rats while both melatonin and CAPE caused a significant reduction in the levels of these parameters. Likewise, renal SOD and GSH-Px activities were decreased in EMR

exposed animals while melatonin caused a significant increase in the activities of these antioxidant enzymes but CAPE did not. Melatonin caused a significant decrease in urinary NAG activity and MDA levels which were increased because of EMR exposure. CAPE also reduced elevated MDA levels in EMR exposed renal tissue, but the effect of melatonin was more potent than that of CAPE. Furthermore, treatment of EMR exposed rats with melatonin increased activities of SOD and GSH-Px to higher levels than those of control rats. In conclusion, melatonin and CAPE prevent renal tubular injury by reducing oxidative stress and protect the kidney from oxidative damage induced by 900 MHz mobile phone. Nevertheless, melatonin seems to be a more potent antioxidant compared with CAPE in kidney.

Ozguner F, Altinbas A, Ozaydin M, Dogan A, Vural H, Kisioglu AN, Cesur G, Yildirim NG. Mobile phone-induced myocardial oxidative stress: protection by a novel antioxidant agent caffeic acid phenethyl ester. Toxicol Ind Health. 21(9):223-230, 2005.

Electromagnetic radiation (EMR) or radiofrequency fields of cellular mobile phones may affect biological systems by increasing free radicals, which appear mainly to enhance lipid peroxidation, and by changing the antioxidant defense systems of human tissues, thus leading to oxidative stress. Mobile phones are used in close proximity to the heart, therefore 900 MHz EMR emitting mobile phones may be absorbed by the heart. Caffeic acid phenethyl ester (CAPE), one of the major components of honeybee propolis, was recently found to be a potent free radical scavenger and antioxidant, and is used in folk medicine. The aim of this study was to examine 900 MHz mobile phone-induced oxidative stress that promotes production of reactive oxygen species (ROS) and the role of CAPE on myocardial tissue against possible oxidative damage in rats. Thirty rats were used in the study. Animals were randomly grouped as follows: sham-operated control group (N: 10) and experimental groups: (a) group II: 900 MHz EMR exposed group (N: 10); and (b) group III: 900 MHz EMR exposed+CAPE-treated group (N: 10). A 900 MHz EMR radiation was applied to groups II and III 30 min/day, for 10 days using an experimental exposure device. Malondialdehyde (MDA, an index of lipid peroxidation), and nitric oxide (NO, a marker of oxidative stress) were used as markers of oxidative stress-induced heart impairment. Superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px) activities were studied to evaluate the changes of antioxidant status. In the EMR exposed group, while tissue MDA and NO levels increased, SOD, CAT and GSH-Px activities were reduced. CAPE treatment in group III reversed these effects. In this study, the increased levels of MDA and NO and the decreased levels of myocardial SOD, CAT and GSH-Px activities demonstrate the role of oxidative mechanisms in 900 MHz mobile phone-induced heart tissue damage, and CAPE, via its free radical scavenging and antioxidant properties, ameliorates oxidative heart injury. These results show that CAPE exhibits a protective effect on mobile phone-induced and free radical mediated oxidative heart impairment in rats.

Ozguner F, Bardak Y, Comlekci S. Protective effects of melatonin and caffeic acid phenethyl ester against retinal oxidative stress in long-term use of mobile phone: A comparative study. Mol Cell Biochem. 282(1-2):83-88, 2006.

There are numerous reports on the effects of electromagnetic radiation (EMR) in various

cellular systems. Melatonin and caffeic acid phenethyl ester (CAPE), a component of honeybee propolis, were recently found to be potent free radical scavengers and antioxidants. Mechanisms of adverse effects of EMR indicate that reactive oxygen species may play a role in the biological effects of this radiation. The present study was carried out to compare the efficacy of the protective effects of melatonin and CAPE against retinal oxidative stress due to long-term exposure to 900 MHz EMR emitting mobile phones. Melatonin and CAPE were administered daily for 60 days to the rats prior to their EMR exposure during our study. Nitric oxide (NO, an oxidant product) levels and malondialdehyde (MDA, an index of lipid peroxidation), were used as markers of retinal oxidative stress in rats following to use of EMR. Superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px) activities were studied to evaluate the changes of antioxidant status in retinal tissue. Retinal levels of NO and MDA increased in EMR exposed rats while both melatonin and CAPE caused a significant reduction in the levels of NO and MDA. Likewise, retinal SOD, GSH-Px and CAT activities decreased in EMR exposed animals while melatonin and CAPE caused a significant increase in the activities of these antioxidant enzymes. Treatment of EMR exposed rats with melatonin or CAPE increased the activities of SOD, GSH-Px and CAT to higher levels than those of control rats. In conclusion, melatonin and CAPE reduce retinal oxidative stress after long-term exposure to 900 MHz emitting mobile phone. Nevertheless, there was no statistically significant difference between the efficacies of these two antioxidants against to EMR induced oxidative stress in rat retina. The difference was in only GSH-Px activity in rat retina. Melatonin stimulated the retinal GSH-Px activity more efficiently than CAPE did.

Özgür A, Tümkaya L, Terzi S, Kalkan Y, Erdivanlı ÖÇ, Dursun E. Effects of chronic exposure to electromagnetic waves on the auditory system. Acta Otolaryngol. 2015 Apr 2:1-6. [Epub ahead of print]

OBJECTIVES: Numerous researches have been done about the risks of exposure to the electromagnetic fields that occur during the use of these devices, especially the effects on hearing. The aim of this study is to evaluate the effects of the electromagnetic waves emitted by the mobile phones through the electrophysiological and histological methods. METHODS: Twelve adult Wistar albino rats were included in the study. The rats were divided into two groups of six rats. The study group was exposed to the electromagnetic waves over a period of 30 days. The control group was not given any exposure to the electromagnetic fields. After the completion of the electromagnetic wave application, the auditory brainstem responses of both groups were recorded under anesthesia. The degeneration of cochlear nuclei was graded by two different histologists, both of whom were blinded to group information. RESULTS: The histopathologic and immunohistochemical analysis showed neuronal degeneration signs, such as increased vacuolization in the cochlear nucleus, pyknotic cell appearance, and edema in the group exposed to the electromagnetic fields compared to the control group. The average latency of wave in the ABR was similar in both groups ($p > 0.05$). CONCLUSION: The results support that chronic electromagnetic field exposure may cause damage by leading to neuronal degeneration of the auditory system.

Ozgur E, Güler G, Seyhan N. Mobile phone radiation-induced free radical

damage in the liver is inhibited by the antioxidants n-acetyl cysteine and epigallocatechin-gallate. Int J Radiat Biol.86(11):935-945, 2010.

Purpose: To investigate oxidative damage and antioxidant enzyme status in the liver of guinea pigs exposed to mobile phone-like radiofrequency radiation (RFR) and the potential protective effects of N-acetyl cysteine (NAC) and epigallocatechin-gallate (EGCG) on the oxidative damage. Materials and methods: Nine groups of guinea pigs were used to study the effects of exposure to an 1800-MHz Global System for Mobile Communications (GSM)-modulated signal (average whole body Specific Absorption Rate (SAR) of 0.38 W/kg, 10 or 20 min per day for seven days) and treatment with antioxidants. Results: Significant increases in malondialdehyde (MDA) and total nitric oxide (NO(x)) levels and decreases in activities of superoxide dismutase (SOD), myeloperoxidase (MPO) and glutathione peroxidase (GSH-Px) were observed in the liver of guinea pigs after RFR exposure. Only NAC treatment induces increase in hepatic GSH-Px activities, whereas EGCG treatment alone attenuated MDA level. Extent of oxidative damage was found to be proportional to the duration of exposure ($P < 0.05$). Conclusion: Mobile phone-like radiation induces oxidative damage and changes the activities of antioxidant enzymes in the liver. The adverse effect of RFR may be related to the duration of mobile phone use. NAC and EGCG protect the liver tissue against the RFR-induced oxidative damage and enhance antioxidant enzyme activities.

Ozgur E, Kismali G, Guler G, Akcay A, Ozkurt G, Sel T, Seyhan N. Effects of Prenatal and Postnatal Exposure to GSM-Like Radiofrequency on Blood Chemistry and Oxidative Stress in Infant Rabbits, an Experimental Study. Cell Biochem Biophys. 2013 Mar 24. [Epub ahead of print]

We aimed to investigate the potential hazardous effects of prenatal and/or postnatal exposure to 1800 MHz GSM-like radiofrequency radiation (RFR) on the blood chemistry and lipid peroxidation levels of infant rabbits. A total of 72 New Zealand female and male white rabbits aged 1-month were used. Thirty-six female and 36 male were divided into four groups which were composed of nine infants: (i) Group 1 were the sham exposure (control), (ii) Group 2 were exposed to RFR, 15 min daily for 7 days in the prenatal period (between 15th and 22nd days of the gestational period) (prenatal exposure group). (iii) Group 3 were exposed to RFR 15 min/day (14 days for male, whereas 7 days for female) after they reached 1-month of age (postnatal exposure group). (iv) Group 4 were exposed to RFR for 15 min daily during 7 days in the prenatal period (between 15th and 22nd days of the gestational period) and 15 min/day (14 days for male, whereas 7 days for female) after they reached 1-month of age (prenatal and postnatal exposure group). Results showed that serum lipid peroxidation level in both female and male rabbits changed due to the RFR exposure. However, different parameters of the blood biochemistry were affected by exposure in male and female infants. Consequently, the whole-body 1800 MHz GSM-like RFR exposure may lead to oxidative stress and changes on some blood chemistry parameters. Studies on RFR exposure during prenatal and postnatal periods will help to establish international standards for the protection of pregnants and newborns from environmental RFR.

Ozgur E, Guler G, Kismali G, Seyhan N. Mobile Phone Radiation Alters Proliferation of Hepatocarcinoma Cells. Cell Biochem Biophys. 2014 May 11. [Epub ahead of print]

This study investigated the effects of intermittent exposure (15 min on, 15 min off for 1, 2, 3, or 4 h, at a specific absorption rate of 2 W/kg) to enhanced data rates for global system for mobile communication evolution-modulated radiofrequency radiation (RFR) at 900- and 1,800-MHz frequencies on the viability of the Hepatocarcinoma cells (Hep G2). Hep G2 cell proliferation was measured by a colorimetric assay based on the cleavage of the tetrazolium salt WST-1 by mitochondrial dehydrogenases in viable cells. Cell injury was evaluated by analyzing the levels of lactate dehydrogenase (LDH) and glucose released from lysed cells into the culture medium. Morphological observation of the nuclei was carried out by 4',6-diamidino-2-phenylindole (DAPI) staining using fluorescence microscopy. In addition, TUNEL assay was performed to confirm apoptotic cell death. It was observed that cell viability, correlated with the LDH and glucose levels, changed according to the frequency and duration of RFR exposure. Four-hour exposure produced more pronounced effects than the other exposure durations. 1,800-MHz RFR had a larger impact on cell viability and Hep G2 injury than the RFR at 900 MHz. Morphological observations also supported the biochemical results indicating that most of the cells showed irregular nuclei pattern determined by using the DAPI staining, as well as TUNEL assay which shows DNA damage especially in the cells after 4 h of exposure to 1,800-MHz RFR. Our results indicate that the applications of 900- and 1,800-MHz (2 W/kg) RFR cause to decrease in the proliferation of the Hep G2 cells after 4 h of exposure. Further studies will be conducted on other frequency bands of RFR and longer duration of exposure.

Ozgur E, Sahin D, Tomruk A, Guler G, Sepici-Dinçel A, Altan N, Seyhan N. The Effects of N-acetyl-L-cysteine and Epigallocatechin-3-gallate on Liver Tissue Protein Oxidation and Antioxidant Enzyme Levels After the Exposure to Radio Frequency Radiation. Int J Radiat Biol. 2014 Sep 24:1-19. [Epub ahead of print]

PURPOSE: The widespread and sustained use of mobile and cordless phones causes unprecedented increase of radiofrequency radiation (RFR). The aim of this experimental study was to investigate the effect of 900 MHz Global System for Mobile Communications (GSM) modulated RFR (average whole body Specific Absorption Rate (SAR) of 0,4 W/kg, 10 or 20 min daily for consecutive 7 days) to the liver tissue of guinea pigs and the protective effects of antioxidant treatments. MATERIALS and METHODS: Adult male guinea pigs were randomly divided into nine groups as; Group I (Sham/saline), Group II (Sham/EGCG), Group III (Sham/NAC), Group IV (10-min RF-exposure/saline), Group V (20-min RF-exposure/saline), Group VI (10-min RF-exposure/EGCG), Group VII (20-min RF-exposure/EGCG), Group VIII (10-min RF-exposure/NAC), Group IX (20-min RF-exposure/NAC). Protein oxidation (PCO), advanced oxidation protein products (AOPP) and antioxidant enzyme activities of superoxide dismutase (SOD) were evaluated after the exposure and the treatments with N-acetylcysteine (NAC) and (-)-epigallocatechin-3-gallate (EGCG). RESULTS and CONCLUSIONS: Significant decreases in the activities of SOD were observed in the liver of guinea pigs after RFR exposure. Protein damage did

not change due to RFR exposure. On the other hand, only NAC treatment induces increase PCO levels, whereas EGCG treatment alone elevated the level of AOPP. Due to antioxidants have pro-oxidant behavior, the well decided doses and treatment time tables of NAC and ECGC is needed.

Ozlem Nisbet H, Nisbet C, Akar A, Cevik M, Karayigit MO. Effects of exposure to electromagnetic field (1.8/0.9 GHz) on testicular function and structure in growing rats. Res Vet Sci. 93(2):1001-1005, 2012.

The aim of our study was to evaluate the possible effects of whole-body electromagnetic field (EMF) exposure on reproduction in growing male rats. Male albino Wistar rats (2 days old) were exposed to EMF 1800 and 900 MHz for 2 h continuously per day for 90 days. Sham control was kept under similar conditions except that the field was not applied for the same period. After blood samples were collected, the animals were sacrificed 24 h after the last exposure and the tissues of interest were harvested. The mean plasma total testosterone showed similarity among the two study groups and was significantly higher than the sham control rats. The percentage of epididymal sperm motility was significantly higher in the 1800 MHz group ($P<0.05$). The morphologically normal spermatozoa rates were higher and the tail abnormality and total percentage abnormalities were lower in the 900 MHz group ($P<0.05$). Histopathologic parameters in the 1800 MHz group were significantly higher ($P<0.05$). In conclusion, the present study indicated that exposure to electromagnetic wave caused an increase in testosterone level, epididymal sperm motility (forward), and normal sperm morphology of rats. As a consequences, 1800 and 900 MHz EMF could be considered to be a cause of precocious puberty in growing rats.

Ozturan O, Erdem T, Miman MC, Kalcioglu MT, Oncel S. Effects of the electromagnetic field of mobile telephones on hearing. Acta Otolaryngol. 122(3):289-293, 2002.

The widespread use of mobile telephones has given rise to concern about the potential influences of electromagnetic fields (EMFs) on human health. Anatomically, the ear is in close proximity to the mobile telephone during use. Hearing loss due to mobile telephone use has not been described in the medical literature; however, if there is a subtle cochlear involvement, it might be detected by means of changes in evoked otoacoustic emissions (OAEs). Thirty volunteers with normal hearing were exposed to mobile telephone EMFs for 10 min and evoked OAEs were measured before and after exposure. No measurable change in evoked OAEs was detected and none of the subjects reported a deterioration in hearing level. To the best of our knowledge, this is the first study on the effects of EMFs emitted by mobile telephones on hearing. It was concluded that a 10-min exposure to the EMF emitted from a mobile telephone had no effect on hearing, at least at outer ear, middle ear and cochlear levels.

Pachón-García FT, Fernández-Ortiz K, Paniagua-Sánchez JM. Assessment of Wi-Fi radiation in indoor environments characterizing the time & space-varying electromagnetic fields. Measurement 63:309-321, 2015.
This paper focuses on the study of emissions in Wi-Fi networks in a typical indoor place, inside a building, by quantifying exposure levels detected in different locations of the

house, when router-terminal devices are in specific positions, and also by characterizing the fluctuations arising from the type of traffic which is sent through the network. The assessment of exposure was carried out collecting measurements with the novel dosimeter 'EME Spy-140' in a real scenario and comparing the results with the corresponding theoretical levels and other studies. A global sum of 4875 samples were collected, analyzing 25 locations in the mentioned house. The ROS-MLE method was used for fitting levels to statistical distributions. Maximum background exposure to WLAN (our WiFi network off) is 0.039 V/m. With our WiFi network in operation, maximum exposure increases to 2.6 V/m in the far field region of the transmitters (with 90th percentile of 2.2 V/m). Concerning the type of traffic, oscillations up to 10 dB were detected for exactly the same position, depending on whether Web-browsing or P2P traffic was being sent. Differences around 62 dB in mean values between the different rooms of the house were found. All values are below the threshold of 61 V/m that standards set (at least 12 times below it). Undoubtedly, this type of study is important to raise awareness that radiation coming from this technology is not negligible, and should be controlled, as well as providing an overview of level fluctuations in a given context. This information helps clarify epidemiological studies about exposure levels.

Pacini S, Ruggiero M, Sardi I, Aterini S, Gulisano F, Gulisano M. Exposure to global system for mobile communication (GSM) cellular phone radiofrequency alters gene expression, proliferation, and morphology of human skin fibroblasts. Oncol Res 13(1):19-24, 2002.

Human skin fibroblasts were exposed to global system for mobile communication (GSM) cellular phone radiofrequency for 1 h. GSM exposure induced alterations in cell morphology and increased the expression of mitogenic signal transduction genes (e.g., MAP kinase kinase 3, G2/mitotic-specific cyclin G1), cell growth inhibitors (e.g., transforming growth factor-beta), and genes controlling apoptosis (e.g., bax). A significant increase in DNA synthesis and intracellular mitogenic second messenger formation matched the high expression of MAP kinase family genes. These findings show that these electromagnetic fields have significant biological effects on human skin fibroblasts.

Paffi A, Apollonio F, Pinto R, Liberti M. Cenarios approach to the electromagnetic exposure: the case study of a train compartment. Biomed Res Int. 2015;2015:869895. doi: 10.1155/2015/869895. Epub 2015 Feb 23.

Previous studies identified the train compartment as the place where people can experience the highest exposure levels (still below the international guideline limits) to electromagnetic fields in the radiofrequency range. Here a possible scenario of a train compartment has been reproduced and characterized, both numerically and experimentally. A good agreement between the simulated electric field distributions and measurements has been found. Results indicate that the higher values of exposure in specific positions inside the train compartment depend on the number of active cell phones, the bad coverage condition, the cell orientation, and the presence of metallic walls. This study shows that the proposed approach, based on the scenarios characterization, may efficiently support the assessment of the individual electromagnetic exposure.

Paglialonga A, Tognola G, Parazzini M, Lutman ME, Bell SL, Thuroczy G, Ravazzani P. Effects of mobile phone exposure on time frequency fine structure of transiently evoked otoacoustic emissions. J Acoust Soc Am. 122(4):2174-2182, 2007.

Mobile phones have become very commonly used worldwide within a short period of time. To date there is only limited knowledge about interaction between electromagnetic fields (EMFs) emitted by mobile phones and the auditory function. Moreover, there is widespread concern that there may be potential for harm. The aim of this study was to assess potential subtle changes in cochlear function by measuring the temporal and spectral fine structure of transiently evoked otoacoustic emissions (TEOAE) in normal hearing subjects after exposure to EMFs emitted by Global System for Mobile Communication (GSM) mobile phones. TEOAEs were recorded in 27 healthy young adults before and after 10 min of real or sham exposure in a double-blind design. TEOAE data were analyzed both globally (broadband analysis) and using the Wavelet Transform (analysis of the time-frequency fine structure). The broadband analysis revealed no significant effect on TEOAEs related to exposure, confirming results of previous studies; in addition, no significant change was detected in the analysis of the elementary wavelet components, suggesting that the temporal and spectral fine structure of TEOAEs is not affected by 10 min exposure to low-intensity EMFs emitted by GSM mobile phones.

Paik MJ, Kim HS, Lee YS, Do Choi H, Pack JK, Kim N, Ahn YH. Metabolomic study of urinary polyamines in rat exposed to 915 MHz radiofrequency identification signal. Amino Acids. 2015 Aug 29. [Epub ahead of print]

Metabolomic analysis of urinary polyamines (PAs) from rat exposed to 915 MHz radiofrequency identification (RFID) signal for 8 h/day for 2 weeks was performed by gas chromatography-mass spectrometry as N-ethoxycarbonyl/N-pentafluoropropionyl derivatives. Large alterations in nine PA levels including four aliphatic and five acetylated PAs were monitored in sham-exposed and RFID-exposed groups. Total PA and urinary levels of N^1-acetylputrescine, N^1-acetylcadaverine, putrescine, cadaverine, N^1-acetylspermidine, N^8-acetylspermidine, spermidine and spermine were reduced, whereas N^1-acetylspermine was significantly increased after sham and RFID exposure compared with those before exposure. Their levels were normalized to the corresponding group means before exposure and then plotted into star symbol patterns. N^1-Acetylspermine after RFID exposure was 54 % higher compared to the level before RFID exposure, while it was elevated by only 17 % in the sham group. The results suggest that 915 MHz RFID exposure may induce metabolic disturbance of PA. It may also elevate spermidine/spermine acetyltransferase (SSAT) activity. Thus, the present metabolic profiling combined with star pattern recognition method might be useful for understanding the complexity of biochemical events after exposure to RFID signal.

Pakhomov AG, [Non-thermal microwave effect on nerve fiber function]. Biofizika 38(2):367-371, 1993. [Article in Russian]

Effects of microwave radiation (915 MHz, PW, peak SAR 20-30 W/g, pulse duration 1 mcs, 50.000 and 25.000 p.p.s.) were investigated in isolated frog nerve cord preparation.

Nerve VHF heating didn't exceed 2.2 degrees C due to intense Ringer's solution perfusion. It was established that nerve irradiation simultaneously with its stimulation lead to significant decrease of action potential amplitude and peak latency. Since the equal conventional heating of the nerve caused the opposite changes (amplitude increase), the results obtained argue for non-thermal mechanism of microwave action.

Pakhomov AG, Dubovick BV, Degtyariov IG, Pronkevich AN, Microwave influence on the isolated heart function: II. Combined effect of radiation and some drugs. Bioelectromagnetics 16(4):250-254, 1995.

The combined effects of microwave radiation and some drugs were studied in an isolated frog auricle preparation. The experiments established that exposure to pulse-modulated 915 MHz microwaves for up to 40 min had no effect on either the rate or the amplitude of spontaneous auricle twitches, unless the average absorbed power was high enough to produce preparation heating. Treatment of the preparation with saline containing (0.6-3.0) 10(-5) M of propranolol or (0.5-1.5) 10(-7) M of atropine altered neither its pacemaker nor its contractile functions; these drugs also had no effect when they were combined with nonthermal microwave irradiation. Caffeine (1 mM) strongly increased the average heart power, which was calculated as the product of twitch rate and amplitude. The caffeine effect appeared to be significantly augmented (by about 15%, $P < 0.02$) under exposure to burst-type pulsed microwaves (pulse width, 1.5 msec; pause, 2.5 msec; 8 pulses/burst, 16 bursts/s; average SAR, 8-10 W/kg). By itself, this modulation was not effective; the heating of the preparation and saline during exposure was approximately 0.1 degrees C, which could not account for the detected changes. The experimental results demonstrate that caffeine treatment increases the microwave sensitivity of the frog auricle preparation and reveals primarily subthreshold, nonthermal microwave effect.

Pakhomov AG, Dubovick BV, Degtyariov IG, Pronkevich AN, Microwave influence on the isolated heart function: I. Effect of modulation. Bioelectromagnetics 16(4):241-249, 1995.

Dependence of the microwave effect on modulation parameters (pulse width, duty ratio, and peak intensity) was studied in an isolated frog auricle preparation. The rate and amplitude of spontaneous auricle twitches were measured during and after a 2 min exposure to 915 or 885 MHz microwaves and were compared to preexposure values. The studied ranges of modulation parameters were: pulse width, 10(-6)-10(-2) s; duty ratio, 7:100000, and peak specific absorption rate, 100-3000 W/kg. Combinations of the parameters were chosen by chance, and about 400 various exposure regimes were tested. The experiments established that no regime was effective unless the average microwave power was high enough to induce preparation heating (0.1-0.4 degree C). The twitch rate instantly increased, and the amplitude decreased, as the temperature rose; similar changes could be induced by equivalent conventional heating. The data provide evidence that the effect of short-term microwave exposure on the isolated heart pacemaker and contractile functions depends on pulse modulation just as much as modulation determines the average absorbed power. These functions demonstrated no specific dependence on exposure parameters such as frequency or power windows.

Pakhomova ON, Belt ML, Mathur SP, Lee JC, Akyel Y, Ultra-wide band

electromagnetic radiation does not affect UV-induced recombination and mutagenesis in yeast. Bioelectromagnetics 19(2):128-130, 1998.

Cell samples of the yeast Saccharomyces cerevisiae were exposed to 100 J/m2 of 254 nm ultraviolet (UV) radiation followed by a 30 min treatment with ultra-wide band (UWB) electromagnetic pulses. The UWB pulses (101-104 kV/m, 1.0 ns width, 165 ps rise time) were applied at the repetition rates of 0 Hz (sham), 16 Hz, or 600 Hz. The effect of exposures was evaluated from the colony-forming ability of the cells on complete and selective media and the number of aberrant colonies. The experiments established no effect of UWB exposure on the UV-induced reciprocal and non-reciprocal recombination, mutagenesis, or cell survival.

Pakhomov AG, Mathur SP, Doyle J, Stuck BE, Kiel JL, Murphy MR, Comparative effects of extremely high power microwave pulses and a brief CW irradiation on pacemaker function in isolated frog heart slices. Bioelectromagnetics 21(4):245-254, 2000.

The existence of specific bioeffects due to high peak power microwaves and their potential health hazards are among the most debated but least explored problems in microwave biology. The present study attempted to reveal such effects by comparing the bioeffects of short trains of extremely high power microwave pulses (EHPP, 1 micros width, 250-350 kW/g, 9.2 GHz) with those of relatively low power pulses (LPP, 0.5-10 s width, 3-30 W/g, 9.2 GHz). EHPP train duration and average power were made equal to those of an LPP; therefore both exposure modalities produced the same temperature rise. Bioeffects were studied in isolated, spontaneously beating slices of the frog heart. In most cases, a single EHPP train or LPP immediately decreased the inter-beat interval (IBI). The effect was proportional to microwave heating, fully reversible, and easily reproducible. The magnitude and time course of EHPP- and LPP-induced changes always were the same. No delayed or irreversible effects of irradiation were observed. The same effect could be repeated in a single preparation numerous times with no signs of adaptation, sensitization, lasting functional alteration, or damage. A qualitatively different effect, namely, a temporary arrest of preparation beats, could be observed when microwave heating exceeded physiologically tolerable limits. This effect also did not depend on whether the critical temperature rise was produced by LPP or EHPP exposure. Within the studied limits, we found no indications of EHPP-specific bioeffects. EHPP- and LPP-induced changes in the pacemaker rhythm of isolated frog heart preparation were identical and could be entirely attributed to microwave heating.

Pakhomov AG, Gaj□ek P, Allen L, Stuck BE, Murphy MR. Comparison of dose dependences for bioeffects of continuous-wave and high-peak power microwave emissions using gel-suspended cell cultures. Bioelectromagnetics 23: 158-167, 2002.

The study compared bioeffects of continuous wave (CW) microwaves and short, extremely high power pulses (EHPP) at the same carrier frequency (9.3 GHz) and average power (1.25 W). The peak transmitted power for EHPP was 250 kW (0.5-μs pulse width, 10 p.p.s.), producing the E field of 1.57 MV/m in the waveguide. A biological endpoint was the density of yeast cells, achieved after a 6 h growth period in a solid nutrient medium (agarose gel) during EHPP or CW exposure. Owing to power losses in

the medium, the specific absorption rate (SAR) ranged from 3.2 kW/kg at the exposed surface of the sample to 0.6 mW/kg at 24 mm depth. Absorption and penetration of EHPP was identical to CW, producing peak SAR values 200 000 times higher than the average SAR, as high as 650 MW/kg at the surface. CW and EHPP exposures produced highly nonuniform but identical heating patterns in exposed samples. Following the exposure, the samples were sliced in a plane perpendicular to the wave propagation, in order to separate cell masses exposed at different SAR levels. Cell density in the slices was determined by nephelometry and compared to unexposed parallel control samples. Cell density was strongly affected by irradiation, and the changes correlated well with the local temperature rise. However, the data revealed no statistically significant difference between CW and EHPP samples across the entire studied range of SAR levels (over six orders of magnitude). A trend ($P < 0.1$) for such a difference was observed in slices that were exposed at a time average SAR of 100 W/kg and higher, which corresponded to peak SAR above 20 MW/kg for the EHPP condition. These numbers could be indicative of a threshold for a specific (not merely thermal) exposure effect if the trend is confirmed by future studies.

Palfia Z, Somosy Z, Rez G. Tight junctional changes upon microwave and x-ray irradiation. Acta Biol Hung 52(4):411-416, 2001.

Tight junctions (zonulae occludentes, ZO) are cellularly regulated dynamic structures sensitive to environmental stress agents including ionizing radiation. Radiation induced pathological alterations of the small intestine (gastrointestinal radiation syndrome) are related to altered ZO-mediated paracellular transport. We carried out a quantitative morphological evaluation of the murine jejunal epithelial tight junctional structure in freeze fracture replicas as changed upon whole body X-ray irradiation and low energy microwave exposition. X-ray treatment (4 Gy, 1, 24 h) brought about a partial dearrangement of the ZO strand network which regenerated only partially by 24 h. This observation is in line with data on paracellular permeability increases and ZO-bound calcium drop caused by X-ray irradiation. On the other hand, microwave treatment (16 Hz-modulated 2.45 GHz wave, 1 mW/cm2 power density, I h exposition, samples at I and 3 h after exposition) did not cause dearrangement but, rather an increase in the integration of thight junctional structure, which is in agreement with an increase in cytochemically detectable ZO-bound calcium.

Palumbo R, Brescia F, Capasso D, Sannino A, Sarti M, Capri M, Grassilli E, Scarfì MR. Exposure to 900 MHz radiofrequency radiation induces caspase 3 activation in proliferating human lymphocytes. Radiat Res. 170(3):327-334, 2008.

In this study, the induction of apoptosis after exposure to 900 MHz radiofrequency radiation (GSM signal) was investigated by assessing caspase 3 activation in exponentially growing Jurkat cells and in quiescent and proliferating human peripheral blood lymphocytes (PBLs). The exposure was carried out at an average specific absorption rate of 1.35 W/kg in a dual wire patch cell exposure system where the temperature of cell cultures was accurately controlled. After 1 h exposure to the radiofrequency field, a slight but statistically significant increase in caspase 3 activity, measured 6 h after exposure, was observed in Jurkat cells (32.4%) and in proliferating human PBLs (22%). In contrast, no effect was detected in quiescent

human PBLs. In the same experimental conditions, apoptosis was also evaluated in Jurkat cells by Western blot analysis and in both cell types by flow cytometry. To evaluate late effects due to caspase 3 activity, flow cytometry was also employed to assess apoptosis and viability 24 h after radiofrequency-radiation exposure in both cell types. Neither the former nor the latter was affected. Since in recent years it has been reported that caspases are also involved in processes other than apoptosis, additional cell cycle studies were carried out on proliferating T cells exposed to radiofrequency radiation; however, we found no differences between sham-exposed and exposed cultures. Further studies are warranted to investigate the biological significance of our findings of a dose-response increase in caspase 3 activity after exposure to radiofrequency radiation.

Panagopoulos DJ, Karabarbounis A, Margaritis LH. Effect of gsm 900-mhz mobile phone radiation on the reproductive capacity of drosophila melanogaster. Electromag Biol Med 23:29-43, 2004.

Pulsed radio frequency, (RF), electromagnetic radiation from common GSM mobile phones, (Global System for Mobile Telecommunications) with a carrier frequency at 900 MHz, “modulated” by human voice, (speaking emission) decreases the reproductive capacity of the insect Drosophila melanogaster by 50%–60%, whereas the corresponding “nonmodulated” field (nonspeaking emission) decreases the reproductive capacity by 15%–20%. The insects were exposed to the near field of the mobile phone antenna for 6 min per day during the first 2–5 days of their adult lives. The GSM field is found to affect both females and males. Our results suggest that this field-radiation decreases the rate of cellular processes during gonad development in insects.

Panagopoulos DJ, Chavdoula ED, Nezis IP, Margaritis LH Cell death induced by GSM 900-MHz and DCS 1800-MHz mobile telephony radiation. Mutat Res.626(1-2):69-78, 2007.

In the present study, the TUNEL (Terminal deoxynucleotide transferase dUTP Nick End Labeling) assay - a well known technique widely used for detecting fragmented DNA in various types of cells - was used to detect cell death (DNA fragmentation) in a biological model, the early and mid stages of oogenesis of the insect Drosophila melanogaster. The flies were exposed in vivo to either GSM 900-MHz (Global System for Mobile telecommunications) or DCS 1800-MHz (Digital Cellular System) radiation from a common digital mobile phone, for few minutes per day during the first 6 days of their adult life. The exposure conditions were similar to those to which a mobile phone user is exposed, and were determined according to previous studies of ours [D.J. Panagopoulos, A. Karabarbounis, L.H. Margaritis, Effect of GSM 900-MHz mobile phone radiation on the reproductive capacity of D. melanogaster, Electromagn. Biol. Med. 23 (1) (2004) 29-43; D.J. Panagopoulos, N. Messini, A. Karabarbounis, A.L. Philippetis, L.H. Margaritis, Radio frequency electromagnetic radiation within "safety levels" alters the physiological function of insects, in: P. Kostarakis, P. Stavroulakis (Eds.), Proceedings of the Millennium International Workshop on Biological Effects of Electromagnetic Fields, Heraklion, Crete, Greece, October 17-20, 2000, pp. 169-175, ISBN: 960-86733-0-5; D.J. Panagopoulos, L.H.

Margaritis, Effects of electromagnetic fields on the reproductive capacity of D. melanogaster, in: P. Stavroulakis (Ed.), Biological Effects of Electromagnetic Fields, Springer, 2003, pp. 545-578], which had shown a large decrease in the oviposition of the same insect caused by GSM radiation. Our present results suggest that the decrease in oviposition previously reported, is due to degeneration of large numbers of egg chambers after DNA fragmentation of their constituent cells, induced by both types of mobile telephony radiation. 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.

Panagopoulos DJ, Chavdoula ED, Karabarbounis A, Margaritis LH. Comparison of bioactivity between GSM 900 MHz and DCS 1800 MHz mobile telephony radiation. Electromagn Biol Med. 26(1):33-44, 2007.

An increasing number of studies find that pulsed Radio Frequency (RF), electromagnetic radiation of both systems of digital mobile telephony, established and commonly used in Europe during the last years, GSM 900 MHz (Global System for Mobile telecommunications) and DCS 1800 MHz (Digital Cellular System), exert intense biological action on different organisms and cells (Hardell et al., 2006; Hyland, 2000; Kundi, 2004; Panagopoulos et al., 2004, 2007). The two types of cellular telephony radiation use different carrier frequencies and give different frequency spectra, but they usually also differ in intensity, as GSM 900 MHz antennas operate at about double the power output than the corresponding DCS 1800 MHz ones. In our present experiments, we used a model biological system, the reproductive capacity of Drosophila melanogaster, to compare the biological activity between the two systems of cellular mobile telephony radiation. Both types of radiation were found to decrease significantly and non thermally the insect's reproductive capacity, but GSM 900 MHz seems to be even more bioactive than DCS 1800 MHz. The difference seems to be dependent mostly on field intensity and less on carrier frequency.

Panagopoulos DJ, Chavdoula ED, Margaritis LH. Bioeffects of mobile telephony radiation in relation to its intensity or distance from the antenna. Int J Radiat Biol. 86(5):345-357, 2010.

PURPOSE: To examine the bioactivity of GSM 900 and 1800 (Global System for Mobile Telecommunications) radiations, in relation to the distance from the antenna or to the radiation-field intensities. MATERIALS AND METHODS: Drosophila melanogaster adult insects were exposed to the radiation of a GSM 900/1800 mobile phone antenna at different distances ranging from 0 to 100 cm, and the effect on their reproductive capacity and cell death induction in the gonads by the use of TUNEL (Terminal deoxynucleotide transferase dUTP Nick End Labeling) assay, was studied. RESULTS: These radiations/fields decreased the reproductive capacity by cell death induction, at all the different distances tested. The effect diminished with the distance/decreasing intensities. An increased bioactivity 'window' was revealed at

distances of 20-30 cm from the mobile phone antenna, (radiation intensity around 10 microW/cm(2)) where the effect became highest, in relation to smaller or longer distances. The effect diminished considerably for distances longer than 40-50 cm and became not evident for distances longer than 1 m or radiation intensities smaller than 1 microW/cm(2). CONCLUSIONS: GSM bioactivity is highest for intensities down to less than 10 microW/cm(2) and still evident until 1 microW/cm(2) exhibiting 'window' effects

Panagopoulos DJ, Margaritis LH. The identification of an intensity 'window' on the bioeffects of mobile telephony radiation. Int J Radiat Biol. 86(5):358-366, 2010.
Erratum in Int J Radiat Biol. 2010 Sep;86(9):809.

PURPOSE: The increased bioactivity 'windows' of GSM 900 and 1800 MHz radiations, (Global System for Mobile telecommunications) revealed recently by us and published in this issue, manifesting themselves as a maximum decrease in the reproductive capacity of the insect Drosophila melanogaster, were examined to discover whether they depend on the intensity of radiation-fields. METHODS: In each experiment, one group of insects were exposed to the GSM 900 or 1800 radiation at 30 or 20 cm distances, respectively, from the antenna of a mobile phone, where the bioactivity 'window' appears for each type of radiation and another group was exposed at 8 or 5 cm, respectively, behind a metal grid, shielding both microwave radiation and the extremely low frequency (ELF) electric and magnetic fields for both types of radiation in a way that radiation and field intensities were roughly equal between the two groups. Then the effect on reproductive capacity was compared between groups for each type of radiation. RESULTS: The decrease in the reproductive capacity did not differ significantly between the two groups. CONCLUSIONS: The bioactivity window seems to be due to the intensity of radiation-field (10 microW/cm(2), 0.6-0.7 V/m) at 30 or 20 cm from the GSM 900 or 1800 mobile phone antenna, respectively

Panagopoulos DJ, Margaritis LH. The effect of exposure duration on the biological activity of mobile telephony radiation. Mutat Res699(1-2):17-22,2010.

In the present experiments we studied the effects of different durations of a single, (continuous), daily exposure, ranging from 1min up to 21min, to the two established systems of digital mobile telephony radiation that are commonly used in Europe, viz. GSM 900MHz (Global System for Mobile telecommunications) and DCS 1800MHz (Digital Cellular System - referred to also as GSM 1800MHz), on a well-tested biological model, the reproductive capacity of the insect Drosophila melanogaster. The insects were exposed to each type of radiation at an intensity of about 10muW/cm(2), corresponding to a distance of 20cm or 30cm from the antenna of a DCS 1800 or a GSM 900 mobile phone handset, respectively. At these distances the bioactivity of mobile telephony radiation was found to be at a maximum due to the existence of a "window" of increased bioactivity around this value, as we have proposed recently [1-4]. The results show that the reproductive capacity decreases almost linearly with increasing exposure duration to both GSM 900 and DCS 1800 radiation, suggesting that short-term exposures to these radiations have cumulative

effects on living organisms. Additionally, our results show again that GSM 900MHz radiation is slightly more bioactive than DCS 1800MHz radiation, at the same exposure durations and under equal radiation intensities, as shown in our previous experiments [5].

Panagopoulos DJ. Effect of microwave exposure on the ovarian development of Drosophila melanogaster.Cell Biochem Biophys. 63(2):121-132, 2012.

In the present experiments the effect of GSM radiation on ovarian development of virgin Drosophila melanogaster female insects was studied. Newly emerged adult female flies were collected and divided into separate identical groups. After the a lapse of certain number of hours-different for each group-the insects (exposed and sham-exposed) were dissected and their intact ovaries were collected and photographed under an optical microscope with the same magnification. The size of the ovaries was compared between exposed and sham-exposed virgin female insects, during the time needed for the completion of oogenesis and maturation of the first eggs in the ovarioles. Immediately after the intact ovaries were photographed, they were further dissected into individual ovarioles and treated for TUNEL and acridine-orange assays to determine the degree of DNA damage in the egg chamber cells. The study showed that the ovarian size of the exposed insects is significantly smaller than that of the corresponding sham-exposed insects, due to destruction of egg chambers by the GSM radiation, after DNA damage and consequent cell death induction in the egg chamber cells of the virgin females as shown in previous experiments on inseminated females. The difference in ovarian size between sham-exposed and exposed virgin female flies becomes most evident 39-45 h after eclosion when the first eggs within the ovaries are at the late vitellogenic and post-vitellogenic stages (mid-late oogenesis). More than 45 h after eclosion, the difference in ovarian size decreases, as the first mature eggs of the sham-exposed insects are leaving the ovaries and are laid.

Panda NK, Jain R, Bakshi J, Munjal S. Audiologic disturbances in long-term mobile phone users. J Otolaryngol Head Neck Surg. 39(1):5-11, 2010.

Abstract. INTRODUCTION:There is general concern regarding the possible hazardous health effects of exposure to radiofrequency electromagnetic radiation emitted from mobile phones. This study aimed to assess the effects of chronic exposure to electromagnetic waves emitted from Global System for Mobile Communication (GSM) mobile phones on auditory functions.MATERIAL AND METHODS:A retrospective, cross-sectional, randomized, case control study was carried out in a tertiary care hospital. One hundred twelve subjects who were long-term mobile phone users (more than 1 year) and 50 controls who had never used a mobile phone underwent a battery of audiologic investigations including pure-tone audiometry (both speech and high frequency), tympanometry, distortion product otoacoustic emissions, auditory brain responses, and middle latency responses. Changes in the various parameters were studied in the mobile phone- and non-mobile phone-using ears of subjects and corresponding ears of the controls to ascertain the effects of electromagnetic exposure.RESULTS:There was no significant difference between users and controls for any of the audiologic parameters. However, trends for audiologic abnormalities were seen within the users. High-frequency

loss and absent distortion product otoacoustic emissions were observed with an increase in the duration of mobile phone use, excessive use of mobile phones, and age more than 30 years. Additionally, users with some complaints during mobile phone use demonstrated absent distortion product otoacoustic emissions and abnormalities in auditory brainstem response.CONCLUSION:Long-term and intensive mobile phone use may cause inner ear damage. A large sample size would be required to reach definitive conclusions.

Panda NK, Modi R, Munjal S, Virk RS. Auditory changes in mobile users: is evidence forthcoming?Otolaryngol Head Neck Surg. 144(4):581-585, 2011.

OBJECTIVE: Genuine concerns are being raised as to the potential health risks posed by electromagnetic frequency exposure secondary to mobile phone usage. This study was undertaken to assess and compare potential changes in hearing function at the level of the inner ear and central auditory pathway due to chronic exposure to electromagnetic waves from both global system for mobile communications (GSM) and code division multiple access (CDMA) mobile phone usage. DESIGN: Cohort study. SETTING: Tertiary referral center. SUBJECTS AND METHODS: One hundred twenty-five subjects who were long-term mobile phone users (more than 1 year; 63 GSM and 62 CDMA) and 58 controls who had never used mobile phones underwent audiological investigations including pure tone audiometry (250-12 kHz), tympanometry, distortion product otoacoustic emissions (DPOAE), auditory brain responses (ABR), and middle latency responses (MLRs). The changes in various parameters were studied in mobile-using and non-mobile-using ears of both GSM and CDMA subjects and corresponding ears of the controls to ascertain the effects of electromagnetic exposure. RESULTS: GSM and CDMA users were found to be at a significantly higher risk of having DPOAE absent as compared with controls ($P < .05$). They were found to have higher speech frequency thresholds and lower MLR wave and Na and Pa amplitudes. More than 3 years of mobile phone usage emerged as a risk factor ($P < .05$). The damage done was bilateral, with the quantum of damage being the same for both GSM and CDMA. CONCLUSION:Long-term and intensive GSM and CDMA mobile phone use may cause damage to cochlea as well as the auditory cortex.

Pandey N, Giri S, Das S, Upadhaya P. Radiofrequency radiation (900 MHz)-induced DNA damage and cell cycle arrest in testicular germ cells in swiss albino mice. Toxicol Ind Health. 33(4):373-384, 2017.

Even though there are contradictory reports regarding the cellular and molecular changes induced by mobile phone emitted radiofrequency radiation (RFR), the possibility of any biological effect cannot be ruled out. In view of a widespread and extensive use of mobile phones, this study evaluates alterations in male germ cell transformation kinetics following RFR exposure and after recovery. Swiss albino mice were exposed to RFR (900 MHz) for 4 h and 8 h duration per day for 35 days. One group of animals was terminated after the exposure period, while others were kept for an additional 35 days post-exposure. RFR exposure caused depolarization of mitochondrial membranes resulting in destabilized cellular redox homeostasis. Statistically significant increases in the damage index in germ cells and sperm head defects were noted in RFR-exposed

animals. Flow cytometric estimation of germ cell subtypes in mice testis revealed 2.5-fold increases in spermatogonial populations with significant decreases in spermatids. Almost fourfold reduction in spermatogonia to spermatid turnover (1C:2C) and three times reduction in primary spermatocyte to spermatid turnover (1C:4C) was found indicating arrest in the premeiotic stage of spermatogenesis, which resulted in loss of post-meiotic germ cells apparent from testis histology and low sperm count in RFR-exposed animals. Histological alterations such as sloughing of immature germ cells into the seminiferous tubule lumen, epithelium depletion and maturation arrest were also observed. However, all these changes showed recovery to varied degrees following the post-exposure period indicating that the adverse effects of RFR on mice germ cells are detrimental but reversible. To conclude, RFR exposure-induced oxidative stress causes DNA damage in germ cells, which alters cell cycle progression leading to low sperm count in mice.

Papageorgiou CC, Nanou ED, Tsiafakis VG, Capsalis CN, Rabavilas AD. Gender related differences on the EEG during a simulated mobile phone signal. Neuroreport. 15(16):2557-2560, 2004.

The present study investigated the gender-related influence of electromagnetic fields (EMF), similar to that emitted by mobile phones, on brain activity. Ten women and nine men performed a short memory task (Wechsler test), both without (baseline) and with exposure to a 900 MHz signal. The EEG energy of the total waveform and the alpha, beta, delta and theta; rhythms were calculated from the recordings of 15 scalp electrodes. Baseline EEG energy of males was greater than that of females, while exposure to EMF decreased EEG energy of males and increased that of females. Memory performance was invariant to EMF exposure and gender influences. These findings indicate that EMF may exert a gender-related nfluence on brain activity.

Papageorgiou CC, Nanou ED, Tsiafakis VG, Kapareliotis E, Kontoangelos KA, Capsalis CN, Rabavilas AD, Soldatos CR. Acute mobile phone effects on pre-attentive operation. Neurosci Lett397(1-2):99-103, 2006.

There is a debate whether electromagnetic field (EMF) emitted by mobile phones (MP) have an effect on cognitive functions. Since the auditory P50 component of event-related potentials (ERPs) reflects pre-attentive processing and working memory (WM) operation, the present study was designed to investigate whether the exposure to MP-EMF affects the patterns of the P50 component of ERPs elicited during a WM test. The P50 elicited during a WM task and evoked by two warning stimuli low and high frequency (500 and 3000Hz) has been assessed in 19 normal subjects (10 women and 9 men) both without and with exposure to a 900MHz signal, emitted by a dipole antenna placed near the subjects. Results showed that the presence of MP-EMFs induced statistically significant increase in the amplitude of P50 evoked by the low frequency stimuli, at Fp1 and O1 electrode leads as compared to themselves without MP-EMF exposure. In contrast the exposure to MP-EMFs revealed statistically significant decrease of the amplitude of P50 evoked by the high frequency stimuli, at Fp1 electrode lead as compared to themselves without MP-EMF exposure. These findings provide evidence that the MP-EMF emitted by mobile phone affect pre-attentive information processing as it is reflected in P50 evoked

potential. The basis of such an effect is unclear, although several possibilities exist and call for potential directions of future research.

Papageorgiou CC, Hountala CD, Maganioti AE, Kyprianou MA, Rabavilas AD, Papadimitriou GN, Capsalis CN. Effects of wi-fi signals on the p300 component of event-related potentials during an auditory hayling task. J Integr Neurosci. 10(2):189-202, 2011.

The P300 component of event-related potentials (ERPs) is believed to index attention and working memory (WM) operation of the brain. The present study focused on the possible gender-related effects of Wi-Fi (Wireless Fidelity) electromagnetic fields (EMF) on these processes. Fifteen male and fifteen female subjects, matched for age and education level, were investigated while performing a modified version of the Hayling Sentence Completion test adjusted to induce WM. ERPs were recorded at 30 scalp electrodes, both without and with the exposure to a Wi-Fi signal. P300 amplitude values at 18 electrodes were found to be significantly lower in the response inhibition condition than in the response initiation and baseline conditions. Independent of the above effect, within the response inhibition condition there was also a significant gender X radiation interaction effect manifested at 15 leads by decreased P300 amplitudes of males in comparison to female subjects only at the presence of EMF. In conclusion, the present findings suggest that 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 WM.

Paparini A, Rossi P, Gianfranceschi G, Brugaletta V, Falsaperla R, De Luca P, Romano Spica V. No evidence of major transcriptional changes in the brain of mice exposed to 1800 MHz GSM signal.Bioelectromagnetics. 29(4):312-323, 2008.

To analyze possible effects of microwaves on gene expression, mice were exposed to global system for mobile communication (GSM) 1800 MHz signal for 1 h at a whole body SAR of 1.1 W/kg. Gene expression was studied in the whole brain, where the average SAR was 0.2 W/kg, by expression microarrays containing over 22,600 probe sets. Comparison of data from sham and exposed animals showed no significant difference in gene expression modulation. However, when less stringent constraints were adopted to analyze microarray results, 75 genes were found to be modulated following exposure. Forty-two probes showed fold changes ranging from 1.5 to 2.8, whereas 33 were down-regulated from 0.67- to 0.29-fold changes, but these differences in gene expression were not confirmed by real-time PCR. Under these specific limited conditions, no consistent indication of gene expression modulation in whole mouse brain was found associated to GSM 1800 MHz exposure.

Parazzini M, Ravazzani P, Tognola G, Thuroczy G, Molnar FB, Sacchettini A, Ardesi G, Mainardi LT. Electromagnetic fields produced by GSM cellular phones and heart rate variability. Bioelectromagnetics.28(2):122-129, 2007.

In this study, 26 healthy young volunteers were submitted to 900 MHz (2 W) GSM cellular phone exposure and to sham exposure in separate sessions. The study was

designed to assess cardiac regulatory mechanism in different autonomic nervous system (ANS) states during exposure to low-intensity EMF. Rest-to-stand protocol was applied to evaluate ANS in quiet condition (rest, vagal prevalence) and after a sympathetic activation (stand). The procedure is conducted twice in a double-blind design: once with a genuine EMF exposure and once with a sham exposure (at least 24 h apart). During each session three-leads electrocardiograms were recorded and RR series extracted off-line. Time domain and frequency domain HRV parameters were calculated in every phase of the protocol and during different exposures. The analysis of the data show there was no statistically significant effect due to EMF exposure both on main (i.e., RR mean) and most of the other HRV parameters. A weak interaction between some HRV parameters (i.e., SDNN, TINN, and triangular index in time domain and LF power in frequency domain analysis) and RF exposure was observed and this effect seems to be gathered around the sympathetic response to stand.

Parazzini M, Brazzale AR, Paglialonga A, Tognola G, Collet L, Moulin A, Lutman ME, Bell SL, Thomas NA, Uloziene I, Uloza V, Thuroczy G, Tavartkiladze G, Tsalighopoulos M, Kyriafinis G, Ravazzani P. Effects of GSM Cellular Phones on Human Hearing: The European Project "GUARD". Radiat Res. 168(5):608-613, 2007.

The European multicenter project named GUARD involved nine centers and aimed to assess potential changes in auditory function as a consequence of exposure to low-intensity electromagnetic fields (EMFs) produced by GSM cellular phones. Participants were healthy young adults without any evidence of hearing or ear disorders. Auditory function was assessed immediately before and after exposure to EMFs, and only the exposed ear was tested. The procedure was conducted twice in a double blinded design, once with a genuine EMF exposure and once with a sham exposure (at least 24 h apart). Tests for assessment of auditory function were hearing threshold level (HTL), transient otoacoustic emissions (TEOAE), distortion product otoacoustic emissions (DPOAE), and auditory brainstem response (ABR). The exposure consisted of speech at a typical conversational level delivered via an earphone to one ear, plus genuine or sham EMF exposure. The EMF exposure used the output of a software-controlled consumer cellular phone at full power for 10 min. A system of phone positioning that allowed participants to freely move their heads without affecting exposure was used. Analysis of the data showed there were no effects of exposure to GSM mobile phone signals on the main measures of the status of the auditory system.

Parazzini M, Sibella F, Lutman ME, Mishra S, Moulin A, Sliwinska-Kowalska M, Woznicka E, Politanski P, Zmyslony M, Thuroczy G, Molnár F, Kubinyi G, Tavartkiladze G, Bronyakin S, Uloziene I, Uloza V, Gradauskiene E, Ravazzani P. Effects of UMTS Cellular Phones on Human Hearing: Results of the European Project "EMFnEAR". Radiat Res. 172(2):244-251, 2009.

Abstract The European project EMFnEAR was undertaken to assess potential changes in human auditory function after a short-term exposure to radiofrequency (RF) radiation produced by UMTS (Universal Mobile Telecommunication System) mobile phones. Participants were healthy young adults with no hearing or ear disorders. Auditory function

was assessed immediately before and after exposure to radiofrequency radiation, and only the exposed ear was tested. Tests for the assessment of auditory function were hearing threshold level (HTL), distortion product otoacoustic emissions (DPOAE), contralateral suppression of transiently evoked otoacoustic emission (CAS effect on TEOAE), and auditory evoked potentials (AEP). The exposure consisted of speech at a typical conversational level delivered via an earphone to one ear, plus genuine or sham RF-radiation exposure produced by a commercial phone controlled by a personal computer. Results from 134 participants did not show any consistent pattern of effects on the auditory system after a 20-min UMTS exposure at the maximum output of the phone with 69 mW/kg SAR in the cochlea region in a double blind comparison of genuine and sham exposure. An isolated effect on the hearing threshold at high frequencies was identified, but this was statistically nonsignificant after correction for multiple comparisons. It is concluded that UMTS short-term exposure at the maximum output of consumer mobile phones does not cause measurable immediate effects on the human auditory system.

Parazzini M, Lutman ME, Moulin A, Barnel C, Sliwinska-Kowalska M, Zmyslony M, Hernadi I, Stefanics G, Thuroczy G, Ravazzani P. Absence of short-term effects of UMTS exposure on the human auditory system. Radiat Res. 173(1):91-97, 2010.

The aim of this study, which was performed in the framework of the European project EMFnEAR, was to investigate the potential effects of Universal Mobile Telecommunications System (UMTS, also known as 3G) exposure at a high specific absorption rate (SAR) on the human auditory system. Participants were healthy young adults with no hearing or ear disorders. Auditory function was assessed immediately before and after exposure to radiofrequency (RF) radiation, and only the exposed ear was tested. Tests for the assessment of auditory function were hearing threshold level (HTL), distortion product otoacoustic emissions (DPOAE), contralateral suppression of transiently evoked otoacoustic emission (CAS effect on TEOAE), and auditory evoked potentials (AEP). The exposure consisted of speech at a typical conversational level delivered via an earphone to one ear, plus genuine or sham RF-radiation exposure obtained by an exposure system based on a patch antenna and controlled by software. Results from 73 participants did not show any consistent pattern of effects on the auditory system after a 20-min UMTS exposure at 1947 MHz at a maximum SAR over 1 g of 1.75 W/kg at a position equivalent to the cochlea. Analysis entailed a double-blind comparison of genuine and sham exposure. It is concluded that short-term UMTS exposure at this relatively high SAR does not cause measurable immediate effects on the human auditory system.

Paredi P, Kharitonov SA, Hanazawa T, Barnes PJ, Local vasodilator response to mobile phones. Laryngoscope 111(1):159-162, 2001.

OBJECTIVES: The use of mobile phones with the resulting generation of potentially harmful electromagnetic fields (EMF) is the focus of public interest. Heat generation and the activation of the inducible form of nitric oxide (NO) synthase may be possible causes of the biological effects of EMF exposure. We investigated if a mobile telephone conversation can modify skin temperature, NO, and nasal resistance. METHODS: We

studied the effect of an EMF (900 MHz) generated by a commercially available cellular phone during a 30-minute telephone conversation on skin temperature, nasal NO measured by chemiluminescence, and nasal minimal cross-sectional area (MCA) measured by rhinometry. Eleven normal subjects (mean age +/- standard error of mean [SEM], 32 +/- 5 y; 10 male) were studied. RESULTS: There was a similar and significant increase in skin temperature of the nostril and occipital area on the same side as the telephone (maximal increase 2.3 +/- 0.2 degrees C at 6 min) as well as a tendency for higher nasal NO levels (maximal increase 12.9 +/- 4.9% at 10 min), whereas the MCA was significantly reduced (maximal decrease -27 +/- 6% at 15 min). Such changes were not recorded when an earpiece was used to avoid the direct exposure to the electromagnetic field. There were no changes in the skin temperature and nasal NO measured on the opposite side to the mobile phone, whereas the MCA was significantly increased (38 +/- 10%). CONCLUSIONS: Exposure to EMF produced by a mobile phone produces biological effects that can be easily measured. Microwaves may increase skin temperature and therefore cause vasodilation and reduce MCA. Further studies are needed to study the long-term effects of mobile phone use and the relation among NO production, vasodilation, and temperature.

Park SK,Ha M, Im H-J.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):387-394, 2004.

Abstract. Objectives Public health concern about the health effects of radio-frequency electromagnetic fields (RF-EMFs) has increased with the increase in public exposure. This study was to evaluate some health effect of RF exposure by the AM radio broadcasting towers in Korea. Methods We calculated cancer mortality rates using Korean death certificates over the period of 1994–1995 and population census data in ten RF-exposed areas, defined as regions that included AM radio broadcasting towers of over 100 kW, and in control areas, defined as regions without a radio broadcasting tower inside and at least 2 km away from the towers. Results All cancers-mortality was significantly higher in the exposed areas [direct standardized mortality rate ratio (MRR) =1.29, 95%CI=1.12–1.49]. When grouped by each exposed area and by electrical power, MRRs for two sites of 100 kW, one site of 250 kW and one site of 500 kW, for all subjects, and for one site of 100 kW and two sites of 250 kW, for male subjects, showed statistically significant increases without increasing trends according to the groups of electric power. Leukemia mortality was higher in exposed areas (MRR=1.70, 95% CI=0.84–3.45), especially among young adults aged under 30 years (0–14 years age group, MRR=2.29, 95% CI=1.05–5.98; 15–29 age group, MRR=2.44, 95% CI=1.07–5.24) . Conclusions We observed higher mortality rates for all cancers and leukemia in some age groups in the area near the AM radio broadcasting towers. Although these findings do not prove a causal link between cancer and RF exposure from AM radio broadcasting towers, it does suggest that further analytical studies on this topic are needed in Korea.

Park J, Kwon JH, Kim N, Song K. Effects of 1950 MHz radiofrequency electromagnetic fields on Aβ processing in human neuroblastoma and mouse hippocampal neuronal cells. J Radiat Res. 2017 Oct 6:1-9. doi: 10.1093/jrr/rrx045. [Epub ahead of print]

Alzheimer's disease (AD) is a neurodegenerative disease leading to progressive loss of memory and other cognitive functions. One of the well-known pathological markers of AD is the accumulation of amyloid-beta protein (Aβ), and its plaques, in the brain. Recent studies using Tg-5XFAD mice as a model of AD have reported that exposure to radiofrequency electromagnetic fields (RF-EMF) from cellular phones reduced Aβ plaques in the brain and showed beneficial effects on AD. In this study, we examined whether exposure to 1950 MHz RF-EMF affects Aβ processing in neural cells. We exposed HT22 mouse hippocampal neuronal cells and SH-SY5Y human neuroblastoma cells to RF-EMF (SAR 6 W/kg) for 2 h per day for 3 days, and analyzed the mRNA and protein expression of the key genes related to Aβ processing. When exposed to RF-EMF, mRNA levels of APP, BACE1, ADAM10 and PSEN1 were decreased in HT22, but the mRNA level of APP was not changed in SH-SY5Y cells. The protein expression of APP and BACE1, as well as the secreted Aβ peptide, was not significantly different between RF-EMF-exposed 7w-PSML, HT22 and SH-SY5Y cells and the unexposed controls. These observations suggest that RF-EMF exposure may not have a significant physiological effect on Aβ processing of neural cells in the short term. However, considering that we only exposed HT22 and SH-SY5Y cells to RF-EMF for 2 h per day for 3 days, we cannot exclude the possibility that 1950 MHz RF-EMF induces physiological change in Aβ processing with long-term and continuous exposure.

Parker JE, Kiel JL, Winters WD. Effect of radiofrequency radiation on mRNA expression in cultured rodent cells. Physiol Chem Phys Med NMR 20(2):129-134, 1988.

Four rodent cell lines were exposed to 2450 MHz microwave radiation at a Specific Absorption Rate (SAR) of 103.5 +/- 4.2 W/kg for varying lengths of time at 37 degrees, 40 degrees, 42 degrees and 45 degrees C. mRNA was extracted from microwave-exposed and sham-exposed cells and dot blotted or Northern blotted to nitrocellulose. Radioisotope labelled DNA probes of oncogenes, heat shock protein or long terminal repeat sequences were hybridized to the mRNA, and the resulting autoradiographs analyzed for differences in levels of mRNA expression between exposed and nonexposed samples. With the cell lines and probes used in this study no significant differences in mRNA expression were observed after microwave exposure.

Parodi S, Merlo DF, Ranucci A, Miligi L, Benvenuti A, Rondelli R, Magnani C, Haupt R; SETIL Working Group. Risk of neuroblastoma, maternal characteristics and perinatal exposures: The SETIL study. Cancer Epidemiol. 2014 Sep 30. pii: S1877-7821(14)00157-X. doi: 10.1016/j.canep.2014.09.007. [Epub ahead of print]

PURPOSE: Neuroblastoma (NB) is the most common extra-cranial paediatric solid tumour. Incidence peaks in infancy, suggesting a role of in-utero and neonatal exposures but its aetiology is largely unknown. The aim of the present study is to evaluate the association between maternal characteristics and perinatal factors with the risk of NB, using data from the SETIL database. METHODS: SETIL is a large Italian population-based case-control study established to evaluate several potential cancer risk factors in 0-10 year olds. Information about maternal characteristics, reproductive history, environmental and occupational exposures during pregnancy, as well as newborns' characteristics were obtained using a structured questionnaire. Extremely low frequency

magnetic field (**ELF**-MF) home exposure was measured. The study included 1044 healthy controls and 153 NB cases, diagnosed between 1998 and 2001. RESULTS: A twofold risk was associated to exposure in pregnancy to chemical products for domestic work and to hair dye. The risk associated with the latter was higher among 0-17 month old children (OR=5.5, 95%CI: 1.0-29.3). Risk was increased for children whose mothers had suffered work related exposure in the preconception period to solvents (OR=2.0 95%CI: 1.0-4.1) and in particular to aromatic hydrocarbons (OR=9.2, 95%CI: 2.4-34.3). No association was observed with **ELF**-MF exposure. A higher risk was found among children with congenital malformations (OR=4.9, 95%CI: 1.8-13.6) or neurofibromatosis (2 cases and 0 controls, p=0.016). CONCLUSIONS: Our study suggests maternal exposure to hair dyes and aromatic hydrocarbons plays a role and deserves further investigation. The association with congenital malformations might also be explained by over-diagnosis. External exposure, in particular during and before pregnancy might contribute to NB occurrence.

Parslow RC, Hepworth SJ, McKinney PA. Recall of past use of mobile phone handsets. Radiat Prot Dosimetry. 106(3):233-240, 2003.

Previous studies investigating health effects of mobile phones have based their estimation of exposure on self-reported levels of phone use. This UK validation study assesses the accuracy of reported voice calls made from mobile handsets. Data collected by postal questionnaire from 93 volunteers was compared to records obtained prospectively over 6 months from four network operators. Agreement was measured for outgoing calls using the kappa statistic, log-linear modelling, Spearman correlation coefficient and graphical methods. Agreement for number of calls gained moderate classification (kappa = 0.39) with better agreement for duration (kappa = 0.50). Log-linear modelling produced similar results. The Spearman correlation coefficient was 0.48 for number of calls and 0.60 for duration. Graphical agreement methods demonstrated patterns of over-reporting call numbers (by a factor of 1.7) and duration (by a factor of 2.8). These results suggest that self-reported mobile phone use may not fully represent patterns of actual use. This has implications for calculating exposures from questionnaire data.

Partsvania B, Sulaberidze T, Shoshiashvili L, Modebadze Z. Acute effect of exposure of mollusk single neuron to 900-MHz mobile phone radiation.Electromagn Biol Med. 30(3):170-179, 2011.

The goal of the present work was to explore the influence of commercially available cell phone irradiation on the single neuron excitability and memory processes. A Transverse Electromagnetic Cell (TEM Cell) was used to expose single neurons of mollusk to the electromagnetic field. Finite-Difference Time-Domain (FDTD) method was used for modeling the TEM Cell and the electromagnetic field interactions with living nerve ganglion and neurons. Neuron electrophysiology was investigated using standard microelectrode technique. The specific absorption rate (SAR) deposited into the single neuron was calculated to be 0.63 W/kg with a temperature increment of 0.1°C. After acute exposure, average firing threshold of the action potentials was not changed. However, the average latent period was significantly decreased. This

indicates that together with latent period the threshold and the time of habituation might be altered during exposure. However, these alterations are transient and only latent period remains on the changed level.

Pashovkina MS, Akoev IG. [Effect of low intensity pulse-modulated electromagnetic radiation on activity of alkaline phosphatase in blood serum]. Radiats Biol Radioecol 41(1):62-66, 2001. [Article in Russian]

The change in alkaline phosphotase activity in vitro with frequencies modulation at low intensity of pulse-modulated electromagnetic radiation was experimentally shown (EMR, 2375 MHz, intensity: 0.8, 8.0; 40.0 microW/cm2; range modulation: 30-310 Hz; time of interaction: 1-3 min). Revealed effects could be regarded as an evidence of informative character of interaction of modulated EMR.

Pashovkina MS, Akoev IG. [Effect of low-intensity pulse-modulated microwave on human blood aspartate aminotransferase activity]. Radiats Biol Radioecol 41(1):59-61, 2001. [Article in Russian]

Pulse-modulated microwaves (frequency 2375 MHz, intensity: 2 microW/cm2 and 8 microW/cm2, pulse modulation from 50 to 390 Hz with step of 20 Hz; exposure time 5 min) changed the activity of aspartataminotranspherase of the donor blood. Aspartataminotranspherase activity was strongly dependent both on modulation frequency and microwave intensity. Maximum activity was found at 390 Hz and 8 microW/cm2. Maximum observed activity was about six times greater than control level of activity.

Pashovkina MS, Akoev IG, [Changes in serum alkaline phosphatase activity during in vitro exposure to amplitude-modulated electromagnetic field of ultrahigh frequency (2375 MHz) in guinea pigs]. Biofizika 45(1):130-136, 2000. [Article in Russian]

The activity of alkaline phosphatase by the action of pulse-modulated microwave radiation was studied. The carrier frequency of radiation was 2375 MHz, the range of modulation pulse rate was 10-390 Hz with the on-off time ratio 2, and the specific absorption rate was 8 and 0.8 microW/cm2. Time of exposure was 1 and 3 min under conditions of continuous temperature control. It was shown that the activity of alkaline phosphatase depends on both modulation frequency and intensity of superhigh-frequency electromagnetic radiation. At a frequency of 70 Hz, the activity of alkaline phosphatases increased 1.8-2.0 times.

Pashovskina MS, Akoev IG, [Effects of 2375 MHz pulse-modulated microwave radiation on ATPase activity of the rat muscle actomyosin]. Radiats Biol Radioecol 36(5):700-705, 1996. [Article in Russian]

Solution of rat muscle actomyosin (AM) was exposed to pulse-modulated microwave. Carried frequency was 2375 MHz. The rectangular pulse modulation was in the range of 50-300 pulses per second. It was shown that AM activity was dependent both on modulation frequency as well as on microwave intensity. It was shown the frequencies of modulation which were changed ATP-ase activity of AM.

Pau HW, Sievert U, Eggert S, Wild W. Can electromagnetic fields emitted by mobile phones stimulate the vestibular organ? Otolaryngol Head Neck Surg. 132(1):43-49, 2005.

Objectives Pulsating electromagnetic (EM) radiation emitted by mobile phones is often incriminated for causing tissue alterations by caloric effects. In particular, the eye and the ear were regarded as possible "hot spots," with heating up to 1 degrees C, in which EM radiation might have negative effects. If so, these temperature increments should be large enough to cause vestibular excitation. In this study, we attempted to verify this theory by clinical testing and in vitro experiments. Methods and measures In our laboratory, a simulated GSM signal (889.6 MHz/2.2 W) was applied to 1 ear at a time, while video nystagmography was performed. The experimental setup was similar to that used for caloric (hot and cold water) testing of the peripheral vestibular organ. Data were evaluated by a computer system. There were 13 volunteers (26 ears) included in our study. In an additional experiment, temperatures of human temporal bones were measured by thermography, while a continuous or pulsating EM field was applied. Results In no volunteer could EM radiation-induced nystagmus be recorded. This corresponds well to our findings that in the human temporal bone very weak caloric effects could only be found in the tissue layers next to the radiation source (antenna of the mobile phone), whereas deeper regions (horizontal semicircular canal) seemed unaffected (at least less than 0.1 degrees C). Clinical significance These results do not support the theory that mobile phone-induced EM radiation may cause caloric negative effects in the human ear.

Paul Raj R, Behari J, Rao AR, Effect of amplitude modulated RF radiation on calcium ion efflux and ODC activity in chronically exposed rat brain. Indian J Biochem Biophys 36(5):337-340, 1999.

The effect of exposing rats to amplitude modulated radiofrequency radiation (112 MHz modulated to 16 Hz) during development and growth has been examined. Wistar rats (35 days old) when exposed at above frequency at the power level 1.0 mW/cm2 (SAR, 0.75 W/kg) for 35 days showed enhanced ornithine decarboxylase activity and Ca2+ efflux in brain indicating potential health hazards due to exposure.

Paulraj R, Behari J. Radio frequency radiation effects on protein kinase C activity in rats' brain. Mutat Res. 545(1-2):127-130, 2004.

The present work describes the effect of amplitude modulated radio frequency (rf) radiation (112 MHz amplitude-modulated at 16 Hz) on calcium-dependent protein kinase C (PKC) activity on developing rat brain. Thirty-five days old Wistar rats were used for this study. The rats were exposed 2 h per day for 35 days at a power density of 1.0 mW/cm2 (SAR = 1.48 W/kg). After exposure, rats were sacrificed and PKC was determined in whole brain, hippocampus and whole brain minus hippocampus separately. A significant decrease in the enzyme level was observed in the exposed group as compared to the sham exposed group. These results indicate that this type of radiation could affect membrane bound enzymes associated with cell signaling, proliferation and differentiation. This may also suggest an affect on the behavior of chronically exposed rats.

Paulraj R, Behari J. The effect of low level continuous 2.45 GHz waves on enzymes of developing rat brain. Electromag Biol Med 21:221-231, 2002.

The present work describes the effect of low level continuous microwaves (2.45 GHz) on developing rat brain. Some 35-day-old Wistar rats were used for this study. The animals were exposed 2 hr/day for 35 days at a power density of 0.34 mW/cm^2 [specific absorption rate (SAR), 0.1 W/kg] in a specially made anechoic chamber. After the exposure, the rats were sacrificed and the brain tissue was dissected out and used for various biochemical assays. A significant increase in calcium ion efflux and ornithine decarboxylase (ODC) activity was observed in the exposed group as compared to the control. Correspondingly, a significant decrease in the calcium-dependent protein kinase activity was observed. These results indicate that this type of radiation affects the membrane bound enzymes, which are associated with cell proliferation and differentiation, thereby pointing out its possible role as a tumor promoter.

Paulraj R, Behari J. Single strand DNA breaks in rat brain cells exposed to microwave radiation. Mutat Res. 596:76-80, 2006.

This investigation concerns with the effect of low intensity microwave (2.45 and 16.5GHz, SAR 1.0 and 2.01W/kg, respectively) radiation on developing rat brain. Wistar rats (35 days old, male, six rats in each group) were selected for this study. These animals were exposed for 35 days at the above mentioned frequencies separately in two different exposure systems. After the exposure period, the rats were sacrificed and the whole brain tissue was dissected and used for study of single strand DNA breaks by micro gel electrophoresis (comet assay). Single strand DNA breaks were measured as tail length of comet. Fifty cells from each slide and two slides per animal were observed. One-way ANOVA method was adopted for statistical analysis. This study shows that the chronic exposure to these radiations cause statistically significant ($p<0.001$) increase in DNA single strand breaks in brain cells of rat.

Paulraj R, Behari J. Protein Kinase C Activity in developing rat brain cells exposed to 2.45 GHz radiation. Electromag Biol Med 25(1) 61-70, 2006.

There is growing concern by the public regarding the potential human health hazard due to exposure to microwave frequencies. 2.45 GHz radiation widespread use in industry, research, and medicine, and leakage into the environment is possible. In order to quantitate this, experiments were performed on developing rat brain. Male Wistar 35-day-old rats ($n = 6$) were used for this study. Animals were exposed to 2.45 GHz radiation for 2 h/day for a period of 35 days at a power density of 0.344 mW/cm^2 (SAR 0.11 W/kg). The control group was sham irradiated. After 35 days these rats were sacrificed and whole brain tissue was isolated for protein kinase C (PKC) assay. For morphological study the forebrain was isolated from the whole brain and PKC activity was measured using P^{32} labeled ATP. Our study reveals a statistically significant ($p < 0.05$) decrease in PKC activity in hippocampus as compared to the remaining portion of the whole brain and the control group. A similar experiment conducted on hippocampus and the whole brain gave a similar result. Electron microscopic study shows an increase in the glial cell population in the exposed group as compared to the control group. This present study is indicative of a significant change after exposure to the above-mentioned field intensity.

This suggests that chronic exposures may affect brain growth and development.

Pavel A, Ungureanu CE, Bara Il, Gassner P, Creanga DE, [Cytogenetic changes induced by low-intensity microwaves in the species Triticum aestivum]. Rev Med Chir Soc Med Nat Iasi 102(3-4):89-92, 1998. [Article in Romanian]

Seeds of Triticum aestivum having an uniform genophond have been exposed to a microwave flow, with a frequency of 9.75 GHz and a low intensity. The effects of microwaves at various doses on mitotic activity have been followed. Our results show that as compared to the controls different types of chromosomal aberrations appeared: delayed chromosomes, micronuclei, interchromosomal bridges, chromosomal fragments.

Pavicic I, Trosic I, Sarolic A. Comparison of 864 MHz and 935 MHz microwave radiation effects on cell culture. Arh Hig Rada Toksikol. 57(2):149-154, 2006.

The objective of this study was to compare the effects of 864 MHz and 935 MHz radiofrequency/microwave radiation on the ability of V79 cells to proliferate, form colonies and on their viability. For one, two and three hours, the cells were exposed to the 864 MHz field in a transversal electromagnetic mode cell (TEM) connected with amplifier and to the 935 MHz field in a gigahertz transversal electromagnetic mode cell (GTEM) equipped with a signal generator. The average specific absorption rate (SAR) was 0.08 W kg(-1) for the 864 MHz field and 0.12 W kg(-1) for the 935 MHz field. In comparison to the control cell samples, the growth curve of the 864 MHz irradiated cells showed a significant decrease after two-hour and three-hour exposure on the Day 3 after exposure. Likewise, cells exposed to 935 MHz microwaves for three hours showed a significant growth on Day 3 after exposure. The colony-forming ability and viability of cells exposed to 864 MHz and 935 MHz microwaves did not significantly differ from the matched controls. The applied RF/MW fields showed a similar effect on cell culture growth, colony-forming ability and viability of V79 cells.

Pavicic I, Trosic I. Impact of 864 MHz or 935 MHz radiofrequency microwave radiation on the basic growth parameters of V79 cell line. Acta Biol Hung. 59(1):67-76, 2008.

The aim of this study was to evaluate and compare the influence of 864 MHz and 935 MHz radiofrequency/microwave (RF/MW) fields on the growth, colony-forming ability, and viability of V79 cells (continuous line). Cell samples with 1 x 10(4) V79 cells each, were exposed to continuous wave frequencies of 864 MHz and 935 MHz for 1, 2 and 3 hours. Exposed samples were matched with unexposed control samples. Specific absorption rate (SAR) was 0.08 W/kg for the 864 MHz or 0.12 W/kg for the 935 MHz field. Cell growth and viability were determined by counting cells every day for five days after exposure. Colony-forming ability was assessed by counting colonies seven days after exposure. The growth of the 864 MHz-irradiated cells was significant after two- and three-hour exposure 72 hours after irradiation ($p < 0.05$). The similar was observed 72 hours after exposure for cells exposed to 935 MHz microwaves for three hours ($p < 0.05$). Colony-forming ability and cell viability in V79 cells exposed to 864 MHz or 935 MHz microwaves did not significantly differ from control cells. The two applied RF/MW fields showed similar effects on the growth, colony-forming ability and viability of V79 cells. Cell growth impact was time-

dependent for both fields.

Pawlak K, Sechman A, Nieckarz Z. Plasma thyroid hormones and corticosterone levels in blood of chicken embryos and post hatch chickens exposed during incubation to 1800 MHz electromagnetic field. Int J Occup Med Environ Health. 2014 Jan 31. [Epub ahead of print]

INTRODUCTION: This study attempted to determine the effect of a 1800 MHz electromagnetic field (EMF) (only carrier frequency) on thyroxine (T4), triiodothyronine (T3) and corticosterone (CORT) concentrations in the blood plasma of chick embryos, and to investigate the effect of electromagnetic field (EMF) exposure during embryogenesis on the level of these hormones in birds that are ready for slaughter. MATERIAL AND METHODS: Throughout the incubation period, embryos from the experimental group were exposed to a 1800 MHz EMF with power density of 0.1 W/m2, 10 times during 24 h for 4 min. Blood samples were collected to determine T4, T3 and CORT concentrations on the 12th (E12) and 18th (E18) day of incubation, from newly hatched chicks (D1) and from birds ready for slaughter (D42). RESULTS: The experiment showed that T4 and T3 concentrations decreased markedly and CORT levels increased in the embryos and in the newly hatched chicks exposed to EMF during embryogenesis. However, no changes were found in the level of the analyzed hormones in the birds ready for slaughter. Differences in T4 and T3 plasma concentrations between the EMF-exposed group and the embryos incubated without additional EMF were the highest in the newly hatched chicks, which may be indicative of the cumulative effect of electromagnetic field on the hypothalamo-pituitary-thyroid axis (HPT). DISCUSSION: The obtained results suggest that additional 1800 MHz radio frequency electromagnetic field inhibits function of HPT axis, however, it stimulates hypothalamo-pituitary-adrenal axis by inducing adrenal steroidogenic cells to synthesize corticosterone. Further investigations are needed to elucidate the mechanisms by which radio EMFs affect HPT and HPA axis function in the chicken embryos.

Pedersen W. [Mobile phones, web chat, and sex among Norwegian adolescents] Tidsskr Nor Laegeforen. 124(13-14):1756-1759, 2004. [article in Norwegian]

BACKGROUND: We investigated the associations between new interactive technology for communication, such as web chat or mobile phones, and sexual behaviour among Norwegian adolescents. MATERIALS AND METHODS: A representative sample of adolescents (age 13-18, N = 10,926) filled in a questionnaire during school hours; the response rate was 92%. RESULTS: Most adolescents have access to communication technology, but how much they use it varies. In particular with regard to mobile phones, a strong association to sexual behaviour was found. Among those who did not use the new technology, less than 10% reported having had intercourse while two out of three of the most active users reported intercourse. The associations remained significant when controls were made for age and a range of contextual, family, peer and individual factors. INTERPRETATION: Norwegian adolescents have changed their sexual behaviour over the last decade. The introduction and widespread use of new communication technology is one of the most salient changes over the same period. The findings suggest that this

technology may in fact be of importance to teenagers' sexual socialisation.

Peinnequin A, Piriou A, Mathieu J, Dabouis V, Sebbah C, Malabiau R, Debouzy JC Non-thermal effects of continuous 2.45 GHz microwaves on Fas-induced apoptosis in human Jurkat T-cell line. Bioelectrochemistry 51(2):157-161, 2000.

Non-thermal effects of microwaves (MWs) are one of the main issues studied for revising standards. The effects of MW exposure on apoptosis at non-thermal level (48 h, 2.45 GHz, 5 mW/cm2) have been studied. Results obtained assess non-thermal MW effects on Fas, but neither on butyrate- nor on ceramide-induced apoptosis in human Jurkat T-cell line. These data show that MW interacts either with Fas pathway between receptor and caspase-3 activation or on membrane proteins (i.e. Fas receptor or neurosphyngomyelinase).

Pelletier A, Delanaud S, Décima P, Thuroczy G, de Seze R, Cerri M, Bach V, Libert JP, Loos N. Effects of chronic exposure to radiofrequency electromagnetic fields on energy balance in developing rats. Environ Sci Pollut Res Int. 20(5):2735-2746, 2013.

The effects of radiofrequency electromagnetic fields (RF-EMF) on the control of body energy balance in developing organisms have not been studied, despite the involvement of energy status in vital physiological functions. We examined the effects of chronic RF-EMF exposure (900MHz, 1 V m(-1)) on the main functions involved in body energy homeostasis (feeding behaviour, sleep and thermoregulatory processes). Thirteen juvenile male Wistar rats were exposed to continuous RF-EMF for 5 weeks at 24 °C of air temperature (T (a)) and compared with 11 non-exposed animals. Hence, at the beginning of the 6th week of exposure, the functions were recorded at T (a) of 24 °C and then at 31 °C. We showed that the frequency of rapid eye movement sleep episodes was greater in the RF-EMF-exposed group, independently of T (a) (+42.1 % at 24 °C and +31.6 % at 31 °C). The other effects of RF-EMF exposure on several sleep parameters were dependent on T (a). At 31 °C, RF-EMF-exposed animals had a significantly lower subcutaneous tail temperature (-1.21 °C) than controls at all sleep stages; this suggested peripheral vasoconstriction, which was confirmed in an experiment with the vasodilatator prazosin. Exposure to RF-EMF also increased daytime food intake (+0.22 g h(-1)). Most of the observed effects of RF-EMF exposure were dependent on T (a). Exposure to RF-EMF appears to modify the functioning of vasomotor tone by acting peripherally through α-adrenoceptors. The elicited vasoconstriction may restrict body cooling, whereas energy intake increases. Our results show that RF-EMF exposure can induce energy-saving processes without strongly disturbing the overall sleep pattern.

Pelletier A, Delanaud S, de Seze R, Bach V, Libert JP, Loos N. Does Exposure to a Radiofrequency Electromagnetic Field Modify Thermal Preference in Juvenile Rats? PLoS One. 2014 Jun 6;9(6):e99007. doi: 10.1371/journal.pone.0099007. eCollection 2014.

Some studies have shown that people living near a mobile phone base station may report sleep disturbances and discomfort. Using a rat model, we have previously shown that chronic exposure to a low-intensity radiofrequency electromagnetic field (RF-EMF) was

associated with paradoxical sleep (PS) fragmentation and greater vasomotor tone in the tail. Here, we sought to establish whether sleep disturbances might result from the disturbance of thermoregulatory processes by a RF-EMF. We recorded thermal preference and sleep stage distribution in 18 young male Wistar rats. Nine animals were exposed to a low-intensity RF-EMF (900 MHz, 1 V.m-1) for five weeks and nine served as non-exposed controls. Thermal preference was assessed in an experimental chamber comprising three interconnected compartments, in which the air temperatures (Ta) were set to 24°C, 28°C and 31°C. Sleep and tail skin temperature were also recorded. Our results indicated that relative to control group, exposure to RF-EMF at 31°C was associated with a significantly lower tail skin temperature (-1.6°C) which confirmed previous data. During the light period, the exposed group preferred to sleep at Ta=31°C and the controls preferred Ta=28°C. The mean sleep duration in exposed group was significantly greater (by 15.5%) than in control group (due in turn to a significantly greater amount of slow wave sleep (SWS, +14.6%). Similarly, frequency of SWS was greater in exposed group (by 4.9 episodes.h-1). The PS did not differ significantly between the two groups. During the dark period, there were no significant intergroup differences. We conclude that RF-EMF exposure induced a shift in thermal preference towards higher temperatures. The shift in preferred temperature might result from a cold thermal sensation. The change in sleep stage distribution may involve signals from thermoreceptors in the skin. Modulation of SWS may be a protective adaptation in response to RF-EMF exposure.

Penafiel LM, Litovitz T, Krause D, Desta A, Mullins JM, Role of modulation on the effect of microwaves on ornithine decarboxylase activity in L929 cells. Bioelectromagnetics 18(2):132-141, 1997.

The effect of 835 MHz microwaves on the activity of ornithine decarboxylase (ODC) in L929 murine cell was investigated at an SAR of approximately 2.5 W/kg. The results depended upon the type of modulation employed. AM frequencies of 16 Hz and 60 Hz produced a transient increase in ODC activity that reached a peak at 8 h of exposure and returned to control levels after 24 h of exposure. In this case, ODC was increased by a maximum of 90% relative to control levels. A 40% increase in ODC activity was also observed after 8 h of exposure with a typical signal from a TDMA digital cellular telephone operating in the middle of its transmission frequency range (approximately 840 MHz). This signal was burst modulated at 50 Hz, with approximately 30% duty cycle. By contrast, 8 h exposure with 835 MHz microwaves amplitude modulated with speech produced no significant change in ODC activity. Further investigations, with 8 h of exposure to AM microwaves, as a function of modulation frequency, revealed that the response is frequency dependent, decreasing sharply at 6 Hz an 600 Hz. Exposure with 835 MHz microwaves, frequency modulated with a 60 Hz sinusoid, yielded no significant enhancement in ODC activity for exposure times ranging between 2 and 24 h. Similarly, exposure with a typical signal from an AMPS analog cellular telephone, which uses a form of frequency modulation, produced no significant enhancement in ODC activity. Exposure with 835 MHz continuous wave microwaves produced no effects for exposure times between 2 and 24 h, except for a small but statistically significant enhancement in ODC activity after 6 h of exposure. Comparison of these results suggests that effects are much more robust when the modulation causes low-frequency periodic changes in the

amplitude of the microwave carrier.

Pereira C, Edwards M, Parotid nodular fasciitis in a mobile phone user. J Laryngol Otol 114(11):886-887, 2000.

We describe the first case of nodular fasciitis affecting the deep lobe of the parotid gland in a 39-year-old male telephone engineer and its possible association with the high usage of mobile phones.

Perentos N, Croft RJ, McKenzie RJ, Cvetkovic D, Cosic I. Comparison of the effects of continuous and pulsed mobile phone like RF exposure on the human EEG. Australas Phys Eng Sci Med. 30(4):274-280, 2007.

It is not clear yet whether Global System for Mobiles (GSM) mobile phone radiation has the ability to interfere with normal resting brain function. There have been reports that GSM exposure increases alpha band power, and does so only when the signal is modulated at low frequencies (Huber, R., Treyer, V., Borbely, A. A., Schuderer, J., Gottselig, J. M., Landolt, H.P., Werth, E., Berthold,T., Kuster, N., Buck, A and Achermann, P. Electromagnetic fields, such as those from mobile phones, alter regional cerebral blood flow and sleep and waking EEG. J Sleep Res 11, 289-295, 2002.) However, as that research employed exposure distributions that are not typical of normal GSM handset usage (deep brain areas were overexposed), it remains to be determined whether a similar result patterning would arise from a more representative exposure. In this fully counterbalanced cross-over design, we recruited 12 participants and tried to replicate the modulation linked post exposure alpha band power increase described above, but with an exposure source (dipole antenna) more closely resembling that of a real GSM handset. Exposures lasted for 15 minutes. No changes to alpha power were found for either modulated or unmodulated radiofrequency fields, and thus we failed to replicate the above results. Possible reasons for this failure to replicate are discussed, with the main reason argued to be the lower and more representative exposure distribution employed in the present study. In addition we investigated the possible GSM exposure related effects on the non-linear features of the resting electroencephalogram using the Approximate Entropy (ApEn) method of analysis. Again, no effect was demonstrated for either modulated or unmodulated radiofrequency exposures.

Perentos N, Croft RJ, McKenzie RJ, Cvetkovic D, Cosic I. The effect of GSM-like ELF radiation on the alpha band of the human resting EEG. Conf Proc IEEE Eng Med Biol Soc. 1:5680-5683, 2008.

Mobile phone handsets such as those operating in the GSM network emit extremely low frequency electromagnetic fields ranging from DC to at least 40 kHz. As a subpart of an extended protocol, the influence of these fields on the human resting EEG has been investigated in a fully counter balanced, double blind, cross-over design study that recruited 72 healthy volunteers. A decrease in the alpha frequency band was observed during the 20 minutes of ELF exposure in the exposed hemisphere only. This result suggests that ELF fields as emitted from GSM handsets during the DTX mode may have an effect on the resting alpha band of the human EEG.

Pérez-Castejón C, Pérez-Bruzón RN, Llorente M, Pes N, Lacasa C, Figols T,

Lahoz M, Maestú C, Vera-Gil A, Del Moral A, Azanza MJ. Exposure to ELF-pulse modulated X band microwaves increases in vitro human astrocytoma cell proliferation. Histol Histopathol. 24(12):1551-1561, 2009.

Common concern about the biological effects of electromagnetic fields (EMF) is increasing with the expansion of X-band microwaves (MW). The purpose of our work was to determine whether exposure to MW pulses in this range can induce toxic effects on human astrocytoma cells. Cultured astrocytoma cells (Clonetics line 1321N1) were submitted to 9.6 GHz carrier, 90% amplitude modulated by extremely low frequency (ELF)-EMF pulses inside a Gigahertz Transversal Electromagnetic Mode cell (GTEM-cell). Astrocytoma cultures were maintained inside a GTEM-incubator in standard culture conditions at 37+/-0.1 degrees C, 5% CO2, in a humidified atmosphere. Two experimental conditions were applied with field parameters respectively of: PW 100-120 ns; PRF 100-800 Hz; PRI 10-1.25 ms; power 0.34-0.60 mW; electric field strength 1.25-1.64 V/m; magnetic field peak amplitude 41.4-54.6 microOe. SAR was calculated to be 4.0 x 10-4 W/Kg. Astrocytoma samples were grown in a standard incubator. Reaching 70-80% confluence, cells were transferred to a GTEM-incubator. Experimental procedure included exposed human astrocytoma cells to MW for 15, 30, 60 min and 24 h and unexposed sham-control samples. Double blind method was applied. Our results showed that cytoskeleton proteins, cell morphology and viability were not modified. Statistically significant results showed increased cell proliferation rate under 24h MW exposure. Hsp-70 and Bcl-2 antiapoptotic proteins were observed in control and treated samples, while an increased expression of connexin 43 proteins was found in exposed samples. The implication of these results on increased proliferation is the subject of our current research.

Persson BRR, Salford LG, Brun A, Blood-brain barrier permeability in rats exposed to electromagnetic fields used in wireless communication. Wireless Network 3:455-461, 1997.

Biological effects of radio frequency electromagnetic fields (EMF) on the blood-brain barrier (BBB) have been studied in Fischer 344 rats of both sexes. The rats were not anesthetised during the exposure. The brains were perfused with saline for 3-4 minutes, and thereafter perfusion fixed with 4% formaldehyde for 5-6 minutes. Whole coronal sections of the brains were dehydrated and embedded in paraffin and sectioned at 5 micrometers. Albumin and fibinogen were demonstrated immunochemically and classified as normal versus pathological leakage. In the present investigation we exposed male and female Fischer 344 rats in a Transverse Electromagnetic Transmission line camber to microwaves of 915 MHz as continuous wave (CW) and pulse-modulated with different pulse power and at various time intervals. The CW-pulse power varied from 0.001 W to 10 W and the exposure time from 2 min to 960 min. In each experiment we exposed 4-6 rats with 2-4 controls randomly placed in excited and non-excited TEM cells, respectively. We have in total investigated 630 exposed rats at various modulation frequencies and 372 controls. The frequency of pathological rats is significantly increased (P< 0.0001) from 62/372 (ratio 0.17 + 0.02) for control rats to 244/630 (ratio: 0.39 + 0.043) in all exposed rats. Grouping the exposed animals according to the level or specific absorption energy (J/kg) give significant difference in all levels above 1.5 J/kg. The

exposure was 915 MHz microwaves either pulse modulated (PW) at 217 Hz with 0.57 ms pulse width, at 50 Hz with 6.6 ms pulse width or continuous wave (CW). The frequency of pathological rats (0.17) among controls in the various groups is not significantly different. The frequency of pathological rats was 170/480 (0.35 + 0.03) among rats exposed to pulse modulated (PW) and 74/149 (0.50 + 0.07) among rats exposed to continuous wave exposure (CW). These results are both highly significantly different to their corresponding controls ($p < 0.0001$) and the frequency of pathological rats after exposure to pulsed radiation (PW) is significantly less ($p < 0.002$) than after exposure to continuous wave radiation (CW).

Pesnya DS, Romanovsky AV. Comparison of cytotoxic and genotoxic effects of plutonium-239 alpha particles and mobile phone GSM 900 radiation in the Allium cepa test.Mutat Res. 2012 Oct 8. pii: S1383-5718(12)00291-4. doi: 10.1016/j.mrgentox.2012.08.010. [Epub ahead of print]

The goal of this study was to compare the cytotoxic and genotoxic effects of plutonium-239 alpha particles and GSM 900 modulated mobile phone (model Sony Ericsson K550i) radiation in the Allium cepa test. Three groups of bulbs were exposed to mobile phone radiation during 0 (sham), 3 and 9h. A positive control group was treated during 20min with plutonium-239 alpha-radiation. Mitotic abnormalities, chromosome aberrations, micronuclei and mitotic index were analyzed. Exposure to alpha-radiation from plutonium-239 and exposure to modulated radiation from mobile phone during 3 and 9h significantly increased the mitotic index. GSM 900 mobile phone radiation as well as alpha-radiation from plutonium-239 induced both clastogenic and aneugenic effects. However, the aneugenic activity of mobile phone radiation was more pronounced. After 9h of exposure to mobile phone radiation, polyploid cells, three-groups metaphases, amitoses and some unspecified abnormalities were detected, which were not registered in the other experimental groups. Importantly, GSM 900 mobile phone radiation increased the mitotic index, the frequency of mitotic and chromosome abnormalities, and the micronucleus frequency in a time-dependent manner. Due to its sensitivity, the A. cepa test can be recommended as a useful cytogenetic assay to assess cytotoxic and genotoxic effects of radiofrequency electromagnetic fields.

Petitdant N, Lecomte A, Robidel F, Gamez C, Blazy K, Villégier AS. Cerebral radiofrequency exposures during adolescence: Impact on astrocytes and brain functions in healthy and pathologic rat models. Bioelectromagnetics. 37(5):338-350, 2016.

The widespread use of mobile phones by adolescents raises concerns about possible health effects of radiofrequency electromagnetic fields (RF EMF 900 MHz) on the immature brain. Neuro-development is a period of particular sensitivity to repeated environmental challenges such as pro-inflammatory insults. Here, we used rats to assess whether astrocyte reactivity, perception, and emotionality were affected by RF EMF exposures during adolescence. We also investigated if adolescent brains were more sensitive to RF EMF exposures after neurodevelopmental inflammation. To do so, we either performed 80 µg/kg intra-peritoneal injections of lipopolysaccharides during gestation or 1.25 µg/h intra-cerebro-ventricular infusions during adolescence. From

postnatal day (P)32 to 62, rats were subjected to 45 min RF EMF exposures to the brain (specific absorption rates: 0, 1.5, or 6 W/kg, 5 days/week). From P56, they were tested for perception of novelty, anxiety-like behaviors, and emotional memory. To assess astrocytic reactivity, Glial Fibrillary Acidic Protein was measured at P64. Our results did not show any neurobiological impairment in healthy and vulnerable RF EMF-exposed rats compared to their sham-exposed controls. These data did not support the hypothesis of a specific cerebral sensitivity to RF EMF of adolescents, even after a neurodevelopmental inflammation.

Pettersson D, Mathiesen T, Prochazka M, Bergenheim T, Florentzson R, Harder H, Nyberg G, Siesjö P, Feychting M. Long-term Mobile Phone Use and Acoustic Neuroma Risk. Epidemiology 25(2):233-41, 2014.

BACKGROUND: There is concern about potential effects of radiofrequency fields generated by mobile phones on cancer risk. Most previous studies have found no association between mobile phone use and acoustic neuroma, although information about long-term use is limited. METHODS: We conducted a population-based, nation-wide, case-control study of acoustic neuroma in Sweden. Eligible cases were persons aged 20 to 69 years, who were diagnosed between 2002 and 2007. Controls were randomly selected from the population registry, matched on age, sex, and residential area. Postal questionnaires were completed by 451 cases (83%) and 710 controls (65%).RESULTS: Ever having used mobile phones regularly (defined as weekly use for at least 6 months) was associated with an odds ratio (OR) of 1.18 (95% confidence interval = 0.88 to 1.59). The association was weaker for the longest induction time (≥10 years) (1.11 [0.76 to 1.61]) and for regular use on the tumor side (0.98 [0.68 to 1.43]). The OR for the highest quartile of cumulative calling time (≥680 hours) was 1.46 (0.98 to 2.17). Restricting analyses to histologically confirmed cases reduced all ORs; the OR for ≥680 hours was 1.14 (0.63 to 2.07). A similar pattern was seen for cordless land-line phones, although with slightly higher ORs. Analyses of the complete history of laterality of mobile phone revealed considerable bias in laterality analyses. CONCLUSIONS:The findings do not support the hypothesis that long-term mobile phone use increases the risk of acoustic neuroma. The study suggests that phone use might increase the likelihood that an acoustic neuroma case is detected and that there could be bias in the laterality analyses performed in previous studies.

Peyman A, Rezazadeh AA, Gabriel C. Changes in the dielectric properties of rat tissue as a function of age at microwave frequencies. Phys Med Biol 46(6):1617-1629, 2001.

The dielectric properties of ten rat tissues at six different ages were measured at 37 degrees C in the frequency range of 130 MHz to 10 GHz using an open-ended coaxial probe and a computer controlled network analyser. The results show a general decrease of the dielectric properties with age. The trend is more apparent for brain, skull and skin tissues and less noticeable for abdominal tissues. The variation in the dielectric properties with age is due to the changes in the water content and the organic composition of tissues. The percentage decrease in the dielectric properties of certain tissues in the 30 to 70 day old rats at cellular phone frequencies have been tabulated. These data provide an

important input in the provision of rigorous dosimetry in lifetime-exposure animal experiments. The results provide some insight into possible differences in the assessment of exposure for children and adults.

Peyman A, Gabriel C, Grant EH, Vermeeren G, Martens L.Variation of the dielectric properties of tissues with age: the effect on the values of SAR in children when exposed to walkie-talkie devices. Phys Med Biol. 54(2):227-241, 2009.

In vitro dielectric properties of ageing porcine tissues were measured in the frequency range of 50 MHz-20 GHz, and the total combined uncertainties of the measurements were assessed. The results show statistically significant reduction with age in both permittivity and conductivity of 10 out of 15 measured tissues. At microwave frequencies, the observed variations are mainly due to the reduction in the water content of tissues as an animal ages. The results obtained were then used to calculate the SAR values in children of age 3 and 7 years when they are exposed to RF induced by walkie-talkie devices. No significant differences between the SAR values for the children of either age or for adults were observed.

Peyman A, Holden SJ, Watts S, Perrott R, Gabriel C. Dielectric properties of porcine cerebrospinal tissues at microwave frequencies: in vivo, in vitro and systematic variation with age. Phys Med Biol. 52(8):2229-2245, 2007.

The dielectric properties of pig cerebrospinal tissues were measured in vivo and in vitro, in the frequency range of 50 MHz-20 GHz. The total combined measurement uncertainty was calculated at each frequency point and is reported over representative frequency regions. Comparisons were made for each tissue between the two sets of data and with the literature of the past decade. The in vitro study was extended to include tissue from pigs weighing approximately 10, 50 and 250 kg to re-visit the question of the variation of dielectric properties with age. White matter and spinal chord showed significant variation as function of animal age, no age-related variations were recorded for grey matter.

Peyman A, Khalid M, Calderon C, Addison D, Mee T, Maslanyj M, Mann S. Assessment of exposure to electromagnetic fields from wireless computer networks (wi-fi) in schools; results of laboratory measurements. Health Phys. 100(6):594-612, 2011.

Abstract. Laboratory measurements have been carried out with examples of Wi-Fi devices used in UK schools to evaluate the radiofrequency power densities around them and the total emitted powers. Unlike previous studies, a 20 MHz bandwidth signal analyzer was used, enabling the whole Wi-Fi signal to be captured and monitored. The radiation patterns of the laptops had certain similarities, including a minimum toward the torso of the user and two maxima symmetrically opposed across a vertical plane bisecting the screen and keyboard. The maxima would have resulted from separate antennas mounted behind the top left and right corners of the laptop screens. The patterns for access points were more symmetrical with generally higher power densities at a given distance. The spherically-integrated radiated power (IRP) ranged from 5 to 17 mW for 15 laptops in the 2.45 GHz band and from 1 to 16 mW for eight laptops in the 5 GHz band. For practical reasons and because access points are generally wall-mounted with beams directed into the rooms, their powers were

integrated over a hemisphere. These ranged from 3 to 28 mW for 12 access points at 2.4 GHz and from 3 to 29 mW for six access points at 5 GHz. In addition to the spherical measurements of IRP, power densities were measured at distances of 0.5 m and greater from the devices, and consistent with the low radiated powers, these were all much lower than the ICNIRP reference level.

Pfützner, H. (2016) “Hot Nano Spots” as an Interpretation of So-Called Non-Thermal Biological Mobile Phone Effects. Journal of Electromagnetic Analysis and Applications, 8, 62-69. doi: 10.4236/jemaa.2016.83007. Environ Res. 2016 Apr 27;148:367-375. doi: 10.1016/j.envres.2016.04.018. [Epub ahead of print]

Indications exist that mobile phones may cause non-specific biological effects. They are classified as being of implausible non-thermal nature due to low quantum energy and low specific absorption rate levels, even if considering worst cases of "hot spots" of only millimeter size. The considerations of this paper demonstrate that classical theory of polarization offers a conventional interpretation for all three the existence of so far unclarified effects, their low reproducibility and their low intensity. The basis of this explanation is given by the assumption that hot spots contain even hotter “nano spots” on a molecular level according to well known mechanisms of γ-relaxation. In this paper, the concept is put for discussion assuming a heterogeneous system that consists of water molecules as well as larger-sized functional molecules. A consistent interpretation through temperature increase on the level of nanometer sized molecular compounds promises to favor interdisciplinary discussions with respect to safety regulations.

Phelan AM, Lange DG, Kues HA, Lutty GA, Modification of membrane fluidity in melanin-containing cells by low-level microwave radiation. Bioelectromagnetics13(2):131-146, 1992.

The treatment of a B16 melanoma cell line with 2.45-GHz pulsed microwaves (10 mW/cm2, 10-microseconds pulses at 100 pps, 1-h exposure; SAR, 0.2 W/kg) resulted in changes of membrane ordering as measured by EPR (electron paramagnetic resonance) reporter techniques. The changes reflected a shift from a more fluid-like phase to a more solid (ordered) state of the cell membrane. Exposure of artificially prepared liposomes that were reconstituted with melanin produced similar results. In contrast, neither B16 melanoma cells treated with 5-Bromo-2-Deoxyuridine (3 micrograms/day x 7 days) to render them amelanotic, nor liposomes prepared without melanin, exhibited the microwave-facilitated increase of ordering. Inhibition of the ordering was achieved by the use of superoxide dismutase (SOD), which strongly implicates oxygen radicals as a cause of the membrane changes. The data indicate that a significant, specific alteration of cell-membrane ordering followed microwave exposure. This alteration was unique to melanotic membranes and was due, at least in part, to the generation of oxygen radicals.

Phelan AM, Neubauer CF, Timm R, Neirenberg J, Lange DG, Athermal alterations in the structure of the canalicular membrane and ATPase activity induced by thermal levels of microwave radiation. Radiat Res 137(1):52-58, 1994.

Sprague-Dawley rats (200-250 g) were exposed 30 min/day for 4 days to thermogenic levels (rectal temperature increase of 2.2 degrees C) of microwave radiation [2.45 GHz, 80 mW/cm2, continuous-wave mode (CW)] or to a radiant heat source resulting in an equivalent increase in body temperature of 2.2 degrees C. On the fifth day after the 4 days of exposure to microwave radiation, the animals were sacrificed and their livers removed. The canalicular membranes were isolated and evaluated for adenosinetriphosphatase (ATPase) activity, total fatty acid composition and membrane fluidity characteristics. Mg(++)-ATPase activity (Vmax) decreased by 48.5% in the group exposed to microwave radiation, with no significant change in the group exposed to radiant heat. The decrease in Mg(++)-ATPase was partially compensated by a concomitant increase in Na+/K(+)-ATPase activity (170% increase in Vmax over control) in animals exposed to microwave radiation, while no change occurred in the group exposed to radiant heat. This alteration in ATPase activity in the group exposed to microwave radiation is associated with a large decrease in the ratio of saturated to unsaturated fatty acids. Conversely, the group exposed to radiant heat had an increase in the ratio of saturated to unsaturated fatty acids. The most dramatic changes were found in the levels of arachidonic acid. Finally, the electron paramagnetic resonance (EPR) spin label technique used to measure the fluidity of the canalicular membranes of the animals in the three groups (sham, microwave radiation and radiant heat) indicated that the results were different in the three groups, reflecting the changes found in their fatty acid composition. The physiological response to "equivalent" thermal loads in rats is expressed differently for different types of energy sources. Possible mechanisms producing these divergent thermogenic responses are discussed.

Phillips, J.L., Ivaschuk, O., Ishida-Jones, T., Jones, R.A., Campbell-Beachler, M. and Haggren, W. DNA damage in Molt-4 T- lymphoblastoid cells exposed to cellular telephone radiofrequency fields in vitro. Bioelectrochem. Bioenerg. 45:103-110, 1998.

Molt-4 T-lymphoblastoid cells have been exposed to pulsed signals at cellular telephone frequencies of 813.5625 MHz (iDEN signal) and 836.55 MHz (TDMA signal). These studies were performed at low SAR (average = 2.4 and 24 microwatt/g for iDEN and 2.6 and 26 microwatt/g for TDMA) in studies designed to look for athermal RF effects. The alkaline comet, or single cell gel electrophoresis, assay was employed to measure DNA single-strand breaks in cell cultures exposed to the radiofrequency (RF) signal as compared to concurrent sham-exposed cultures. Tail moment and comet extent were calculated as indicators of DNA damage. Statistical differences in the distribution of values for tail moment and comet extent between exposed and control cell cultures were evaluated with the SKolmogorov-Smirnoff distribution test. Data points for all experiments of each exposure condition were pooled and analyzed as single groups. It was found that: 1) exposure of cells to the iDEN signal at an SAR of 2.4 microwatt/g for 2 h or 21 h significantly decreased DNA damage; 2) exposure of cells to the TDMA signal at an SAR of 2.6 microwatt/g for 2 h and 21 h significantly decreased DNA damage; 3) exposure of cells to the iDEN signal at an SAR of 24 microwatt/g for 2 h and 21 h significantly increased DNA damage; 4) exposure of cells to the TDMA signal at an SAR of 26 microwatt/g for 2 h significantly decreased DNA damage. The data indicate a need to

study the effects of exposure to RF signals on direct DNA damage and on the rate at which DNA damage is repaired.

Philippova TM, Novoselov VI, Alekseev SI, Influence of microwaves on different types of receptors and the role of peroxidation of lipids on receptor-protein shedding. Bioelectromagnetics 15(3):183-192, 1994.

The effects of a continuous wave or pulse-modulated, 900 MHz microwave field were studied by in vitro assays of rat chemoreceptors. The pulsed field was modulated as rectangular waves at rates of 1, 6, 16, 32, 75, or 100 pps. The pulse-period to pulse-duration ratio was 5 in all cases, and specific absorption rates (SARs) ranged from 0.5 to 18 W/kg. Binding of ligands to cell membranes was differentially affected by exposure to microwaves. For example, binding of H3-glutamic acid to hippocampal cells was not altered by a 15 min exposure to a continuous wave field at 1 W/kg, but binding of H3-dihydroalprenolol to liver-cell membranes of neonates underwent a fivefold decrease under the same field conditions. This effect was not dependent on modulation or on a change in the constant of stimulus-receptor binding but depended on a shedding of the membrane's receptor elements into solution. The magnitude of inhibition correlated with the oxygen concentration in the exposed suspension. Antioxidants (dithiothreitol and ionol) inhibited the shedding of receptor elements. The microwave exposure did not cause an accumulation of products from the peroxidation of lipids (POL). Ascorbate-dependent or non-enzymatic POL was not responsible for the inhibition, and POL was not found in other model systems. However, enzymatic POL mechanisms in localized areas of receptor binding remain a possibility.

Pilla AA. Electromagnetic fields instantaneously modulate nitric oxide signaling in challenged biological systems.Biochem Biophys Res Commun. 426(3):330-333, 2012.

This study shows that a non-thermal pulse-modulated RF signal (PRF), configured to modulate calmodulin (CaM) activation via acceleration of Ca(2+) binding kinetics, produced an immediate nearly 3-fold increase in nitric oxide (NO) from dopaminergic MN9D cultures (P<0.001). NO was measured electrochemically in real-time using a NO selective membrane electrode, which showed the PRF effect occurred within the first seconds after lipopolysaccharide (LPS) challenge. Further support that the site of action of PRF involves CaM is provided in human fibroblast cultures challenged with low serum and exposed for 15min to the identical PRF signal. In this case a CaM antagonist W-7 could be added to the culture 3h prior to PRF exposure. Those results showed the PRF signal produced nearly a two-fold increase in NO, which could be blocked by W-7 (P<0.001). To the authors' knowledge this is the first report of a real-time effect of non-thermal electromagnetic fields (EMF) on NO release from challenged cells. The results provide mechanistic support for the many reported bioeffects of EMF in which NO plays a role. Thus, in a typical clinical application for acute post operative pain, or chronic pain from, e.g., osteoarthritis, EMF therapy could be employed to modulate the dynamics of NO via Ca/CaM-dependent constitutive nitric oxide synthase (cNOS) in the target tissue. This, in turn, would modulate the dynamics of the signaling pathways the body uses in response to the various phases of healing after physical or chemical insult or injury.

Pinto R, Lopresto V, Galloni P, Marino C, Mancini S, Lodato R, Pioli C, Lovisolo GA. Dosimetry of a set-up for the exposure of newborn mice to 2.45-GHZ WiFi frequencies. Radiat Prot Dosimetry. 140(4):326-332, 2010.

This work describes the dosimetry of a two waveguide cell system designed to expose newborn mice to electromagnetic fields associated with wireless fidelity signals in the frequency band of 2.45 GHz. The dosimetric characterisation of the exposure system was performed both numerically and experimentally. Specific measures were adopted with regard to the increase in both weight and size of the biological target during the exposure period. The specific absorption rate (SAR, W kg(-1)) for 1 W of input power vs. weight curve was assessed. The curve evidenced an SAR pattern varying from <1 W kg(-1) to >6 W kg(-1) during the first 5 weeks of the life of mice, with a peak resonance phenomenon at a weight around 5 g. This curve was used to set the appropriate level of input power during experimental sessions to expose the growing mice to a defined and constant dose.

Platano D, Mesirca P, Paffi A, Pellegrino M, Liberti M, Apollonio F, Bersani F, Aicardi G. Acute exposure to low-level CW and GSM-modulated 900 MHz radiofrequency does not affect Ba(2+) currents through voltage-gated calcium channels in rat cortical neurons. Bioelectromagnetics.28(8):599-607, 2007.

We have studied the non-thermal effects of radiofrequency (RF) electromagnetic fields (EMFs) on Ba(2+) currents ($I_{{\rm Ba};{2+ } }$) through voltage-gated calcium channels (VGCC), recorded in primary cultures of rat cortical neurons using the patch-clamp technique. To assess whether low-level acute RF field exposure could modify the amplitude and/or the voltage-dependence of $I_{{\rm Ba};{2+ } }$, Petri dishes containing cultured neurons were exposed for 1-3 periods of 90 s to 900 MHz RF-EMF continuous wave (CW) or amplitude-modulated according to global system mobile communication standard (GSM) during whole-cell recording. The specific absorption rates (SARs) were 2 W/kg for CW and 2 W/kg (time average value) for GSM-modulated signals, respectively. The results obtained indicate that single or multiple acute exposures to either CW or GSM-modulated 900 MHz RF-EMFs do not significantly alter the current amplitude or the current-voltage relationship of $I_{{\rm Ba};{2+ } }$, through VGCC.

Podkovkin VG, [The modification of the effect of microwave radiation on the biochemical processes in anaphylactic shock by using exposure to a weak and perturbed geomagnetic field]. Radiobiologiia 33(1):166-169, 1993. [Article in Russian]

Repeated exposure of guinea pigs to microwave radiation (1 mW/cm2) caused in some animals inhibition of anaphylactic response accompanied by increasing the content of histamine, epinephrine and norepinephrine in the blood. This increase was more pronounced in irradiated guinea pigs died from anaphylactic shock than in nonirradiated animals. The long-term stay in the perturbed and weak geometric field reduced the effect induced by microwave radiation.

Pologea-Moraru R, Kovacs E, Iliescu KR, Calota V, Sajin G. The effects of low level microwaves on the fluidity of photoreceptor cell membrane. Bioelectrochemistry

56(1-2):223-225, 2002.

Due to the extensive use of electromagnetic fields in everyday life, more information is required for the detection of mechanisms of interaction and the possible side effects of electromagnetic radiation on the structure and function of the organism.In this paper, we study the effects of low-power microwaves (2.45 GHz) on the membrane fluidity of rod photoreceptor cells. The retina is expected to be very sensitive to microwave irradiation due to the polar character of the photoreceptor cells [Biochim. Biophys. Acta 1273 (1995) 217] as well as to its high water content [Stud. Biophys. 81 (1981) 39].

Port M, Abend M, Romer B, Van Beuningen D. Influence of high-frequency electromagnetic fields on different modes of cell death and gene expression. Int J Radiat Biol. 79(9):701-708, 2003.

PURPOSE: International thresholds for exposure to non-ionizing radiation leading to non-thermal effects were conservatively set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The aim of this study was to examine whether biological effects such as different modes of cell death and gene expression modifications related to tumorgenesis are detectable above the threshold defined. MATERIALS AND METHODS: Human leukaemia cells (HL-60) grown in vitro were exposed to electromagnetic fields (EMF; t 1/2(r) about 1 ns; field strength about 25 times higher than the ICNIRP reference levels for occupational exposure) leading to non-thermal effects using a high-voltage-improved GTEM cell 5302 (EMCO) connected to a pulse generator NP20 (C = 1 nF, U(Load) = 20kV). HL-60 cells were harvested at 0, 24, 48 and 72 h after radiation exposure. Micronuclei, apoptosis and abnormal cells (e.g. necrosis) were determined using morphological criteria. In parallel, the expression of 1176 genes was measured using Atlas Human 1.2. Array. Based on high data reproducibility calculated from two independent experiments (> 99%), array analysis was performed. RESULTS: No significant change in apoptosis, micronucleation, abnormal cells and differential gene expression was found. CONCLUSIONS: Exposure of HL-60 cells to EMFs 25 times higher than the ICNIRP reference levels for occupational exposure failed to induce any changes in apoptosis, micronucleation, abnormal morphologies and gene expression. Further experiments using EMFs above the conservatively defined reference level set by the ICNIRP may be desirable.

Poulletier de Gannes F, Haro E, Hurtier A, Taxile M, Ruffié G, Billaudel B, Veyret B, Lagroye I. Effect of exposure to the edge signal on oxidative stress in brain cell models. Radiat Res. 175(2):225-230, 2011.

In this study we investigated the effect of the Enhanced Data rate for GSM Evolution (EDGE) signal on cells of three human brain cell lines, SH-SY5Y, U87 and CHME5, used as models of neurons, astrocytes and microglia, respectively, as well as on primary cortical neuron cultures. SXC-1800 waveguides (IT'IS-Foundation, Zürich, Switzerland) were modified for in vitro exposure to the EDGE signal radiofrequency (RF) radiation at 1800 MHz. Four exposure conditions were tested: 2 and 10 W/kg for 1 and 24 h. The production of reactive oxygen species (ROS) was measured by flow cytometry using the dichlorofluorescein diacetate (DCFH-DA) probe at the end of the 24-h exposure or 24 h after the 1-h exposure. Rotenone treatment was used as a positive control. All cells tested responded to rotenone treatment by increasing ROS

production. These findings indicate that exposure to the EDGE signal does not induce oxidative stress under these test conditions, including 10 W/kg. Our results are in agreement with earlier findings that RF radiation alone does not increase ROS production.

Poulletier de Gannes F, Haro E, Hurtier A, Taxile M, Athane A, Ait-Aissa S, Masuda H, Percherncier Y, Ruffié G, Billaudel B, Dufour P, Veyret B, Lagroye I. Effect of in utero wi-fi exposure on the pre- and postnatal development of rats. Birth Defects Res B Dev Reprod Toxicol. 95(2):130-136, 2012.

BACKGROUND: The increase in exposure to the Wireless Fidelity (Wi-Fi) wireless communication signal has raised public health concerns especially for young people. Animal studies looking at the effects of early life and prenatal exposure to this source of electromagnetic fields, in the radiofrequency (RF) range, on development and behavior have been considered as high priority research needs by the World Health Organization. METHODS: For the first time, our study assessed the effects of in utero exposure to a 2450 MHz Wi-Fi signal (2 hr/day, 6 days/week for 18 days) on pregnant rats and their pups. Three levels in terms of whole-body specific absorption rate were used: 0.08, 0.4, and 4 W/kg. The prenatal study on fetuses delivered by caesarean (P20) concerned five females/group. The dams and their offspring were observed for 28 days after delivery (15 females/group). RESULTS: For all test conditions, no abnormalities were noted in the pregnant rats and no significant signs of toxicity were observed in the pre- and postnatal development of the pups, even at the highest level of 4 W/kg. CONCLUSIONS: In the present study, no teratogenic effect of repeated exposures to the Wi-Fi wireless communication signal was demonstrated even at the highest level of 4 W/kg. The results from this screening study aimed at investigating Wi-Fi effects, strengthen the previous conclusions that teratology and development studies have not detected any noxious effects of exposures to mobile telephony-related RF fields at exposure levels below standard limits.

Poulletier de Gannes F, Billaudel B, Haro E, Taxile M, Le Montagner L, Hurtier A, Ait Aissa S, Masuda H, Percherancier Y, Ruffié G, Dufour P, Veyret B, Lagroye I. Rat fertility and embryo fetal development: influence of exposure to the Wi-Fi signal. Reprod Toxicol. 36:1-5, 2013.

In recent decades, concern has been growing about decreasing fecundity and fertility in the human population. Exposure to non-ionizing electromagnetic fields (EMF), especially radiofrequency (RF) fields used in wireless communications has been suggested as a potential risk factor. For the first time, we evaluated the effects of exposure to the 2450MHz Wi-Fi signal (1h/day, 6days/week) on the reproductive system of male and female Wistar rats, pre-exposed to Wi-Fi during sexual maturation. Exposure lasted 3 weeks (males) or 2 weeks (females), then animals were mated and couples exposed for 3 more weeks. On the day before delivery, the fetuses were observed for lethality, abnormalities, and clinical signs. In our experiment, no deleterious effects of Wi-Fi exposure on rat male and female reproductive organs and fertility were observed for 1h per days. No macroscopic abnormalities in fetuses were noted, even at the critical level of 4W/kg.

Poulletier de Gannes F, Masuda H, Billaudel B, Poque-Haro E, Hurtier A, Lévêque P, Ruffié G, Taxile M, Veyret B, Lagroye I. Effects of GSM and UMTS mobile telephony signals on neuron degeneration and blood-brain barrier permeation in the rat brain. Sci Rep. 2017 Nov 14;7(1):15496. doi: 10.1038/s41598-017-15690-1.

Blood-brain barrier (BBB) permeation and neuron degeneration were assessed in the rat brain following exposure to mobile communication radiofrequency (RF) signals (GSM-1800 and UMTS-1950). Two protocols were used: (i) single 2 h exposure, with rats sacrificed immediately, and 1 h, 1, 7, or 50 days later, and (ii) repeated exposures (2 h/day, 5 days/week, for 4 weeks) with the effects assessed immediately and 50 days after the end of exposure. The rats' heads were exposed at brain-averaged specific absorption rates (BASAR) of 0.026, 0.26, 2.6, and 13 W/kg. No adverse impact in terms of BBB leakage or neuron degeneration was observed after single exposures or immediately after the end of repeated exposure, with the exception of a transient BBB leakage (UMTS, 0.26 W/kg). Fifty days after repeated exposure, the occurrence of degenerating neurons was unchanged on average. However, a significant increased albumin leakage was detected with both RF signals at 13 W/kg. In this work, the strongest, delayed effect was induced by GSM-1800 at 13 W/kg. Considering that 13 W/kg BASAR in the rat head is equivalent to 4 times as much in the human head, deleterious effects may occur following repeated human brain exposure above 50 W/kg.

Poulsen AH, Friis S, Johansen C, Jensen A, Frei P, Kjær SK, Dalton SO, Schüz J. Mobile Phone Use and the Risk of Skin Cancer: A Nationwide Cohort Study in Denmark. Am J Epidemiol. 2013 Jun 20. [Epub ahead of print]

The International Agency for Research on Cancer has classified radiofrequency radiation as possibly carcinogenic. Previous studies have focused on intracranial tumors, although the skin receives much radiation. In a nationwide cohort study, 355,701 private mobile phone subscribers in Denmark from 1987 to 1995 were followed up through 2007. We calculated incidence rate ratios (IRRs) for melanoma, basal cell carcinoma, and squamous cell carcinoma by using Poisson regression models adjusted for age, calendar period, educational level, and income. Separate IRRs for head/neck tumors and torso/leg tumors were compared (IRRs) to further address potential confounders. We observed no overall increased risk for basal cell carcinoma, squamous cell carcinoma, or melanoma of the head and neck. After a follow-up period of at least 13 years, the IRRs for basal cell carcinoma and squamous cell carcinoma remained near unity. Among men, the IRR for melanoma of the head and neck was 1.20 (95% confidence interval: 0.65, 2.22) after a minimum 13-year follow-up, whereas the corresponding IRR for the torso and legs was 1.16 (95% confidence interval: 0.91, 1.47), yielding an IRR of 1.04 (95% confidence interval: 0.54, 2.00). A similar risk pattern was seen among women, though it was based on smaller numbers. In this large, population-based cohort study, little evidence of an increased skin cancer risk was observed among mobile phone users.

Poysti L, Rajalin S, Summala H. Factors influencing the use of cellular (mobile) phone during driving and hazards while using it. Accid Anal Prev. 37(1):47-51, 2005.

This study addressed the strategic decisions on not using a mobile phone at all while driving, and phone-related driving hazards among those drivers who do use one, reflecting tactical and operational level processes. A representative sample of 834 licensed drivers who own a mobile phone were interviewed on their phone use and hazards, background factors, and self-image as a driver. Logistic regression models indicated that older age, female gender, smaller amount of driving, and occupation promoted not using a phone at all while driving. Additionally, low skill level and high safety motivation contributed to this decision. Among those who used a phone while driving, exposure to risk in terms of higher mileage and more extensive phone use increased phone-related hazards, as also did young age, leading occupational position, and low safety motivation. Neither gender nor driving skill level had any effect on such self-reported hazards. This study clearly indicates that potential risks of mobile phones are being controlled at many levels, by strategic as well as tactical decisions and, consequently, phone-related accidents have not increased in line with the use of the mobile phones.

Preece, AW, Iwi, G, Davies-Smith, A, Wesnes, K, Butler, S, Lim, E, Varey, A, Effect of a 915-MHz simulated mobile phone signal on cognitive function in man. Int J Radiat Biol 75(4):447-456, 1999.

PURPOSE: To examine whether a simulated mobile telephone transmission at 915 MHz has an effect on cognitive function in man. MATERIALS AND METHODS: Thirty-six subjects in two groups were each given two training sessions and then three test sessions in a randomized three-way cross-over design. About 1 W mean power at 915 MHz from a quarter-wave antenna mounted on a physical copy of an analogue phone, as a sine wave, or modulated at 217 Hz with 12.5% duty cycle, or no power, was applied to the left squamous temple region of the subjects while they undertook a series of cognitive function tests lasting approximately 25-30 min. The second group was investigated for sleep, consumption of alcohol and beverages, and any other substances that might affect performance. RESULTS: In both groups, the only test affected was the choice reaction time and this showed as an increase in speed (a decrease in reaction time). There were no changes in word, number or picture recall, or in spatial memory. While an effect of visit-order was evident suggesting a learning effect of repeat tests, the design of the study allowed for this. Additionally, there was no systematic error introduced as a result of consumption of substances or sleep time. CONCLUSIONS: There was evidence of an increase in responsiveness, strongly in the analogue and less in the digital simulation, in choice reaction time. This could be associated with an effect on the angular gyrus that acts as an interface between the visual and speech centres and which lies directly under and on the same side as the antenna. Such an effect could be consistent with mild localized heating, or possibly a non-thermal response, which is nevertheless power-dependent.

Preece AW, Goodfellow S, Wright MG, Butler SR, Dunn EJ, Johnson Y, Manktelow TC, Wesnes K.Effect of 902 MHz mobile phone transmission on cognitive function in children. Bioelectromagnetics.Suppl 7:S138-43, 2005.

We examine whether a standard mobile exposure at 902 MHz has a significant effect on cognitive function in 18 children 10-12 years of age. These were in a single group in

which each child was given a single training session and then three test sessions in a randomized, three-way crossover design, using the cognitive drug research (CDR) cognitive assessment system. Exposures were 0, 0.025, or 0.25 W from a standard Nokia 3110 mobile phone handset mounted on a plastic headset in normal use position. The results of testing showed that the baseline (0 W) performance for the reaction time measurements was considerably slower than for the comparable measures in adult. There was a tendency for reaction time to be shorter during exposure to radiation than in the sham (baseline) condition, an effect that was most marked for simple reaction time. However, no effects reached statistical significance after Bonferroni correction. Therefore, we conclude that this study on 18 children did not replicate our earlier finding in adults that exposure to microwave radiation was associated with a reduction in reaction time. It should be noted that the present study investigated the effects of radiation from a GSM handset, whereas in our previous study the effect on reaction time was observed only with a more powerful analogue handset.

Preece AW, Georgiou AG, Dunn EJ, Farrow S. Health response of two communities to military antennae in Cyprus. Occup Environ Med.64(6):402-8,2007.

OBJECTIVES: This study investigated concerns that have been raised about past and future health effects caused by high power transmissions of high frequency (7 to 30MHz) radio waves from military antenna systems at Akrotiri, Cyprus. METHODS: A cross-sectional study of three villages (two exposed, one unexposed) collected longitudinal and short-term radiofrequency (RF) measurements. Health data were collected using questionnaires containing information on demographic factors, specific illnesses, general health (SF36 well-being questionnaire), reproductive history, childhood illnesses, risk perception and mortality. Analysis was with SPSS v11.5 using cross tabulations of non-parametric data and tests for significance. Key health outcomes were subjected to logistic regression analysis. RESULTS: Field strengths within the two 'exposed' villages were a maximum of 0.30 Vm-1 from the 17.6 MHz military transmissions and up to 1.4 Vm-1 from unspecified sources, mainly cell-phone frequencies. The corresponding readings in the control village were <0.01 Vm-1. Compared with the control village there were highly significant differences in the reporting of migraine (OR 2.7 p0.0001), headache (3.7 p0.001), and dizziness (2.7 p 0.0001). Residents of the exposed villages showed greater negative views of their health in all eight domains of the SF36. There were also higher levels of perceived risk, particularly to noise and electromagnetic (EM) 'pollution'. All three villages reported higher values of risk perception than a UK population. There was no evidence of birth abnormalities or differences in gynaecological or obstetric history. Numbers of cancers were too small to show differences. CONCLUSION: It was clear that even this close (1-3km) to powerful transmissions, the dominant sources of RF fields were cell-phone and national broadcast systems. There was no excess of cancer, birth defects or obstetric problems. There was heightened risk perception and a considerable excess of migraine, headache and dizziness, which appears to share a gradient with RF exposure. The authors report this association but suggest this is unlikely to be an effect of RF and more likely to be antenna visibility or aircraft noise.

Prisco MG, Nasta F, Rosado MM, Lovisolo GA, Marino C, Pioli C. Effects of GSM-modulated radiofrequency electromagnetic fields on mouse bone marrow cells.

Radiat Res. 170(6):803-810, 2008.

We examined the effects of in vivo exposure to a GSM-modulated 900 MHz RF field on the ability of bone marrow cells to differentiate, colonize lymphatic organs, and rescue lethally X-irradiated mice from death. X-irradiated mice were injected with medium alone or containing bone marrow cells from either RF-field-exposed (SAR 2 W/kg, 2 h/day, 5 days/ week, 4 weeks) or sham-exposed or cage control donor mice. Whereas all mice injected with medium alone died, mice that received bone marrow cells survived. Three and 6 weeks after bone marrow cell transplantation, no differences in thymus cellularity and in the frequencies of differentiating cell subpopulations (identified by CD4/CD8 expression) were observed among the three transplanted groups. Mitogen-induced thymocyte proliferation yielded comparable levels in all transplanted groups. As to the spleen, no effects of the RF-field exposure on cell number, percentages of B and T (CD4 and CD8) cells, B- and T-cell proliferation, and IFN-gamma production were found in transplanted mice. In conclusion, our results show no effect of in vivo exposure to GSM-modulated RF fields on the ability of bone marrow precursor cells to home and colonize lymphoid organs and differentiate in phenotypically and functionally mature T and B lymphocytes.

Prochnow N, Gebing T, Ladage K, Krause-Finkeldey D, El Ouardi A, Bitz A, Streckert J, Hansen V, Dermietzel R. Electromagnetic field effect or simply stress? Effects of UMTS exposure on hippocampal longterm plasticity in the context of procedure related hormone release.PLoS One. 6(5):e19437, 2011.

Harmful effects of electromagnetic fields (EMF) on cognitive and behavioural features of humans and rodents have been controversially discussed and raised persistent concern about adverse effects of EMF on general brain functions. In the present study we applied radio-frequency (RF) signals of the Universal Mobile Telecommunications System (UMTS) to full brain exposed male Wistar rats in order to elaborate putative influences on stress hormone release (corticosteron; CORT and adrenocorticotropic hormone; ACTH) and on hippocampal derived synaptic long-term plasticity (LTP) and depression (LTD) as electrophysiological hallmarks for memory storage and memory consolidation. Exposure was computer controlled providing blind conditions. Nominal brain-averaged specific absorption rates (SAR) as a measure of applied mass-related dissipated RF power were 0, 2, and 10 W/kg over a period of 120 min. Comparison of cage exposed animals revealed, regardless of EMF exposure, significantly increased CORT and ACTH levels which corresponded with generally decreased field potential slopes and amplitudes in hippocampal LTP and LTD. Animals following SAR exposure of 2 W/kg (averaged over the whole brain of 2.3 g tissue mass) did not differ from the sham-exposed group in LTP and LTD experiments. In contrast, a significant reduction in LTP and LTD was observed at the high power rate of SAR (10 W/kg). The results demonstrate that a rate of 2 W/kg displays no adverse impact on LTP and LTD, while 10 W/kg leads to significant effects on the electrophysiological parameters, which can be clearly distinguished from the stress derived background. Our findings suggest that UMTS exposure with SAR in the range of 2 W/kg is not harmful to critical markers for memory storage and

memory consolidation, however, an influence of UMTS at high energy absorption rates (10 W/kg) cannot be excluded.

Prohofsky EW. RF absorption involving biological macromolecules. Bioelectromagnetics. 25(6):441-451, 2004.

The fundamental intramolecular frequency of a globular protein can be obtained from the measurements of acoustic velocities of bulk protein matter. This lowest frequency for common size molecules is shown to be above several hundred GHz. All modes below this frequency would then be intermolecular modes or bulk modes of the molecule and surrounding matter or tissue. The lowest frequency modes of an extended DNA double helix are also shown to be bulk modes because of interaction with water. Only DNA modes, whose frequency is well above 4 GHz, can be intrahelical modes, that is, confined to the helix rather than in the helix plus surroundings. Near 4 GHz, they are heavily damped and, therefore, not able to resonantly absorb. Modes that absorb radio frequency (RF) below this frequency are bulk modes of the supporting matter. Bulk modes rapidly thermalize all absorbed energy. The implication of these findings for the possibility of athermal RF effects is considered. The applicability of these findings for other biological molecules is discussed.

Pu, JS, Chen, J, Yang, YH, Bai, YQ, The effects of 3000 MHz microwave irradiation on electroencephalic energy and energy metabolism in mouse brain. Electro-and Magnetobiology 16:243-247, 1997.

Mice were exposed to 3000 MHz PW 1h daily for 7 days, with long axes parallel to the magnetic field in an anechoic chamber. The average power density was 5mW/cm^2, and the estimated SAR was about 2 W/kg. There was no significant core temperature rise in the mice after exposure. After the last irradiation, mice were euthanized and the whole brain were frozen. Half of each brain were measured for SDH, and the other half for ATP. Results showed that the ATP in the brains and SDH in the hippocampus and hypothalamus in the irradiation group were significantly decreased as compared to the control. The authors suggested that the decrease in SDH caused the decrease in ATP.

Pyrpasopoulou A, Kotoula V, Cheva A, Hytiroglou P, Nikolakaki E, Magras IN, Xenos TD, Tsiboukis TD, Karkavelas G. Bone morphogenetic protein expression in newborn rat kidneys after prenatal exposure to radiofrequency radiation. Bioelectromagnetics 25(3):216-227, 2004.

Effects of nonthermal radiofrequency radiation (RFR) of the global system of mobile communication (GSM) cellular phones have been as yet mostly studied at the molecular level in the context of cellular stress and proliferation, as well as neurotransmitter production and localization. In this study, a simulation model was designed for the exposure of pregnant rats to pulsed GSM-like RFR (9.4 GHz), based on the different resonant frequencies of man and rat. The power density applied was 5 microW/cm2, in order to avoid thermal electromagnetic effects as much as possible. Pregnant rats were exposed to RFR during days 1-3 postcoitum (p.c.) (embryogenesis, pre-implantation) and days 4-7 p.c. (early organogenesis, peri-implantation). Relative expression and

localization of bone morphogenetic proteins (BMP) and their receptors (BMPR), members of a molecular family currently considered as major endocrine and autocrine morphogens and known to be involved in renal development, were investigated in newborn kidneys from RFR exposed and sham irradiated (control) rats. Semi-quantitative duplex RT-PCR for BMP-4, -7, BMPR-IA, -IB, and -II showed increased BMP-4 and BMPR-IA, and decreased BMPR-II relative expression in newborn kidneys. These changes were statistically significant for BMP-4, BMPR-IA, and -II after exposure on days 1-3 p.c. (P <.001 each), and for BMP-4 and BMPR-IA after exposure on days 4-7 p.c. (P <.001 and P =.005, respectively). Immunohistochemistry and in situ hybridization (ISH) showed aberrant expression and localization of these molecules at the histological level. Our findings suggest that GSM-like RFR interferes with gene expression during early gestation and results in aberrations of BMP expression in the newborn. These molecular changes do not appear to affect renal organogenesis and may reflect a delay in the development of this organ. The differences of relative BMP expression after different time periods of exposure indicate the importance of timing for GSM-like RFR effects on embryonic development.

Qiao S, Peng R, Yan H, Gao Y, Wang C, Wang S, Zou Y, Xu X, Zhao L, Dong J, Su Z, Feng X, Wang L, Hu X. Reduction of Phosphorylated Synapsin I (Ser-553) Leads to Spatial Memory Impairment by Attenuating GABA Release after Microwave Exposure in Wistar Rats. PLoS One. 2014 Apr 17;9(4):e95503. doi: 10.1371/journal.pone.0095503. eCollection 2014.

BACKGROUND: Abnormal release of neurotransmitters after microwave exposure can cause learning and memory deficits. This study investigated the mechanism of this effect by exploring the potential role of phosphorylated synapsin I (p-Syn I). METHODS: Wistar rats, rat hippocampal synaptosomes, and differentiated (neuronal) PC12 cells were exposed to microwave radiation for 5 min at a mean power density of 30 mW/cm2. Sham group rats, synaptosomes, and cells were otherwise identically treated and acted as controls for all of the following post-exposure analyses. Spatial learning and memory in rats was assessed using the Morris Water Maze (MWM) navigation task. The protein expression and presynaptic distribution of p-Syn I and neurotransmitter transporters were examined via western blotting and immunoelectron microscopy, respectively. Levels amino acid neurotransmitter release from rat hippocampal synaptosomes and PC12 cells were measured using high performance liquid chromatograph (HPLC) at 6 hours after exposure, with or without synapsin I silencing via shRNA transfection. RESULTS: In the rat experiments, there was a decrease in spatial memory performance after microwave exposure. The expression of p-Syn I (ser-553) was decreased at 3 days post-exposure and elevated at later time points. Vesicular GABA transporter (VGAT) was significantly elevated after exposure. The GABA release from synaptosomes was attenuated and p-Syn I (ser-553) and VGAT were both enriched in small clear synaptic vesicles, which abnormally assembled in the presynaptic terminal after exposure. In the PC12 cell experiments, the expression of p-Syn I (ser-553) and GABA release were both attenuated at 6 hours after exposure. Both microwave exposure and p-Syn I silencing reduced GABA release and maximal reduction was found for the combination of the two, indicating a synergetic effect. CONCLUSION: p-Syn I (ser-553) was found to play a key

role in the impaired GABA release and cognitive dysfunction that was induced by microwave exposure.

Qin F, Zhang J, Cao H, Yi C, Li JX, Nie J, Chen LL, Wang J, Tong J.Effects of 1800-MHz radiofrequency fields on circadian rhythm of plasma melatonin and testosterone in male rats. J Toxicol Environ Health A.75(18):1120-1128, 2012.

Radiofrequency fields (RF) at 1800 MHz are known to affect melatonin (MEL) and testosterone in male rats, but it remains to be determined whether RF affected circadian rhythm of these plasma hormones. Male Sprague-Dawley rats were exposed to 1800-MHz RF at 208 μw/cm² power density (SAR: 0.5762 W/kg) at different zeitgeber (ZT) periods of the day, including 0 (ZT0), 4 (ZT4), 8 (ZT8), 12 (ZT12), 16 (ZT16), and 20 (ZT20) h. RF exposure was 2 h/d for 32 d. From each rat, the concentrations of plasma MEL and testosterone were determined in plasma after RF exposure and compared with controls. The results confirmed the existence of circadian rhythms in the synthesis of MEL and testosterone, but revealed an inverse relationship in peak phase of these rhythms. These rhythms were disturbed after exposure to RF, with the effect being more pronounced on MEL than testosterone. The most pronounced effect of RF exposure on MEL and testosterone appears to be in rats exposed to RF at ZT 16 and ZT0 h, respectively. Data suggest that regulation of testosterone is controlled by MEL and that MEL is more sensitive to RF exposure.

Qin F, Zhang J, Cao H, Guo W, Chen L, Shen O, Sun J, Yi C, Li J, Wang J, Tong J. Circadian alterations of reproductive functional markers in male rats exposed to 1800-MHz radiofrequency field. Chronobiol Int. 2013 Oct 11. [Epub ahead of print]

In this study, we explored the circadian effects of daily radiofrequency field (RF) exposure on reproductive functional markers in adult male Sprague-Dawley rats. Animals in circadian rhythm (as indicated by melatonin measurements), were divided into several groups and exposed to 1800 MHz RF at 205 μw/cm^2 power density (specific absorption rate 0.0405 W/kg) for 2 h/day for 32 days at different zeitgeber time (ZT) points, namely, ZT0, ZT4, ZT8, ZT12, ZT16 and ZT20. Sham-exposed animals were used as controls in the study. From each rat, testicular and epididymis tissues were collected and assessed for testosterone levels, daily sperm production and sperm motility, testis marker enzymes γ-GT and ACP, cytochrome P450 side-chain cleavage (p450cc) mRNA expression, and steroidogenic acute regulatory protein (StAR) mRNA expression. Via these measurements, we confirmed the existence of circadian rhythms in sham-exposed animals. However, rats exposed to RF exhibited a disruption of circadian rhythms, decreased testosterone levels, lower daily sperm production and sperm motility, down-regulated activity of γ-GT and ACP, as well as altered mRNA expression of cytochrome P450 and StAR. All of these observations were more pronounced when rats were exposed to RF at ZT0. Thus, our findings indicate potential adverse effects of RF exposure on male reproductive functional markers, in terms of both the daily overall levels as well as the circadian rhythmicity.

Qin F, Yuan H, Nie J, Cao Y, Tong J. [Effects of nano-selenium on cognition performance of mice exposed in 1800 MHz radiofrequency fields]. Wei Sheng Yan Jiu. 43(1):16-21, 2014. [Article in Chinese]

OBJECTIVE: To study the effects of nano-selenium (NSe) on cognition performance of mice exposed to 1800 MHz radiofrequency fields (RF).METHODS: Male mice were randomly divided into four groups, control and nano-Se low, middle and high dose groups (L, M, H). Each group was sub-divided into three groups, RF 0 min, RF 30 min and RF 120 min. Nano-se solution (2, 4 and 8 microg/ml) were administered to mice of L, M, H groups by intra-gastric injection respectively, 0.5 ml/d for 50 days, the conctral group were administered with distilled water. At the 21st day, the mice in RF subgroup were exposed to 208 microW/cm2 1800 MHz radiofrequency fields (0, 30 and 120 min/d respectively) for 30 days. The cognitive ability of the mice were tested with Y-maze. Further, the levels of MDA, GABA, Glu, Ach and the activities of CAT and GSH-Px in cerebra were measured. RESULTS: Significant impairments in learning and memory ($P < 0.05$) were observed in the RF 120 min group, and with reduction of the Ach level and the activities of CAT and GSH-Px and increase of the content of GABA, Glu and MDA in cerebrum. NSe enhanced cognitive performance of RF mice, decreased GABA, Glu and MDA levels, increased Ach levels, GSH-Px and CAT activities. CONCLUSION: NSe could improve cognitive impairments of mice exposed to RF, the mechanism of which might involve the increasing antioxidation, decreasing free radical content and the changes of cerebra neurotransmitters.

Quock RM, Klauenberg BJ, Hurt WD, Merritt JH , Influence of microwave exposure on chlordiazepoxide effects in the mouse staircase test. Pharmacol Biochem Behav 47(4):845-849, 1994.

To ascertain whether behavioral effects of benzodiazepines are altered by exposure to microwave radiation, we compared the performance of male, Swiss CD1 mice in the staircase test 30 min after pretreatment with chlordiazepoxide (8, 16, and 32 mg/kg, IP) and immediately following a 5-min exposure to microwave radiation (4, 12, and 36 W/kg, continuous wave, 1.8 or 4.7 GHz). In this paradigm, chlordiazepoxide reduction in the number of rears (NR) and number of steps ascended (NSA) is postulated to reflect anxiolytic and sedative drug effects, respectively. In sham-exposed mice, increasing doses of chlordiazepoxide increased NSA without affecting NR, increased NSA and decreased NR, then decreased both NSA and NR. Microwave exposure generally did not alter NSA or NR in mice pretreated with lower doses of chlordiazepoxide. However, in mice pretreated with 32 mg/kg chlordiazepoxide, exposure to 36 W/kg microwave radiation significantly reversed the reductions in NSA and NR at 4.7 GHz but not at 1.8 GHz. These findings indicate that exposure to microwave radiation can selectively alter effects of chlordiazepoxide in this psychopharmacological paradigm.

Qureshi ST, Memon SA, Abassi AR, Sial MA, Bughio FA. Radiofrequency radiations induced genotoxic and carcinogenic effects on chickpea (Cicer arietinum L.) root tip cells. Saudi J Biol Sci. 24(4):883-891, 2017.

Present study was under taken to predict the possible DNA damages (genotoxicity) and carcinogenicity caused by radiofrequency radiations (RF) to living tissue. Dry seeds of chickpea were treated with GSM cell phone (900 MHz) and laptop (3.31 GHz) as RF source for 24 and 48 h. Untreated seeds were used as (0 h) negative control and Gamma rays (250 Gray) as positive control. Plant chromosomal aberration assay was used as genotoxicity marker. All the treatment of RF inhibits seed germination percentage. 48 h laptop treatment has the most negative effect as compared to untreated control. A decrease was observed in mitotic index (M.I) and increase in abnormality index (A.I) with the increase in exposure duration and frequency in (Hz). Cell membrane damages were also observed only in 48 h exposure of cell phone and laptop (RF). Maximum nuclear membrane damages and ghost cells were again recorded in 48 h exposure of cell phone and laptop. The radiofrequency radiations (900 MHz and 3.31 GHz) are only genotoxic as they induce micronuclei, bi-nuclei, multi-nuclei and scattered nuclei but could be carcinogenic as 48 h incubation of RF induced fragmentation and ghost cells. Therefore cell phones and laptop should not be used unnecessarily to avoid possible genotoxic and carcinogenic effects.

Qureshi MRA, Alfadhl Y, Chen X, Peyman A, Maslanyj M, Mann S. Assessment of exposure to radio frequency electromagnetic fields from smart utility meters in GB; part II) numerical assessment of induced SAR within the human body. Bioelectromagnetics. 2017 Nov 16.

Human body exposure to radiofrequency electromagnetic waves emitted from smart meters was assessed using various exposure configurations. Specific energy absorption rate distributions were determined using three anatomically realistic human models. Each model was assigned with age- and frequency-dependent dielectric properties representing a collection of age groups. Generalized exposure conditions involving standing and sleeping postures were assessed for a home area network operating at 868 and 2,450 MHz. The smart meter antenna was fed with 1 W power input which is an overestimation of what real devices typically emit (15 mW max limit). The highest observed whole body specific energy absorption rate value was 1.87 mW kg^{-1}, within the child model at a distance of 15 cm from a 2,450 MHz device. The higher values were attributed to differences in dimension and dielectric properties within the model. Specific absorption rate (SAR) values were also estimated based on power density levels derived from electric field strength measurements made at various distances from smart meter devices. All the calculated SAR values were found to be very small in comparison to International Commission on Non-Ionizing Radiation Protection limits for public exposure.

Qutob SS, Chauhan V, Bellier PV, Yauk CL, Douglas GR, Berndt L, Williams A, Gajda GB, Lemay E, Thansandote A, McNamee JP. Microarray gene expression profiling of a human glioblastoma cell line exposed in vitro to a 1.9 GHz pulse-modulated radiofrequency field. Radiat Res. 165(6):636-644, 2006.

The widespread use of mobile phones has led to public concerns about the health effects associated with exposure to radiofrequency (RF) fields. The paramount concern of most persons relates to the potential of these fields to cause cancer. Unlike ionizing radiation,

RF fields used for mobile telecommunications (800-1900 MHz) do not possess sufficient energy to directly damage DNA. Most rodent bioassay and in vitro genotoxicity/mutation studies have reported that RF fields at non-thermal levels have no direct mutagenic, genotoxic or carcinogenic effects. However, some evidence has suggested that RF fields may cause detectable postexposure changes in gene expression. Therefore, the purpose of this study was to assess the ability of exposure to a 1.9 GHz pulse-modulated RF field for 4 h at specific absorption rates (SARs) of 0.1, 1.0 and 10.0 W/kg to affect global gene expression in U87MG glioblastoma cells. We found no evidence that non-thermal RF fields can affect gene expression in cultured U87MG cells relative to the nonirradiated control groups, whereas exposure to heat shock at 43 degrees C for 1 h up-regulated a number of typical stress-responsive genes in the positive control group. Future studies will assess the effect of RF fields on other cell lines and on gene expression in the mouse brain after in vivo exposure.

Radicheva N, Mileva K, Georgieva B, Kristev I. Long-lasting (fatiguing) activity of isolated muscle fibres influenced by microwave electromagnetic field. Acta Physiol Pharmacol Bulg 26(1-2):37-40, 2001.

The study aims to clarify the effect of exposure to microwave electromagnetic field (MMW) on muscle fibre fatigue. Repetitive stimulation with interstimulus interval of 200 ms was applied on isolated frog muscle fibre to evoke intracellular action potentials and twitch contractions. After their recording muscle fibre preparation was moved in a Petri dish with radius of 28 mm on open air for one hour exposure to continuous MMW with frequency of 2.45 GHz and power density of 20 mW/cm2. Then it was again moved in the chamber with non irradiated Ringer's solution at controlled temperature for the repeated records. After MMW exposure the changes in amplitude and time parameters characterizing fatigue were attenuated and delayed vs. controls. The twitch amplitude curve described an drastic fall in the first 5 sec followed by an increase and next decrease. MMW (2.45 GHz) have a specific, non-thermal influence on muscle fibre activity resulting in some resistance to fatigue.

Radon K, Spegel H, Meyer N, Klein J, Brix J, Wiedenhofer A, Eder H, Praml G, Schulze A, Ehrenstein V, von Kries R, Nowak D. Personal dosimetry of exposure to mobile telephone base stations? An epidemiologic feasibility study comparing the Maschek dosimeter prototype and the Antennessa SP-090 system. Bioelectromagnetics.27(1):77-81, 2006.

The aim of our study was to test the feasibility and reliability of personal dosimetry. Twenty-four hour exposure assessment was carried out in 42 children, 57 adolescents, and 64 adults using the Maschek dosimeter prototype. Self-reported exposure to mobile phone frequencies were compared with the dosimetry results. In addition, dosimetry readings of the Maschek device and those of the Antennessa DSP-090 were compared in 40 subjects. Self-reported exposures were not associated with dosimetry readings. The measurement results of the two dosimeters were in moderate agreement (r(Spearman) = 0.35; P = .03). Personal dosimetry for exposure to mobile phone base station might be feasible in epidemiologic studies. However, the consistency seems to be moderate.

Radzievsky AA, Gordiienko OV, Szabo I, Alekseev SI, Ziskin MC. Millimeter wave-induced suppression of B16 F10 melanoma growth in mice: involvement of

endogenous opioids. Bioelectromagnetics. 25(6):466-473, 2004.

Millimeter wave treatment (MMWT) is widely used in Eastern European countries, but is virtually unknown in Western medicine. Among reported MMWT effects is suppression of tumor growth. The main aim of the present "blind" and dosimetrically controlled experiments was to evaluate quantitatively the ability of MMWT to influence tumor growth and to assess whether endogenous opioids are involved. The murine experimental model of B16 F10 melanoma subcutaneous growth was used. MMWT characteristics were: frequency, 61.22 GHz; average incident power density, 13.3 x 10(-3) W/cm2; single exposure duration, 15 min; and exposure area, nose. Naloxone (1 mg/kg, intraperitoneally, 30 min prior to MMWT) was used as a nonspecific blocker of opioid receptors. Five daily MMW exposures, if applied starting at the fifth day following B16 melanoma cell injection, suppressed subcutaneous tumor growth. Pretreatment with naloxone completely abolished the MMWT-induced suppression of melanoma growth. The same course of 5 MMW treatments, if started on day 1 or day 10 following tumor inoculations, was ineffective. We concluded that MMWT has an anticancer therapeutic potential and that endogenous opioids are involved in MMWT-induced suppression of melanoma growth in mice. However, appropriate indications and contraindications have to be developed experimentally before recommending MMWT for clinical usage.

Rağbetli MC, Aydinlioğlu A, Koyun N, Rağbetli C, Karayel M. Effect of prenatal exposure to mobile phone on pyramidal cell numbers in the mouse hippocampus: a stereological study. Int J Neurosci. 119(7):1031-1041, 2009.

Because of the possible risk factor for the health, World Health Organization (WHO) recommended the study with animals on the developing nervous system concerning the exposure to radiofrequency (RF) field. A few studies related to hippocampal exposure are available, which indicate the impact of RF field in some parameters. The present study investigated the effect of exposure to mobile phone on developing hippocampus. Male and female Swiss albino mice were housed as control and mobile phone exposed groups. The pregnant animals in tested group were exposed to the effects of mobile phone in a room possessing the exposure system. The left hemispheres of the brains were processed by frozen microtome. The sections obtained were stained with Hematoxylin & Eosin. For cell counting by the optical fractionator method, a pilot study was first performed. Hippocampal areas were analyzed using Axiovision software running on a personal computer. The optical dissector, systematically and randomly spaced, was focused to the widest profile of the pyramidal cell nucleus. No significant difference in pyramidal cell number of total Cornu Ammonis (CA) sectors of hippocampus was found between the control and the mobile phone exposed groups ($p > .05$). It was concluded that further study is needed in this field due to popular use of mobile telephones and relatively high exposure to the developing brain.

Rağbetlı MC, Aydinlioğlu A, Koyun N, Rağbetlı C, Bektas S, Ozdemır S. The effect of mobile phone on the number of Purkinje cells: A stereological study. Int J Radiat Biol.86(7):548-54, 2010

Purpose: The World Health Organisation proposed an investigation concerning the

exposure of animals to radiofrequency fields because of the possible risk factor for health. At power frequencies there is evidence to associate both childhood leukaemia and brain tumours with magnetic field exposures. There is also evidence of the effect of mobile phone exposure on both cognitive functions and the cerebellum. Purkinje cells of the cerebellum are also sensitive to high dose microwave exposure in rats. The present study investigated the effect of exposure to mobile phone on the number of Purkinje and granule neurons in the developing cerebellum. Material and methods: Male and female Swiss albino mice were housed as control and mobile phone-exposed groups. Pregnant animals in the experimental group were exposed to Global System for Mobile Communication (GSM) mobile phone radiation at 890-915 MHz at 0.95 W/Kg specific absorption rate (SAR). The cerebella were processed by frozen microtome. The sections obtained were stained with Haematoxylin-eosin and cresyl violet. For cell counting by the optical fractionator method, a pilot study was firstly performed. Cerebellar areas were analysed by using Axiovision software running on a personal computer. The optical dissectors were systematically spaced at random, and focused to the widest profile of the neuron cell nucleus. Results: A significant decrease in the number of Purkinje cells and a tendency for granule cells to increase in cerebellum was found. Conclusion: Further studies in this area are needed due to the popular use of mobile telephones and relatively high exposure on developing brain.

Rago R, Salacone P, Caponecchia L, Sebastianelli A, Marcucci I, Calogero AE, Condorelli R, Vicari E, Morgia G, Favilla V, Cimino S, Arcoria AF, La Vignera S. The semen quality of the mobile phone users. J Endocrinol Invest. 36(11):970-974, 2013.

BACKGROUND: The increased use of mobile phones, the media's attention for general health, and the increase of idiopathic male infertility suggest to investigate the possible consequences of an excessive use of mobile phones on semen quality. AIM: To evaluate the conventional and some of the main biofunctional sperm parameters in healthy men according to the different use of the mobile phone. SUBJECTS AND METHODS: All the enrolled subjects in this study were divided into four groups according to their active cell phone use: group A= no use (no.=10 subjects); group B= <2 h/day (no.=16); group C= 2-4 h/day (no.=17); and group D= >4 h/day (no.=20). Among the subjects of the group D (>4 h/day), a further evaluation was made between the "trousers users"(no.=12) and "shirt users"(no.=8), and they underwent semen collection to evaluate conventional and biofunctional sperm parameters (density, total count, morphology, progressive motility, apoptosis, mithocondrial membrane potential, chromatin compaction, DNA fragmentation). RESULTS: None of the conventional sperm parameters examined were significantly altered. However, the group D and the trousers users showed a higher percentage of sperm DNA fragmentation compared to other groups. CONCLUSION: These results suggest that the sperm DNA fragmentation could represent the only parameter significantly altered in the subjects who use the mobile phone for more than 4 h/day and in particular for those who use the device in the pocket of the trousers.

Ragy MM. Effect of exposure and withdrawal of 900-MHz-electromagnetic waves on brain, kidney and liver oxidative stress and some biochemical parameters in male rats. Electromagn Biol Med. 2014 Apr 8. [Epub ahead of print]

Increasing use of mobile phones in daily life with increasing adverse effects of electromagnetic radiation (EMR), emitted from mobile on some physiological processes, cause many concerns about their effects on human health. Therefore, this work was designed to study the effects of exposure to mobile phone emits 900-MHz EMR on the brain, liver and kidney of male albino rats. Thirty male adult rats were randomly divided into four groups (10 each) as follows: control group (rats without exposure to EMR), exposure group (exposed to 900-MHz EMR for 1 h/d for 60 d) and withdrawal group (exposed to 900-MHz electromagnetic wave for 1 h/d for 60 d then left for 30 d without exposure). EMR emitted from mobile phone led to a significant increase in malondialdehyde (MDA) levels and significant decrease total antioxidant capacity (TAC) levels in brain, liver and kidneys tissues. The sera activity of alanine transaminase (ALT), aspartate aminotransferase (AST), urea, creatinine and corticosterone were significantly increased ($p < 0.05$), while serum catecholamines were insignificantly higher in the exposed rats. These alterations were corrected by withdrawal. In conclusion, electromagnetic field emitting from mobile phone might produce impairments in some biochemicals changes and oxidative stress in brain, liver and renal tissue of albino rats.

Ramundo-Orlando A, Liberti M, Mossa G, D'Inzeo G. Effects of 2.45 GHz microwave fields on liposomes entrapping glycoenzyme ascorbate oxidase: evidence for oligosaccharide side chain involvement. Bioelectromagnetics. 25(5):338-345, 2004.

Previous observations reported by our group indicate that 2.45 GHz microwave fields at specific absorption rate (SAR) of 5.6 W/kg reduce the enzyme activity rate of ascorbate oxidase (AO) trapped in liposomes. In this study, we report dose-response studies on these AO containing liposomes irradiated at different SAR values (1.4, 2.8, 4.2, and 5.6 W/kg). No response was observed for SAR below 5.6 W/kg. Liposomes entrapping functional AO in its deglycated form (AO-D) were also used. In this case, no MW related enzyme activity changes were observed, demonstrating a direct involvement of oligosaccharide chains of AO. Furthermore, the catalytic properties of both AO and AO-D were not impaired by MW irradiation, neither in homogeneous solution nor loaded in liposomes, excluding possible changes in the conformation of enzyme as a mechanism. Our results suggest that the oligosaccharide chains of AO are critical to elicit the microwave observed effects on lipid membrane.

Rao VS, Titushkin IA, Moros EG, Pickard WF, Thatte HS, Cho MR. Nonthermal effects of radiofrequency-field exposure on calcium dynamics in stem cell-derived neuronal cells: elucidation of calcium pathways. Radiat Res. 169(3):319-329, 2008.

Intracellular Ca(2+) spikes trigger cell proliferation, differentiation and cytoskeletal reorganization. In addition to Ca(2+) spiking that can be initiated by a ligand binding to its receptor, exposure to electromagnetic stimuli has also been shown to alter Ca(2+) dynamics. Using neuronal cells differentiated from a mouse embryonic stem cell line and a custom-built, frequency-tunable applicator, we examined in real time the altered Ca(2+) dynamics and observed increases in the cytosolic Ca(2+) in

response to nonthermal radiofrequency (RF)-radiation exposure of cells from 700 to 1100 MHz. While about 60% of control cells (not exposed to RF radiation) were observed to exhibit about five spontaneous Ca(2+) spikes per cell in 60 min, exposure of cells to an 800 MHz, 0.5 W/kg RF radiation, for example, significantly increased the number of Ca(2+) spikes to 15.7 +/- 0.8 ($P < 0.05$). The increase in the Ca(2+) spiking activities was dependent on the frequency but not on the SAR between 0.5 to 5 W/kg. Using pharmacological agents, it was found that both the N-type Ca(2+) channels and phospholipase C enzymes appear to be involved in mediating increased Ca(2+) spiking. Interestingly, microfilament disruption also prevented the Ca(2+) spikes. Regulation of Ca(2+) dynamics by external physical stimulation such as RF radiation may provide a noninvasive and useful tool for modulating the Ca(2+)-dependent cellular and molecular activities of cells seeded in a 3D environment for which only a few techniques are currently available to influence the cells.

Raslear TG, Akyel Y, Bates F, Belt M, Lu ST, Temporal bisection in rats: the effects of high-peak-power pulsed microwave irradiation. Bioelectromagnetics 14(5):459-478, 1993.

The effects of high-peak-power, pulsed microwaves on a time perception and discrimination task were studied in rats. Exposures were performed with the TEMPO exposure system, which produces an 80 nanosecond pulse with peak-power levels in excess of 700 megawatts. The ability to expose animals to such fields within a controlled environment is unique. As determined by calorimetry, a maximal, whole-body-averaged, specific-absorption rate of 0.072 W/kg was produced. Thus exposures were well below a recommended SAR limit of 0.4 W/kg. Power levels of transmitted microwaves were varied over a 50 dB range to obtain ascending and descending dose-response functions for each of the behavioral measures. Measures of time perception, response bias, and total trials did not change with power level. Dose-response effects were observed for discriminability (ability to distinguish between durations), session time, and trial completions (null responses, failures to respond on a trial). Covarying sound and X-ray exposures produced by TEMPO did not reliably correlate with the observed microwave effects. The observation of repeatable dose-response effects on discriminability and null responses indicates that the microwave exposures were affecting cognitive function in the rats, particularly the decision-making process.

Ray S, Behari J, Physiological changes in rats after exposure to low levels of microwaves. Radiat Res 123(2):199-202, 1990.

The effects of exposure to sublethal levels of microwaves were studied. Young albino rats of both sexes were exposed for 60 days to 7.5-GHz microwaves (1.0-KHz square wave modulation, average power 0.6 mW/cm2) for 3 h daily. During and after microwave exposure several physiological parameters were measured in both control and exposed animals. It was found that the animals exposed to microwaves tended to eat and drink less and thus showed a smaller gain in body weight. Some of the hematological parameters and organ weights were also significantly different. It is proposed that a nonspecific stress response due to microwave exposure and mediated through the central nervous system is responsible for the observed physiological changes.

Razavinasab M, Moazzami K, Shabani M. Maternal mobile phone exposure alters intrinsic electrophysiological properties of CA1 pyramidal neurons in rat offspring. Toxicol Ind Health. 2014 Mar 6. [Epub ahead of print]

Some studies have shown that exposure to electromagnetic field (EMF) may result in structural damage to neurons. In this study, we have elucidated the alteration in the hippocampal function of offspring Wistar rats (n = 8 rats in each group) that were chronically exposed to mobile phones during their gestational period by applying behavioral, histological, and electrophysiological tests. Rats in the EMF group were exposed to 900 MHz pulsed-EMF irradiation for 6 h/day. Whole cell recordings in hippocampal pyramidal cells in the mobile phone groups did show a decrease in neuronal excitability. Mobile phone exposure was mostly associated with a decrease in the number of action potentials fired in spontaneous activity and in response to current injection in both male and female groups. There was an increase in the amplitude of the afterhyperpolarization (AHP) in mobile phone rats compared with the control. The results of the passive avoidance and Morris water maze assessment of learning and memory performance showed that phone exposure significantly altered learning acquisition and memory retention in male and female rats compared with the control rats. Light microscopy study of brain sections of the control and mobile phone-exposed rats showed normal morphology.Our results suggest that exposure to mobile phones adversely affects the cognitive performance of both female and male offspring rats using behavioral and electrophysiological techniques.

Redelmeier DA, Tibshirani RJ, Association between cellular-telephone calls and motor vehicle collisions. N Engl J Med 13;336(7):453-458, 1997.

BACKGROUND: Because of a belief that the use of cellular telephones while driving may cause collisions, several countries have restricted their use in motor vehicles, and others are considering such regulations. We used an epidemiologic method, the case-crossover design, to study whether using a cellular telephone while driving increases the risk of a motor vehicle collision. METHODS: We studied 699 drivers who had cellular telephones and who were involved in motor vehicle collisions resulting in substantial property damage but no personal injury. Each person's cellular-telephone calls on the day of the collision and during the previous week were analyzed through the use of detailed billing records. RESULTS: A total of 26,798 cellular-telephone calls were made during the 14-month study period. The risk of a collision when using a cellular telephone was four times higher than the risk when a cellular telephone was not being used (relative risk, 4.3; 95 percent confidence interval, 3.0 to 6.5). The relative risk was similar for drivers who differed in personal characteristics such as age and driving experience; calls close to the time of the collision were particularly hazardous (relative risk, 4.8 for calls placed within 5 minutes of the accident, as compared with 1.3 for calls placed more than 15 minutes before the accident; P<0.001); and units that allowed the hands to be free (relative risk, 5.9) offered no safety advantage over hand-held units (relative risk, 3.9; P not significant). Thirty-nine percent of the drivers called emergency services after the collision, suggesting that having a cellular telephone may have had advantages in the aftermath of an event. CONCLUSIONS: The use of cellular telephones in motor vehicles is associated with a quadrupling of the risk of a collision during the brief time interval involving a call.

Decisions about regulation of such telephones, however, need to take into account the benefits of the technology and the role of individual responsibility.

Redmayne M, Inyang I, Dimitriadis C, Benke G, Abramson MJ. Cordless telephone use: implications for mobile phone research. J Environ Monit. 12(4):809-812, 2010.

Cordless and mobile (cellular) telephone use has increased substantially in recent years causing concerns about possible health effects. This has led to much epidemiological research, but the usual focus is on mobile telephone radiofrequency (RF) exposure only despite cordless RF being very similar. Access to and use of cordless phones were included in the Mobile Radiofrequency Phone Exposed Users Study (MoRPhEUS) of 317 Year 7 students recruited from Melbourne, Australia. Participants completed an exposure questionnaire-87% had a cordless phone at home and 77% owned a mobile phone. There was a statistically significant positive relationship ($r = 0.38$, $p < 0.01$) between cordless and mobile phone use. Taken together, this increases total RF exposure and its ratio in high-to-low mobile users. Therefore, the design and analysis of future epidemiological telecommunication studies need to assess cordless phone exposure to accurately evaluate total RF telephone exposure effects.

Redmayne M, Smith E, Abramson MJ. Adolescent in-school cellphone habits: a census of rules, survey of their effectiveness, and fertility implications. Reprod Toxicol. 32(3):354-359, 2011.

We explored school cellphone rules and adolescent exposure to cellphone microwave emissions during school with a census and survey, respectively. The data were used to assess health and policy implications through a review of papers assessing reproductive bio-effects after exposure to cellphone emissions, this being most relevant to students' exposure. All schools banned private use of cellphones in class. However, 43% of student participants admitted breaking this rule. A high-exposure group of risk-takers was identified for whom prohibited in-school use was positively associated with high texting rates, carrying the phone switched-on >10h/day, and in-pocket use. The fertility literature is inconclusive, but increasingly points towards significant time- and dose-dependent deleterious effects from cellphone exposure on sperm. Genotoxic effects have been demonstrated from 'non-thermal' exposures, but not consistently. There is sufficient evidence and expert opinion to warrant an enforced school policy removing cellphones from students during the day.

Redmayne M, Smith E, Abramson MJ. A forecasting method to reduce estimation bias in self-reported cell phone data. J Expo Sci Environ Epidemiol. 2012 Jul 18. doi: 10.1038/jes.2012.70. [Epub ahead of print]

There is ongoing concern that extended exposure to cell phone electromagnetic radiation could be related to an increased risk of negative health effects. Epidemiological studies seek to assess this risk, usually relying on participants' recalled use, but recall is notoriously poor. Our objectives were primarily to produce a

forecast method, for use by such studies, to reduce estimation bias in the recalled extent of cell phone use. The method we developed, using Bayes' rule, is modelled with data we collected in a cross-sectional cluster survey exploring cell phone user-habits among New Zealand adolescents. Participants recalled their recent extent of SMS-texting and retrieved from their provider the current month's actual use-to-date. Actual use was taken as the gold standard in the analyses. Estimation bias arose from a large random error, as observed in all cell phone validation studies. We demonstrate that this seriously exaggerates upper-end forecasts of use when used in regression models. This means that calculations using a regression model will lead to underestimation of heavy-users' relative risk. Our Bayesian method substantially reduces estimation bias. In cases where other studies' data conforms to our method's requirements, application should reduce estimation bias, leading to a more accurate relative risk calculation for mid-to-heavy users.

Redmayne M, Smith E, Abramson MJ. Patterns in wireless phone estimation data from a cross-sectional survey: what are the implications for epidemiology? BMJ Open. 2012 Sep 4;2(5). pii: e000887. doi: 10.1136/bmjopen-2012-000887. Print 2012.

OBJECTIVE: Self-reported recall data are often used in wireless phone epidemiological studies, which in turn are used to indicate relative risk of health outcomes from extended radiofrequency exposure. We sought to explain features commonly observed in wireless phone recall data and to improve analytical procedures. SETTING: Wellington Region, New Zealand. PARTICIPANTS: Each of the 16 schools selected a year 7 and/or 8 class to participate, providing a representative regional sample based on socioeconomic school ratings, school type and urban/rural balance. There was an 85% participation rate (N=373). MAIN OUTCOME MEASURES: Planned: the distribution of participants' estimated extent of SMS-texting and cordless phone calls, and the extent of rounding to a final zero or five within the full set of recall data and within each order of magnitude. Unplanned: the distribution of the leading digits of these raw data, compared with that of billed data in each order of magnitude. RESULTS: The nature and extent of number-rounding, and the distribution of data across each order in recall data indicated a logarithmic (ratio-based) mental process for assigning values. Responses became less specific as the leading-digit increased from 1 to 9, and 69% of responses for weekly texts sent were rounded by participants to a single non-zero digit (eg, 2, 20 and 200). CONCLUSIONS: Adolescents' estimation of their cellphone use indicated that it was performed on a mental logarithmic scale. This is the first time this phenomenon has been observed in the estimation of recalled, as opposed to observed, numerical quantities. Our findings provide empirical justification for log-transforming data for analysis. We recommend the use of the geometric rather than arithmetic mean when a recalled numerical range is provided. A point of calibration may improve recall.

Redmayne M. New Zealand adolescents' cellphone and cordless phone user-habits: are they at increased risk of brain tumours already? A cross-sectional study. Environ Health. 12(1):5, 2013.

BACKGROUND: Cellphone and cordless phone use is very prevalent among early adolescents, but the extent and types of use is not well documented. This paper explores how, and to what extent, New Zealand adolescents are typically using and exposed to active cellphones and cordless phones, and considers implications of this in relation to brain tumour risk, with reference to current research findings. **METHODS:** This cross-sectional study recruited 373 Year 7 and 8 school students with a mean age of 12.3 years (range 10.3-13.7 years) from the Wellington region of New Zealand. Participants completed a questionnaire and measured their normal body-to-phone texting distances. Main exposure-metrics included self-reported time spent with an active cellphone close to the body, estimated time and number of calls on both phone types, estimated and actual extent of SMS text-messaging, cellphone functions used and people texted. Statistical analyses used Pearson Chi2 tests and Pearson's correlation coefficient (r). Analyses were undertaken using SPSS version 19.0. **RESULTS:** Both cellphones and cordless phones were used by approximately 90% of students. A third of participants had already used a cordless phone for ≥ 7 years. In 4 years from the survey to mid-2013, the cordless phone use of 6% of participants would equal that of the highest Interphone decile (≥ 1640 hours), at the surveyed rate of use. High cellphone use was related to cellphone location at night, being woken regularly, and being tired at school. More than a third of parents thought cellphones carried a moderate-to-high health risk for their child. **CONCLUSIONS:** While cellphones were very popular for entertainment and social interaction via texting, cordless phones were most popular for calls. If their use continued at the reported rate, many would be at increased risk of specific brain tumours by their mid-teens, based on findings of the Interphone and Hardell-group studies.

Redmayne M, Smith E, and Abramson MJ. The relationship between adolescents' well-being and their wireless phone use: a cross-sectional study. Environmental Health 12(1):90, 2013.

Background. The exposure of young people to radiofrequency electromagnetic fields (RF-EMFs) has increased rapidly in recent years with their increased use of cellphones and use of cordless phones and WiFi. We sought to ascertain associations between New Zealand early-adolescents' subjective well-being and self-reported use of, or exposure to, wireless telephone and internet technology. Methods. In this cross-sectional survey, participants completed questionnaires in class about their cellphone and cordless phone use, their self-reported well-being, and possible confounding information such as whether they had had influenza recently or had a television in the bedroom. Parental questionnaires provided data on whether they had WiFi at home and cordless phone ownership and model. Data were analysed with Ordinal Logistic Regression adjusting for common confounders. Odds ratios (OR) and 95% confidence intervals were calculated. Results. The number and duration of cellphone and cordless phone calls were associated with increased risk of headaches (>6 cellphone calls over 10 minutes weekly, adjusted OR 2.4, CI 1.2-4.8; >15 minutes cordless use daily adjusted OR 1.74, CI 1.1-2.9)). Texting and extended use of wireless phones was related to having a painful 'texting' thumb). Using a wired cellphone headset was associated with tinnitus (adjusted OR 1.8, CI 1.0-3.3), while wireless headsets were associated with headache (adjusted OR 2.2, CI 1.1-4.5), feeling down/depressed (adjusted OR 2.0, CI 1.1-3.8), and waking in the night

(adjusted OR 2.4, CI 1.2-4.8). Several cordless phone frequencies bands were related to tinnitus, feeling down/depressed and sleepiness at school, while the last of these was also related to modulation. Waking nightly was less likely for those with WiFi at home (adjusted OR 0.7, CI 0.4-0.99). Being woken at night by a cellphone was strongly related to tiredness at school (OR 4.1, CI 2.2-7.7). Conclusions . There were more statistically significant associations (36%) than could be expected by chance (5%). Several were dose-dependent relationships. To safeguard young people's well-being, we suggest limiting their use of cellphones and cordless phones to less than 15 minutes daily, and employing a speaker-phone device for longer daily use. We recommend parental measures are taken to prevent young people being woken by their cellphones.

Redmayne M, Smith CL, Benke G, Croft RJ, Dalecki A, Dimitriadis C, Kaufman J, Macleod S, Sim MR, Wolfe R, Abramson MJ. Use of mobile and cordless phones and cognition in Australian primary school children: a prospective cohort study. Environ Health. 15(1):26, 2016.

BACKGROUND: Use of mobile (MP) and cordless phones (CP) is common among young children, but whether the resulting radiofrequency exposure affects development of cognitive skills is not known. Small changes have been found in older children. This study focused on children's exposures to MP and CP and cognitive development. The hypothesis was that children who used these phones would display differences in cognitive function compared to those who did not. METHODS: We recruited 619 fourth-grade students (8-11 years) from 37 schools around Melbourne and Wollongong, Australia. Participants completed a short questionnaire, a computerised cognitive test battery, and the Stroop colour-word test. Parents completed exposure questionnaires on their child's behalf. Analysis used multiple linear regression. The principal exposure-metrics were the total number of reported MP and CP calls weekly categorised into no use ('None'); use less than or equal to the median amount ('Some'); and use more than the median ('More'). The median number of calls/week was 2.5 for MP and 2.0 for CP. RESULTS: MP and CP use for calls was low; and only 5 of 78 comparisons of phone use with cognitive measures were statistically significant. The reaction time to the response-inhibition task was slower in those who used an MP 'More' compared to the 'Some' use group and non-users. For CP use, the response time to the Stroop interference task was slower in the 'More' group versus the 'Some' group, and accuracy was worse in visual recognition and episodic memory tasks and the identification task. In an additional exploratory analysis, there was some evidence of a gender effect on mean reaction times. The highest users for both phone types were girls. CONCLUSIONS: Overall, there was little evidence cognitive function was associated with CP and MP use in this age group. Although there was some evidence that effects of MP and CP use on cognition may differ by gender, this needs further exploration. CP results may be more reliable as parents estimated children's phone use and the CPs were at home; results for CP use were broadly consistent with our earlier study of older children.

Reeves GI. Review of extensive workups of 34 patients overexposed to radiofrequency radiation. Aviat Space Environ Med 71(3):206-215, 2000.

BACKGROUND: The medical records of 34 patients seen at the Aerospace Medicine Directorate, U.S. Air Force Research Laboratory for confirmed exposure to radiofrequency radiation (RFR) exceeding the permitted exposure limits were reviewed to see if RFR overexposure created any detectable clinical or laboratory alterations that could be correlated with power density or the product of power density and time exposed. The goal of this study was to determine which physiological and laboratory parameters required closest attention on work up of future patients with RFR exposure. METHODS: All 34 patients received an extensive history and physical examination, and a large battery of laboratory studies. Clinical findings were also compared with laboratory results. RESULTS: A sensation of warmth was positively associated with power density. A negative correlation was observed between an abnormal tissue destruction screen and power density. Sophisticated neurological tests in 23 patients and extensive psychometric and psychological exams in 30 patients revealed no neurological or ophthalmologic findings attributable to RFR. A few patients reported burning pain that resolved over several weeks; neurological findings were minimal or absent. CONCLUSIONS: Patients with suspected RFR overexposures need to be seen promptly at the nearest medical facility. Based on this study, an extensive evaluation of persons overexposed to non-ionizing radiation should not be routinely performed. However, a careful history and physical examination with laboratory studies as indicated should be performed and the patient's concerns about RFR effects addressed fully.

Regel SJ, Negovetic S, Roosli M, Berdinas V, Schuderer J, Huss A, Lott U, Kuster N, Achermann P. UMTS Base Station-like Exposure, Well-Being, and Cognitive Performance. Environ Health Perspect. 114(8):1270-1275, 2006.

Background: Radio-frequency electromagnetic fields (RF EMF) of mobile communication systems are widespread in the living environment, yet their effects on humans are uncertain despite a growing body of literature. Objectives: We investigated the influence of a Universal Mobile Telecommunications System (UMTS) base station-like signal on well-being and cognitive performance in subjects with and without self-reported sensitivity to RF EMF. Methods: We performed a controlled exposure experiment (45 min at an electric field strength of 0, 1, or 10 V/m, incident with a polarization of 45 degrees from the left back side of the subject, weekly intervals) in a randomized, double-blind crossover design. A total of 117 healthy subjects (33 self-reported sensitive, 84 nonsensitive subjects) participated in the study. We assessed well-being, perceived field strength, and cognitive performance with questionnaires and cognitive tasks and conducted statistical analyses using linear mixed models. Organ-specific and brain tissue-specific dosimetry including uncertainty and variation analysis was performed. Results: In both groups, well-being and perceived field strength were not associated with actual exposure levels. We observed no consistent condition-induced changes in cognitive performance except for two marginal effects. At 10 V/m we observed a slight effect on speed in one of six tasks in the sensitive subjects and an effect on accuracy in another task in nonsensitive subjects. Both effects disappeared after multiple end point adjustment. Conclusions: In contrast to a recent Dutch study, we could not confirm a short-term effect of UMTS base station-like exposure on well-being. The reported effects on brain functioning were marginal and may have occurred by chance. Peak spatial

absorption in brain tissue was considerably smaller than during use of a mobile phone. No conclusions can be drawn regarding short-term effects of cell phone exposure or the effects of long-term base station-like exposure on human health. Key words: base station, cognitive function, electromagnetic hypersensitivity, human exposure, mobile phones, RF EMF.

Regel SJ, Tinguely G, Schuderer J, Adam M, Kuster N, Landolt HP, Achermann P. Pulsed radio-frequency electromagnetic fields: dose-dependent effects on sleep, the sleep EEG and cognitive performance. J Sleep Res. 16(3):253-258, 2007.

To establish a dose-response relationship between the strength of electromagnetic fields (EMF) and previously reported effects on the brain, we investigated the influence of EMF exposure by varying the signal intensity in three experimental sessions. The head of 15 healthy male subjects was unilaterally exposed for 30 min prior to sleep to a pulse-modulated EMF (GSM handset like signal) with a 10 g-averaged peak spatial specific absorption rate of (1) 0.2 W kg(-1), (2) 5 W kg(-1), or (3) sham exposed in a double-blind, crossover design. During exposure, subjects performed two series of three computerized cognitive tasks, each presented in a fixed order [simple reaction time task, two-choice reaction time task (CRT), 1-, 2-, 3-back task]. Immediately after exposure, night-time sleep was polysomnographically recorded for 8 h. Sleep architecture was not affected by EMF exposure. Analysis of the sleep electroencephalogram (EEG) revealed a dose-dependent increase of power in the spindle frequency range in non-REM sleep. Reaction speed decelerated with increasing field intensity in the 1-back task, while accuracy in the CRT and N-back task were not affected in a dose-dependent manner. In summary, this study reveals first indications of a dose-response relationship between EMF field intensity and its effects on brain physiology as demonstrated by changes in the sleep EEG and in cognitive performance.

Reiser H, Dimpfel W, Schober F, The influence of electromagnetic fields on human brain activity. Eur J Med Res 1(1):27-32, 1995.

Possible effects of electromagnetic fields on human brain activity were studied. In a single-blind, cross-over-designed and placebo-controlled study 36 volunteers were exposed firstly to an electromagnetic field originating form a MediLine "MEGA-WAVE 150/1" therapy instrument and secondly to a field originating from a mobile, digital tetlephone as used for wireless telecommunication. All volunteers also underwent a control experiment with no field exposure. Application of the MEGA-WAVE instrument caused an increase in EEG power in the frequency bands Alpha2, Beta1 and Beta2 during and after field exposure. Operation of the mobile telephone caused an increase in the same frequency bands with a delay of approximately 15 minutes after exposure.

Remondini D, Nylund R, Reivinen J, Poulletier de Gannes F, Veyret B, Lagroye I, Haro E, Trillo MA, Capri M, Franceschi C, Schlatterer K, Gminski R, Fitzner R, Tauber R, Schuderer J, Kuster N, Leszczynski D, Bersani F, Maercker C. Gene expression changes in human cells after exposure to mobile phone microwaves. Proteomics. 6(17):4745-4754, 2006.

Possible biological effects of mobile phone microwaves were investigated in vitro. In

this study, which was part of the 5FP EU project REFLEX (Risk Evaluation of Potential Environmental Hazards From Low-Energy Electromagnetic Field Exposure Using Sensitive in vitro Methods), six human cell types, immortalized cell lines and primary cells, were exposed to 900 and 1800 MHz. RNA was isolated from exposed and sham-exposed cells and labeled for transcriptome analysis on whole-genome cDNA arrays. The results were evaluated statistically using bioinformatics techniques and examined for biological relevance with the help of different databases. NB69 neuroblastoma cells, T lymphocytes, and CHME5 microglial cells did not show significant changes in gene expression. In EA.hy926 endothelial cells, U937 lymphoblastoma cells, and HL-60 leukemia cells we found between 12 and 34 up- or down-regulated genes. Analysis of the affected gene families does not point towards a stress response. However, following microwave exposure, some but not all human cells might react with an increase in expression of genes encoding ribosomal proteins and therefore up-regulating the cellular metabolism.

Repacholi, MH, Basten, A, Gebski, V, Noonan, D, Finnie, J, Harris, AW, Lymphomas in E mu-Pim1 transgenic mice exposed to pulsed 900 MHZ electromagnetic fields. Radiat Res 147(5):631-640, 1997.

Whether radiofrequency (RF) fields are carcinogenic is controversial; epidemiological data have been inconclusive and animal tests limited. The aim of the present study was to determine whether long-term exposure to pulse-modulated RF fields similar to those used in digital mobile telecommunications would increase the incidence of lymphoma in E mu-Pim1 transgenic mice, which are moderately predisposed to develop lymphoma spontaneously. One hundred female E mu-Pim1 mice were sham-exposed and 101 were exposed for two 30-min periods per day for up to 18 months to plane-wave fields of 900 MHz with a pulse repetition frequency of 217 Hz and a pulse width of 0.6 ms. Incident power densities were 2.6-13 W/m2 and specific absorption rates were 0.008-4.2 W/kg, averaging 0.13-1.4 W/kg. Lymphoma risk was found to be significantly higher in the exposed mice than in the controls (OR = 2.4. P = 0.006, 95% CI = 1.3-4.5). Follicular lymphomas were the major contributor to the increased tumor incidence. Thus long-term intermittent exposure to RF fields can enhance the probability that mice carrying a lymphomagenic oncogene will develop lymphomas. We suggest that such genetically cancer-prone mice provide an experimental system for more detailed assessment of dose-response relationships for risk of cancer after RF-field exposure.

Rezk AY, **Abdulqawi K**, **Mustafa RM**, **Abo El-Azm TM**, **Al-Inany H**. **Fetal and neonatal responses following maternal exposure to mobile phones. Saudi Med J. 29(2):218-223, 2008.**

OBJECTIVE: To study fetal and neonatal heart rate (HR) and cardiac output (COP), following acute maternal exposure to electromagnetic fields (EMF) emitted by mobile phones. METHODS: The present study was carried out at Benha University Hospital and El-Shorouq Hospital, Cairo, Egypt, from October 2003 to March 2004. Ninety women with uncomplicated pregnancies aged 18-33 years, and 30 full term healthy newborn infants were included. The pregnant mothers were exposed to EMF emitted by mobile telephones while on telephone-dialing mode for 10 minutes during pregnancy and after birth. The main outcome were measurements of fetal and

neonatal HR and COP. RESULTS: A statistical significant increase in fetal and neonatal HR, and statistical significant decrease in stroke volume and COP before and after use of mobile phone were noted. All these changes are attenuated with increase in gestational age. CONCLUSION: Exposure of pregnant women to mobile phone significantly increase fetal and neonatal HR, and significantly decreased the COP.

Ribeiro EP, Rhoden EL, Horn MM, Rhoden C, Lima LP, Toniolo L, Effects of Subchronic Exposure to Radio Frequency From a Conventional Cellular Telephone on Testicular Function in Adult Rats. J Urol 177:395-399, 2007.

Purpose. We investigated the effects of subchronic exposure to radio frequency emitted from a conventional cellular telephone on the testicular function in adult rats. Materials and Methods. A total of 16 male Wistar rats at age 30 days were randomly divided into 2 groups, including experimental and control groups. The experimental group was exposed to radio frequency emitted from a conventional GSM (global system for mobile communications) cellular telephone (1,835 to 1,850 MHz) for 1 hour daily during 11 weeks. Rectal temperature was measured before and after the exposure period. Testicular and epididymal weight, lipid peroxidation levels in these organs, serum total testosterone and the epididymal sperm count were evaluated. Maturation phase spermatid retention at stage IX-X, interstitial infiltration, cellular vacuolation and multinucleate giant cells were among the qualitative testicular histopathological end points analyzed. Each rat had 10 consecutive round seminiferous tubules at stage VII-VIII evaluated for the mean seminiferous tubular diameter measurement, the crude histological count of round spermatids, pachytene spermatocytes and Sertoli's cells with evident nucleoli, and the true histological count (Abercrombie's correction factor) of round spermatids and pachytene spermatocytes. Results. Mean rectal temperature did not alter following exposure. There was no statistical difference between the control and experimental groups in any end points evaluated. Conclusions: The current study shows that the low intensity pulsed radio frequency emitted by a conventional cellular telephone does not impair testicular function in adult rats.

Richter E, Berman T, Ben-Michael E, Laster R, Westin JB, Cancer in Radar Technicians Exposed to Radiofrequency/Microwave Radiation: Sentinel Episodes. Int J Occup Environ Health 6(3):187-193, 2000.

Controversy exists concerning the health risks from exposures to radiofrequency/microwave irradiation (RF/MW). The authors report exposure-effect relationships in sentinel patients and their co-workers, who were technicians with high levels of exposure to RF/MW radiation. Information about exposures of patients with sentinel tumors was obtained from interviews, medical records, and technical sources. One patient was a member of a cohort of 25 workers with six tumors. The authors estimated relative risks for cancer in this group and latency periods for a larger group of self-reported individuals. Index patients with melanoma of the eye, testicular cancer, nasopharyngioma, non-Hodgkin's lymphoma, and breast cancer were in the 20-37-year age group. Information about work conditions suggested prolonged exposures to high levels of RF/MW radiation that produced risks for the entire body. Clusters involved many

different types of tumors. Latency periods were extremely brief in index patients and a larger self-reported group. The findings suggest that young persons exposed to high levels of RF/MW radiation for long periods in settings where preventive measures were lax were at increased risk for cancer. Very short latency periods suggest high risks from high-level exposures. Calculations derived from a linear model of dose-response suggest the need to prevent exposures in the range of 10-100 muw/cm(2).

Richter ED, Berman T, Levy O. Brain cancer with induction periods of less than 10 years in young military radar workers. Arch Environ Health 57(4):270-272, 2002.

The authors have reported on 5 young patients who had brain tumors that appeared within 10 yr of initial occupational exposures to radar. Four of the patients were less than 30 yr of age when the diagnoses were initially made. Brief induction periods that follow high exposures in individual sentinel patients are a recognized indicator of impending group risk, and these periods call attention to the need for precautionary measures. Similarly, reports of short induction periods for brain cancer on the side of the head in which there has been prior use of cell phones may also indicate increased risk.

Riddervold IS, Pedersen GF, Andersen NT, Pedersen AD, Andersen JB, Zachariae R, Mølhave L, Sigsgaard T, Kjaergaard SK. Cognitive function and symptoms in adults and adolescents in relation to rf radiation from UMTS base stations. Bioelectromagnetics. 29(4):257-267, 2008.

There is widespread public concern about the potential adverse health effects of mobile phones in general and their associated base stations in particular. This study was designed to investigate the acute effects of radio frequency (RF) electromagnetic fields (EMF) emitted by the Universal Mobile Telecommunication System (UMTS) mobile phone base stations on human cognitive function and symptoms. Forty adolescents (15-16 years) and 40 adults (25-40 years) were exposed to four conditions: (1) sham, (2) a Continuous Wave (CW) at 2140 MHz, (3) a signal at 2140 MHz modulated as UMTS and (4) UMTS at 2140 MHz including all control features in a randomized, double blinded cross-over design. Each exposure lasted 45 min. During exposure the participants performed different cognitive tasks with the Trail Making B (TMB) test as the main outcome and completed a questionnaire measuring self reported subjective symptoms. No statistically significant differences between the UMTS and sham conditions were found for performance on TMB. For the adults, the estimated difference between UMTS and sham was -3.2% (-9.2%; 2.9%) and for the adolescents 5.5% (-1.1%; 12.2%). No significant changes were found in any of the cognitive tasks. An increase in 'headache rating' was observed when data from the adolescents and adults were combined (P = 0.027), an effect that may be due to differences at baseline. In conclusion, the primary hypothesis that UMTS radiation reduces general performance in the TMB test was not confirmed. However, we suggest that the hypothesis of subjective symptoms and EMF exposure needs further research.

Rittweger J, Lambertz M, Kluge W, Kramer K, Langhorst P, Influence of modulated high-frequency electromagnetic fields on the functional organization and dynamics of the common brainstem system. Bioelectrochem Bioenerg 37(1):31-37, 1995.

The immediate influence of low-frequency modulated high-frequency electromagnetic fields (MHF) on regulatory patterns in the state of relaxed wakefulness was investigated in five healthy volunteers. The differences in magnetoencephalogram, heart frequency and ventilatory parameters before and after occipital application of MHF indicate that the effects can be explained by an influence on the common brainstem system (CBS). The CBS is part of the central nervous system which organizes and regulates the prerequisites necessary for the execution of meaningful behaviour.

Riu PJ, Foster KR, Blick DW, Adair ER, A thermal model for human thresholds of microwave-evoked warmth sensations. Bioelectromagnetics 18(8):578-583, 1997.

Human thresholds for skin sensations of warmth were measured at frequencies from 2.45 to 94 GHz. By solving the one-dimensional bioheat equation, we calculated the temperature increase at the skin surface or at a depth of 175 microm at incident power levels corresponding to the observed thresholds. The thermal analysis suggests that the thresholds correspond to a localized temperature increase of about 0.07 degrees C at and near the surface of the skin. We also found that, even at the highest frequency of irradiation, the depth at which the temperature receptors are located is not a relevant parameter, as long as it is within 0.3 mm of the surface. Over the time range of the simulation, the results of the thermal model are insensitive to blood flow, but sensitive to thermal conduction; and this sensitivity increases strongly with frequency. We conclude with an analysis of the effect of thermal conduction on surface temperature rise, which becomes a dominant factor at microwave frequencies over 10 GHz.

Rodina A, Lass J, Riipulk J, Bachmann T, Hinrikus H. Study of effects of low level microwave field by method of face masking. Bioelectromagnetics. 26(7):571-577, 2005.

The aim of this study was to examine experimentally effects of low level, modulated microwaves on human central nervous system function utilizing the phenomenon of visual masking. Ten healthy volunteers, four males and six females, were exposed to electromagnetic field (450 MHz, 0.16 mW/cm2) with 7 Hz modulation frequency. Two photo series (visual stimuli) of unfamiliar, young male faces were presented to the subjects, one picture after another. All the photos were frontal views of unfamiliar faces, which could be recognized only by their unique combinations of features. The task was to identify the pictures from a group of six photos and to decide which order they were presented in. The phenomenon of visual masking is revealed as anamorphosis in subject's perception of two instantaneous visual stimuli presented within a short time interval. When both stimuli were to be recognized correctly and put in the right order, there was a statistically significant difference ($P < 0.05$) between the identification of the stimulus with microwave electromagnetic field and sham exposure. Recognition of both stimuli in a pair was better under the sham exposure conditions but the actual difference was only 5%. It was concluded that early stages of visual information processing are overwhelmingly robust and routine (and adaptively significant) activities, so that the low level 7 Hz modulated electromagnetic field effects exerted upon it are extremely weak.

Roggeveen S, van Os J, Lousberg R. Does the Brain Detect 3G Mobile Phone Radiation Peaks? An Explorative In-Depth Analysis of an Experimental Study. PLoS One. 2015 May 11;10(5):e0125390. doi: 10.1371/journal.pone.0125390. eCollection 2015.

This study aimed to investigate whether third generation mobile phone radiation peaks result in event related potentials. Thirty-one healthy females participated. In this single-blind, cross-over design, a 15 minute mobile phone exposure was compared to two 15 minute sham phone conditions, one preceding and one following the exposure condition. Each participant was measured on two separate days, where mobile phone placement was varied between the ear and heart. EEG activity and radiofrequency radiation were recorded jointly. Epochs of 1200ms, starting 200ms before and lasting until 1000ms after the onset of a radiation peak, were extracted from the exposure condition. Control epochs were randomly selected from the two sham phone conditions. The main a-priori hypothesis to be tested concerned an increase of the area in the 240-500ms post-stimulus interval, in the exposure session with ear-placement. Using multilevel regression analyses the placement*exposure interaction effect was significant for the frontal and central cortical regions, indicating that only in the mobile phone exposure with ear-placement an enlarged cortical reactivity was found. Post-hoc analyses based on visual inspection of the ERPs showed a second significantly increased area between 500-1000ms post-stimulus for almost every EEG location measured. It was concluded that, when a dialing mobile phone is placed on the ear, its radiation, although unconsciously, is electrically detected by the brain. The question of whether or not this cortical reactivity results in a negative health outcome has to be answered in future longitudinal experiments.

Roggeveen S, van Os J, Viechtbauer W, Lousberg R. EEG Changes Due to Experimentally Induced 3G Mobile Phone Radiation. PLoS One. 2015 Jun 8;10(6):e0129496. doi: 10.1371/journal.pone.0129496.

The aim of this study was to investigate whether a 15-minute placement of a 3G dialing mobile phone causes direct changes in EEG activity compared to the placement of a sham phone. Furthermore, it was investigated whether placement of the mobile phone on the ear or the heart would result in different outcomes. Thirty-one healthy females participated. All subjects were measured twice: on one of the two days the mobile phone was attached to the ear, the other day to the chest. In this single-blind, cross-over design, assessments in the sham phone condition were conducted directly preceding and following the mobile phone exposure. During each assessment, EEG activity and radiofrequency radiation were recorded jointly. Delta, theta, alpha, slowbeta, fastbeta, and gamma activity was computed. The association between radiation exposure and the EEG was tested using multilevel random regression analyses with radiation as predictor of main interest. Significant radiation effects were found for the alpha, slowbeta, fastbeta, and gamma bands. When analyzed separately, ear location of the phone was associated with significant results, while chest placement was not. The results support the notion that EEG alterations are associated with mobile phone usage and that the effect is dependent

on site of placement. Further studies are required to demonstrate the physiological relevance of these findings.

Roggeveen S, van Os J, Lousberg R. Does the Brain Detect 3G Mobile Phone Radiation Peaks? An Explorative In-Depth Analysis of an Experimental Study. PLoS One. 2015 May 11;10(5):e0125390.

This study aimed to investigate whether third generation mobile phone radiation peaks result in event related potentials. Thirty-one healthy females participated. In this single-blind, cross-over design, a 15 minute mobile phone exposure was compared to two 15 minute sham phone conditions, one preceding and one following the exposure condition. Each participant was measured on two separate days, where mobile phone placement was varied between the ear and heart. EEG activity and radiofrequency radiation were recorded jointly. Epochs of 1200 ms, starting 200 ms before and lasting until 1000 ms after the onset of a radiation peak, were extracted from the exposure condition. Control epochs were randomly selected from the two sham phone conditions. The main a-priori hypothesis to be tested concerned an increase of the area in the 240-500 ms post-stimulus interval, in the exposure session with ear-placement. Using multilevel regression analyses the placement*exposure interaction effect was significant for the frontal and central cortical regions, indicating that only in the mobile phone exposure with ear-placement an enlarged cortical reactivity was found. Post-hoc analyses based on visual inspection of the ERPs showed a second significantly increased area between 500-1000 ms post-stimulus for almost every EEG location measured. It was concluded that, when a dialing mobile phone is placed on the ear, its radiation, although unconsciously, is electrically detected by the brain. The question of whether or not this cortical reactivity results in a negative health outcome has to be answered in future longitudinal experiments.

Roivainen P, Eskelinen T, Jokela K, Juutilainen J. Occupational exposure to intermediate frequency and extremely low frequency magnetic fields among personnel working near electronic article surveillance systems. Bioelectromagnetics. 2014 Feb 24. doi: 10.1002/bem.21850. [Epub ahead of print]

Cashiers are potentially exposed to intermediate frequency (IF) magnetic fields at their workplaces because of the electronic article surveillance (EAS) systems used in stores to protect merchandise against theft. This study aimed at investigating occupational exposure of cashiers to IF magnetic fields in Finnish stores. Exposure to extremely low frequency (ELF) magnetic fields was also evaluated because cashiers work near various devices operating with 50 Hz electric power. The peak magnetic flux density was measured for IF magnetic fields, and was found to vary from 0.2 to 4 μT at the cashier's seat. ELF magnetic fields from 0.03 to 4.5 μT were found at the cashier's seat. These values are much lower than exposure limits. However, according to the International Commission on Non-Ionizing Radiation Protection (ICNIRP) occupational reference levels for IF magnetic fields (141 μT for the peak field) were exceeded in some cases (maximum 189 μT) for short periods of time when cashiers walked through the EAS gates. As the ICNIRP reference levels do not

define any minimum time for exposure, additional investigations are recommended to determine compliance with basic restrictions. Even if the basic restrictions are not exceeded, persons working near EAS devices represent an exceptional group of workers with respect to exposure to electromagnetic fields. This group could serve as a basis for epidemiological studies addressing possible health effects of IF magnetic fields. Compliance with the reference levels for IF fields was evaluated using both broadband measurement of peak fields and the ICNIRP summation rule for multiple frequencies. The latter was generally more conservative, and the difference between the two methods was large (>10-fold) for EAS systems using a 58 kHz signal with complex waveform. This indicates that the ICNIRP multiple frequency rule can be unnecessarily conservative when measuring complex waveforms.

Rojavin MA, Ziskin MC, Electromagnetic millimeter waves increase the duration of anaesthesia caused by ketamine and chloral hydrate in mice. Int J Radiat Biol 72(4):475-480, 1997.

BALB/c mice were injected i.p. with either ketamine 80 mg/kg or chloral hydrate 450 mg/kg. Anaesthetized mice were exposed to unmodulated electromagnetic millimeter waves at the frequency of 61.22 GHz with a peak specific absorption rate of 420 W/kg and corresponding incident power density of 15 mW/cm2 for 15 min or sham-exposed. In combination with either of the anaesthetics used, mm waves increased the duration of anaesthesia by approximately 50% ($p < 0.05$) in a dose (power)-dependent manner. Sham exposure to mm waves did not affect the sleeping time of mice. Pretreatment of mice with naloxone, an opioid antagonist, did not change the duration of anaesthesia caused by the corresponding chemical agent, but completely blocked or decreased the additional effect of mm waves. The data in this study indicates that exposure of mice to mm waves in vivo releases endogenous opioids or enhances the activity of opioid signalling pathway.

Romano-Spica V, Mucci N, Ursini CL, Ianni A, Bhat NK, Ets1 oncogene induction by ELF-modulated 50 MHz radiofrequency electromagnetic field. Bioelectromagnetics 21(1):8-18, 2000.

We have analyzed gene expression in hemopoietic and testicular cell types after their exposure to 50 MHz radiofrequency (RF) non-ionizing radiation modulated (80%) with a 16 Hz frequency. The exposure system generates a 0.2 microT magnetic field parallel to the ground and a 60 V/m electric field orthogonal to the earth's magnetic field. Exposure conditions were selected so as to interfere with the calcium ion flow. Under these electromagnetic field (EMF) conditions, we observed an overexpression of the ets1 mRNA in Jurkat T-lymphoblastoid and Leydig TM3 cell lines. This effect was observed only in the presence of the 16 Hz modulation, corresponding to the resonance frequency for calcium ion with a DC magnetic field of 45.7 microT. We have also identified a putative candidate gene repressed after EMF exposure. The experimental model described in this paper may contribute to the understanding of the biological mechanisms involved in EMF effects.

Röösli M. Radiofrequency electromagnetic field exposure and non-specific symptoms of ill health: A systematic review. Environ Res.107(2):277-287,2008.

This article is a systematic review of whether everyday exposure to radiofrequency electromagnetic field (RF-EMF) causes symptoms, and whether some individuals are able to detect low-level RF-EMF (below the ICNIRP [International Commission on Non-Ionizing Radiation Protection] guidelines). Peer-reviewed articles published before August 2007 were identified by means of a systematic literature search. Meta-analytic techniques were used to pool the results from studies investigating the ability to discriminate active from sham RF-EMF exposure. RF-EMF discrimination was investigated in seven studies including a total of 182 self-declared electromagnetic hypersensitive (EHS) individuals and 332 non-EHS individuals. The pooled correct field detection rate was 4.2% better than expected by chance (95% CI: -2.1 to 10.5). There was no evidence that EHS individuals could detect presence or absence of RF-EMF better than other persons. There was little evidence that short-term exposure to a mobile phone or base station causes symptoms based on the results of eight randomized trials investigating 194 EHS and 346 non-EHS individuals in a laboratory. Some of the trials provided evidence for the occurrence of nocebo effects. In population based studies an association between symptoms and exposure to RF-EMF in the everyday environment was repeatedly observed. This review showed that the large majority of individuals who claims to be able to detect low level RF-EMF are not able to do so under double-blind conditions. If such individuals exist, they represent a small minority and have not been identified yet. The available observational studies do not allow differentiating between biophysical from EMF and nocebo effects.

Roosli M, Michel G, Kuehni CE, Spoerri A. Cellular telephone use and time trends in brain tumour mortality in Switzerland from 1969 to 2002.Eur J Cancer Prev. 16(1):77-82. 2007.

A rising concern exists that with the widespread use of mobile communication technologies, the incidence of brain tumours may increase. On the basis of data from the Swiss national mortality registry from 1969 to 2002, annual age-standardized brain tumour mortality rates per 100 000 person-years were calculated using the European standard population. Time trend analyses were performed by the Poisson regression for six different age groups in men and women separately. The study period was divided into two intervals: before and after 1987, when the analogue mobile technology was introduced in Switzerland. Age-standardized brain tumour mortality rates ranged between 3.7 and 6.7 for men and 2.5 and 4.4 for women per 100 000 person-years. For the whole study period, a significant increase in brain tumour mortality was observed for men and women in the older age groups (60-74 and 75+ years) but not in the younger ones in whom mobile phone use was more prevalent. Time trend analyses restricted to data from 1987 onwards revealed relatively stable brain tumour mortality rates in all age groups. For instance, the annual change in brain tumour mortality rate for the 45-59-year age group was -0.3% (95% confidence interval: -1.7; 1.1) for men and -0.4% (95% confidence interval:-2.2; 1.3) for women. We conclude that after the introduction of mobile phone technology in Switzerland, brain tumour mortality rates remained stable in all age groups. Our results suggest that mobile phone use is not a strong risk factor in the short term for mortality from brain tumours. Ecological analyses like this, however, are limited in

their ability to reveal potentially small increases in risk for diseases with a long latency period.

Röösli M, Frei P, Mohler E, Hug K. Systematic review on the health effects of exposure to radiofrequency electromagnetic fields from mobile phonebase **stations. Bull World Health Organ. 88(12):887-896F, 2010.**

OBJECTIVE: to review and evaluate the recent literature on the health effects of exposure to mobile phonebasestation (MPBS) radiation. METHODS: we performed a systematic review of randomized human trials conducted in laboratory settings and of epidemiological studies that investigated the health effects of MPBS radiation in the everyday environment. FINDINGS: we included in the analysis 17 articles that met our basic quality criteria: 5 randomized human laboratory trials and 12 epidemiological studies. The majority of the papers (14) examined self-reported non-specific symptoms of ill-health. Most of the randomized trials did not detect any association between MPBS radiation and the development of acute symptoms during or shortly after exposure. The sporadically observed associations did not show a consistent pattern with regard to symptoms or types of exposure. We also found that the more sophisticated the exposure assessment, the less likely it was that an effect would be reported. Studies on health effects other than non-specific symptoms and studies on MPBS exposure in children were scarce. CONCLUSION: the evidence for a missing relationship between MPBS exposure up to 10 volts per metre and acute symptom development can be considered strong because it is based on randomized, blinded human laboratory trials. At present, there is insufficient data to draw firm conclusions about health effects from long-term low-level exposure typically occurring in the everyday environment.

Rosaspina S, Salvatorelli G, Anzanel D, Bovolenta R, Effect of microwave radiation on Candida albicans. Microbios 78(314):55-59, 1994.

Microwave exposure (90 s) provides an effective, rapid sterilization for surgical scalpel blades which have been contaminated with Candida albicans. SEM analysis showed that microwave irradiation induced a morphological modification of the cells. The longer the exposure time the greater such alterations and this micro-organism in effect fractures after 9 min. No evidence was found of morphological alteration of the fungus after being submerged in boiling water for the same amount of time even though cell death was actually achieved.

Roschke, J, Mann, K, No short-term effects of digital mobile radio telephone on the awake human electroencephalogram. Bioelectromagnetics 18(2):172-176, 1997.

A recent study reported the results of an exploratory study of alterations of the quantitative sleep profile due to the effects of a digital mobile radio telephone. Rapid eye movement (REM) was suppressed, and the spectral power density in the 8-13 Hz frequency range during REM sleep was altered. The aim of the present study was to illuminate the influence of digital mobile radio telephone on the awake electroencephalogram (EEG) of healthy subjects. For this purpose, we investigated 34 male subjects in a single-blind cross-over design experiment by measuring spontaneous EEGs under closed-eyes condition from scalp positions C3 and C4 and comparing the

effects of an active (0.05 mW/cm2) and an inactive digital mobile radio telephone (GSM) system. During exposure of nearly 3.5 min to the 900 MHz electromagnetic field pulsed at a frequency of 217 Hz and with a pulse width of 580 microseconds, we could not detect any difference in the awake EEGs in terms of spectral power density measures.

Roser K, Schoeni A, Röösli M. Mobile phone use, behavioural problems and concentration capacity in adolescents: A prospective study. Int J Hyg Environ Health. 219(8):759-769, 2016.

The aim of this study is to prospectively investigate whether exposure to radiofrequency electromagnetic fields (RF-EMF) emitted by mobile phones and other wireless communication devices is related to behavioural problems or concentration capacity in adolescents. The HERMES (Health Effects Related to Mobile phonE use in adolescentS) study sample consisted of 439 Swiss adolescents aged 12-17 years. Behavioural problems were assessed using the Strengths and Difficulties Questionnaire (SDQ), concentration capacity of the adolescents was measured by means of a standardized computerized cognitive test named FAKT. Cross-sectional and longitudinal (1year of follow-up) analyses were performed to investigate possible associations between behavioural problems and concentration capacity and different exposure measures: self-reported and operator-recorded wireless communication device use, cumulative RF-EMF brain and whole body dose and measured personal RF-EMF exposure. In the cross-sectional analyses behavioural problems were associated with several self-reported wireless device use measures but not operator-recorded mobile phone use measures, concentration capacity was associated with several self-reported and operator-recorded exposures. The longitudinal analyses point towards absence of associations. The lack of consistent exposure-response patterns in the longitudinal analyses suggests that behavioural problems and concentration capacity are not affected by the use of wireless communication devices or RF-EMF exposure. Information bias and reverse causality are likely explanations for the observed cross-sectional findings.

Roser K, Schoeni A, Struchen B, Zahner M, Eeftens M, Fröhlich J, Röösli M. Personal radiofrequency electromagnetic field exposure measurements in Swiss adolescents. Environ Int. 99:303-314, 2017.

BACKGROUND: Adolescents belong to the heaviest users of wireless communication devices, but little is known about their personal exposure to radiofrequency electromagnetic fields (RF-EMF). OBJECTIVES: The aim of this paper is to describe personal RF-EMF exposure of Swiss adolescents and evaluate exposure relevant factors. Furthermore, personal measurements were used to estimate average contributions of various sources to the total absorbed RF-EMF dose of the brain and the whole body. METHODS: Personal exposure was measured using a portable RF-EMF measurement device (ExpoM-RF) measuring 13 frequency bands ranging from 470 to 3600MHz. The participants carried the device for three consecutive days and kept a time-activity diary. In total, 90 adolescents aged 13 to 17years participated in the study conducted between May 2013 and April 2014. In addition, personal measurement values were combined with dose calculations for the use of wireless communication devices to

quantify the contribution of various RF-EMF sources to the daily RF-EMF dose of adolescents. RESULTS: Main contributors to the total personal RF-EMF measurements of 63.2μW/m^2 (0.15V/m) were exposures from mobile phones (67.2%) and from mobile phone base stations (19.8%). WLAN at school and at home had little impact on the personal measurements (WLAN accounted for 3.5% of total personal measurements). According to the dose calculations, exposure from environmental sources (broadcast transmitters, mobile phone base stations, cordless phone base stations, WLAN access points, and mobile phones in the surroundings) contributed on average 6.0% to the brain dose and 9.0% to the whole-body dose. CONCLUSIONS: RF-EMF exposure of adolescents is dominated by their own mobile phone use. Environmental sources such as mobile phone base stations play a minor role.

Ros-Llor I, Sanchez-Siles M, Camacho-Alonso F, Lopez-Jornet P. Effect of mobile phones on micronucleus frequency in human exfoliated oral mucosal cells.Oral Dis.18(8):786-792, 2012.

Objective: In the last two decades, the use of mobile phones has increased enormously all over the world. The controversy regarding whether radiofrequency (RF) fields exert effects upon biological systems is a concern for the general population. An evaluation is made of DNA damage and cytokinetic defects, proliferative potential, and cell death because of RF radiation emitted by mobile phones in healthy young users. Study design: This cohort study was carried out in 50 Caucasian mobile phone users. We collected two cell samples from each subject (a total of 100 cell samples), corresponding to the right and left cheek mucosa, respectively. Case histories and personal information were assessed, including age, gender, body height and weight, history of cancer, smoking and alcohol consumption, exposure to chemical carcinogens or radiation, and dietary habits. Sampling comprised cell collection from both cheeks with a cytobrush, centrifugation, slide preparation, fixation, and staining, followed by fluorescent microscopic analysis. A total of 2000 exfoliated cells were screened for nuclear abnormalities, especially micronucleus. Results: No statistically significant changes were recorded in relation to age, gender, body mass index, or smoking status. A comparison of the results vs the control area according to the side of the face on which the mobile phone was placed, and in relation to the duration of exposure (years) to mobile phone radiation in the total 100 samples, yielded no significant differences. Conclusions: No genotoxic effects because of RF exposure were observed in relation to any of the study parameters.

Ross A, Barker K. Cell phones, clothing, and sex: first impressions of power using older African Americans as stimuli. Psychol Rep. 93(3 Pt 1): 879-882, 2003.

Sex, material possessions, and race have long been associated with prestige or status in American society, yet little research has examined this idea. Little is known about the effect of cell phones on first impressions. In a 2 (cell phone: present, absent) x 2 (clothing: jacket, no jacket) x 2 (sex) between-subjects design, 160 women from a predominantly Black college rated stimuli of older, African Americans on 15 items measuring perceived power on three power subscales: expert, legitimate, and coercive. Multivariate analysis of variance showed a 3-way interaction for clothing, cell phone, and sex of stimulus person.

Rothman KJ, Loughlin JE, Funch DP, Dreyer NA, Overall mortality of cellular telephone customers. Epidemiology 7(3):303-305, 1996.

Unlike mobile cellular telephones, in which the antenna is not part of the handset, a portable cellular telephone exposes the user's head to radio frequency energy transmitted from the antenna. This exposure has prompted concerns about potential biological effects, including brain cancer. As a first step in a record-based mortality surveillance of cellular telephone customers, we report on overall mortality of a cohort of more than 250,000 portable and mobile telephone customers during 1994. We found age-specific rates to be similar for users of the two types of telephones. For customers with accounts at least 3 years old, the ratio of mortality rates in 1994 for portable telephone users, compared with mobile telephone users, was 0.86 (90% Confidence interval = 0.47-1.53).

Roti Roti JL , Malyapa RS, Bisht KS, Ahern EW, Moros EG, Pickard WF, Straube WL, Neoplastic Transformation in C3H 10T(1/2) Cells after Exposure to 835.62 MHz FDMA and 847.74 MHz CDMA Radiations. Radiat Res 155(1):239-247, 2001.

The effect of radiofrequency (RF) radiation in the cellular phone communication range (835.62 MHz frequency division multiple access, FDMA; 847.74 MHz code division multiple access, CDMA) on neoplastic transformation frequency was measured using the in vitro C3H 10T(1/2) cell transformation assay system. To determine if 835.62 MHz FDMA or 847.74 MHz CDMA radiations have any genotoxic effects that induce neoplastic transformation, C3H 10T(1/2) cells were exposed at 37 degrees C to either of the above radiations [each at a specific absorption rate (SAR) of 0.6 W/kg] or sham-exposed at the same time for 7 days. After the culture medium was changed, the cultures were transferred to incubators and refed with fresh growth medium every 7 days. After 42 days, the cells were fixed and stained with Giemsa, and transformed foci were scored. To determine if exposure to 835.62 MHz FDMA or 847.74 MHz CDMA radiation has any epigenetic effects that can promote neoplastic transformation, cells were first exposed to 4.5 Gy of X rays to induce the transformation process and then exposed to the above radiations (SAR = 0.6 W/kg) in temperature-controlled irradiators with weekly refeeding for 42 days. After both the 7-day RF exposure and the 42-day RF exposure after X irradiation, no statistically significant differences in the transformation frequencies were observed between incubator controls, the sham-exposed (maintained in irradiators without power to the antenna), and the 835.62 MHz FDMA or 847.74 MHz CDMA-exposed groups

Rotkovska D, Bartonickova A, Kautska J, Effects of microwaves on membranes of hematopoietic cells in their structural and functional organization. Bioelectromagnetics 14(1):79-85, 1993.

The role of cell membranes in stimulating and inhibiting the effects of microwaves was investigated in experiments carried out with a suspension of murine bone marrow cells irradiated with microwaves in vitro [f = 2.45 GHz, CW, specific absorption rate (SAR) = 12 W/kg]. Results obtained by means of a structural probe, 2.4-TNS, indicate that no structural changes occur in the region of the protein-lipid interphase under conditions of short-term irradiation with microwaves that induced temperatures in the range 36-45 degrees C (exposure time 315 and 525 s, respectively). Investigation of one functional parameter--the ability to produce

hematopoietic colonies in the spleen after transplantation of the bone marrow irradiated in vitro by microwaves--indicated the possibility of affecting stimulatory and inhibitory effects of microwaves by using a blocker of cell receptors, Trimepranol. The role of microwaves as a physical factor interfering in the process of cell proliferation at the level of receptor regulation is discussed.

Rougier C, Prorot A, Chazal P, Leveque P, Leprat P. EFFECT OF DISCONTINUOUS MICROWAVES EXPOSURE (2.45 GHz) ON ESCHERICHIA COLI MEMBRANE: INVESTIGATIONS ON THERMAL VERSUS NON THERMAL EFFECTS. Appl Environ Microbiol. 2014 Jun 6. pii: AEM.00789-14. [Epub ahead of print]

The aim of this study was to investigate the effects on the cell membranes of Escherichia coli of 2.45 GHz - microwave (MW) treatment under various conditions with an average temperature of the cell suspension maintained at 37°C in order to examine the possible thermal versus non thermal effects of short duration MW exposure. To this purpose, microwave irradiation of bacteria was performed under carefully defined and controlled parameters, resulting in a discontinuous MW exposure in order to maintain the average temperature of the bacterial cell suspensions at 37°C. Escherichia coli cells were exposed to 200 - 2000 W discontinuous microwaves (DW) treatments for different periods of time. For each experiment, conventional heating (CH) in a water bath at 37°C was performed as control. The effects of DW exposure on cell membranes was investigated using flow cytometry (FCM), after propidium iodide (PI) staining of cells in addition to the assessment of intracellular proteins release in bacterial suspensions. No effect was detected when bacteria were exposed to conventional heating or 200 W, whereas cell membrane integrity was slightly altered when cell suspensions were submitted to powers ranging from 400 to 2000 W. The thermal characterization suggested that the temperature reached by the microwave-exposed samples for the contact time studied was not high enough to explain the measured modifications of cell membrane integrity. Because the results indicated that the cell-response is power dependent, the hypothesis of a specific electromagnetic threshold effect, probably related to the temperature increase, can be advanced.

Roux D, Faure C, Bonnet P, Girard S, Ledoigt G, Davies E, Gendraud M, Paladian F, Vian A. A possible role for extra-cellular ATP in plant responses to high frequency, low amplitude electromagnetic field. to the reports of health hazards among mobile-phone users. Plant Signal Behav. 3(6):383-385, 2008.

In parallel to evoking the accumulation of stress-related transcripts, exposure to low level 900 MHz EMF affected the levels of ATP, the main energy molecule of the cell. Its concentration dropped rapidly (27% after 30 min) in response to EMF exposure, along with a 18% decrease in the adenylate energy charge (AEC), a good marker of cell energy status. One could interpret this decrease in ATP and AEC in a classical way, i.e., as the result of an increase in cellular energy usage, but recent work brings exciting new insights in pointing out a signalling function for ATP, especially in the stress physiology context where it could trigger both reactive oxygen species and calcium movement (this latter being involved in plant responses to EMF exposure). In this addendum, we discuss our results within this new perspective for ATP function

Roux D, Vian A, Girard S, Bonnet P, Paladian F, Davies E, Ledoigt G. High frequency (900 MHz) low amplitude (5 V m-1) electromagnetic field: a genuine environmental stimulus that affects transcription, translation, calcium and energy charge in tomato. Planta. 227(4):883-891, 2008.

Using an especially-designed facility, the Mode Stirred Reverberation Chamber, we exposed tomato plants (Lycopersicon esculentum Mill. VFN8) to low level (900 MHz, 5 V m(-1)) electromagnetic fields for a short period (10 min) and measured changes in abundance of three specific mRNA soon after exposure. Within minutes of electromagnetic stimulation, stress-related mRNA (calmodulin, calcium-dependent protein kinase and proteinase inhibitor) accumulated in a rapid, large and 3-phase manner typical of an environmental stress response. Accumulation of these transcripts into the polysomal RNA also took place (indicating that the encoded proteins were translated) but was delayed (indicating that newly-synthesized mRNA was not immediately recruited into polysomes). Transcript accumulation was maximal at normal Ca(2+) levels and was depressed at higher Ca(2+), especially for those encoding calcium-binding proteins. Removal of Ca(2+) (by addition of chelating agents or Ca(2+) channel blocker) led to total suppression of mRNA accumulation. Finally, 30 min after the electromagnetic treatment, ATP concentration and adenylate energy charge were transiently decreased, while transcript accumulation was totally prevented by application of the uncoupling reagent, CCCP. These responses occur very soon after exposure, strongly suggesting that they are the direct consequence of application of radio-frequency fields and their similarities to wound responses strongly suggests that this radiation is perceived by plants as an injurious stimulus.

Roux D, Girard S, Paladian F, Bonnet P, Lalléchère S, Gendraud M, Davies E, Vian A. Human keratinocytes in culture exhibit no response when exposed to short duration, low amplitude, high frequency (900 MHz) electromagnetic fields in a reverberation chamber. Bioelectromagnetics. 32(4):302-311, 2011.

Abstract. We exposed normal human epidermal keratinocytes to short duration, high frequency, and low amplitude electromagnetic fields, similar to that used by mobile phone technologies. We paid particular attention to the control of the characteristics of the electromagnetic environment generated within a mode stirred reverberation chamber (statistical homogeneity and isotropy of the field and SAR distribution). Two non-thermal exposure conditions were tested on the epidermal cells: 10-min exposure with a field amplitude of 8 V/m, and 30 min with 41 V/m. Corresponding specific absorption rates ranged from 2.6 to 73 mW/kg (continuous wave, 900 MHz carrier frequency). We collected RNA from cells subjected to these conditions and used it for a large-scale microarray screening of over 47000 human genes. Under these conditions, exposure of keratinocytes to the electromagnetic field had little effect; only 20 genes displayed significant modulation. The expression ratios were very small (close to 1.5-fold change), and none of them were shared by the two tested conditions. Furthermore, those assayed using polymerase chain reaction did not display significant expression modulation (overall mean of the exposed samples: 1.20 ± 0.18). In conclusion, the data presented here show that cultured keratinocytes are not significantly affected by EMF exposure.

Rowley JT, Joyner KH. Observations from national Italian fixed radiofrequency monitoring network. Bioelectromagnetics. 37(2):136-139, 2016.

We analyzed a database of more than 50 million data points from the national Italian fixed radiofrequency (RF) field monitoring network that was operational between June 2002 and November 2006. We applied a modified Regression on Order Statistics approach to reanalyze the database and to deal with the large proportion of entries (39.8%) below detection sensitivity of the probe systems. We found no more than an 18% variation in annual wideband levels during the 2002-2006 period. Mean value for mobile communications band was 0.047 μW/cm(2) for the period 2005-2006. Findings of this analysis are consistent with similar previous studies and we conclude that mean environmental RF levels from cellular mobile communications systems are typically less than 0.1 μW/cm(2) .

Ruan P, Yong J, Shen H, Zheng X. Monitoring dynamic reactions of red blood cells to UHF electromagnetic waves radiation using a novel micro-imaging technology. Electromagn Biol Med. 31(4):365-374, 2012.

Multiple state-of-the-art techniques, such as multi-dimensional micro-imaging, fast multi-channel micro-spetrophotometry, and dynamic micro-imaging analysis, were used to dynamically investigate various effects of cell under the 900 MHz electromagnetic radiation. Cell changes in shape, size, and parameters of Hb absorption spectrum under different power density electromagnetic waves radiation were presented in this article. Experimental results indicated that the isolated human red blood cells (RBCs) do not have obviously real-time responses to the ultra-low density (15 μW/cm(2), 31 μW/cm(2)) electromagnetic wave radiation when the radiation time is not more than 30 min; however, the cells do have significant reactions in shape, size, and the like, to the electromagnetic waves radiation with power densities of 1 mW/cm(2) and 5 mW/cm(2). The data also reveal the possible influences and statistical relationships among living human cell functions, radiation amount, and exposure time with high-frequency electromagnetic waves. The results of this study may be significant on protection of human being and other living organisms against possible radiation affections of the high-frequency electromagnetic waves.

Rubin GJ, Cleare AJ, Wessely S. Psychological factors associated with self-reported sensitivity to mobile phones. J Psychosom Res. 64(1):1-9; discussion 11-12, 2008

OBJECTIVE: Some people report symptoms associated with mobile phone use. A minority also report "electrosensitivity," experiencing symptoms following exposure to other electrical devices. Research suggests that electromagnetic fields do not trigger these symptoms. In this study, we examined the differences between these two "sensitive" groups and healthy controls. METHODS: Fifty-two people who reported sensitivity to mobile phones, 19 people who reported sensitivity to mobile phones and "electrosensitivity," and 60 nonsensitive controls completed a questionnaire assessing the following: primary reason for using a mobile phone, psychological health, symptoms of

depression, modern health worries (MHW), general health status, symptom severity, and the presence of other medically unexplained syndromes. RESULTS: Perceived sensitivity was associated with an increased likelihood of using a mobile phone predominantly for work (3% of controls, 13% of those sensitive to mobile phones, and 21% of those reporting "electrosensitivity") and greater MHW concerning radiation [mean (S.D.) on a scale of 1-5: 2.0 (1.0), 2.7 (0.9), and 4.0 (0.8), respectively]. Participants who reported "electrosensitivity" also experienced greater depression, greater worries about tainted food and toxic interventions, worse general health on almost every measure, and a greater number of other medically unexplained syndromes compared to participants from the other two groups. No group differences were observed with regards to psychiatric cases. CONCLUSIONS: The data illustrate that patients reporting "electrosensitivity" experience substantially worse health than either healthy individuals or people who report sensitivity to mobile phones but who do not adopt the label "electrosensitivity." Clinicians and researchers would be wise to pay greater attention to this subdivision**.**

Rufo MM, Paniagua JM, Jiménez A, Antolín A. Exposure to high-frequency electromagnetic fields (100 kHz-2 GHz) in Extremadura (Spain). Health Phys. 101(6):739-745, 2011.

The last decade has seen a rapid increase in people's exposure to electromagnetic fields. This paper reports the measurements of radiofrequency (RF) total power densities and power density spectra in 35 towns of the region of Extremadura, Spain. The spectra were taken with three antennas covering frequencies from 100 kHz to 2.2 GHz. This frequency range includes AM/FM radio broadcasting, television, and cellular telephone signals. The power density data and transmitting antenna locations were stored in a geographic information system (GIS) as an aid in analyzing and interpreting the results. The results showed the power density levels to be below the reference level guidelines for human exposure and that the power densities are different for different frequency ranges and different size categories of towns.

Ruigrok HJ, Arnaud-Cormos D, Hurtier A , Poque E, de Gannes FP, Ruffié G, Bonnaudin F, Lagroye I, Sojic N, Arbault S, Lévêque P, Veyret B, Percherancier Y. Activation of the TRPV1 Thermoreceptor Induced by Modulated or Unmodulated 1800 MHz Radiofrequency Field Exposure. Radiat Res. 2017 Oct 23. doi: 10.1667/RR14877.1. [Epub ahead of print]

The existence of effects of radiofrequency field exposure at environmental levels on living tissues and organisms remains controversial, in particular regarding potential "nonthermal" effects produced in the absence of temperature elevation. Therefore, we investigated whether TRPV1, one of the most studied thermosensitive channels, can be activated by the heat produced by radiofrequency fields and by some specific nonthermal interaction with the fields. We have recently shown that TRPV1 activation can be assessed in real-time on live cells using the bioluminescence resonance energy transfer technique. Taking advantage of this innovative assay, we monitored TRPV1 thermal and chemical modes of activation under radiofrequency exposure at 1800 MHz using different signals (CW, GSM, UMTS, LTE, Wi-Fi and WiMAX) at specific absorption rates between

8 and 32 W/kg. We showed that, as expected, TRPV1 channels were activated by the heat produced by radiofrequency field exposure of transiently-transfected HEK293T cells, but found no evidence of TRPV1 activation in the absence of temperature elevation under radiofrequency field exposure. There was no evidence either that, at fixed temperature, radiofrequency exposure altered the maximal efficacy of the agonist Capsaicin to activate TRPV1.

Russo R, Fox E, Cinel C, Boldini A, Defeyter MA, Mirshekar-Syahkal D, Mehta A. Does acute exposure to mobile phones affect human attention? Bioelectromagnetics.27(3):215-220, 2006.

Recent studies have indicated that acute exposure to low level radiofrequency (RF) electromagnetic fields generated by mobile phones affects human cognition. However, the relatively small samples used, in addition to methodological problems, make the outcomes of these studies difficult to interpret. In our study we tested a large sample of volunteers (168) using a series of cognitive tasks apparently sensitive to RF exposure (a simple reaction task, a vigilance task, and a subtraction task). Participants performed those tasks twice, in two different sessions. In one session they were exposed to RFs, with half of subjects exposed to GSM signals and the other half exposed to CW signals, while in the other session they were exposed to sham signals. No significant effects of RF exposure on performance for either GSM or CW were found, independent of whether the phone was positioned on the left or on the right side.

Ryan KL, Walters TJ, Tehrany MR, Lovelace JD, Jauchem JR.Age does not affect thermal and cardiorespiratory responses to microwave heating in calorically restricted rats. Shock 8(1):55-60, 1997.

This study sought to determine whether age influences the thermal distribution and cardiorespiratory responses to 35 GHz microwave (MW) heating. Male Sprague-Dawley rats (n = 8/group) 3 to 4 mo old (young), 15 to 16 mo old (middle-aged), and 24 to 25 mo old (old) were used. All animals were restricted to 63% of ad libitum feed. Rats were anesthetized (ketamine) and a catheter was placed into a carotid artery for measurement of mean arterial blood pressure (MAP). Anesthetized rats were then exposed to MWs until death, while measuring MAP, heart rate and temperatures at five sites (colonic, left and right tympanic, subcutaneous, and tail). Before MW exposure, there were no significant ($p < .05$) differences among age groups in measured parameters. MW produced increases in temperature at each of the measured sites; temperatures at death did not differ between groups. Heart rate increased throughout MW exposure, in a statistically identical manner in all age groups. MAP was initially well maintained and then, in the latter phases of heating, precipitously declined until death, with no discernible age-related difference. Respiration rate was not altered by MW exposure in any group. Finally, there were no group differences in the MW exposure time required to induce death. Thus, age does not alter thermal and cardiorespiratory responses to 35 GHz MW heating in food-restricted rats.

Saalman E, Norden B, Arvidsson L, Hamnerius Y, Hojevik P, Connell KE, Kurucsev T, Effect of 2.45 GHz microwave radiation on permeability of unilamellar liposomes to 5(6)-carboxyfluorescein. Evidence of non-thermal leakage. Biochim Biophys

Acta 1064(1):124-130, 1991.

The influence of 2.45 GHz microwave radiation on the membrane permeability of unilamellar liposomes was studied using the marker 5(6)-carboxyfluorescein trapped in phosphatidylcholine liposomes. The release of the fluorescent marker was followed by spectrofluorimetry after an exposure of 10 minutes to either microwave radiation or to heat alone of the liposome solutions. A significant increase of the permeability of carboxyfluorescein through the membrane was observed for the microwave-exposed samples compared to those exposed to normal heating only. Exposure to 2.45 GHz microwave radiation of liposomes has been previously found to produce increased membrane permeability as compared with heating. However, in contrast to previous studies, the observations reported here were made above the phase transition temperature of the lipid membrane. The experimental setup included monitoring of the temperature during microwave exposure simultaneously at several points in the solution volume using a fiberoptic thermometer. Possible mechanisms to explain the observations are discussed.

Sadetzki S, Chetrit A, Jarus-Hakak A, Cardis E, Deutch Y, Duvdevani S, Zultan A, Novikov I, Freedman L, Wolf M. Cellular phone use and risk of benign and malignant parotid gland tumors--a nationwide case-control study. Am J Epidemiol. 167(4):457-467, 2008.

The objective of this nationwide study was to assess the association between cellular phone use and development of parotid gland tumors (PGTs). The methods were based on the international INTERPHONE study that aimed to evaluate possible adverse effects of cellular phone use. The study included 402 benign and 58 malignant incident cases of PGTs diagnosed in Israel at age 18 years or more, in 2001-2003, and 1,266 population individually matched controls. For the entire group, no increased risk of PGTs was observed for ever having been a regular cellular phone user (odds ratio = 0.87; p = 0.3) or for any other measure of exposure investigated. However, analysis restricted to regular users or to conditions that may yield higher levels of exposure (e.g., heavy use in rural areas) showed consistently elevated risks. For ipsilateral use, the odds ratios in the highest category of cumulative number of calls and call time without use of hands-free devices were 1.58 (95% confidence interval: 1.11, 2.24) and 1.49 (95% confidence interval: 1.05, 2.13), respectively. The risk for contralateral use was not significantly different from 1. A positive dose-response trend was found for these measurements. Based on the largest number of benign PGT patients reported to date, our results suggest an association between cellular phone use and PGTs.

Saffer JD, Profenno LA, Microwave-specific heating affects gene expression. Bioelectromagnetics 13(1):75-78, 1992.

The effects of low-level microwave radiation on gene expression in Escherichia coli have been examined in a sensitive model. We confirm the previously reported existence of an increase in beta-galactosidase expression by microwave radiation--an increase not duplicated by bulk heating. However, the effect was not frequency dependent and appeared to be due to heating effects peculiar to microwaves. These results indicate that small thermal gradients may be a source of biological effects of non-ionizing radiation.

Safian F, Khalili MA, Khoradmehr A, Anbari F, Soltani S, Halvaei I. Survival Assessment of Mouse Preimplantation Embryos After Exposure to Cell Phone Radiation. J Reprod Infertil. 17(3):138-143, 2016.

BACKGROUND: Using cellular phone has rapidly increased all over the world. Also, the concern on the possible health hazards of electromagnetic fields (EMF) induced from cell phones to reproduction has been growing in many countries. The aim of this study was to assess the consequences and effects of exposure to the cell phone radiation on the quality and survival rates of preimplantation embryos in mice. METHODS: A total of 40 mice (20 females and 20 males), 6 weeks old and sexually mature BALB/c, were used for control and experimental groups. The ovary burses were removed and the zygotes were dissected in the morning after mating. Next, 2-cell embryos were divided into two groups of control (n=150) and experimental (n=150). EMF (900-1800 MHz) was used for four days in experimental group for 30 min/day in culture at 37°C in a CO 2 incubator. The quality of embryos was recorded daily and the fluorescent staining was used for identification of viable blastocysts. All data were compared by Student's t-test and Mann-Whitney test ($p<0.05$). RESULTS: The rate of embryo survival to the blastocysts stage was similar in both groups. However, the percentage of dead embryos at the 2-cell stage was significantly higher in EMF-exposed group compared with controls ($p=0.03$). Also, the loss of cell viability significantly increased in experimental blastocysts ($p=0.002$). CONCLUSION: The normal embryonic development up to the blastocyst stage indicates that EMF-exposure commonly did not have adverse effect on embryo development in mice. But, it caused loss of blastocysts cell viability.

Safronova VG, Gapeev AB, Alovskaia AA, Gabdulkhakova AG, Chemeris NK, Fesenko EE [Millemetre waves inhibit the synergistic effect of calcium ionophore A23187 and phorbol ester in neutrophil respiratory burst]. Biofizika 42(6):1267-1273, 1997. [Article in Russian]

The effect of extremely high frequency electromagnetic field (mm-waves) on respiratory burst of neutrophils was studied. The peritoneal evoked neutrophils of the mice (NMRI line) were used. The production of reactive oxygen species was estimated by luminol-dependent chemiluminescence technique. Cells were irradiated by the mm-waves of 41. 95 GHz in the far field zone of the channel radiator during 20 min. Absorbed energy flux density was 150 microW/cm2. The irradiation was carried out at different concentrations of calcium ionophore A23187 and then neutrophils were stimulated by phorbol 12-myristate 13-acetate (PMA) 1 microM, activator of PKC. At irradiation of neutrophils the synergistic action of A23187 and PMA was not changed at low concentration of ionophore 10 nM-0.5 microM and was suppressed at high concentrations 0.5-10 microM. The largest inhibition of about 60% was obtained at the concentration of A23187 20 microM. The effect of mm-waves was not found under exposure in Ca(2+)-free medium for all used A23187 concentrations. We suggest that the mm-wave effect on the production of reactive oxygen species by neutrophils is determined by the influx of extracellular Ca2+ and PKC.

Sage C, Johansson O, Sage SA. Personal digital assistant (PDA) cell phone units

produce elevated extremely-low frequency electromagnetic field emissions. Bioelectromagnetics.28(5):386-92,2007.

Initial tests indicate that personal and occupational use of personal digital assistants (PDAs or palm-held wireless units) produce high intensity bursts of extremely-low frequency electromagnetic fields (ELF-EMF). These emissions could result in comparatively high ELF-EMF exposure in persons that carry a PDA close to the body (i.e., in a pocket or on a belt); or held to the head for cell phone conversations. ELF-EMF emissions of 10 microT were recorded on PDAs during normal office use over a 24 h test period. Results of ELF-EMF measurements show that email transmit and receive functions produce rapid, short-duration ELF-EMF spikes in the 2-10 microT range, each lasting several seconds to over a minute apparently depending on file download size. Some units produced spikes as high as 30-60 microT during email activities. Cell phone activity on PDAs produced continuously elevated ELF-EMF readings in the 0.5-1 microT range, as opposed to the rapid spiking pattern for email receipt and transmission. Switching the PDA unit from "OFF" to "ON" position resulted in single ELF-EMF pulses of over 90 microT on two units. Email downloads into the PDA can occur randomly throughout the day and night when the unit is "ON"; thus the user who wears the PDA may be receiving high-intensity ELF-EMF pulses throughout the day and night. The frequency of email traffic on the PDA, and the power switching unit (battery unit) may affect the frequency and intensity of ELF-EMF emissions.

Saghiri MA, Orangi J, Asatourian A, Mehriar P, Sheibani N. Effect of mobile phone use on metal ion release from fixed orthodontic appliances. Am J Orthod Dentofacial Orthop. 147(6):719-724, 2015.

INTRODUCTION: The aim of this study was to evaluate the effect of exposure to radiofrequency electromagnetic fields emitted by mobile phones on the level of nickel in saliva. METHODS: Fifty healthy patients with fixed orthodontic appliances were asked not to use their cell phones for a week, and their saliva samples were taken at the end of the week (control group). The patients recorded their time of mobile phone usage during the next week and returned for a second saliva collection (experimental group). Samples at both times were taken between 8:00 and 10:00 pm, and the nickel levels were measured. Two-tailed paired-samples t test, linear regression, independent t test, and 1-way analysis of variance were used for data analysis. RESULTS: The 2-tailed paired-samples t test showed significant differences between the levels of nickel in the control and experimental groups (t [49] = 9.967; P <0.001). The linear regression test showed a significant relationship between mobile phone usage time and the nickel release (F [1, 48] = 60.263; P <0.001; R(2) = 0.577). CONCLUSIONS: Mobile phone usage has a time-dependent influence on the concentration of nickel in the saliva of patients with orthodontic appliances.

Sagioglou NE, Manta AK, Giannarakis IK, Skouroliakou AS, Margaritis LH. Apoptotic cell death during Drosophila oogenesis is differentially increased by electromagnetic radiation depending on modulation, intensity and duration of exposure. Electromagn Biol Med. 2014 Oct 21:1-14. [Epub ahead of print]

Abstract Present generations are being repeatedly exposed to different types and doses of non-ionizing radiation (NIR) from wireless technologies (FM radio, TETRA and TV stations, GSM and UMTS phones/base stations, Wi-Fi networks, DECT phones). Although there is controversy on the published data regarding the non-thermal effects of NIR, studies have convincingly demonstrated bioeffects. Their results indicate that modulation, intensity, exposure duration and model system are important factors determining the biological response to irradiation. Attempting to address the dependence of NIR bioeffectiveness on these factors, apoptosis in the model biological system Drosophila melanogaster was studied under different exposure protocols. A signal generator was used operating alternatively under Continuous Wave (CW) or Frequency Modulation (FM) emission modes, at three power output values (10 dB, 0, -10 dB), under four carrier frequencies (100, 395, 682, 900 MHz). Newly emerged flies were exposed either acutely (6 min or 60 min on the 6th day), or repeatedly (6 min or 60 min daily for the first 6 days of their life). All exposure protocols resulted in an increase of apoptotic cell death (ACD) observed in egg chambers, even at very low electric field strengths. FM waves seem to have a stronger effect in ACD than continuous waves. Regarding intensity and temporal exposure pattern, EMF-biological tissue interaction is not linear in response. Intensity threshold for the induction of biological effects depends on frequency, modulation and temporal exposure pattern with unknown so far mechanisms. Given this complexity, translating such experimental data into possible human exposure guidelines is yet arbitrary.

Şahin A, Aslan A, Baş O, İkinci A, Özyılmaz C, Fikret Sönmez O, Çolakoğlu S, Odacı E. Deleterious impacts of a 900MHz electromagnetic field on hippocampal pyramidal neurons of 8-week-old Sprague Dawley male rats. Brain Res. 2015 Jul 31. pii: S0006-8993(15)00586-7. doi: 10.1016/j.brainres.2015.07.042. [Epub ahead of print]

Children are at potential risk due to their intense use of mobile phones. We examined 8-week-old rats because that age is comparable with the preadolescent period in humans. The numbers of pyramidal neurons in the cornu ammonis of the Sprague Dawley male rat (8-weeks old, weighing 180-250g) hippocampus following exposure to a 900MHz (MHz) electromagnetic field (EMF) were examined. The study consisted of control (CN-G), sham exposed (SHM-EG) and EMF exposed (EMF-EG) groups, 6 rats in each. The EMF-EG rats were exposed to 900MHz EMF (1h/day for 30 days) in an EMF jar. The SHM-EG rats were placed in the EMF jar but not exposed to EMF (1h/day for 30 days). The CN-G rats were not placed into the exposure jar and were not exposed to EMF during the study period. All animals were sacrificed at the end of the experiment, and their brains were removed for histopathological and stereological analysis. The number of pyramidal neurons in the cornu ammonis of the hippocampus was estimated on Cresyl violet stained sections of the brain using the optical dissector counting technique. Histopathological evaluations were also performed on these sections. Histopathological observation showed abundant cells with abnormal, black or dark blue cytoplasm and shrunken morphology among the normal pyramidal neurons. The largest lateral ventricles were observed in the EMF-EG sections compared to those from the other groups. Stereological analyses showed that the total number of pyramidal neurons in the cornu

ammonis of the EMF-EG rats was significantly lower than those in CN-G ($p<0.05$) and SHM-EG ($p<0.05$). In conclusion, our results suggest that pyramidal neuron loss and histopathological changes in the cornu ammonis of 8-week-old male rats may be due to 900MHz EMF exposure.

Şahin D, Özgür E, Güler G, Tomruk A, Ünlü İ, Sepici-Dinçel A, Seyhan N. The 2100MHz radiofrequency radiation of a 3G-mobile phone and the DNA oxidative damage in brain. J Chem Neuroanat. 2016 Jan 8. pii: S0891-0618(16)00004-1. doi: 10.1016/j.jchemneu.2016.01.002. [Epub ahead of print]

We aimed to evaluate the effect of 2100MHz radiofrequency radiation emitted by a generator, simulating a 3G-mobile phone on the brain of rats during 10 and 40 days of exposure. The female rats were randomly divided into four groups. Group I; exposed to 3G modulated 2100MHz RFR signal for 6h/day, 5 consecutive days/wk for 2 weeks, Group II; control 10 days, were kept in an inactive exposure set-up for 6h/day, 5 consecutive days/wk for 2 weeks, Group III; exposed to 3G modulated 2100MHz RFR signal for 6h/day, 5 consecutive days/wk for 8 weeks and Group IV; control 40 days, were kept in an inactive exposure set-up for 6h/day, 5 consecutive days/wk for 8 weeks. After the genomic DNA content of brain was extracted, oxidative DNA damage (8-hydroxy-2'deoxyguanosine, pg/mL) and malondialdehyde (MDA, nmoL/g tissue) levels were determined. Our main finding was the increased oxidative DNA damage to brain after 10 days of exposure with the decreased oxidative DNA damage following 40 days of exposure compared to their control groups. Besides decreased lipid peroxidation end product, MDA, was observed after 40 days of exposure. The measured decreased quantities of damage during the 40 days of exposure could be the means of adapted and increased DNA repair mechanisms.

Saikhedkar N, Bhatnagar M, Jain A, Sukhwal P, Sharma C, Jaiswal N. Effects of mobile phone radiation (900 MHz radiofrequency) on structure and functions of rat brain. Neurol Res. 2014 May 26:1743132814Y0000000392. [Epub ahead of print]

Objectives: The goals of this study were: (1) to obtain basic information about the effects of long-term use of mobile phone on cytological makeup of the hippocampus in rat brain (2) to evaluate the effects on antioxidant status, and (3) to evaluate the effects on cognitive behavior particularly on learning and memory. Methods: Rats (age 30 days, 120 ± 5 g) were exposed to 900 MHz radio waves by means of a mobile hand set for 4 hours per day for 15 days. Effects on anxiety, spatial learning, and memory were studied using open field test, elevated plus maze, Morris water maze (MWM), and classic maze test. Effects on brain antioxidant status were also studied. Cresyl violet staining was done to access the neuronal damage. Result: A significant change in behavior, i.e., more anxiety and poor learning was shown by test animals as compared to controls and sham group. A significant change in level of antioxidant enzymes and non-enzymatic antioxidants, and increase in lipid peroxidation were observed in test rats. Histological examination showed neurodegenerative cells in hippocampal sub regions and cerebral cortex. Discussion: Thus our findings indicate extensive neurodegeneration on exposure to radio waves. Increased production of reactive oxygen species due to exhaustion of enzymatic and

non-enzymatic antioxidants and increased lipid peroxidation are indicating extensive neurodegeneration in selective areas of CA1, CA3, DG, and cerebral cortex. This extensive neuronal damage results in alterations in behavior related to memory and learning.

Sakakibara Y, Mitsui T, Concerns about sources of electromagnetic interference in patients with pacemakers. Jpn Heart J 40(6):737-743, 1999.

Electromagnetic noise is rapidly increasing in our environment so electromagnetic interference (EMI) with pacemakers (PM) may become a more important problem despite technological improvements in PM. The aim of this study was to evaluate the kinds of EMI which affect the quality of life of PM patients. The participants (1,942 Japanese Association for Pacemaker Patients: Pacemaker-Tomonokai) were asked to respond to a questionnaire about their major EMI troubles, and 1,567 patients (80.7%) responded by mail. The main concerns were from mobile telephones (MT) (39%), magnetic resonance imaging (MRI) (17%), electronic kitchen appliances, automobile engines and high voltage power lines. If possible, PM implantation sites should be carefully selected not only according to the physician's convenience but also considering information on each patient's habits and physical limitations.

Sakuma N, Komatsubara Y, Takeda H, Hirose H, Sekijima M, Nojima T, Miyakoshi J.DNA strand breaks are not induced in human cells exposed to 2.1425 GHz band CW and W-CDMA modulated radiofrequency fields allocated to mobile radio base stations. Bioelectromagnetics. 27:51-57, 2006.

We conducted a large-scale in vitro study focused on the effects of low level radiofrequency (RF) fields from mobile radio base stations employing the International Mobile Telecommunication 2000 (IMT-2000) cellular system in order to test the hypothesis that modulated RF fields may act as a DNA damaging agent. First, we evaluated the responses of human cells to microwave exposure at a specific absorption rate (SAR) of 80 mW/kg, which corresponds to the limit of the average whole body SAR for general public exposure defined as a basic restriction in the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. Second, we investigated whether continuous wave (CW) and Wideband Code Division Multiple Access (W-CDMA) modulated signal RF fields at 2.1425 GHz induced different levels of DNA damage. Human glioblastoma A172 cells and normal human IMR-90 fibroblasts from fetal lungs were exposed to mobile communication frequency radiation to investigate whether such exposure produced DNA strand breaks in cell culture. A172 cells were exposed to W-CDMA radiation at SARs of 80, 250, and 800 mW/kg and CW radiation at 80 mW/kg for 2 and 24 h, while IMR-90 cells were exposed to both W-CDMA and CW radiations at a SAR of 80 mW/kg for the same time periods. Under the same RF field exposure conditions, no significant differences in the DNA strand breaks were observed between the test groups exposed to W-CDMA or CW radiation and the sham exposed negative controls, as evaluated immediately after the exposure periods by alkaline comet assays. Our results confirm that low level exposures do not act as a genotoxicant up to a SAR of 800 mW/kg.

Sakurai T, Kiyokawa T, Narita E, Suzuki Y, Taki M, Miyakoshi J. Analysis of gene

expression in a human-derived glial cell line exposed to 2.45 GHz continuous radiofrequency electromagnetic fields.J Radiat Res. 52(2):185-192, 2011.

The increasing use of mobile phones has aroused public concern regarding the potential health risks of radiofrequency (RF) fields. We investigated the effects of exposure to RF fields (2.45 GHz, continuous wave) at specific absorption rate (SAR) of 1, 5, and 10 W/kg for 1, 4, and 24 h on gene expression in a normal human glial cell line, SVGp12, using DNA microarray. Microarray analysis revealed 23 assigned gene spots and 5 non-assigned gene spots as prospective altered gene spots. Twenty-two genes out of the 23 assigned gene spots were further analyzed by reverse transcription-polymerase chain reaction to validate the results of microarray, and no significant alterations in gene expression were observed. Under the experimental conditions used in this study, we found no evidence that exposure to RF fields affected gene expression in SVGp12 cells.

Saili L, Hanini A, Smirani C, Azzouz I, Azzouz A, Sakly M, Abdelmelek H, Bouslama Z. Effects of acute exposure to WIFI signals (2.45GHz) on heart variability and blood pressure in Albinos rabbit. Environ Toxicol Pharmacol. 2015 Sep;40(2):600-605, 2015.

Electrocardiogram and arterial pressure measurements were studied under acute exposures to WIFI (2.45GHz) during one hour in adult male rabbits. Antennas of WIFI were placed at 25cm at the right side near the heart. Acute exposure of rabbits to WIFI increased heart frequency (+22%) and arterial blood pressure (+14%). Moreover, analysis of ECG revealed that WIFI induced a combined increase of PR and QT intervals. By contrast, the same exposure failed to alter maximum amplitude and P waves. After intravenously injection of dopamine (0.50ml/kg) and epinephrine (0.50ml/kg) under acute exposure to RF we found that, WIFI alter catecholamines (dopamine, epinephrine) action on heart variability and blood pressure compared to control. These results suggest for the first time, as far as we know, that exposure to WIFI affect heart rhythm, blood pressure, and catecholamines efficacy on cardiovascular system; indicating that radiofrequency can act directly and/or indirectly on cardiovascular system.

Salah MB, Abdelmelek H, Abderraba M. Effects of olive leave extract on metabolic disorders and oxidative stress induced by 2.45 GHz WIFI signals. Environ Toxicol Pharmacol. 36(3):826-834, 2013.

We investigated the effect of olive leaves extract administration on glucose metabolism and oxidative response in liver and kidneys of rats exposed to radio frequency (RF). The exposure of rats to RF (2.45 GHz, 1h/day during 21 consecutive days) induced a diabetes-like status. Moreover, RF decreased the activities of glutathione peroxidase (GPx, -33.33% and -49.40%) catalase (CAT, -43.39% and -39.62%) and the superoxide dismutase (SOD, -59.29% and -68.53%) and groups thiol amount (-62.68% and -34.85%), respectively in liver and kidneys. Indeed, exposure to RF increased the malondialdehyde (MDA, 29.69% and 51.35%) concentration respectively in liver and kidneys. Olive leaves extract administration (100 mg/kg, ip) in RF-exposed rats prevented glucose metabolism disruption and restored the activities of GPx, CAT and SOD and thiol

group amount in liver and kidneys. Moreover, olive leave extract administration was able to bring down the elevated levels of MDA in liver but not in kidneys. Our investigations suggested that RF exposure induced a diabetes-like status through alteration of oxidative response. Olive leaves extract was able to correct glucose metabolism disorder by minimizing oxidative stress induced by RF in rat tissues.

Salahaldin AH, Bener A. Long-term and frequent cellular phone use and risk of acoustic neuroma. Int Tinnitus J. 12(2):145-148, 2006.

Human exposure to radio frequency radiation has increased dramatically during recent years from widespread use of mobile phones, and in some studies this exposure has been linked to the development of acoustic neuroma. The aim of our study was to describe the epidemiology of acoustic neuroma in a newly developed country, Qatar. We reviewed all cases of acoustic neuroma registered at the Hamad Medical Corporation during the period 2004-2005. We collected and assessed the sociodemographic information, presenting complaints, audiological evaluation, and laboratory investigations. During the study period, we diagnosed acoustic neuroma in 13 patients (10 women, median age 55 years, and 3 men, median age 49 years). Most of the cell phones were used daily for an average of 14 times per day (range, 8-20 times) and had been used for the duration of more than 5 years, with the exception of 3 patients who had used the cell phone excessively (> 20 minutes per call more than five times daily) owing to the nature of their jobs. The total incidence rate for Qatar was found to be 17.2 per million population. In conclusion, the incidence of acoustic neuroma in Qatar is slightly higher than that in other countries. Despite the presence of facilities in Qatar, no proper screening and management protocol is available. This study highlights the need for the development and implementation of a national registry plan whereby effective care services can be delivered and high-risk groups can be targeted.

Salama N, Kishimoto T, Kanayama HO. Effects of exposure to a mobile phone on testicular function and structure in adult rabbit. Int J Androl.33(1):88-94, 2010.

Summary The accumulating effects of exposure to electromagnetic radiation emitted by a conventional mobile phone (standby position) on the testicular function and structure are not yet fully investigated. To study these effects longitudinally, a total of 24 adult male rabbits were randomly and equally divided into three groups. Rabbits in the first (phone) group were exposed, in specially designed cages, to radio frequency emitted from the mobile phone (800 MHz) in a standby position opposite to that of testes for 8 h daily for 12 weeks. The second group consisted of the stress controls which were kept in the same kind of cages to appreciate any cage-induced anxiety. The third group included the ordinary controls which were kept in the conventional roomy cages. Semen analysis and sperm function tests (viability, hypo-osmotic swelling and acridine orange) were conducted weekly. Histological testicular sections and serum total testosterone were also evaluated. A drop in the sperm concentration appeared in the phone group at week 6. This became statistically significant at week 8, compared with the two control (stress and ordinary) groups (133, 339 and 356 x 106/mL, respectively) and to the initial sperm count (341 x 106/mL) of this group. Motile sperm population showed similarity amongst the

three study groups until week 10 when it declined significantly, and thereafter in the phone and stress control groups, with more significant decline in the phone animals (50, 61 and 72.4%, respectively). Histological examination showed also a significant decrease in the diameter of seminiferous tubules in the phone group vs. the stress and ordinary controls (191 mum vs. 206 and 226 mum, respectively). The other study points did not show any difference. In conclusion, low intensity pulsed radio frequency emitted by a conventional mobile phone kept in the standby position could affect the testicular function and structure in the adult rabbit.

Salama N, Kishimoto T, Kanayama HO, Kagawa S. Effects of exposure to a mobile phone on sexual behavior in adult male rabbit: an observational study. Int J Impot Res.22(2):127-33, 2010.

The accumulating effects of exposure to electromagnetic radiation emitted by a conventional mobile phone (MP) on male sexual behaviour have not yet been analyzed. Therefore, we studied these effects in 18 male rabbits that were randomly divided into phone and control groups. Six female teasers were taken successively to the male's cage and the copulatory behavior was recorded. Serum total testosterone, dopamine and cortisol were evaluated. The animals of the phone group were exposed to MPs (800 MHz) in a standby position for 8 h daily for 12 weeks. At the end of the study, the copulatory behavior and hormonal assays were re-evaluated. Mounts without ejaculation were the main mounts in the phone group and its duration and frequency increased significantly compared with the controls, whereas the reverse was observed in its mounts with ejaculation. Ejaculation frequency dropped significantly, biting/grasping against teasers increased notably and mounting latency in accumulated means from the first to the fourth teasers were noted in the phone group. The hormonal assays did not show any significant differences between the study groups. Therefore, the pulsed radiofrequency emitted by a conventional MP, which was kept on a standby position, could affect the sexual behavior in the rabbit.

Salama N, Kishimoto T, Kanayama HO, Kagawa S. The mobile phone decreases fructose but not citrate in rabbit semen: a longitudinal study. Syst Biol Reprod Med. 55(5):181-187, 2009.

The negative impact of mobile phones on sperm motility has been previously described. Both fructose and citrate are important components in semen that facilitate sperm motility. To date, no studies have investigated the effect of exposure to electromagnetic radiation emitted from the mobile phone on their levels.. Therefore, a longitudinal study using the adult rabbit as a model was undertaken. A total of 30 adult male rabbits were randomly divided into three groups. The first (phone) group was placed in specially designed cages, and exposed to radio frequency emitted from a mobile phone (900 MHz) kept in standby mode and positioned adjacent to the genitalia for 8 h daily for 12 weeks. The other two groups served as controls; the stress group which was housed in the same kind of cages to evaluate any cage-induced anxiety, and the control group which was housed in the conventional roomy cages. Semen samples were retrieved weekly. Sperm motility and viability, semen fructose and citrate, and serum testosterone were measured. Histological sections

from the prostatic complex, ampulla, and vesicular gland were evaluated. A significant drop in both fructose levels (257 +/-11.6 vs. 489 +/- 8.4 mg %, the baseline level) and number of motile sperms (50 vs. 72%) was observedin the phone group at the 10th week. However, no correlation was found between the two values. The stress control animals showed a similar but significantly less decline in motility No significant changes in citrate levels or other study parameters were seen in the three animal groups throughout the study. In conclusion, the pulsed radio frequency emitted by the mobile phone kept in the standby position longitudinally affected sperm motility and fructose but not citrate levels in rabbit semen.

Salford LG, Brun A, Sturesson K, Eberhardt JL, Persson BR Permeability of the blood-brain barrier induced by 915 MHz electromagnetic radiation, continuous wave and modulated at 8, 16, 50, and 200 Hz. Microsc Res Tech 27(6):535-542, 1994.

Biological effects of electromagnetic fields (EMF) on the blood-brain barrier (BBB) can be studied in sensitive and specific models. In a previous investigation of the permeability of the blood-brain barrier after exposure to the various EMF-components of proton magnetic resonance imaging (MRI), we found that the exposure to MRI induced leakage of Evans Blue labeled proteins normally not passing the BBB of rats [Salford et al. (1992), in: Resonance Phenomena in Biology, Oxford University Press, pp. 87-91]. In the present investigation we exposed male and female Fischer 344 rats in a transverse electromagnetic transmission line chamber to microwaves of 915 MHz as continuous wave (CW) and pulse-modulated with repetition rates of 8, 16, 50, and 200 s-1. The specific energy absorption rate (SAR) varied between 0.016 and 5 W/kg. The rats were not anesthetized during the 2-hour exposure. All animals were sacrificed by perfusion-fixation of the brains under chloral hydrate anesthesia about 1 hour after the exposure. The brains were perfused with saline for 3-4 minutes, and thereafter fixed in 4% formaldehyde for 5-6 minutes. Central coronal sections of the brains were dehydrated and embedded in paraffin and sectioned at 5 microns. Albumin and fibrinogen were demonstrated immunohistochemically. The results show albumin leakage in 5 of 62 of the controls and in 56 of 184 of the animals exposed to 915 MHz microwaves. Continuous wave resulted in 14 positive findings of 35, which differ significantly from the controls (P = 0.002).

Salford LG, Brun A, Persson BRR, Brain tumour development in rats exposed to electromagnetic fields used in wireless cellular communication. Wireless network 3: 463-469, 1997.

It has been suggested that electromagnetic fields (EMF) act as promoters late in the carcinogenesis process. To date, however, there is no convincing laboratory evidence that EMFs cause tumour promotion at non-thermal exposure levels. Therefore the effects of exposure to electromagnetic fields were investigated in a rat brain glioma model. Some of the exposures correspond to electromagnetic fields used in wireless communication. Microwaves at 915 MHz were used both as continuous waves (1 W), and pulse-modulated at 4, 8, 16 and 217 Hz in 0.57 ms pulses and 50 Hz in 6.67 ms pulses (2 W per pulse). Fischer 344 rats of both sexes were used in the experiments. By stereotaxic technique rat glioma cells (RG2 and N32) were injected into the head of the right caudate

nucleus in 154 pairs of rats, exposed and matched controls. Starting on day 5 after inoculation, the animals were exposed for 7 hours a day, 5 days a week during 2-3 weeks. Exposed animals were kept unanaesthetized in well-ventilated TEM cells producing 915 MHz continuous or modulated microwaves. Their matched controls were kept in identical TEM cells without EMF exposure. All brains were examined histopathologically and the tumour size was estimated as the volume of an ellipsoid. Our study of 154matched pairs of rats does not show any significant difference in tumour size between animals exposed to 915 MHz, and those not exposed. Thus our results do not support that even an extensive daily exposure to EMF promotes tumour growth when given from the fifth day after the start of tumour growth in the rat brain until the sacrifice of the animal after about 16 days.

Salford LG, Brun AR, Eberhardt JL, Malmgren L, Persson BRR, Nerve cell damage in mammalian brain after exposure to microwaves from GSM mobile phones. Environ Health Persp 111:881-883, 2003.

The possible risks of radio-frequency electromagnetic fields for the human body is a growing concern for the society. We have earlier shown that weak pulsed microwaves give rise to a significant leakage of albumin through the blood-brain barrier (BBB). Now we have investigated whether a pathological leakage over the BBB might be combined with damage to the neurons. Three groups of each 8 rats were exposed for 2 hours to GSM mobile phone electromagnetic fields of different strengths. We found, and present here for the first time, highly significant ($p < 0.002$) evidence for neuronal damage in both the cortex, the hippocampus and the basal ganglia in the brains of exposed rats.

Salunke BP, Umathe SN, Chavan JG. Behavioral in-effectiveness of high frequency electromagnetic field in mice. Physiol Behav. 2014 Dec 10;140C:32-37. doi: 10.1016/j.physbeh.2014.12.019. [Epub ahead of print]

The present investigation was carried out with an objective to study the influence of high frequency electromagnetic field (HF-EMF) on anxiety, obsessive compulsive disorder (OCD) and depression-like behavior. For exposure to HF-EMF, non-magnetic material was used to fabricate the housing. Mice were exposed to HF-EMF (2.45GHz), 60min/day for 7 or 30 or 60 or 90 or 120days. The exposure was carried out by switching-on inbuilt class-I BLUETOOTH device that operates on 2.45GHz frequency in file transfer mode at a peak density of 100mW. Mice were subjected to the assessment of anxiety, OCD and depression-like behavior for 7 or 30 or 60 or 90 or 120days of exposure. The anxiety-like behavior was assessed by elevated plus maze, open field test and social interaction test. OCD-like behavior was assessed by marble burying behavior, whereas depression-like behavior was assessed by forced swim test and tail suspension test. The present experiment demonstrates that up to 120days of exposure to HF-EMF does not produce anxiety, OCD and depression-like behavior in mice.

Sambucci M, Laudisi F, Nasta F, Pinto R, Lodato R, Altavista P, Lovisolo GA, Marino C, Pioli C. Prenatal exposure to non-ionizing radiation: effects of WiFi signals on pregnancy outcome, peripheral B-cell compartment and antibody production. Radiat Res. 174(6):732-740, 2010.

During embryogenesis, the development of tissues, organs and systems, including the immune system, is particularly susceptible to the effects of noxious agents. We examined the effects of prenatal (in utero) exposure to WiFi signals on pregnancy outcome and the immune B-cell compartment, including antibody production. Sixteen mated (plug-positive) female mice were assigned to each of the following groups: cage control, sham-exposed and microwave-exposed (WiFi signals at 2.45 GHz, whole body, SAR 4 W/kg, 2 h/day, 14 consecutive days starting 5 days after mating). No effects due to exposure to WiFi signals during pregnancy on mating success, number of newborns/mother and body weight at birth were found. Newborn mice were left to grow until 5 or 26 weeks of age, when immunological analyses were performed. No differences due to exposure were found in spleen cell number, B-cell frequency or antibody serum levels. When challenged in vitro with LPS, B cells from all groups produced comparable amounts of IgM and IgG, and proliferated at a similar level. All these findings were consistently observed in the female and male offspring at both juvenile (5 weeks) and adult (26 weeks) ages. Stress-associated effects as well as age- and/or sex-related differences were observed for several parameters. In conclusion, our results do not show any effect on pregnancy outcome or any early or late effects on B-cell differentiation and function due to prenatal exposure to WiFi signals.

Sambucci M, Laudisi F, Nasta F, Pinto R, Lodato R, Lopresto V, Altavista P, Marino C, Pioli C. Early life exposure to 2.45GHz WiFi-like signals: effects on development and maturation of the immune system. Prog Biophys Mol Biol. 107(3):393-398, 2011.

The development of the immune system begins during embryogenesis, continues throughout fetal life, and completes its maturation during infancy. Exposure to immune-toxic compounds at levels producing limited/transient effects in adults, results in long-lasting or permanent immune deficits when it occurs during perinatal life. Potentially harmful radiofrequency (RF) exposure has been investigated mainly in adult animals or with cells from adult subjects, with most of the studies showing no effects. Is the developing immune system more susceptible to the effects of RF exposure? To address this question, newborn mice were exposed to WiFi signals at constant specific absorption rates (SAR) of 0.08 or 4 W/kg, 2h/day, 5 days/week, for 5 consecutive weeks, starting the day after birth. The experiments were performed with a blind procedure using sham-exposed groups as controls. No differences in body weight and development among the groups were found in mice of both sexes. For the immunological analyses, results on female and male newborn mice exposed during early post-natal life did not show any effects on all the investigated parameters with one exception: a reduced IFN-γ production in spleen cells from microwaves (MW)-exposed (SAR 4 W/kg) male (not in female) mice compared with sham-exposed mice. Altogether our findings do not support the hypothesis that early post-natal life exposure to WiFi signals induces detrimental effects on the developing immune system.

Samkange-Zeeb F, Berg G, Blettner M. Validation of self-reported cellular phone

use. J Expo Anal Environ Epidemiol. 14(3):245-248, 2004.

BACKGROUND: In recent years, concern has been raised over possible adverse health effects of cellular telephone use. In epidemiological studies of cancer risk associated with the use of cellular telephones, the validity of self-reported cellular phone use has been problematic. Up to now there is very little information published on this subject. METHODS: We conducted a study to validate the questionnaire used in an ongoing international case-control study on cellular phone use, the "Interphone study". Self-reported cellular phone use from 68 of 104 participants who took part in our study was compared with information derived from the network providers over a period of 3 months (taken as the gold standard). RESULTS: Using Spearman's rank correlation, the correlation between self-reported phone use and information from the network providers for cellular phone use in terms of the number of calls per day was good (r=0.62, 95% CI: 0.45-0.75), while that of the average duration of each call was rather moderate (r=0.34, 95% CI: 0.11-0.54). Similar results were found when Kappa coefficients were estimated. A value of r=0.56 (Spearman's correlation, CI: 0.38-0.70) was found for cumulative cellular phone use. CONCLUSION: Our study suggests that cellular phone use is easier to recall in terms of number of calls made than in terms of cumulative phone use and should thus be used as the basis for the dose-response analysis.

Sanchez S, Milochau A, Ruffie G, Poulletier de Gannes F, Lagroye I, Haro E, Surleve-Bazeille JE, Billaudel B, Lassegues M, Veyret B. Human skin cell stress response to GSM-900 mobile phone signals.FEBS J. 273(24):5491-5507, 2006.

In recent years, possible health hazards due to radiofrequency radiation (RFR) emitted by mobile phones have been investigated. Because several publications have suggested that RFR is stressful, we explored the potential biological effects of Global System for Mobile phone communication at 900 MHz (GSM-900) exposure on cultures of isolated human skin cells and human reconstructed epidermis (hRE) using human keratinocytes. As cell stress markers, we studied Hsc70, Hsp27 and Hsp70 heat shock protein (HSP) expression and epidermis thickness, as well as cell proliferation and apoptosis. Cells were exposed to GSM-900 under optimal culture conditions, for 48 h, using a specific absorption rate (SAR) of 2 W.kg(-1). This SAR level represents the recommended limit for local exposure to a mobile phone. The various biological parameters were analysed immediately after exposure. Apoptosis was not induced in isolated cells and there was no alteration in hRE thickness or proliferation. No change in HSP expression was observed in isolated keratinocytes. By contrast, a slight but significant increase in Hsp70 expression was observed in hREs after 3 and 5 weeks of culture. Moreover, fibroblasts showed a significant decrease in Hsc70, depending on the culture conditions. These results suggest that adaptive cell behaviour in response to RFR exposure, depending on the cell type and culture conditions, is unlikely to have deleterious effects at the skin level.

Sagar S, Dongus S, Schoeni A, Roser K, Eeftens M, Struchen B, Foerster M, Meier N , Adem S, Röösli M. Radiofrequency electromagnetic field exposure in everyday microenvironments in Europe: A systematic literature review. J Expo Sci Environ Epidemiol. 2017 Aug 2. doi: 10.1038/jes.2017.13. [Epub ahead of print]

The impact of the introduction and advancement in communication technology in recent years on exposure level of the population is largely unknown. The main aim of this study is to systematically review literature on the distribution of radiofrequency electromagnetic field (RF-EMF) exposure in the everyday environment in Europe and summarize key characteristics of various types of RF-EMF studies conducted in the European countries. We systematically searched the ISI Web of Science for relevant literature published between 1 January 2000 and 30 April 2015, which assessed RF-EMF exposure levels by any of the methods: spot measurements, personal measurement with trained researchers and personal measurement with volunteers. Twenty-one published studies met our eligibility criteria of which 10 were spot measurements studies, 5 were personal measurement studies with trained researchers (microenvironmental), 5 were personal measurement studies with volunteers and 1 was a mixed methods study combining data collected by volunteers and trained researchers. RF-EMF data included in the studies were collected between 2005 and 2013. The mean total RF-EMF exposure for spot measurements in European "Homes" and "Outdoor" microenvironments was 0.29 and 0.54 V/m, respectively. In the personal measurements studies with trained researchers, the mean total RF-EMF exposure was 0.24 V/m in "Home" and 0.76 V/m in "Outdoor". In the personal measurement studies with volunteers, the population weighted mean total RF-EMF exposure was 0.16 V/m in "Homes" and 0.20 V/m in "Outdoor". Among all European microenvironments in "Transportation", the highest mean total RF-EMF 1.96 V/m was found in trains of Belgium during 2007 where more than 95% of exposure was contributed by uplink. Typical RF-EMF exposure levels are substantially below regulatory limits. We found considerable differences between studies according to the type of measurements procedures, which precludes cross-country comparison or evaluating temporal trends. A comparable RF-EMF monitoring concept is needed to accurately identify typical RF-EMF exposure levels in the everyday environment.

Sanchez S, Masuda H, Billaudel B, Haro E, Anane R, Leveque P, Ruffie G, Lagroye I, Veyret B.Effect of GSM-900 and -1800 signals on the skin of hairless rats. II: 12-week chronic exposures.Int J Radiat Biol. 82(9):675-680, 2006.

Purpose: The purpose of this work was to determine whether the cellular components of Hairless-rat skin are affected by a chronic local exposure to non-ionizing radiations of Global Mobile Phone System: GSM-900 or -1800 radiations at specific absorption rate (SAR) 2.5 and 5 W/kg.Materials and methods: A selected part of the right back of five-week old female hairless rats was exposed or sham exposed (n = 8) for 2 h per day, 5 days a week, for 12 weeks to GSM-900 or -1800 signals using a loop-antenna. At the end of the experiment, skin biopsies were taken.Results: Analyses of skin sections using hematoxylin eosin saffron (HES) coloration showed no significant difference in skin thickness among the groups. Immunohistochemical analysis of basal lamella cells in radiofrequency radiation (RFR)-exposed epidermis showed that the ratio of the antigen Ki-67 (cellular proliferation marker) positive cells to total lamella cells remained within the range of the normal proliferation ratio. No significant differences in the level of filaggrin, collagen, and elastin were observed among the different groups.Conclusions: The results of this 12-week chronic study do not demonstrate major histological variations in the skin of hairless rats exposed to RFR used in mobile telephony (GSM-900 or -1800).

Sanchez, S., Haro, E., Ruffie, G., Veyret, B. and Lagroye, I. In Vitro Study of the Stress Response of Human Skin Cells to GSM-1800 Mobile Phone Signals Compared to UVB Radiation and Heat Shock. Radiat. Res. 167, 572-580, 2007.

The evolution of mobile phone technology is toward an increase of the carrier frequency up to 2.45 GHz. Absorption of radiofrequency (RF) radiation becomes more superficial as the frequency increases. This increasingly superficial absorption of RF radiation by the skin, which is the first organ exposed to RF radiation, may lead to stress responses in skin cells. We thus investigated the expression of three heat-shock proteins (HSP70, HSC70, HSP27) using immunohistochemistry and induction of apoptosis by flow cytometry on human primary keratinocytes and fibroblasts. A well-characterized exposure system, SXC 1800, built by the IT'IS foundation was used at 1800 MHz, with a 217 Hz modulation. We tested a 48-h exposure at an SAR of 2 W/kg (ICNIRP local exposure limit). Skin cells were also irradiated with a 600 mJ/cm(2) single dose of UVB radiation and subjected to heat shock (45 degrees C, 20 min) as positive controls for apoptosis and HSP expression, respectively. The results showed no effect of a 48-h GSM-1800 exposure at 2 W/kg on either keratinocytes or fibroblasts, in contrast to UVB-radiation or heat-shock treatments, which injured cells. We thus conclude that the GSM-1800 signal does not act as a stress factor on human primary skin cells in vitro.

Sanchez S, Masuda H, Ruffié G, De Gannes FP, Billaudel B, Haro E, Lévêque P, Lagroye I, Veyret B. Effect of GSM-900 and -1800 signals on the skin of hairless rats. III: Expression of heat shock proteins. Int J Radiat Biol.84(1):61-68, 2008.

Purpose: We previously reported the inability of Global System for Mobile communication (GSM) signals at 900 (GSM-900) and 1800 (GSM-1800) MegaHertz (MHz) to induce morphological and physiological changes in epidermis of Hairless rats. The present work aimed at investigating heat shock proteins (HSP) expression - as a cellular stress marker - in the skin of Hairless rats exposed to GSM-900 and -1800 signals. Materials and methods: We studied the expression of the Heat-shock cognate (Hsc) 70, and the inducible forms of the Heat-shock proteins (Hsp) 25 and 70. Rat skin was locally exposed using loop antenna and restrain rockets to test several Specific Absorption Rates (SAR) and exposure durations: (i) single exposure: 2 hours at 0 and 5 W/kg; (ii) repeated exposure: 2 hours per day, 5 days per week, for 12 weeks, at 0, 2.5, and 5 W/kg. HSP expression was detected on skin slices using immunolabeling in the epidermal area. Results: Our data indicated that neither single nor repeated exposures altered HSP expression in rat skin, irrespective of the GSM signal or SAR considered. Conclusions: Under our experimental conditions (local SAR <5 W/kg), there was no evidence that GSM signals alter HSP expression in rat skin.

Sandblom J, Theander S, The effect of microwave radiation on the stability and formation of gramicidin-A channels in lipid bilayer membranes. Bioelectromagnetics 12(1):9-20, 1991.

The effects of microwaves on the single-channel kinetics of gramicidin-A channels in lipid bilayer membranes were examined. Attempts were made to separate thermal and athermal effects by accurate measurements of temperature at the site of the membrane

and by relating the measured parameters to their previously characterized temperature dependence. It was found that microwave radiation does not affect single-channel conductance or channel life time to a degree that is significantly different from that expected of a purely thermal effect. On the other hand, the rate of channel formation is decreased during exposure, which is opposite to that expected of a purely thermal effect. The mechanism of this effect is discussed in terms of the dimerization process of channel formation.

Sandrini L, Vaccari A, Malacarne C, Cristoforetti L, Pontalti R. RF dosimetry: a comparison between power absorption of female and male numerical models from 0.1 to 4 ghz. Phys Med Biol. 49(22):5185-5201, 2004.

Realistic numerical models of human subjects and their surrounding environment represent the basic points of radiofrequency (RF) electromagnetic dosimetry. This also involves differentiating the human models in men and women, possibly with different body shapes and postures. In this context, the aims of this paper are, firstly, to propose a female dielectric anatomical model (fDAM) and, secondly, to compare the power absorption distributions of a male and a female model from 0.1 to 4 GHz. For realizing the fDAM, a magnetic resonance imaging tomographer to acquire images and a recent technique which avoids the discrete segmentation of body tissues into different types have been used. Simulations have been performed with the FDTD method by using a novel filtering-based subgridding algorithm. The latter is applied here for the first time to dosimetry, allowing an abrupt mesh refinement by a factor of up to 7. The results show that the whole-body-averaged specific absorption rate (WBA-SAR) of the female model is higher than that of the male counterpart, mainly because of a thicker subcutaneous fat layer. In contrast, the maximum averaged SAR over 1 g (1gA-SAR) and 10 g (10gA-SAR) does not depend on gender, because it occurs in regions where no subcutaneous fat layer is present.

Sandstrom M, Wilen J, Oftedal G, Hansson Mild K, Mobile phone use and subjective symptoms. Comparison of symptoms experienced by users of analogue and digital mobile phones. Occup Med (Lond) 51(1):25-35, 2001.

In 1995 many people reported symptoms such as headaches, feelings of discomfort, warmth behind/around or on the ear and difficulties concentrating while using mobile phones. The number of complaints was higher for people using the digital (GSM) system, i.e. with pulse modulated fields, than for those using the analogue (NMT) system. Our main hypothesis was that GSM users experience more symptoms than NMT users. An epidemiological investigation was initiated including 6379 GSM users and 5613 NMT 900 users in Sweden, and 2500 from each category in Norway. The adjusted odds ratio did not indicate any increased risk for symptoms for GSM users compared with NMT 900 users. Our hypothesis was therefore disproved. However, we observed a statistically significant lower risk for sensations of warmth on the ear for GSM users compared with NMT 900 users. The same trend was seen in Norway for sensations of warmth behind/around the ear and in Sweden for headaches and fatigue. Factors distinguishing the two systems (radio frequency emission, phone temperatures and various ergonomic factors) may be responsible for these results, as well as for a secondary finding: a statistically significant association between calling time/number of calls per day and the

prevalence of warmth behind/around or on the ear, headaches and fatigue.

Sangun O, Dundar B, Darici H, Comlekci S, Doguc DK, Celik S. The effects of long-term exposure to a 2450 MHz electromagnetic field on growth and pubertal development in female Wistar rats. Electromagn Biol Med. 2014 Jan 24. [Epub ahead of print]

The aim of this study was to investigate the effects of a 2450 MHz electromagnetic field (EMF) (wireless internet frequency) on the growth and development of female Wistar rats. The study was conducted on three groups of rats. The prenatal and postnatal groups were exposed to EMF 1 h/day beginning from intrauterine and postnatal periods, respectively. The third group was the sham-exposed group. Growth, nutrition and vaginal opening (VO) were regularly monitored. Serum and tissue specimens were collected at puberty. Histological examinations, total antioxidant status (TAS), total oxidant status (TOS) and oxidative stress index (OSI) measurements in ovary and brain tissues and also immunohistochemical staining of the hypothalamus were performed besides the determination of serum FSH, LH, E2 and IGF-1 values. Birth masses of the groups were similar ($p > 0.05$). Mass gain per day was significantly lower and the puberty was significantly later in the prenatal group. Brain and ovary TOS and OSI values in the prenatal group were significantly increased ($p < 0.05$) compared to the control group. Serum LH levels of the prenatal and postnatal groups were increased, although serum FSH, and E2 values did not differ among the groups ($p > 0.05$). Histological examinations of the specimens revealed no statistically significant difference between the groups ($p > 0.05$). Exposure to 2450 MHz EMF, particularly in the prenatal period, resulted in postnatal growth restriction and delayed puberty in female Wistar rats. Increased TOS and OSI values in the brain and ovary tissues can be interpreted as a sign of chronic stress induced by EMF. This is the first longitudinal study which investigates the effects of EMF induced by wireless internet on pubertal development beside growth.

Sanmartin M, Fernandez Lozano I, Marquez J, Antorrena I, Bautista A, Silva L, Ortigosa J, de Artaza M, [The absence of interference between GSM mobile telephones and implantable defibrillators: an in-vivo study. Groupe Systemes Mobiles]. Rev Esp Cardiol 50(10):715-719, 1997. [Article in Spanish]

Introduction and Objectives: The electromagnetic field created by mobile telephones can cause pacemaker dysfunction. Although implantable cardioverter defibrillators are also susceptible to electromagnetic interference, few studies have addressed this issue and compatibility with the GSM mode has not been tested. This study was developed to detect possible "in vivo" interference between GSM mobile telephones and implantable cardioverter defibrillators. Material and Methods: The study group is composed of 30 patients with 8 different models of defibrillators. Twenty six had endocardial leads and 4 epicardial. Three GSM mobile phones were used: Siemens S3 COM and Motorola 6200 in all cases and Ericsson GA 318 in one. The tests were performed under continuous electrocardiographic monitoring. All therapies were deactivated and sensitivities were set to maximal parameters. The telephones were positioned in close contact to the defibrillator can and precordium, in two different angles. Three situations were evaluated:

calling, established contact for 15 seconds and ringing. The protocol was repeated during pacing to assess the possibility of pacemaker mode inhibition. RESULTS: No cases of electromagnetic interference were observed. One patient presented non-sustained ventricular tachycardia episodes during the tests that were detected by the defibrillator. Conclusions: These results suggest that electromagnetic interference by GSM mobile phones are not a probable cause of implantable defibrillators dysfunction.

Sannino A, Di Costanzo G, Brescia F, Sarti M, Zeni O, Juutilainen J, Scarfì MR. Human Fibroblasts and 900 MHz Radiofrequency Radiation: Evaluation of DNA Damage after Exposure and Co-exposure to 3-Chloro-4-(dichloromethyl)-5-Hydroxy-2(5h)-furanone (MX). Radiat Res. 171(6):743-751, 2009.

The aim of this study was to investigate DNA damage in human dermal fibroblasts from a healthy subject and from a subject affected by Turner's syndrome that were exposed for 24 h to radiofrequency (RF) radiation at 900 MHz. The RF-radiation exposure was carried out alone or in combination with 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX), a well-known environmental mutagen and carcinogen produced during the chlorination of drinking water. Turner's syndrome fibroblasts were also exposed for a shorter time (1 h). A signal similar to that emitted by Global System for Mobile Communications (GSM) mobile phones was used at a specific absorption rate of 1 W/kg under strictly controlled conditions of temperature and dosimetry. To evaluate DNA damage after RF-radiation exposure alone, the alkaline comet assay and the cytokinesis-block micronucleus assay were used. In the combined-exposure experiments, MX was given at a concentration of 25 microM for 1 h immediately after the RF-radiation exposure, and the effects were evaluated by the alkaline comet assay. The results revealed no genotoxic and cytotoxic effects from RF radiation alone in either cell line. As expected, MX treatment induced an increase in DNA migration in the comet assay, but no enhancement of the MX-induced DNA damage was observed in the cells exposed to RF radiation.

Sannino A, Sarti M, Reddy SB, Prihoda TJ, Vijayalaxmi, Scarfi MR. Induction of adaptive response in human blood lymphocytes exposed to radiofrequency radiation. Radiat Res. 171(6):735-742, 2009.

Abstract Sannino, A., Sarti, M., Reddy, S. B., Prihoda, T. J., Vijayalaxmi and Scarfì, M. R. Induction of Adaptive Response in Human Blood Lymphocytes Exposed to Radiofrequency Radiation. Radiat. Res. 171, 735-742 (2009). The incidence of micronuclei was evaluated to assess the induction of an adaptive response to non-ionizing radiofrequency (RF) radiation in peripheral blood lymphocytes collected from five different human volunteers. After stimulation with phytohemagglutinin for 24 h, the cells were exposed to an adaptive dose of 900 MHz RF radiation used for mobile communications (at a peak specific absorption rate of 10 W/kg) for 20 h and then challenged with a single genotoxic dose of mitomycin C (100 ng/ml) at 48 h. Lymphocytes were collected at 72 h to examine the frequency of micronuclei in cytokinesis-blocked binucleated cells. Cells collected from four donors exhibited the induction of adaptive response (i.e., responders). Lymphocytes that were pre-exposed to 900 MHz RF radiation had a significantly decreased incidence of micronuclei induced by the challenge dose of mitomycin C compared to those that were not pre-exposed to 900 MHz RF

radiation. These preliminary results suggested that the adaptive response can be induced in cells exposed to non-ionizing radiation. A similar phenomenon has been reported in cells as well as in animals exposed to ionizing radiation in several earlier studies. However, induction of adaptive response was not observed in the remaining donor (i.e., non-responder). The incidence of micronuclei induced by the challenge dose of mitomycin C was not significantly different between the cells that were pre-exposed and unexposed to 900 MHz RF radiation. Thus the overall data indicated the existence of heterogeneity in the induction of an adaptive response between individuals exposed to RF radiation and showed that the less time-consuming micronucleus assay can be used to determine whether an individual is a responder or non-responder.

Sannino A, Zeni O, Sarti M, Romeo S, Reddy SB, Belisario MA, Prihoda TJ, Vijayalaxmi, Scarfi MR. Induction of adaptive response in human blood lymphocytes exposed to 900 MHz radiofrequency fields: influence of cell cycle.Int J Radiat Biol. 87(9):993-999, 2011.

PURPOSE: To investigate the influence of cell cycle on the adaptive response (AR) induced by the exposure of human blood lymphocytes to radiofrequency fields (RF). **MATERIALS AND METHODS:** Human peripheral blood lymphocytes in G(0)-, G(1)- or S-phase of the cell cycle were exposed for 20 hours to an adaptive dose (AD) of 900 MHz RF at an average specific absorption rate of 1.25 W/kg and then treated with a challenge dose (CD) of 100 ng/ml mitomycin C (MMC). Un-exposed and sham-exposed controls as well as cells treated with MMC alone were included in the study. The incidence of micronuclei (MN) was evaluated to determine the induction of AR. **RESULTS:** The results indicated that the cells which were exposed to AD of RF in G(0)- and G(1)-phase of the cell cycle did not exhibit AR while such a response was observed when the cells were exposed to AD of RF in S-phase of the cell cycle. **CONCLUSIONS:** These results confirmed the observations reported in our previous investigation where AR was observed in human blood lymphocytes exposed to AD of RF in S-phase of the cell cycle and further suggested that the timing of AD exposure of RF is important to elicit AR.

Sannino A, Zeni O, Romeo S, Massa R, Gialanella G, Grossi G, Manti L, Vijayalaxmi, Scarfì MR. Adaptive response in human blood lymphocytes exposed to non-ionizing radiofrequency fields: resistance to ionizing radiation-induced damage. J Radiat Res. 2013 Aug 26. [Epub ahead of print]

The aim of this preliminary investigation was to assess whether human peripheral blood lymphocytes which have been pre-exposed to non-ionizing radiofrequency fields exhibit an adaptive response (AR) by resisting the induction of genetic damage from subsequent exposure to ionizing radiation. Peripheral blood lymphocytes from four healthy donors were stimulated with phytohemagglutinin for 24 h and then exposed for 20 h to 1950 MHz radiofrequency fields (RF, adaptive dose, AD) at an average specific absorption rate of 0.3 W/kg. At 48 h, the cells were subjected to a challenge dose (CD) of 1.0 or 1.5 Gy X-irradiation (XR, challenge dose, CD). After a 72 h total culture period, cells were collected to examine the incidence of micronuclei (MN). There was a significant decrease in the number of MN in lymphocytes exposed to RF + XR (AD + CD) as compared with those subjected to XR alone (CD). These

observations thus suggested a RF-induced AR and induction of resistance to subsequent damage from XR. There was variability between the donors in RF-induced AR. The data reported in our earlier investigations also indicated a similar induction of AR in human blood lymphocytes that had been pre-exposed to RF (AD) and subsequently treated with a chemical mutagen, mitomycin C (CD). Since XR and mitomycin-C induce different kinds of lesions in cellular DNA, further studies are required to understand the mechanism(s) involved in the RF-induced adaptive response.

Santini R, Seigne M, Bonhomme-Faivre L, Bouffet S, Defrasne E, Sage M. Symptoms experienced by users of digital cellular phones: a pilot study in a French engineering school. Pathol Biol (Paris) 49(3):222-226, 2001. [Article in French]

A survey study, using questionnaire, was conducted in 161 students and workers in a French engineering school on symptoms experienced during use of digital cellular phones. A significant increase in concentration difficult ($p < 0.05$) was reported by users of 1800-MHz (DCS) cellular phones compared to 900-MHz (GSM) phone users. In users of cellular phones, women significantly ($p < 0.05$) complained more often of sleep disturbance than men. This sex difference for sleep complaint is not observed between women and men non-users of cellular phone. The use of both cellular phones and VDT significantly (p Ä 0.05) increased concentration difficulty. Digital cellular phone users also significantly ($p < 0.05$) more often complained of discomfort, warmth, and picking on the ear during phone conversation in relation with calling duration per day and number of calls per day. The complaint warmth on the ear might be a signal to users for stopping the call.

Santini R, Santini P, Danze JM, Le Ruz P, Seigne M.Study of the health of people living in the vicinity of mobile phone base stations: I. Influence of distance and sex. Pathol Biol (Paris) 50(6):369-373, 2002. [Article in French]

A survey study using questionnaire was conducted in 530 people (270 men, 260 women) living or not in vicinity of cellular phone base stations, on 18 Non Specific Health Symptoms. Comparisons of complaints frequencies (CHI-SQUARE test with Yates correction) in relation with distance from base station and sex, show significant ($p < 0.05$) increase as compared to people living > 300 m or not exposed to base station, till 300 m for tiredness, 200 m for headache, sleep disturbance, discomfort, etc. 100 m for irritability, depression, loss of memory, dizziness, libido decrease, etc. Women significantly more often than men ($p < 0.05$) complained of headache, nausea, loss of appetite, sleep disturbance, depression, discomfort and visual perturbations. This first study on symptoms experienced by people living in vicinity of base stations shows that, in view of radioprotection, minimal distance of people from cellular phone base stations should not be < 300 m.

Santini R, Santini P, Le Ruz P, Danze JM, Seigne M, Survey study of people living in the vicinity of cellular phone base stations. Electromag Biol Med 22:41-49, 2003.

A survey study was conducted, using a questionnaire, on 530 people (270 men, 260 women) living or not in proximity to cellular phone base stations. Eighteen different symptoms (Non Specific Health Symptoms-NSHS), described as radiofrequency

sickness, were studied by means of the chi-square test with Yates correction. The results that were obtained underline that certain complaints are experienced only in the immediate vicinity of base stations (up to 10 m for nausea, loss of appetite, visual disturbances), and other at greater distances from base stations (up to 100 m for irritability, depressive tendencies, lowering of libido, and up to 200 m for headaches, sleep disturbance, feeling of discomfort). In the 200 m to 300 m zone, only the complaint of fatigue is experienced significantly more often when compared with subjects residing at more than 300 m or not exposed (reference group). For seven of the studied symptoms and for the distance up to 300 m, the frequency of reported complaints is significantly higher ($P< 0.05$) for women in comparison to men. Significant differences are also observed in relation to the ages of subjects, and for the location of subjects in relation to the antennas and to other electromagnetic factors.

Saran A, Pazzaglia S, Mancuso M, Rebessi S, Di Majo V, Tanori M, Lovisolo GA, Pinto R, Marino C. Effects of exposure of newborn patched1 heterozygous mice to GSM, 900 MHz.Radiat Res. 168(6):733-740, 2007.

Patched1 heterozygous knockout mice (Ptc1+/-), an animal model of multiorgan tumorigenesis in which ionizing radiation dramatically accelerates tumor development, were used to study the potential tumorigenic effects of electromagnetic fields (EMFs) on neonatal mice. Two hundred Ptc1+/- mice and their wild-type siblings were enrolled in this study. Newborn mice were exposed to 900 MHz radiofrequency radiation (average SAR: 0.4 W/kg for 5 days, 0.5 h twice a day) or were sham exposed. We found that RF EMFs simulating the Global System for Mobile Communications (GSM) did not affect the survival of the mice, because no statistically significant differences in survival were found between exposed and sham-exposed animals. Also, no effects attributable to radiofrequency radiation were observed on the incidence and histology of Ptc1-associated cerebellar tumors. Moreover, the skin phenotype was analyzed to look for proliferative effects of RF EMFs on the epidermal basal layer and for acceleration of preneoplastic lesions typical of the basal cell carcinoma phenotype of this model. We found no evidence of proliferative or promotional effects in the skin from neonatal exposure to radiofrequency radiation. Furthermore, no difference in Ptc1-associated rhabdomyosarcomas was detected between sham-exposed and exposed mice. Thus, under the experimental conditions tested, there was no evidence of life shortening or tumorigenic effects of neonatal exposure to GSM RF radiation in a highly tumor-susceptible mouse model.

Sarapultseva EI, Igolkina JV, Tikhonov VN, Dubrova YE.THE IN VIVO EFFECTS OF LOW-INTENSITY RADIOFREQUENCY FIELDS ON THE MOTOR ACTIVITY OF PROTOZOA. Int J Radiat Biol. 2013 Nov 25. [Epub ahead of print]

Purpose: To analyze the direct and transgenerational effects of exposure to low-dose 1 GHz (mobile phone/wireless telecommunication range) and 10 GHz (radar/satellite communication range) radiofrequency electromagnetic fields (RF-EMF) on the motility of ciliates Spirostomum ambiguum. Materials and Methods: S. ambiguum were exposed to 1 GHz and 10 GHz RF-EMF with power flux densities (PD) ranging from 0.05 to 0.5 W/m^2 over a period of time from 0.05 to 10 h. The motility of directly

exposed ciliates and their non-exposed progeny across 10-15 generations was measured. Results: Exposure to 0.1 W/m^2 of either 1 or 10 GHz RF-EMF resulted in a significant decrease in the motility. The dose of exposure capable of altering the mobility of ciliates was inversely correlated with the flux density of RF-EMF. The motility of the non-exposed progeny of ciliates irradiated with 0.1 W/m^2 of 10 GHz RF-EMF remained significantly compromised, at least, across 10-15 generations, thus indicating the presence of transgenerational effects. Conclusions: The results of our study show that low-dose exposure to RF-EMF can significantly affect the motility of irradiated ciliates and their non-exposed offspring, thus providing further insights into the unknown mechanisms underlying the in vivo effects of RF-EMF.

Sarimov, R., Malmgren, L.O.G., Markova, E., Persson, B.R.R.. Belyaev, I.Y. Nonthermal GSM microwaves affect chromatin conformation in human lymphocytes similar to heat shock. IEEE Trans Plasma Sci 32:1600-1608, 2004.

Here we investigated whether microwaves (MWs) of Global System for Mobile Communication (GSM) induce changes in chromatin conformation in human lymphocytes. Effects of MWs were studied at different frequencies in the range of 895-915 MHz in experiments with lymphocytes from seven healthy persons. Exposure was performed in transverse electromagnetic transmission line cell (TEM-cell) using a GSM test-mobile phone. All standard modulations included 2 W output power in the pulses, specific absorbed rate (SAR) being 5.4 mW/kg. Changes in chromatin conformation, which are indicative of stress response and genotoxic effects, were measured by the method of anomalous viscosity time dependencies (AVTD). Heat shock and treatment with the genotoxic agent camptothecin, were used as positive controls. 30-min exposure to MWs at 900 and 905 MHz resulted in statistically significant condensation of chromatin in lymphocytes from 1 of 3 tested donors. This condensation was similar to effects of heat shock within the temperature window of 40/spl deg/C-44/spl deg/C. Analysis of pooled data from all donors showed statistically significant effect of 30-min exposure to MWs. Stronger effects of MWs was found following 1-h exposure. In replicated experiments, cells from four out of five donors responded to 905 MHz. Responses to 915 MHz were observed in cells from 1 out of 5 donors, $p<0.002$. Dependent on donor, condensation, 3 donors, or decondensation, 1 donor, of chromatin was found in response to 1-h exposure. Analysis of pooled data from all donors showed statistically significant effect of 1-h exposure to MWs. In cells from one donor, this effect was frequency-dependent ($p<0.01$). Effects of MWs correlated statistically significantly with effects of heat shock and initial state of chromatin before exposure. MWs at 895 and 915 MHz affected chromatin conformation in transformed lymphocytes. The conclusion-GSM microwaves under specific conditions of exposure affected human lymphocytes similar to stress response. The data suggested that the MW effects differ at various GSM frequencies and vary between donors.

Sarkar S, Ali S, Behari J, Effect of low power microwave on the mouse genome: a direct DNA analysis. Mutat Res 320(1-2):141-147, 1994.

The potential mutagenic effect of low power microwave at the DNA sequence level in the mouse genome was evaluated by direct DNA analysis. Animals were exposed to microwave at a power density of 1 mW/cm2 for 2 h/day at a frequency of 2.45 GHz over a

period of 120, 150 and 200 days. HinfI digested DNA samples from testis and brain of control and exposed animals were hybridized with a synthetic oligo probe (OAT 36) comprising nine repeats of 5'-GACA-3'. As compared to control animals, band patterns in exposed animals were found to be distinctly altered in the range of 7-8 kb which was also substantiated by densitometric analysis. Though the mechanism of this rearrangement is not yet clear, the results obtained at the present dose are of significance. This dose, which has been set as the safe limit for general public exposure by the Non-Ionizing Radiation Committee of the International Radiation Protection Association, may imply a need for (re)evaluation of the mutagenic potential of microwaves at the prescribed safe limit for the personnel and people who are being exposed.

Sasaki K, Wake K, Watanabe S. Measurement of the dielectric properties of the epidermis and dermis at frequencies from 0.5 GHz to 110 GHz. Phys Med Biol. 59(16):4739-4747, 2014.

Numerous studies have reported the measurements of the dielectric properties of the skin. Clarifying the manner in which the human body interacts with electromagnetic waves is essential for medical research and development, as well as for the safety assessment of electromagnetic wave exposure. The skin comprises several layers: the epidermis, the dermis, and the subcutaneous fat. Each of these skin layers has a different constitution; however, the previous measurements of their dielectric properties were typically conducted on tissue which included all three layers of the skin. This study presents novel dielectric property data for the epidermis and dermis with in vitro measurement at frequencies ranging from 0.5 GHz to 110 GHz. Measured data was compared with literature values; in particular, the findings were compared with Gabriel's widely used data on skin dielectric properties. The experimental results agreed with the data reported by Gabriel for the dermis of up to 20 GHz, which is the upper limit of the range of frequencies at which Gabriel reported measurements. For frequencies of 20-100 GHz, the experimental results indicated larger values than those extrapolated from Gabriel's data using parametric expansion. For frequencies over 20 GHz, the dielectric properties provided by the parametric model tend toward the experimental results for the epidermis with increasing frequency.

Sato Y, Kiyohara K, Kojimahara N, Yamaguchi N. Time trend in incidence of malignant neoplasms of the central nervous system in relation to mobile phone use among young people in Japan. Bioelectromagnetics. 2016 May 19. doi: 10.1002/bem.21982. [Epub ahead of print]

The aim of this study was to examine whether incidence of malignant neoplasms of the central nervous system from 1993 to 2010 has increased among young people in Japan, and whether the increase could be explained by increase in mobile phone use. Joinpoint regression analysis of incidence data was performed. Subsequently, the expected incidence rate was calculated assuming that the relative risk was 1.4 for those who used mobile phones more than 1640 h cumulatively. Annual percent change was 3.9% (95% confidence interval [CI], 1.6-6.3) for men in their 20s from 1993 to 2010, 12.3% (95% CI, 3.3-22.1) for women in their 20s from 2002 to 2010, 2.7% (95% CI, 1.3-4.1) for men in their 30s from 1993 to 2010, and 3.0% (95% CI, 1.4-4.7) for women in their 30s from

1993 to 2010. Change in incidence rates from 1993 to 2010 was 0.92 per 100,000 people for men in their 20s, 0.83 for women in their 20s, 0.89 for men in their 30s, and 0.74 for women in their 30s. Change in expected incidence rates from 1993 to 2010 was 0.08 per 100,000 people for men in their 20s, 0.03 for women in their 20s, 0.15 for men in their 30s, and 0.05 for women in their 30s. Patterns in sex-, age-, and period-specific incidence increases are inconsistent with sex-, age-, and period-specific prevalence trends, suggesting the overall incidence increase cannot be explained by heavy mobile phone use.

Sato Y, Kojimahara N, Yamaguchi N. Analysis of mobile phone use among young patients with brain tumors in Japan. Bioelectromagnetics. 38(5):349-355, 2017.

The purpose of this study was to clarify ownership and usage of mobile phones among young patients with brain tumors in Japan. The subjects of this study were patients with brain tumors diagnosed between 2006 and 2010 who were between the ages of 6 and 18 years. The target population for the analysis was 82 patients. Patients were divided into two groups: 16 patients who were mobile phone owners 1 year before diagnosis, and 66 patients who did not own mobile phones (non-owners). Using data on the mobile phone ownership rate obtained from three general-population surveys, we calculated the expected number of mobile phone owners. The three age-adjusted standardized ownership ratios were 0.83 (95% confidence interval [CI]: 0.56-1.22), 0.51 (95% CI: 0.24-1.04), and 0.75 (95% CI: 0.42-1.32). The mobile phone ownership prevalence among the young Japanese patients with brain tumors in the current study does not differ from available estimates for the general population of corresponding age. However, since the use of mobile phones among children is increasing annually, investigations into the health effects of mobile phone use among children should continue.

Sato Y, Kojimahara N, Taki M, Yamaguchi N. Analysis of ear side of mobile phone use in the general population of Japan. Bioelectromagnetics. 2017 Nov 24. doi: 10.1002/bem.22098. [Epub ahead of print]

This study aimed to clarify the distribution of the ear side of mobile phone use in the general population of Japan and clarify what factors are associated with the ear side of mobile phone use. Children at elementary and junior high schools (n = 2,518) and adults aged ≥20 years (n = 1,529) completed an Internet-based survey. Data were subjected to a logistic regression analysis. In children, due to the tendency to use the dominant hand, we analyzed the factors associated with the use of right ear in right-handed people. Statistically significant differences were observed only in talk time per call (odds ratio (OR) = 2.17; 95% confidence interval (CI): 1.22-3.99). In adults, due to the tendency to use the left ear, we analyzed factors associated with the use of left ear in right-handed people. Significant differences were observed in those aged 30-39 years (OR = 2.55; 95% CI: 1.79-3.68), those aged 40-49 years (OR = 3.08; 95% CI: 2.15-4.43), those aged >50 years (OR = 1.85; 95% CI: 1.20-2.85), and in those with a percentage of total talk time when using mobile phones at work of 51-100% (OR = 1.75; 95% CI: 1.21-2.55). We believe that future epidemiological studies on

mobile phone use can be improved by considering the trends in mobile phone use identified in this study.

Sauter C, Dorn H, Bahr A, Hansen ML, Peter A, Bajbouj M, Danker-Hopfe H. Effects of exposure to electromagnetic fields emitted by GSM 900 and WCDMA mobile phones on cognitive function in young male subjects.Bioelectromagnetics. 32(3):179-190, 2011.

Results of studies on the possible effects of electromagnetic fields emitted by mobile phones on cognitive functions are contradictory, therefore, possible effects of long-term (7 h 15 min) electromagnetic field (EMF) exposure to handset-like signals of Global System for Mobile Communications (GSM) 900 and Wideband Code-Division Multiple Access (WCDMA) on attention and working memory were studied. The sample comprised 30 healthy male subjects (mean ± SD: 25.3 ± 2.6 years), who were tested on nine study days in which they were exposed to three exposure conditions (sham, GSM 900 and WCDMA) in a randomly assigned and balanced order. All tests were presented twice (morning and afternoon) on each study day within a fixed timeframe. Univariate comparisons revealed significant changes when subjects were exposed to GSM 900 compared to sham, only in the vigilance test. In the WCDMA exposure condition, one parameter in the vigilance and one in the test on divided attention were altered compared to sham. Performance in the selective attention test and the n-back task was not affected by GSM 900 or WCDMA exposure. Time-of-day effects were evident for the tests on divided and selective attention, as well as for working memory. After correction for multiple testing, only time-of-day effects remained significant in two tests, resulting in faster reactions in the afternoon trials. The results of the present study do not provide any evidence of an EMF effect on human cognition, but they underline the necessity to control for time of day.

Sauter C, Eggert T, Dorn H, Schmid G, Bolz T, Marasanov A, Hansen ML, Peter A, Danker-Hopfe H. Do signals of a hand-held TETRA transmitter affect cognitive performance, well-being, mood or somatic complaints in healthy young men? Results of a randomized double-blind cross-over provocation study. Environ Res. 140:85-94, 2015.

BACKGROUND: TETRA (terrestrial trunked radio) is a digital radio communication standard, which has been implemented in several European countries and is used by public executives, transportation services, and by private companies. Studies on possible impacts on the users' health considering different exposure conditions are missing. OBJECTIVES: To investigate possible acute effects of electromagnetic fields (EMF) of two different levels of TETRA hand-held transmitter signals on cognitive function and well-being in healthy young males. METHODS: In the present double-blind cross-over study possible effects of short-term (2.5h) EMF exposure of handset-like signals of TETRA (385MHz) were studied in 30 healthy male participants (mean±SD: 25.4±2.6 years). Individuals were tested on nine study days, on which they were exposed to three different exposure conditions (Sham, TETRA 1.5W/kg and TETRA 6.0W/kg) in a randomly assigned and balanced order. Participants were tested in the afternoon at a fixed timeframe. RESULTS: Attention remained unchanged in two out of three tasks. In the

working memory significant changes were observed in two out of four subtasks. Significant results were found in 5 out of 35 tested parameters, four of them led to an improvement in performance. Mood, well-being and subjective somatic complaints were not affected by TETRA exposure. CONCLUSIONS: The results of the present study do not indicate a negative impact of a short-term EMF-effect of TETRA on cognitive function and well-being in healthy young men.

Saygin M, Caliskan S, Karahan N, Koyu A, Gumral N, Uguz A. Testicular apoptosis and histopathological changes induced by a 2.45 GHz electromagnetic field. Toxicol Ind Health. 27(5):455-463, 2011.

There is a growing public concern about the potential human health hazard caused by exposure to electromagnetic radiation (EMR). The objective of this study is to investigate the effects of 2450 mhz electromagnetic field on apoptosis and histopathological changes on rat testis tissue. Twelve-week-old male Wistar Albino rats were used in this study. Eighteen rats equally divided into three different groups which were named group I, II and III. Cage control (group I), sham control (group II) and 2.45 GHz EMR (group III) groups were formed. Group III were exposed to 2.45 GHz EMR, at 3.21 W/kg specific absorption rate for 60 minutes/ day for 28 days. There was no difference among the groups for the diameter of the seminiferous tubules, pyknotic, karyolectic and karyotic cells. However, the number of Leydig cells of testis tissue of the rats in group III was significantly reduced comparing with the group I ($p < 0.05$). Estimation of spermatogenesis using the Johnsen testicular biopsy score revealed that the difference between groups is statistically significant. The level of TNF-α, Caspase-3 and Bcl-2 were compared, and no significant difference was found between the groups. When Bax apoptosis genes and Caspase-8 apoptosis enzyme were compared, there were significant differences between the groups ($p < 0.05$). Electromagnetic field affects spermatogenesis and causes to apoptosis due to the heat and other stress-related events in testis tissue.

Saygin M, Asci H, Ozmen O, Cankara FN, Dincoglu D, Ilhan I. Impact of 2.45 GHz microwave radiation on the testicular inflammatory pathway biomarkers in young rats: The role of gallic acid. Environ Toxicol. 2015 Aug 13. doi: 10.1002/tox.22179. [Epub ahead of print]

The aim of this study was to investigate electromagnetic radiation (EMR) transmitted by wireless devices (2.45 GHz), which may cause physiopathological or ultrastructural changes, in the testes of rats. We addressed if the supplemental gallic acid (GA) may reduce these adverse effects. Six-week-old male Sprague Dawley rats were used in this study. Forty eight rats were equally divided into four groups, which were named: Sham, EMR only (EMR, 3 h day^{-1} for 30 days), EMR + GA (30 mg/kg/daily), and GA (30 mg/kg/daily) groups. Malondialdehyde (MDA) and total oxidant status (TOS) levels increased ($p = 0.001$ for both) in EMR only group. TOS and oxidative stress index (OSI) levels decreased in GA treated group significantly ($p = 0.001$ and $p = 0.045$, respectively). Total antioxidant status (TAS) activities decreased in EMR only group and increased in GA treatment group ($p = 0.001$ and $p = 0.029$, respectively). Testosterone and vascular endothelial growth factor (VEGF) levels decreased in EMR only group, but this was not statistically significant.

Testosterone and VEGF levels increased in EMR+GA group, compared with EMR only group ($p = 0.002$), and also increased in GA group compared with the control and EMR only group ($p = 0.044$ and $p = 0.032$, respectively). Prostaglandin E_2 (PGE_2) and calcitonin gene releated peptide (CGRP) staining increased in tubules of the testes in EMR only group ($p < 0.001$ for both) and decreased in tubules of the testes in EMR+GA group ($p < 0.001$ for all parameters). In EMR only group, most of the tubules contained less spermatozoa, and the spermatozoon counts decreased in tubules of the testes. All these findings and the regenerative reaction, characterized by mitotic activity, increased in seminiferous tubules cells of the testes in EMR+GA group ($p < 0.001$). Long term EMR exposure resulted in testicular physiopathology via oxidative damage and inflammation. GA may have ameliorative effects on the prepubertal rat testes physiopathology.

Scarfi MR, Fresegna AM, Villani P, Pinto R, Marino C, Sarti M, Altavista P, Sannino A, Lovisolo GA. Exposure to radiofrequency radiation (900 MHz, GSM signal) does not affect micronucleus frequency and cell proliferation in human peripheral blood lymphocytes: an interlaboratory study. Radiat Res. 165(6):655-663, 2006.

The objective of this study was to investigate whether 24 h exposure to radiofrequency electromagnetic fields similar to those emitted by mobile phones induces genotoxic effects and/or effects on cell cycle kinetics in cultured human peripheral blood lymphocytes. The effect of 900 MHz exposure (GSM signal) was evaluated at four specific absorption rates (SARs, 0, 1, 5 and 10 W/kg peak values). The exposures were carried out in wire patch cells under strictly controlled conditions of both temperature and dosimetry, and the induction of genotoxic effects was evaluated in lymphocyte cultures from 10 healthy donors by applying the cytokinesis-block micronucleus assay. Positive controls were provided by using mitomycin C. Two research groups were involved in the study, one at ENEA, Rome, and the other at CNR-IREA, Naples. Each laboratory tested five donors, and the resulting slides were scored by both laboratories. Following this experimental scheme, it was also possible to compare the results obtained by cross-scoring of slides. The results obtained provided no evidence for the existence of genotoxic or cytotoxic effects in the range of SARs investigated. These findings were confirmed in the two groups of five donors examined in the two laboratories and when the same slides were scored by two operators.

Schauer I, Mohamad Al-Ali B.Combined effects of varicocele and cell phones on semen and hormonal parameters. Wien Klin Wochenschr. 2017 Oct 13. doi: 10.1007/s00508-017-1277-9. [Epub ahead of print]

BACKGROUND: The objective of this study was to evaluate if there is a combined effect of varicocele and **cell phone** storage in trousers pockets on semen and hormonal parameters. METHODS: A retrospective analysis of 468 men attending an infertility clinic from 1993-2007 was performed. Varicoceles were determined by clinical examination and patients were questioned on **cell phone** usage and storage fashion. Semen samples were analyzed according to the World Health Organization (WHO) guidelines of 1999. Serum testosterone, luteinizing hormone (LH) and follicle stimulating hormone (FSH) were assessed. RESULTS: There was a significant effect of **cell phone** storage in trousers pockets and varicocele in multivariate analysis (both $p < 0.001$). Varicocele

showed an effect on sperm concentration (p = 0.003), LH (p = 0.014) and testosterone (p = 0.003). Compared to grade 1, grade 2 varicoceles showed a difference in sperm concentration (p = 0.004). Regarding testosterone differences were shown for grade 3 versus grade 1 (p = 0.002) and grade 3 compared to grade 2 (p = 0.003). **Cell phone** storage in trousers pockets showed an influence on the percentage of normal sperm morphology and LH (both p < 0.001). Varicocele and **cell phone** storage in trousers pockets did not show a combined effect (p = 0.76).CONCLUSIONS: This analysis showed an inverse relation between sperm concentration and degree of varicocele, with lower concentrations in higher grade varicoceles. Testosterone was significantly higher in higher grade varicoceles, which could reflect a compensatory mechanism to the impaired testicular function. **Cell phone** storage in trousers pockets showed an effect on LH and sperm morphology. A combined effect of varicocele and **cell phone** storage in trousers pockets was not detected.

Schilling, CJ, Effects of acute exposure to ultrahigh radiofrequency radiation on three antenna engineers. Occup Environ Med 54(4):281-284, 1997.

Three men were accidentally exposed to high levels of ultrahigh frequency radiofrequency radiation (785 MHz mean frequency) while working on a television mast. They experienced an immediate sensation of intense heating of the parts of the body in the electromagnetic field followed by a variety of symptoms and signs which included pain, headache, numbness, and parasthesiae, malaise, diarrhoea, and skin erythema. The most notable problem was that of acute then chronic headache involving the part of the head which was most exposed.

Schilling CJ, Effects of exposure to very high frequency radiofrequency radiation on six antenna engineers in two separate incidents. Occup Med 60:49-56, 2000.

Six men are likely to have been accidentally exposed to high levels of very high frequency (VHF) radiofrequency radiation (100 MHz) while working on transmission masts; four men in one incident and two in another. They experienced symptoms and signs which included headache, parasthesiae, diarrhoea, malaise and lassitude. The condition of four men, two men from each incident likely to have had the highest exposure, has shown no significant improvement. The first incident occurred in 1995 and the second in 1996.

Schirmacher A, Winters S, Fischer S, Goeke J, Galla H, Kullnick U, Ringelstein EB, Stogbauer F, Electromagnetic fields (1.8 GHz) increase the permeability to sucrose of the blood-brain barrier in vitro. Bioelectromagnetics 21(5):338-345, 2000.

We report an investigation on the influence of high frequency electromagnetic fields (EMF) on the permeability of an in vitro model of the blood-brain barrier (BBB). Our model was a co-culture consisting of rat astrocytes and porcine brain capillary endothelial cells (BCEC). Samples were characterized morphologically by scanning electron microscopy and immunocytochemistry. The BBB phenotype of the BCEC was shown by the presence of zona occludens protein (ZO-1) as a marker for tight junctions and the close contact of the cells together with the absence of intercellular clefts. Permeability measurements using (14)C-sucrose indicated a physiological tightness which correlated with the morphological findings and verified the usefulness of our in vitro model. Samples

were exposed to EMF conforming to the GSM1800-standard used in mobile telephones (1.8 GHz). The permeability of the samples was monitored over four days and compared with results of samples that were cultured identically but not exposed to EMF. Exposure to EMF increased permeability for (14)C-sucrose significantly compared to unexposed samples. The underlying pathophysiological mechanism remains to be investigated.

Schlegel RE, Grant FH, Raman S, Reynolds D Electromagnetic compatibility study of the in-vitro interaction of wireless phones with cardiac pacemakers. Biomed Instrum Technol 32(6):645-655, 1998.

This large-scale in-vitro investigation of the interaction between hand-held wireless phones and cardiac pacemakers tested 29 pacemaker models with five different phone standards. The phones were operational and suspended on a grid above a torso simulator filled with a saline bath with the pacemaker submerged at 0.5 cm. Testing consisted of 8,296 runs, during which any interactions detected were classified by type and regularity. Only a few pacemakers were responsible for a disproportionately large number of interactions. Likewise, interactions occurred during 21% of the tests using one particular phone technology, with little or no interaction resulting from use of the other standards. Other significant factors included the relative orientation of the phone and the pacemaker case, as well as the presence or absence of an injected ECG signal. The ECG signal facilitated observation of certain forms of interaction to the extent that this study indicates the importance of including an injected ECG signal in all testing. The study also supports the recommendation to maintain a separation distance of at least 6 inches between pacemakers and wireless phones. Each pacemaker reverted to its normal operation when the phone creating an interaction was turned off. This study may be useful in ongoing efforts to define test protocols, evaluate pacemaker designs, and mitigate interactions, perhaps providing the basis for future certification and screening efforts.

Schmid G, Sauter C, Stepansky R, Lobentanz IS, Zeitlhofer J. No influence on selected parameters of human visual perception of 1970 MHz UMTS-like exposure. Bioelectromagnetics. 26(4):243-250, 2005.

In recent years several studies regarding possible effects of radio frequency (RF) electromagnetic fields (EMFs) on cognitive brain function were reported. In many of these studies on awake humans the working tasks were presented visually to the test subjects, e.g., on a computer screen. Therefore, the question of where in the chain of visual perception, brain processing and response a possible effect could be induced seems to be of interest. In this study, possible effects of exposure to a generic 1.97 GHz UMTS-like signal on human visual perception were investigated in a double blinded, crossover study including 58 healthy volunteer subjects (29 male, 29 female), aged 29 +/- 5.1 years (mean +/- SD). Each test subject underwent a battery of four different clinical tests three times (two different exposure levels and sham exposure) to assess selected parameters of visual perception. The generic signals applied to the subjects' head represented the RF emissions of an UMTS mobile phone under constant receiving conditions and the under condition of strongly varying transmit power, i.e., the signal envelope contained low frequency components. In the high exposure condition the resulting average exposure of the test subjects in the cortex of the left temporal lobe of the brain was 0.63 W/kg (1 g

averaged SAR) and 0.37 W/kg (10 g averaged SAR). Low exposure condition was one tenth of high exposure and sham was at least 50 dB (corresponding to a factor of 100 000) below low exposure. Statistical evaluation of the obtained test results revealed no statistically significant differences in the investigated parameters of visual perception between the exposure conditions and sham exposure.

Schmid G, Uberbacher R, Samaras T, Jappel A, Baumgartner WD, Tschabitscher M, Mazal PR. High-resolution numerical model of the middle and inner ear for a detailed analysis of radio frequency absorption. Phys Med Biol. 52(7):1771-1781, 2007.

In order to enable a detailed analysis of radio frequency (RF) absorption in the human middle and inner ear organs, a numerical model of these organs was developed at a spatial resolution of 0.1 mm, based on a real human tissue sample. The dielectric properties of the liquids (perilymph and endolymph) inside the bony labyrinth were measured on samples of ten freshly deceased humans. After inserting this model into a commercially available numerical head model, FDTD-based computations for exposure scenarios with generic models of handheld devices operated close to the head in the frequency range 400-3700 MHz were carried out. For typical output power values of real handheld mobile communication devices the obtained results showed only very small amounts of absorbed RF power in the middle and inner ear organs. Highest absorption in the middle and inner ear was found for the 400 MHz irradiation. In this case, the RF power absorbed inside the labyrinth and the vestibulocochlear nerve was as low as 166 microW and 12 microW, respectively, when considering a device of 500 mW output power operated close to the ear. For typical mobile phone frequencies (900 MHz and 1850 MHz) and output power values (250 mW and 125 mW) the corresponding values of absorbed RF power were found to be more than one order of magnitude lower than the values given above. These results indicate that temperature-related biologically relevant effects on the middle and inner ear, induced by the RF emissions of typical handheld mobile communication devices, are unlikely.

Schmid G, Uberbacher R, Samaras T, Tschabitscher M, Mazal PR. The dielectric properties of human pineal gland tissue and RF absorption due to wireless communication devices in the frequency range 400-1850 MHz. Phys Med Biol. 52(17):5457-5468, 2007.

In order to enable a detailed analysis of radio frequency (RF) absorption in the human pineal gland, the dielectric properties of a sample of 20 freshly removed pineal glands were measured less than 20 h after death. Furthermore, a corresponding high resolution numerical model of the brain region surrounding the pineal gland was developed, based on a real human tissue sample. After inserting this model into a commercially available numerical head model, FDTD-based computations for exposure scenarios with generic models of handheld devices operated close to the head in the frequency range 400-1850 MHz were carried out. For typical output power values of real handheld mobile communication devices, the obtained results showed only very small amounts of absorbed RF power in the pineal gland when compared to SAR limits according to international safety standards. The

highest absorption was found for the 400 MHz irradiation. In this case the RF power absorbed inside the pineal gland (organ mass 96 mg) was as low as 11 microW, when considering a device of 500 mW output power operated close to the ear. For typical mobile phone frequencies (900 MHz and 1850 MHz) and output power values (250 mW and 125 mW) the corresponding values of absorbed RF power in the pineal gland were found to be lower by a factor of 4.2 and 36, respectively. These results indicate that temperature-related biologically relevant effects on the pineal gland induced by the RF emissions of typical handheld mobile communication devices are unlikely.

Schmid MR, Loughran SP, Regel SJ, Murbach M, Bratic Grunauer A, Rusterholz T, Bersagliere A, Kuster N, Achermann P. Sleep EEG alterations: effects of different pulse-modulated radio frequency electromagnetic fields.J Sleep Res. 21(1):50-58, 2012.

Previous studies have observed increases in electroencephalographic power during sleep in the spindle frequency range (approximately 11-15 Hz) after exposure to mobile phone-like radio frequency electromagnetic fields (RF EMF). Results also suggest that pulse modulation of the signal is crucial to induce these effects. Nevertheless, it remains unclear which specific elements of the field are responsible for the observed changes. We investigated whether pulse-modulation frequency components in the range of sleep spindles may be involved in mediating these effects. Thirty young healthy men were exposed, at weekly intervals, to three different conditions for 30 min directly prior to an 8-h sleep period. Exposure consisted of a 900-MHz RF EMF, pulse modulated at 14 Hz or 217 Hz, and a sham control condition. Both active conditions had a peak spatial specific absorption rate of 2 W kg(-1) . During exposure subjects performed three different cognitive tasks (measuring attention, reaction speed and working memory), which were presented in a fixed order. Electroencephalographic power in the spindle frequency range was increased during non-rapid eye movement sleep (2nd episode) following the 14-Hz pulse-modulated condition. A similar but non-significant increase was also observed following the 217-Hz pulse-modulated condition. Importantly, this exposure-induced effect showed considerable individual variability. Regarding cognitive performance, no clear exposure-related effects were seen. Consistent with previous findings, our results provide further evidence that pulse-modulated RF EMF alter brain physiology, although the time-course of the effect remains variable across studies. Additionally, we demonstrated that modulation frequency components within a physiological range may be sufficient to induce these effects.

Schmid MR, Murbach M, Lustenberger C, Maire M, Kuster N, Achermann P, Loughran SP. Sleep EEG alterations: effects of pulsed magnetic fields versus pulse-modulated radio frequency electromagnetic fields.J Sleep Res.21(6):620-629, 2012.

Studies have repeatedly shown that electroencephalographic power during sleep is enhanced in the spindle frequency range following radio frequency electromagnetic field exposures pulse-modulated with fundamental frequency components of 2, 8, 14 or 217 Hz and combinations of these. However, signals used in previous studies also had

significant harmonic components above 20 Hz. The current study aimed: (i) to determine if modulation components above 20 Hz, in combination with radio frequency, are necessary to alter the electroencephalogram; and (ii) to test the demodulation hypothesis, if the same effects occur after magnetic field exposure with the same pulse sequence used in the pulse-modulated radio frequency exposure. In a randomized double-blind crossover design, 25 young healthy men were exposed at weekly intervals to three different conditions for 30 min before sleep. Cognitive tasks were also performed during exposure. The conditions were a 2-Hz pulse-modulated radio frequency field, a 2-Hz pulsed magnetic field, and sham. Radio frequency exposure increased electroencephalogram power in the spindle frequency range. Furthermore, delta and theta activity (non-rapid eye movement sleep), and alpha and delta activity (rapid eye movement sleep) were affected following both exposure conditions. No effect on sleep architecture and no clear impact of exposure on cognition was observed. These results demonstrate that both pulse-modulated radio frequency and pulsed magnetic fields affect brain physiology, and the presence of significant frequency components above 20 Hz are not fundamental for these effects to occur. Because responses were not identical for all exposures, the study does not support the hypothesis that effects of radio frequency exposure are based on demodulation of the signal only.

Schneider J, Stangassinger M. Nonthermal Effects of Lifelong High-Frequency Electromagnetic Field Exposure on Social Memory Performance in Rats. Behav Neurosci. 2014 Jul 7. [Epub ahead of print]

We are today surrounded almost constantly by high-frequency electromagnetic fields (EMFs) from mobile communications base stations. To date, however, there has been little concern regarding nonthermal effects of EMFs on cognition. In the present study, male and female rats were subjected to continuous far-field exposure to a frequency of 900-MHz (Global System for Mobile Communications [GSM]) or 1.966-GHz (Universal Mobile Telecommunications System [UMTS]) at 0.4 W/kg. Memory performance of adult EMF-exposed and sham-exposed female rats (at 6 months of age) and male rats (at 3 and 6 months of age) was tested using a social discrimination procedure. For this procedure, a target juvenile male was introduced to the subject's home cage for 4 min (Trial 1). After 30 min, the same target animal and a novel juvenile male were simultaneously presented to the subject for 4 min (Trial 2). Differences in sniffing duration to the familiar and novel target rats during Trial 2 were used to assess memory performance. EMF-exposed females exhibited no differences in sniffing duration compared with controls. In contrast, the sniffing durations of EMF-exposed males at 3 months of age were significantly affected. At 6 months of age, GSM-, but not UMTS-, exposed male adults showed a memory performance deficit. These findings provide new insight into the nonthermal effects of long-term high-frequency EMF exposure on memory.

Schoemaker MJ, Swerdlow AJ, Ahlbom A, Auvinen A, Blaasaas KG, Cardis E, Collatz Christensen H, Feychting M, Hepworth SJ, Johansen C, Klæboe L, Lönn S, McKinney PA, Muir K, Raitanen J, Salminen T, Thomsen J, Tynes T. Mobile phone use and risk of acoustic neuroma: results of the Interphone case-control study in

five North European countries. Br J Cancer 93:842-848, 2005.

There is public concern that use of mobile phones could increase the risk of brain tumours. If such an effect exists, acoustic neuroma would be of particular concern because of the proximity of the acoustic nerve to the handset. We conducted, to a shared protocol, six population-based case-control studies in four Nordic countries and the UK to assess the risk of acoustic neuroma in relation to mobile phone use. Data were collected by personal interview from 678 cases of acoustic neuroma and 3553 controls. The risk of acoustic neuroma in relation to regular mobile phone use in the pooled data set was not raised (odds ratio (OR)=0.9, 95% confidence interval (CI): 0.7-1.1). There was no association of risk with duration of use, lifetime cumulative hours of use or number of calls, for phone use overall or for analogue or digital phones separately. Risk of a tumour on the same side of the head as reported phone use was raised for use for 10 years or longer (OR=1.8, 95% CI: 1.1-3.1). The study suggests that there is no substantial risk of acoustic neuroma in the first decade after starting mobile phone use. However, an increase in risk after longer term use or after a longer lag period could not be ruled out.

Schoemaker MJ, Swerdlow AJ. Risk of pituitary tumors in cellular phone users: a case-control study. Epidemiology. 20(3):348-54, 2009.

BACKGROUND:: There is public concern and scientific interest regarding a potential effect of cellular phone use on the risk of developing intracranial tumors. Tumors of the pituitary gland have barely been investigated in this context, but are of interest because of their intracranial location. METHODS:: We conducted a population-based case-control study between 2001 and 2005 of the risk of developing pituitary tumors in relation to cellular phone use in Southeast England, with 291 cases and 630 controls. Detailed information on cellular phone use was collected by personal interview. RESULTS:: Tumor risk was not associated with cellular phone use overall (adjusted odds ratio = 0.9, 95% confidence interval = 0.7-1.3), and was not appreciably increased 10 or more years after first use (1.0; 0.5-1.9), or after 10 or more years of cumulative use (1.1; 0.5-2.4). Odds ratios were 1.2 (0.7-1.9) for users in the highest quartile of cumulative number of calls and 1.1 (0.7-1.7) in the highest quartile of hours of use. Separate analyses of analog and digital phone use showed no associations with tumor risk. CONCLUSIONS:: We found no evidence that the risk of developing pituitary tumors is associated with cellular phone use for the induction time periods and intensities of use observed.

Schoeni A, Roser K, Röösli M. Memory performance, wireless communication and exposure to radiofrequency electromagnetic fields: A prospective cohort study in adolescents. Environ Int. 85:343-351, 2015.

BACKGROUND: The aim of this study is to investigate whether memory performance in adolescents is affected by radiofrequency electromagnetic fields (RF-EMF) from wireless device use or by the wireless device use itself due to non-radiation related factors in that context. METHODS: We conducted a prospective cohort study with 439 adolescents. Verbal and figural memory tasks at baseline and after one year were completed using a standardized, computerized cognitive test battery. Use of wireless devices was inquired by questionnaire and operator recorded mobile phone use data was obtained for a

subgroup of 234 adolescents. RF-EMF dose measures considering various factors affecting RF-EMF exposure were computed for the brain and the whole body. Data were analysed using a longitudinal approach, to investigate whether cumulative exposure over one year was related to changes in memory performance. All analyses were adjusted for relevant confounders. RESULTS: The kappa coefficients between cumulative mobile phone call duration and RF-EMF brain and whole body dose were 0.62 and 0.67, respectively for the whole sample and 0.48 and 0.28, respectively for the sample with operator data. In linear exposure-response models an interquartile increase in cumulative operator recorded mobile phone call duration was associated with a decrease in figural memory performance score by -0.15 (95% CI: -0.33, 0.03) units. For cumulative RF-EMF brain and whole body dose corresponding decreases in figural memory scores were -0.26 (95% CI: -0.42, -0.10) and -0.40 (95% CI: -0.79, -0.01), respectively. No exposure-response associations were observed for sending text messages and duration of gaming, which produces tiny RF-EMF emissions. CONCLUSIONS: A change in memory performance over one year was negatively associated with cumulative duration of wireless phone use and more strongly with RF-EMF dose. This may indicate that RF-EMF exposure affects memory performance.

Schoeni A, Roser K, Röösli M. Symptoms and Cognitive Functions in Adolescents in Relation to Mobile Phone Use during Night. PLoS One. 2015 Jul 29;10(7):e0133528. doi: 10.1371/journal.pone.0133528. eCollection 2015.

Many adolescents tend to leave their mobile phones turned on during night, accepting that they may be awakened by an incoming text message or call. Using self-reported and objective operator recorded mobile phone use data, we thus aimed to analyze how being awakened during night by mobile phone affects adolescents' perceived health and cognitive functions. In this cross-sectional study, 439 adolescents completed questionnaires about their mobile phone use during night, health related quality of life and possible confounding factors. Standardized computerized cognitive tests were performed to assess memory and concentration capacity. Objective operator recorded mobile phone use data was further collected for 233 study participants. Data were analyzed by multivariable regression models adjusted for relevant confounders including amount of mobile phone use. For adolescents reporting to be awakened by a mobile phone during night at least once a month the odds ratio for daytime tiredness and rapid exhaustibility were 1.86 (95% CI: 1.02-3.39) and 2.28 (95% CI: 0.97-5.34), respectively. Similar results were found when analyzing objective operator recorded mobile phone use data (tiredness: 1.63, 95% CI: 0.94-2.82 and rapid exhaustibility: 2.32, 95% CI: 1.01-5.36). The cognitive tests on memory and concentration capacity were not related to mobile phone use during night. Overall, being awakened during night by mobile phone was associated with an increase in health symptom reports such as tiredness, rapid exhaustibility, headache and physical ill-being, but not with memory and concentration capacity. Prevention strategies should focus on helping adolescents set limits for their accessibility by mobile phone, especially during night.

Schoeni A, Roser K, Röösli M. Symptoms and the use of wireless communication devices: A prospective cohort study in Swiss adolescents. Environ Res. 154:275-283, 2017.

BACKGROUND: We investigated whether radiofrequency electromagnetic fields (RF-EMF) from mobile phones and other wireless devices or by the wireless device use itself due to non-radiation related factors in that context are associated with an increase in health symptom reports of adolescents in Central Switzerland. METHODS: In a prospective cohort study, 439 study participants (participation rate: 36.8%) aged 12-17 years, completed questionnaires about their mobile and cordless phone use, their self-reported symptoms and possible confounding factors at baseline (2012/2013) and one year later (2013/2014). Operator recorded mobile phone data was obtained for a subgroup of 234 adolescents. RF-EMF dose measures considering various factors affecting RF-EMF exposure were computed for the brain and the whole body. Data were analysed using a mixed-logistic cross-sectional model and a cohort approach, where we investigated whether cumulative dose over one year was related to a new onset of a symptom between baseline and follow-up. All analyses were adjusted for relevant confounders. RESULTS: Participation rate in the follow-up was 97% (425 participants). In both analyses, cross-sectional and cohort, various symptoms tended to be mostly associated with usage measures that are only marginally related to RF-EMF exposure such as the number of text messages sent per day (e.g. tiredness: OR:1.81; 95%CI:1.20-2.74 for cross-sectional analyses and OR:1.87; 95%CI:1.04-3.38 for cohort analyses). Outcomes were generally less strongly or not associated with mobile phone call duration and RF-EMF dose measures. CONCLUSIONS: Stronger associations between symptoms of ill health and wireless communication device use than for RF-EMF dose measures were observed. Such a result pattern does not support a causal association between RF-EMF exposure and health symptoms of adolescents but rather suggests that other aspects of extensive media use are related to symptoms.

Schonborn F, Burkhardt M, Kuster N, Differences in energy absorption between heads of adults and children in the near field of sources. Health Phys 74(2):160-168, 1998.

This paper was motivated by a recent article in which the levels of electromagnetic energy absorbed in the heads of mobile phone users were compared for children and adults at the frequencies of 835 MHz and 1,900 MHz. Significant differences were found, in particular substantially greater absorption in children's heads at 835 MHz. These findings contradict other studies in which no significant changes had been postulated. The clarification of this issue is crucial to the mobile communications industry since current SAR evaluations as required by the FCC are only performed with phantoms based on the heads of adults. In order to investigate the differences in absorption between adults and children due to their differing anatomies, simulations have been performed using head phantoms based on MRI scans of an adult (voxel size 2 x 2 x 1 mm3) and two children (voxel size 2 x 2 x 1.1 mm3) of the ages of 3 and 7 y. Ten different tissue types were distinguished. The differences in absorption were investigated for the frequencies of 900 MHz and 1,800 MHz using 0.45 lambda dipoles instead of actual mobile phones. These well-defined sources simplified the investigation and facilitated the comparison to

previously published data obtained from several numerical and experimental studies on phantoms based on adults. All simulations were performed using a commercial code based on the finite integration technique. The results revealed no significant differences in the absorption of electromagnetic radiation in the near field of sources between adults and children. The same conclusion holds when children are approximated as scaled adults.

Schrader, SM, Langford, RE, Turner, TW, Breitenstein, MJ, Clark, JC, Jenkins, BL, Lundyl DO, Simonl SD, Weyandtl TBl, Reproductive function in relation to duty assignments among military personnel. Reprod Toxicol 12(4):465-468, 1998.

As a follow-up to the pilot study of semen quality of soldiers with various military assignments a larger, more complete study was conducted. Soldiers were recruited at Fort Hood, Texas. Thirty-three men were exposed to radar as part of their duty assignment in the Signal Corps, 57 men were involved with firing the 155 mm howitzer (potential lead exposure), and 103 soldiers had neither lead nor radar exposure and served as the comparison control group. Both serum and urinary follicle-stimulating hormone and luteinizing hormone and serum, salivary, and urine testosterone levels were determined in all men. A complete semen analysis was conducted on each soldier. For statistical analysis, the primary study variables were: sperm concentration, sperm/ejaculate, semen volume, percent normal morphology, percent motile, percent viable (both vital stain and hypoosmotic swelling), curvilinear velocity,straight-line velocity, linearity, sperm head length, width, area, and perimeter. Variables were adjusted for significant confounders (e.g., abstinence, sample age, race). No statistical differences ($P < 0.05$) were observed in any measurement. While these results are in agreement with two previous studies assessing soldiers firing the 155-mm howitzer, they contradict our previous report indicating that radar exposure caused a significant decrease in sperm numbers. A possible explanation is that the radar exposure in this study was that used in Signal Corps operations while the men in the previous study were using different radar as part of military intelligence operations. The data presented here in men firing the 155-mm howitzer combined with the results from the previous studies confirms that there are no deficits in semen quality in these men. The contradiction between the results of the radar exposure studies indicates that more data are needed to evaluate the relationship of military radar and male reproductive health.

Schuz J, Mann S, A discussion of potential exposure metrics for use in epidemiological studies on human exposure to radiowaves from mobile phone base stations. J Expo Anal Environ Epidemiol 10(6 Pt 1):600-605, 2000.

There is currently a high level of concern in many countries that exposure to radiowaves from mobile phone base stations may be hazardous to health. When investigating such suggested risks, epidemiologists need to define an exposure metric that can reliably discriminate between exposed and unexposed groups of people. We conducted a feasibility study to investigate if either short-term measurements of electric field strength, calculations of electric field strength, or distance from nearby mobile phone base stations could be used to develop a metric reflecting an individual's exposure to radiowaves. With electric field strengths in the range of 0.012-0.343 V/m, radiowaves from mobile phone base stations were found to give a material contribution to total exposure; however,

stronger signals were frequently measured from other sources such as broadcast radio and television transmitters. Theoretical considerations and the measurements made during this work demonstrated that studies at the population level on suggested adverse effects of radiowaves from mobile phone base stations are not feasible since no valid metric for estimating historical exposures is currently available. The pace of radio infrastructure development is also such that today's measurements are unlikely to be good proxies for either past or future exposures. The complex propagation characteristics affecting the beams from base station antennas include shielding effects and multiple reflections from house walls and other buildings. These factors, combined with the presence of other environmental sources of radiowaves, cause distance from a base station to be a poor proxy for exposure to radiowaves indoors. It may be possible to adapt computer models developed by network providers to predict network coverage for epidemiological purposes; however, this has yet to be investigated. Furthermore, there is little evidence that presently justifies epidemiological studies being restricted to adverse effects of radiowaves from mobile phone base stations while neglecting radiowaves at other frequencies produced by different transmitters.

Schuz J. Mobile phone use and exposures in children. Bioelectromagnetics. Suppl 7:S45-50,2005.

The main difference concerning the use of mobile phones (MPs) between today's children and adults is the longer lifetime exposure of children when they grow older, due to starting to use MPs at an early age. Additionally, recent trends lead to a higher frequency of use among children, including higher popularity of MPs and features specifically designed to attract children. The prevalence of MP users is already very high and reaches >90% among adolescents in some countries. In a German study, 6% of 9-10 years old children used a MP for making calls daily; 35% owned their own MP. For children, MPs are dominant sources of radio wave exposures and relevant sources of extremely low frequency magnetic fields. For very young children, however, environmental exposure to radio waves may be of concern. In conclusion, children will have a much higher cumulative exposure to radio waves than today's adults when they are at the same age. Radio wave exposure of children may be estimated more easily, because the variety of exposure sources is smaller than for adults. As long as adverse health effects cannot be ruled out with some degree of certainty, it appears to be appropriate to instruct children and their parents about a prudent use of MPs.

Schuz J, Bohler E, Berg G, Schlehofer B, Hettinger I, Schlaefer K, Wahrendorf J, Kunna-Grass K, Blettner M. Cellular phones, cordless phones, and the risks of glioma and meningioma (Interphone Study Group, Germany). Am J Epidemiol. 163(6):512-520, 2006

The widespread use of cellular telephones has generated concern about possible adverse health effects, particularly brain tumors. In this population-based case-control study carried out in three regions of Germany, all incident cases of glioma and meningioma among patients aged 30-69 years were ascertained during 2000-2003. Controls matched on age, gender, and region were randomly drawn from population registries. In total, 366 glioma cases, 381 meningioma cases, and 1,494 controls were interviewed. Overall use of a cellular phone was not associated with brain tumor risk; the

respective odds ratios were 0.98 (95% confidence interval (CI): 0.74, 1.29) for glioma and 0.84 (95% CI: 0.62, 1.13) for meningioma. Among persons who had used cellular phones for 10 or more years, increased risk was found for glioma (odds ratio = 2.20, 95% CI: 0.94, 5.11) but not for meningioma (odds ratio = 1.09, 95% CI: 0.35, 3.37). No excess of temporal glioma (p = 0.41) or meningioma (p = 0.43) was observed in cellular phone users as compared with nonusers. Cordless phone use was not related to either glioma risk or meningioma risk. In conclusion, no overall increased risk of glioma or meningioma was observed among these cellular phone users; however, for long-term cellular phone users, results need to be confirmed before firm conclusions can be drawn.

Schuz J, Bohler E, Schlehofer B, Berg G, Schlaefer K, Hettinger I, Kunna-Grass K, Wahrendorf J, Blettner M. Radiofrequency Electromagnetic Fields Emitted from Base Stations of DECT Cordless Phones and the Risk of Glioma and Meningioma (Interphone Study Group, Germany). Radiat Res. 166(1):116-119, 2006.

The objective of this study was to test the hypothesis that exposure to continuous low-level radiofrequency electromagnetic fields (RF EMFs) increases the risk of glioma and meningioma. Participants in a population-based case-control study in Germany on the risk of brain tumors in relation to cellular phone use were 747 incident brain tumor cases between the ages of 30 and 69 years and 1494 matched controls. The exposure measure of this analysis was the location of a base station of a DECT (Digital Enhanced Cordless Telecommunications) cordless phone close to the bed, which was used as a proxy for continuous low-level exposure to RF EMFs during the night. Estimated odds ratios were 0.82 (95% confidence interval: 0.29-2.33) for glioma and 0.83 (0.29-2.36) for meningioma. There was also no increasing risk observed with duration of exposure to DECT cordless phone base stations. Although the study was limited due to the small number of exposed subjects, it is still a first indication that residential low-level exposure to RF EMFs may not pose a higher risk of brain tumors.

Schüz J, Jacobsen R, Olsen JH, Boice, JD Jr, McLaughlin JK, Johansen C. Cellular Telephone Use and Cancer Risk: Update of a nationwide Danish cohort. J Natl Cancer Inst 98:1707-1713, 2006.

Background: The widespread use of cellular telephones has heightenedconcerns about possible adverse health effects. The objectiveof this study was to investigate cancer risk among Danish cellulartelephone users who were followed for up to 21 years. Methods:This study is an extended follow-up of a large nationwide cohortof 420 095 persons whose first cellular telephone subscriptionwas between 1982 and 1995 and who were followed through 2002for cancer incidence. Standardized incidence ratios (SIRs) werecalculated by dividing the number of observed cancer cases inthe cohort by the number expected in the Danish population.Results: A total of 14 249 cancers were observed (SIR = 0.95;95% confidence interval [CI] = 0.93 to 0.97) for men and womencombined. Cellular telephone use was not associated with increasedrisk for brain tumors (SIR = 0.97), acoustic neuromas (SIR =0.73), salivary gland tumors (SIR = 0.77), eye tumors (SIR =0.96), or leukemias (SIR = 1.00). Among long-term subscribersof 10 years or more, cellular telephone use was not associatedwith increased risk for brain tumors (SIR = 0.66, 95% CI = 0.44to 0.95), and there was no trend with time since first subscription.The risk for smoking-related

cancers was decreased among men(SIR = 0.88, 95% CI = 0.86 to 0.91) but increased among women(SIR = 1.11, 95% CI = 1.02 to 1.21). Additional data on incomeand smoking prevalence, primarily among men, indicated thatcellular telephone users who started subscriptions in the mid-1980sappeared to have a higher income and to smoke less than thegeneral population. Conclusions: We found no evidence for anassociation between tumor risk and cellular telephone use amongeither short-term or long-term users. Moreover, the narrow confidenceintervals provide evidence that any large association of riskof cancer and cellular telephone use can be excluded.

Schüz J, Waldemar G, Olsen JH, Johansen C. Risks for central nervous system diseases among mobile phone subscribers: a Danish retrospective cohort study. PLoS One. 4(2):e4389, 2009

The aim of this study was to investigate a possible link between cellular telephone use and risks for various diseases of the central nervous system (CNS). We conducted a large nationwide cohort study of 420 095 persons whose first cellular telephone subscription was between 1982 and 1995, who were followed through 2003 for hospital contacts for a diagnosis of a CNS disorder. Standardized hospitalization ratios (SHRs) were derived by dividing the number of hospital contacts in the cohort by the number expected in the Danish population. The SHRs were increased by 10-20% for migraine and vertigo. No associations were seen for amyotrophic lateral sclerosis, multiple sclerosis or epilepsy in women. SHRs decreased by 30-40% were observed for dementia (Alzheimer disease, vascular and other dementia), Parkinson disease and epilepsy among men. In analyses restricted to subscribers of 10 years or more, the SHRs remained similarly increased for migraine and vertigo and similarly decreased for Alzheimer disease and other dementia and epilepsy (in men); the other SHRs were close to unity. In conclusion, the excesses of migraine and vertigo observed in this first study on cellular telephones and CNS disease deserve further attention. An interplay of a healthy cohort effect and reversed causation bias due to prodromal symptoms impedes detection of a possible association with dementia and Parkinson disease. Identification of the factors that result in a healthy cohort might be of interest for elucidation of the etiology of these diseases.

Schwartz JL, House DE, Mealing GA, Exposure of frog hearts to CW or amplitude-modulated VHF fields: selective efflux of calcium ions at 16 Hz. Bioelectromagnetics 11(4):349-358, 1990.

Isolated frog hearts were exposed for 30-min periods in a Crawford cell to a 240-MHz electromagnetic field, either continuous-wave or sinusoidally modulated at 0.5 or 16 Hz. Radiolabeled with calcium (45Ca), the hearts were observed for movement of Ca2+ at calculated SARs of 0.15, 0.24, 0.30, 0.36, 1.50, or 3.00 mW/kg. Neither CW radiation nor radiation at 0.5 Hz, which is close to the beating frequency of the frog's heart, affected movement of calcium ions. When the VHF field was modulated at 16 Hz, a field-intensity-dependent change in the efflux of calcium ions was observed. Relative to control values, ionic effluxes increased by about 18% at 0.3 mW/kg (P less than .01) and by 21% at 0.15 mW/kg (P less than .05), but movement of ions did not change significantly at other rates

of energy deposition. These data indicate that the intact myocardium of the frog, akin to brain tissue of neonatal chicken, exhibits movement of calcium ions in response to a weak VHF field that is modulated at 16 Hz.

Schwartz JL, Mealing GA, Calcium-ion movement and contractility in atrial strips of frog heart are not affected by low-frequency-modulated, 1 GHz electromagnetic radiation. Bioelectromagnetics 14(6):521-533, 1993.

Calcium efflux from electrically stimulated, 45Ca(2+)-preloaded atrial strips of the frog heart was measured from samples of the rinsing perfusate collected at 2-min intervals for 32 min in a continuous perfusion chamber. Contractile force was simultaneously monitored. The specimen chamber was located in a stripline apparatus in which the atrial strips were exposed for 32 min to constant (CW) or amplitude-modulated (AM), 1 GHz electromagnetic (EM) fields at specific absorption rates (SAR) ranging from 3.2 microW/kg to 1.6 W/kg. Amplitude modulation was either at 0.5 Hz, in synchrony with the electrical stimulus applied to the preparation, or at 16 Hz. Neither unmodulated nor 0.5 Hz or 16 Hz modulated 1 GHz waves affected the movement of calcium ions or the contractile force in isolated atrial strips of the frog heart.

Schwarz C, Kratochvil E, Pilger A, Kuster N, Adlkofer F, Rüdiger HW. Radiofrequency electromagnetic fields (UMTS, 1,950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes. Int Arch Occup Environ Health. 81(6):755-767, 2008.

OBJECTIVE: Universal Mobile Telecommunication System (UMTS) was recently introduced as the third generation mobile communication standard in Europe. This was done without any information on biological effects and genotoxic properties of these particular high-frequency electromagnetic fields. This is discomforting, because genotoxic effects of the second generation standard Global System for Mobile Communication have been reported after exposure of human cells in vitro. METHODS: Human cultured fibroblasts of three different donors and three different short-term human lymphocyte cultures were exposed to 1,950 MHz UMTS below the specific absorption rate (SAR) safety limit of 2 W/kg. The alkaline comet assay and the micronucleus assay were used to ascertain dose and time-dependent genotoxic effects. Five hundred cells per slide were visually evaluated in the comet assay and comet tail factor (CTF) was calculated. In the micronucleus assay 1,000 binucleated cells were evaluated per assay. The origin of the micronuclei was determined by fluorescence labeled anticentromere antibodies. All evaluations were performed under blinded conditions. RESULTS: UMTS exposure increased the CTF and induced centromere-negative micronuclei (MN) in human cultured fibroblasts in a dose and time-dependent way. Incubation for 24 h at a SAR of 0.05 W/kg generated a statistically significant rise in both CTF and MN (P = 0.02). At a SAR of 0.1 W/kg the CTF was significantly increased after 8 h of incubation (P = 0.02), the number of MN after 12 h (P = 0.02). No UMTS effect was obtained with lymphocytes, either unstimulated or stimulated with Phytohemagglutinin. CONCLUSION: UMTS exposure may cause genetic alterations in some but not in all human cells in vitro.

Schwarze S, Schneider NL, Reichl T, Dreyer D, Lefeldt N, Engels S, Baker N, Hore PJ, Mouritsen H. Weak Broadband Electromagnetic Fields are More Disruptive to Magnetic Compass Orientation in a Night-Migratory Songbird (Erithacus rubecula) than Strong Narrow-Band Fields.Front Behav Neurosci. 2016 Mar 22;10:55.

Magnetic compass orientation in night-migratory songbirds is embedded in the visual system and seems to be based on a light-dependent radical pair mechanism. Recent findings suggest that both broadband electromagnetic fields ranging from ~2 kHz to ~9 MHz and narrow-band fields at the so-called Larmor frequency for a free electron in the Earth's magnetic field can disrupt this mechanism. However, due to local magnetic fields generated by nuclear spins, effects specific to the Larmor frequency are difficult to understand considering that the primary sensory molecule should be organic and probably a protein. We therefore constructed a purpose-built laboratory and tested the orientation capabilities of European robins in an electromagnetically silent environment, under the specific influence of four different oscillating narrow-band electromagnetic fields, at the Larmor frequency, double the Larmor frequency, 1.315 MHz or 50 Hz, and in the presence of broadband electromagnetic noise covering the range from ~2 kHz to ~9 MHz. Our results indicated that the magnetic compass orientation of European robins could not be disrupted by any of the relatively strong narrow-band electromagnetic fields employed here, but that the weak broadband field very efficiently disrupted their orientation.

Seaman RL, Beblo DA, Modification of acoustic startle by microwave pulses in the rat: a preliminary report. Bioelectromagnetics 13(4):323-328, 1992.

Single, 1.25-GHz microwave pulses of 0.8- to 1.0-microseconds duration were presented to each of four rats 100 ms before presentation of a startle-inducing acoustic stimulus. This sequential pairing of microwave pulse and acoustic stimulus was found to modify the startle response. At an energy dose to the head of 22-43 mJ/kg per pulse (peak SAR, 23-48 kW/kg), the mean latency to the startle response was longer and the mean amplitude of the response was smaller with respect to control responses that occurred to acoustic stimuli alone. However, at a higher energy dose per microwave pulse in the range of 59-107 mJ/kg (peak SAR, 63-111 kW/kg), the mean latency and amplitude of the startle response were not statistically different from the respective means of control responses.

Seaman RL, DeHaan RL, Inter-beat intervals of cardiac-cell aggregates during exposure to 2.45 GHz CW, pulsed, and square-wave-modulated microwaves. Bioelectromagnetics 14(1):41-55, 1993.

Inter-beat intervals of aggregated cardiac cells from chicken embryos were studied during 190 s exposures to 2.45 GHz microwaves in an open-ended coaxial device. Averaged specific-absorption rates (SARs) and modulation conditions were 1.2-86.9 W/kg continuous-wave (CW), 1.2-12.2 W/kg pulse modulation (PW, duty cycle approximately 11%), and 12.0-43.5 W/kg square-wave modulation (duty cycle = 50%). The inter-beat interval decreased during microwave exposures at 42.0 W/kg and higher when CW or square-wave modulation was used, which is consistent with established effects of elevated temperatures. However, increases in the inter-beat

interval during CW exposures at 1.2-12.2 W/kg, and decreases in the inter-beat interval after PW exposures at 8.4-12.2 W/kg, are not consistent with simple thermal effects. Analysis of variance indicated that SAR, modulation, and the modulation-SAR interaction were all significant factors in altering the inter-beat interval. The latter two factors indicated that the cardiac cells were affected by athermal as well as thermal effects of microwave exposure.

Seaman RL, Belt ML, Doyle JM, Mathur SP, Ultra-wideband electromagnetic pulses and morphine-induced changes in nociception and activity in mice. Physiol Behav 65(2):263-270, 1998.

Mice were exposed to ultra-wideband (UWB) electromagnetic pulses averaging 99-105 kV/m peak amplitude, 0.97-1.03 ns duration, and 155-174 ps rise time, after intraperitoneal administration of saline or morphine sulfate. They were then tested for thermal nociception on a 50 degrees C surface and for spontaneous locomotor activity and its time profile over 5 min. Analysis of results showed no effect of UWB exposure on nociception and activity measures in CF-1 mice after 15-, 30-, or 45-min exposure to pulses at 600/s or after 30-min exposure to UWB pulses at 60/s. Similarly, no effect was seen in C57BL/6 mice after 30-min exposure to pulses at 60/s or 600/s. Although trends in morphine-modified measures seen with UWB pulse repetition frequency could be expected because of increased levels of low-frequency energy, no significant change was seen in normal or morphine-modified nociception or activity after UWB exposure. This indicated lack of effect of the UWB pulses used in these experiments on nervous system components, including endogenous opioids, involved in these behaviors.

Seaman RL, Belt ML, Doyle JM, Mathur SP, Hyperactivity caused by a nitric oxide synthase inhibitor is countered by ultra-wideband pulses. Bioelectromagnetics 20(7):431-439, 1999.

Potential action of ultra-wideband (UWB) electromagnetic field pulses on effects of N(G)-nitro- L-arginine methyl ester (L-NAME), an inhibitor of nitric oxide synthase (NOS), on nociception and locomotor activity was investigated in CF-1 mice. Animals were injected IP with saline or 50 mg/kg L-NAME and exposed for 30 min to no pulses (sham exposure) or UWB pulses with electric field parameters of 102+/-1 kV/m peak amplitude, 0.90+/-0.05 ns duration, and 160+/-5 ps rise time (mean+/-S.D.) at 600/s. Animals were tested for thermal nociceptive responses on a 50 degrees C surface and for spontaneous locomotor activity for 5 min. L-NAME by itself increased mean first-response (paw lift, shake, or lick; jump) and back-paw-lick response latencies and mean locomotor activity. Exposure to UWB pulses reduced the L-NAME-induced increase in back-paw-lick latency by 22%, but this change was not statistically significant. The L-NAME-induced hyperactivity was not present after UWB exposure. Reduction and cancellation of effects of L-NAME suggest activation of opposing mechanism(s) by the UWB pulses, possibly including increase of nitric oxide production by NOS. The action, or actions, of UWB pulses appears to be more effective on locomotor activity than on thermal nociception in CF-1 mice.

Seaman RL, Phelix CF. Acute effects of pulsed microwaves and 3-nitropropionic acid on neuronal ultrastructure in the rat caudate-putamen. Bioelectromagnetics. 26(2):82-101, 2005.

Ultrastructure of the medium sized "spiny" neuron in rat dorsal-lateral caudate-putamen was assessed after administration of 3-nitropropionic acid (3-NP) and exposure to pulsed microwaves. Sprague-Dawley male rats were given two daily intraperitoneal doses of 0 or 10 mg/kg 3-NP and 1.5 h after each dose were exposed to microwave radiation at a whole body averaged specific absorption rate (SAR) of 0 (sham exposure), 0.6, or 6 W/kg for 30 min. Microwave exposure consisted of 1.25 GHz radiation delivered as 5.9 mus pulses with repetition frequency 10 Hz. Tissue samples taken 2-3 h after the second sham or microwave exposure showed no injury with light microscope methods. Blinded qualitative assessment of ultrastructure of randomly selected neurons from the same samples did reveal differences. Subsequent detailed, quantitative measurements showed that, when followed by sham exposure, administration of 3-NP significantly increased endoplasmic reticulum (ER) intracisternal width, ER area density, and nuclear envelope thickness. Microwave exposure at 6 W/kg alone also significantly increased these measures. Exposure of 3-NP treated animals at 6 W/kg significantly increased effects of 3-NP on ultrastructure. Although exposure at 0.6 W/kg alone did not affect ultrastructure measures, exposure of 3-NP treated animals at 0.6 W/kg reduced the effects of 3-NP. We concluded that 3-NP changed neuronal ultrastructure and that the microwave exposures used here changed neuronal ultrastructure in ways that depended on microwave SAR and neuron metabolic status. The apparent cancellation of 3-NP induced changes by exposure to pulsed microwaves at 0.6 W/kg indicated the possibility that such exposure can protect against the effects of mitochondrial toxins on the nervous system.

Sebastian JL, Munoz S, Sancho M, Miranda JM, Analysis of the influence of the cell geometry, orientation and cell proximity effects on the electric field distribution from direct RF exposure. Phys Med Biol 46(1):213-225, 2001.

This paper shows the importance of using a cell model with the proper geometry, orientation and internal structure to study possible cellular effects from direct radiofrequency exposure. For this purpose, the electric field intensity is calculated, using the finite element numerical technique, in single- and multilayer spherical, cylindrical and ellipsoidal mammalian cell models exposed to linearly polarized electromagnetic plane waves of frequencies 900 and 2450 MHz. An extensive analysis is performed on the influence that the cell geometry and orientation with respect to the external field have in the value of the electric field induced in the membrane and cytoplasm. We also show the significant role that the cytoplasmic and extracellular bound water layers play in determining the electric field intensity for the cylindrical and ellipsoidal cell models. Finally, a study of the mutual interactions between cells shows that polarizing effects between cells significantly modify the values of field intensity within the cell.

Seckin E, Suren Basar F, Atmaca S, Kaymaz FF, Suzer A, Akar A, Sunan E, Koyuncu M.The effect of radiofrequency radiation generated by a Global System for Mobile Communications source on cochlear development in a rat model. J Laryngol Otol. 2014 May 1:1-6. [Epub ahead of print]

Objective: This study aimed to determine the effect of radiofrequency radiation generated by 900 and 1800 MHz Global System for Mobile Communications sources on cochlear development in the rat model. Methods: Eight pregnant albino Wistar rats were divided

into three groups: control, 900 MHz and 1800 MHz. The latter two groups of pregnant rats were exposed to radiofrequency radiation for 1 hour per day starting on the 12th day of pregnancy until delivery. The rats in the control, 900 MHz and 1800 MHz groups gave birth to 24, 31 and 26 newborn rats respectively. Newborn rats in the 900 MHz and 1800 MHz groups were exposed to radiofrequency radiation for 1 hour per day for 21 days after delivery. Hearing evaluations of newborn rats were carried out using distortion product otoacoustic emissions testing. Eight newborn rats were randomly selected from each group for electron microscopic evaluation. Results: Distortion product otoacoustic emission tests revealed no significant difference among the groups, but electron microscopic evaluation revealed significant differences among the groups with regard to the number of normal, apoptotic and necrotic cells. Conclusion: The findings indicated cellular structural damage in the cochlea caused by radiofrequency radiation exposure during cochlear development in the rat model.

Sefidbakht Y, Hosseinkhani S, Mortazavi M, Tavakkolnia I, Khellat MR, Shakiba-Herfeh M, Saviz M, Faraji-Dana R, Saboury AA, Sheibani N, Moosavi-Movahedi AA. Effects of 940 MHz EMF on Luciferase Solution: Structure, Function, and Dielectric Studies. Bioelectromagnetics. 2013 Apr 30. doi: 10.1002/bem.21792. [Epub ahead of print]

We designed a rectangular waveguide exposure system to study the effects of mobile phone frequency (940 MHz) electromagnetic fields (EMF) on luciferase structure and activity. The luciferase activity of exposed samples was significantly higher than that of unexposed samples. Dynamic light scattering of the exposed samples showed smaller hydrodynamic radii compared to unexposed samples (20 nm vs. 47 nm ± 5%). The exposed samples also showed less tendency to form aggregates, monitored by turbidity measurements at λ = 360 nm. A microwave dielectric measurement was performed to study the hydration properties of luciferase solutions with a precision network analyzer over frequency ranges from 0.2 to 20 GHz before and after exposure. The change in the dielectric properties of the exposed luciferase solution was related to the disaggregation potency of the applied field. Together, our results suggested that direct interactions with luciferase molecules and its dipole moment were responsible for the reduced aggregation and enhanced luciferase activity upon exposure to the EMF.

Sefidbakht Y, Moosavi-Movahedi AA, Hosseinkhani S, Khodagholi F, Torkzadeh-Mahani M, Foolad F, Faraji-Dana R. Effects of 940 MHz EMF on bioluminescence and oxidative response of stable luciferase producing HEK cells. Photochem Photobiol Sci. 2014 Jun 2. [Epub ahead of print]

The effects of mobile phone frequency electromagnetic field (RF-EMF, 940 MHz) on a stable cell line (HEK293T) harbouring the firefly luciferase gene were evaluated. A waveguide exposure system with 1 W input power provided the mean specific absorption rate of ≈0.09 W kg^{-1} in 35 mm Petri dishes. The effects of exposure duration (15, 30, 45, 60 and 90 min) on luciferase activity and oxidative response elements were investigated. Endogenous luciferase activity was reduced after 30 and 45 min of continuous exposure,

while after 60 min, the exposed cell lysate showed higher luciferase activity compared with the non-exposed control. Reactive oxygen species (ROS) generation was highest in the 30 min exposed cells as studied by 2',7'-dichlorodihydrofluorescein diacetate (DCFH-DA) fluorescence. The observed boost in ROS was then followed by a sharp rise in catalase (CAT) and superoxide dismutase (SOD) activity and elevation of glutathione (GSH) during the 45 min exposure. Decrease in lipid peroxidation (malondialdehyde, MDA) was meaningful for the 45 and 60 min exposed cells. Therefore, it appears that an increase in the activity of luciferase after 60 min of continuous exposure could be associated with a decrease in ROS level caused by activation of the oxidative response. This ability in cells to overcome oxidative stress and compensate the luciferase activity could also be responsible for the adaptive response mechanism detected in ionizing radiation studies with RF-EMF pre-treatments.

Sehitoglu I, Tumkaya L, Kalkan Y, Bedir R, Cure MC, Zorba OU, Cure E, Yuce S. Biochemical and histopathological effects on the rat testis after exposure to electromagnetic field during fetal period. Arch Esp Urol. 68(6):562-568, 2015.

OBJECTIVES: Electromagnetic radiation (ER) emitted from cell phones may exert a detrimental influence on human health and may affect the man reproductive system. We aimed to study the biological and morphological effects on the testes of 60-day-old male rats after ER exposure (900 MHz), which was applied continuously throughout embryogenesis. METHODS: A total of six pregnant Sprague Dawley rats were included in the study. Three pregnant rats (experimental group) were exposed to radiation from a cell phone set to talking mode for 24 hours a day for 20 days, and the other 3 pregnant rats (control group) were not to exposed to radiation. Newborn male rats were included from the experimental group (n=7) and the control group (n=7). At the end of 60 days, the rats' testes were excised, and testis length, width, depth, and weight were measured. Histopathological examinations were compared and serum testosterone (T) levels were assayed biochemically. RESULTS: While serum T level (3.51±0.21 ng/ml) of ER Exposed group was significantly lower than the control group (4.04±0.47 ng/ml, p=0.018), Caspase-3 enzyme activity (2.00±0.88) was significantly higher than the control group control (1.00±0.63, p=0.026). Johnsen score (8.4±0.5) of ER group was fairly lower than the control group (9.4±0.5, p= 0.010). CONCLUSION: Our study demonstrated that ER exposure throughout embryogenesis may cause reductions in serum total T levels and in the size and weight of the testes of male rats, while causing modest increase in apoptosis.

Seishima M, Oyama Z, Oda M. Cellular phone dermatitis with chromate allergy. Dermatology. 207(1):48-50, 2003.

BACKGROUND: A patient with allergic contact dermatitis caused by hexavalent chromium plating on a cellular phone has already been reported. OBJECTIVES: This study described the clinical characteristics and results of patch tests in 8 patients with contact dermatitis possibly caused by handling a cellular phone. PATIENTS: The 8 patients were 4 males and 4 females aged from 14 to 54 years. They each noticed skin eruptions after 9-25 days of using a cellular phone. All patients had erythema, and 7 had papules on the hemilateral auricle or in the preauricular region. Three of 8 patients had a

history of metal allergy. Chromate, aluminium and acrylnitrile-butadiene-styrene copolymer were used as plating on the cellular phones used by these patients. METHODS: Closed patch tests and photopatch tests were performed using metal standard antigens. RESULTS: The patch test was positive for 0.5, 0.1 and 0.05% potassium dichromate in all 8 patients. The photopatch test showed the same results. One patient was positive for 2% cobalt chloride and one for 5% nickel sulfate. CONCLUSION: It is important to consider the possibility of contact dermatitis due to a cellular phone, possibly caused by chromate, when the patients have erythema and papules on the hemilateral auricle or in the preauricular region.

Seitz H, Stinner D, Eikmann T, Herr C, Röösli M. Electromagnetic hypersensitivity (EHS) and subjective health complaints associated with electromagnetic fields of mobile phone communication--a literature review published between 2000 and 2004. Sci Total Environ. 349(1-3):45-55, 2005.

Literature published between 2000 to 2004 concerning electromagnetic fields (EMF) of mobile communication and electromagnetic hypersensitivity (EHS) or unspecific symptoms of ill health, respectively, is reviewed. Basically, literature from established databases was systematically searched for. For each study, the design and quality were evaluated by means of a criteria list in order to judge evidence for causality of exposures on effects. Finally, 13 studies of sufficient quality were considered for this review. In only one provocation study, individuals with self-reported electromagnetic hypersensitivity were exposed to EMF. Their perception of field status was no better than would have been expected by chance. Results of five randomised cross-over studies on impaired well-being due to mobile phone exposure were contradictory. Even though these studies would allow more reliable exposure assessment, they are limited due to short exposure period and the small study size. No firm conclusion could be drawn from a few observational epidemiological studies finding a positive association between exposure and unspecific symptoms of ill health due to methodological limitations. Causality of exposure and effect was not derivable from these cross-sectional studies as field status and health complaints were assessed at the same time. In addition, exposure assessment has not been validated. In conclusion, based on the limited studies available, there is no valid evidence for an association between impaired well-being and exposure to mobile phone radiation presently. However, the limited quantity and quality of research in this area do not allow to exclude long-term health effects definitely.

Sekeroğlu V, Akar A, Sekeroğlu ZA. Cytotoxic and genotoxic effects of high-frequency electromagnetic fields (GSM 1800 MHz) on immature and mature rats. Ecotoxicol Environ Saf. 80:140-144, 2012.

We investigated the cytogenotoxic effects of high frequency electromagnetic fields (HF-EMF) for 45 day and the effect of a recovery period of 15 day after exposure to EMF on bone marrow cells of immature and mature rats. The animals in treatment groups were exposed to 1800 MHz EMF at SAR of 0.37 W/kg and 0.49 W/kg for 2h/day for 45 day. Two recovery groups were kept for a recovery period of 15 day without EMF after exposure to HF-EMF. Two control groups for both immature and

mature rats were also included. Significant differences were also observed in chromosome aberrations (CA), micronucleus (MN) frequency, mitotic index (MI) and ratio of polychromatic erythrocytes (PCEs) in all treatment groups. The cytogenotoxic damage was more remarkable in immature rats and, the recovery period did not improve this damage in immature rats. Because much higher and irreversible cytogenotoxic damage was observed in immature rats than in mature rats, further studies are needed to understand effects of EMF on DNA damage and DNA repair, and to determine safe limits for environment and human, especially for children.

Sekijima M, Takeda H, Yasunaga K, Sakuma N, Hirose H, Nojima T, Miyakoshi J. 2-GHz band CW and W-CDMA modulated radiofrequency fields have no significant effect on cell proliferation and gene expression profile in human cells. J Radiat Res. 51(3):277-284, 2010.

We investigated the mechanisms by which radiofrequency (RF) fields exert their activity, and the changes in both cell proliferation and the gene expression profile in the human cell lines, A172 (glioblastoma), H4 (neuroglioma), and IMR-90 (fibroblasts from normal fetal lung) following exposure to 2.1425 GHz continuous wave (CW) and Wideband Code Division Multiple Access (W-CDMA) RF fields at three field levels. During the incubation phase, cells were exposed at the specific absorption rates (SARs) of 80, 250, or 800 mW/kg with both CW and W-CDMA RF fields for up to 96 h. Heat shock treatment was used as the positive control. No significant differences in cell growth or viability were observed between any test group exposed to W-CDMA or CW radiation and the sham-exposed negative controls. Using the Affymetrix Human Genome Array, only a very small (< 1%) number of available genes (ca. 16,000 to 19,000) exhibited altered expression in each experiment. The results confirm that low-level exposure to 2.1425 GHz CW and W-CDMA RF fields for up to 96 h did not act as an acute cytotoxicant in either cell proliferation or the gene expression profile.These results suggest that RF exposure up to the limit of whole-body average SAR levels as specified in the ICNIRP guidelines is unlikely to elicit a general stress response in the tested cell lines under these conditions.

Senavirathna MD, Asaeda T, Thilakarathne BL, Kadono H. Nanometer-scale elongation rate fluctuations in the Myriophyllum aquaticum (Parrot feather) stem were altered by radio-frequency electromagnetic radiation. Plant Signal Behav. 2014 Apr;9(4):e28590. doi: 10.4161/psb.28590.

The emission of radio-frequency electromagnetic radiation (EMR) by various wireless communication base stations has increased in recent years. While there is wide concern about the effects of EMR on humans and animals, the influence of EMR on plants is not well understood. In this study, we investigated the effect of EMR on the growth dynamics of Myriophyllum aquaticum (Parrot feather) by measuring the nanometric elongation rate fluctuation (NERF) using a statistical interferometry technique. Plants were exposed to 2 GHz EMR at a maximum of 1.42 Wm(-2) for 1 h. After continuous exposure to EMR, M. aquaticum plants exhibited a statistically significant 51 ± 16% reduction in NERF standard deviation. Temperature observations revealed that EMR exposure did not cause dielectric heating of the plants. Therefore, the reduced NERF was due to a non-thermal effect

caused by EMR exposure. The alteration in NERF continued for at least 2.5 h after EMR exposure and no significant recovery was found in post-EMR NERF during the experimental period.

Sepehrimanesh M, Kazemipour N, Saeb M, Nazifi S. Analysis of rat testicular proteome following 30-days exposure to 900 MHz electromagnetic field radiation. Electrophoresis. 2014 Aug 21. doi: 10.1002/elps.201400273. [Epub ahead of print]

The use of electromagnetic field (EMF) generating apparatuses such as cell phones is increasing, and has caused an interest in the investigations of its effects on human health. We analyzed proteome in preparations from the whole testis in adult male Sprague-Dawley rats exposed for 1, 2 or 4 h/d for 30 consecutive days to 900 MHz EMF radiation, simulating a range of possible human cell phone use. Subjects were sacrificed immediately after the end of the experiment and testes fractions were solubilized and separated via high resolution 2-dimensional electrophoresis, and gel patterns were scanned, digitized and processed. Thirteen of the proteins which found only in sham or in exposure groups were identified by MALDI-TOF/TOF-MS. Among them, heat shock proteins, superoxide dismutase, peroxiredoxin-1 and other proteins related to misfolding of proteins and/or stress were identified. These results demonstrate significant effects of radio-frequency modulated electromagnetic fields (RF-EMF) exposure on proteome, particularly in protein species in the rodent testis, and suggest that a 30 d exposure to EMF radiation induces non-thermal stress in testicular tissue. The functional implication of the identified proteins was discussed.

Sepehrimanesh M, Kazemipour N, Saeb M, Nazifi S, Davis DL. Proteomic analysis of continuous 900-MHz radiofrequency electromagnetic field exposure in testicular tissue: a rat model of human cell phone exposure. Environ Sci Pollut Res Int. 24(15):13666-13673, 2017.

Although cell phones have been used worldwide, some adverse and toxic effects were reported for this communication technology apparatus. To analyze in vivo effects of exposure to radiofrequency-electromagnetic field (RF-EMF) on protein expression in rat testicular proteome, 20 Sprague-Dawley rats were exposed to 900 MHz RF-EMF for 0, 1, 2, or 4 h/day for 30 consecutive days. Protein content of rat testes was separated by high-resolution two-dimensional electrophoresis using immobilized pH gradient (pI 4-7, 7 cm) and 12% acrylamide and identified by MALDI-TOF/TOF-MS. Two protein spots were found differentially overexpressed ($P < 0.05$) in intensity and volume with induction factors 1.7 times greater after RF-EMF exposure. After 4 h of daily exposure for 30 consecutive days, ATP synthase beta subunit (ASBS) and hypoxia up-regulated protein 1 precursor (HYOU1) were found to be significantly up-regulated. These proteins affect signaling pathways in rat testes and spermatogenesis and play a critical role in protein folding and secretion in the endoplasmic reticulum. Our results indicate that exposure to RF-EMF produces increases in testicular proteins in adults that are related to carcinogenic risk and reproductive damage. In light of the widespread practice of men carrying phones in their pockets near their gonads, where exposures can exceed as-tested guidelines, further study of these effects should be a high priority.

Shahbazi-Gahrouei D, Hashemi-Beni B, Ahmadi Z. Effects of RF-EMF Exposure from GSM Mobile Phones on Proliferation Rate of Human Adipose-derived Stem Cells: An In-vitro Study. Biomed Phys Eng. 6(4):243-252, 2016.

BACKGROUND: As the use of mobile phones is increasing, public concern about the harmful effects of radiation emitted by these devices is also growing. In addition, protection questions and biological effects are among growing concerns which have remained largely unanswered. Stem cells are useful models to assess the effects of radiofrequency electromagnetic fields (RF-EMF) on other cell lines. Stem cells are undifferentiated biological cells that can differentiate into specialized cells. Adipose tissue represents an abundant and accessible source of adult stem cells. The aim of this study is to investigate the effects of GSM 900 MHz on growth and proliferation of mesenchymal stem cells derived from adipose tissue within the specific distance and intensity. MATERIALS AND METHODS: ADSCs were exposed to GSM mobile phones 900 MHz with intensity of 354.6 μW/cm^2 square waves (217 Hz pulse frequency, 50% duty cycle), during different exposure times ranging from 6 to 21 min/day for 5 days at 20 cm distance from the antenna. MTT assay was used to determine the growth and metabolism of cells and trypan blue test was also done for cell viability. Statistical analyses were carried out using analysis of one way ANOVA. $P<0.05$ was considered to be statistically significant. RESULTS: The proliferation rates of human ADSCs in all exposure groups were significantly lower than control groups ($P<0.05$) except in the group of 6 minutes/day which did not show any significant difference with control groups. CONCLUSION: The results show that 900 MHz RF signal radiation from antenna can reduce cell viability and proliferation rates of human ADSCs regarding the duration of exposure.

Shahin S, Singh SP, Chaturvedi CM. Mobile phone (1800MHz) radiation impairs female reproduction in mice, Mus musculus, through stress induced inhibition of ovarian and uterine activity. Reprod Toxicol. 73:41-60, 2017.

Present study investigated the long-term effects of mobile phone (1800MHz) radiation in stand-by, dialing and receiving modes on the female reproductive function (ovarian and uterine histo-architecture, and steroidogenesis) and stress responses (oxidative and nitrosative stress). We observed that mobile phone radiation induces significant elevation in ROS, NO, lipid peroxidation, total carbonyl content and serum corticosterone coupled with significant decrease in antioxidant enzymes in hypothalamus, ovary and uterus of mice. Compared to control group, exposed mice exhibited reduced number of developing and mature follicles as well as corpus lutea. Significantly decreased serum levels of pituitary gonadotrophins (LH, FSH), sex steroids (E2 and P4) and expression of SF-1, StAR, P-450scc, 3β-HSD, 17β-HSD, cytochrome P-450 aromatase, ER-α and ER-β were observed in all the exposed groups of mice, compared to control. These findings suggest that mobile phone radiation induces oxidative and nitrosative stress, which affects the reproductive performance of female mice.

Solomentsev GY, English NJ, Mooney DA.Hydrogen bond perturbation in hen egg white lysozyme by external electromagnetic fields: a nonequilibrium molecular dynamics study.J Chem Phys. 133(23):235102, 2010.

Nonequilibrium molecular dynamics simulations of a charge-neutral mutant of hen egg white lysozyme have been performed at 300 K and 1 bar in the presence of external microwave fields (2.45 to 100 GHz) of an rms electric field intensity of 0.05 V Å(-1). A systematic study was carried out of the distributions of persistence times and energies of each intraprotein hydrogen bond in between breakage and reformation, in addition to overall persistence over 20 ns simulations, vis-á-vis equilibrium, zero-field conditions. It was found that localized translational motion for formally charged residues led to greater disruption of associated hydrogen bonds, although induced rotational motion of strongly dipolar residues also led to a degree of hydrogen bond perturbation. These effects were most apparent in the solvent exposed exterior of hen egg white lysozyme, in which the intraprotein hydrogen bonds tend to be weaker.

Semin IuA, Shvartsburg LK, Dubovik BV. [Changes in the secondary structure of DNA under the influence of external low-intensity electromagnetic field] Radiats Biol Radioecol 35(1):36-41, 1995. [Article in Russian]

The effect of weak RF on the stability of DNA secondary structure was studied in vitro. DNA was exposed in the presence of glycine and formaldehyde. Aminomethynol compounds, which form in this medium, react with DNA bases at single-strand sites, which prevents recovery from damage to the DNA secondary structure. The damage accumulates during the incubation, and its amount canbe estimated from the dynamics of thermal DNA denaturalization after RF or sha exposure. Samples were exposed in an anechoic chamber at 18^{o}C at 10 different microwave frequencies simultaneously (4- to 8 GHz, 25 ms pulses, 0.4 to 0.7 mW/cm2 peak power, 1- to 6-Hz repetition rate, no heating). Parallel control samples were sham exposed in a shielded area in the same chamber. The experiments established that irradiation at 3 or 4 Hz and 0.6 mW/cm2 peak power clearly increased the accumulated damage to the DNA secondary structure (P< .00001). However, changing the pulse repetition rate to 1, 5, 6 Hz, as well as changing the peak power to 0.4 or 0.7 mW/cm2, eliminated the effect entirely. Thus, the effect occurred only within narrow ‘windows’ of the peak intensities and modulation frequencies.

Senavirathna MD, Asaeda T, Thilakarathne BL, Kadono H. Nanometer-scale elongation rate fluctuations in the Myriophyllum aquaticum (Parrot feather) stem were altered by radio-frequency electromagnetic radiation. Plant Signal Behav. 2014 Mar 26;9(3). pii: e28590. [Epub ahead of print]

The emission of radio-frequency electromagnetic radiation (EMR) by various wireless communication base stations has increased in recent years. While there is wide concern about the effects of EMR on humans and animals, the influence of EMR on plants is not well understood. In this study, we investigated the effect of EMR on the growth dynamics of Myriophyllum aquaticum (Parrot feather) by measuring the nanometric elongation rate fluctuation (NERF) using a statistical interferometry technique. Plants were exposed to 2 GHz EMR at a maximum of 1.42 Wm-2 for 1 h. After continuous exposure to EMR, M. aquaticum plants exhibited a statistically significant 51 ± 16% reduction in NERF standard deviation. Temperature observations revealed that EMR exposure did not cause dielectric heating of the plants. Therefore, the reduced NERF was due to a non-thermal effect caused by EMR exposure. The alteration in NERF continued for at least 2.5 h after EMR

exposure and no significant recovery was found in post-EMR NERF during the experimental period.

Sepehrimanesh M, Saeb M, Nazifi S, Kazemipour N, Jelodar G, Saeb S. Impact of 900 MHz electromagnetic field exposure on main male reproductive hormone levels: a Rattus norvegicus model. Int J Biometeorol. 2013 Dec 20. [Epub ahead of print]

This work analyzes the effects of radiofrequency-electromagnetic field (RF-EMF) exposure on the reproductive system of male rats, assessed by measuring circulating levels of FSH, LH, inhibin B, activin B, prolactin, and testosterone. Twenty adult male Sprague-Dawley rats (180 ± 10 g) were exposed to 900 MHz RF-EMF in four equal separated groups. The duration of exposure was 1, 2, and 4 h/day over a period of 30 days and sham-exposed animals were kept under the same environmental conditions as the exposed group except with no RF-EMF exposure. Before the exposure, at 15 and 30 days of exposure, determination of the abovementioned hormone levels was performed using ELISA. At the end of the experiment, FSH and LH values of the long time exposure (LTE) group were significantly higher than the sham-exposed group ($p < 0.05$). Serum activin B and prolactin in the LTE group showed significant increase and inhibin B showed significant decrease than sham and short time exposed (STE) groups after 30 days RF-EMF exposure ($p < 0.05$). Also, a significant decrease in serum testosterone levels in the LTE group was found compared to short and moderate time exposed (MTE) groups after 30 days RF-EMF exposure ($p < 0.05$). Results suggest that reproductive hormone levels are disturbed as a result of RF-EMF exposure and it may possibly affect reproductive functions. However, testosterone and inhibin B concentrations as a fertility marker and spermatogenesis were decreased significantly.

Sepehrimanesh M, Kazemipour N, Saeb M, Nazifi S, Davis DL. Proteomic analysis of continuous 900-MHz radiofrequency electromagnetic field exposure in testicular tissue: a rat model of human cell phone exposure. Environ Sci Pollut Res Int. 24(15):13666-13673, 2017.

Although cell phones have been used worldwide, some adverse and toxic effects were reported for this communication technology apparatus. To analyze in vivo effects of exposure to radiofrequency-electromagnetic field (RF-EMF) on protein expression in rat testicular proteome, 20 Sprague-Dawley rats were exposed to 900 MHz RF-EMF for 0, 1, 2, or 4 h/day for 30 consecutive days. Protein content of rat testes was separated by high-resolution two-dimensional electrophoresis using immobilized pH gradient (pI 4-7, 7 cm) and 12% acrylamide and identified by MALDI-TOF/TOF-MS. Two protein spots were found differentially overexpressed ($P < 0.05$) in intensity and volume with induction factors 1.7 times greater after RF-EMF exposure. After 4 h of daily exposure for 30 consecutive days, ATP synthase beta subunit (ASBS) and hypoxia up-regulated protein 1 precursor (HYOU1) were found to be significantly up-regulated. These proteins affect signaling pathways in rat testes and spermatogenesis and play a critical role in protein folding and

secretion in the endoplasmic reticulum. Our results indicate that exposure to RF-EMF produces increases in testicular proteins in adults that are related to carcinogenic risk and reproductive damage. In light of the widespread practice of men carrying phones in their pockets near their gonads, where exposures can exceed as-tested guidelines, further study of these effects should be a high priority.

Shahbazi-Gahrouei D, Mortazavi SM, Nasri H, Baradaran A, Baradaran-Ghahfarokhi M, Baradaran-Ghahfarokhi HR. Mobile phone radiation interferes laboratory immunoenzymometric assays: Example chorionic gonadotropin assays. Pathophysiology. 19(1):43-47, 2012.

The radiofrequency radiation is of concern in hospital laboratories as the microwaves have many health effects even on immune functions. The aim of this study was, however, to evaluate the effects of cell phone radiation on chorionic gonadotropin immunoassays of human serum. Two cell phones with 0.69 and 1.09W/kg (head SAR) emitting 900MHz radiation were used. Sixty wells with five human serum concentrations (0, 10, 100, 250, 500mIU/mL) were used in three batches. The well heads in each batch were exposed to 900MHz emitted from these phones, and the 0.69, 1.09W/kg exposed batches were compared with the unexposed controls. Radiation exposure from mobile phones altered the measured serum levels especially in the wells with 100, 250, 500mIU/mL hormone concentrations. Exposure at 1.09W/kg SAR caused a significant loss compared to 0.69W/kg SAR exposure. In conclusion, the microwave exposures may require attention in laboratories using immunoassays.

Shahbazi-Gahrouei D, Hashemi-Beni B, Ahmadi Z. Effects of RF-EMF Exposure from GSM Mobile Phones **on Proliferation Rate of Human Adipose-derived Stem Cells: An In-vitro Study. J Biomed Phys Eng. 6(4):243-252, 2016.**

BACKGROUND: As the use of **mobile phones** is increasing, public concern about the harmful effects of radiation emitted by these devices is also growing. In addition, protection questions and biological effects are among growing concerns which have remained largely unanswered. Stem cells are useful models to assess the effects of radiofrequency electromagnetic fields (RF-EMF) on other **cell** lines. Stem cells are undifferentiated biological cells that can differentiate into specialized cells. Adipose tissue represents an abundant and accessible source of adult stem cells. The aim of this study is to investigate the effects of GSM 900 MHz on growth and proliferation of mesenchymal stem cells derived from adipose tissue within the specific distance and intensity. MATERIALS AND METHODS: ADSCs were exposed to GSM **mobile phones** 900 MHz with intensity of 354.6 μW/cm^2 square waves (217 Hz pulse frequency, 50% duty cycle), during different exposure times ranging from 6 to 21 min/day for 5 days at 20 cm distance from the antenna. MTT assay was used to determine the growth and metabolism of cells and trypan blue test was also done for **cell** viability. Statistical analyses were carried out using analysis of one way ANOVA. $P<0.05$ was considered to be statistically significant. RESULTS: The proliferation rates of human ADSCs in all exposure groups were significantly lower than control groups ($P<0.05$) except in the group of 6 minutes/day which did not show any significant difference with control groups. CONCLUSION: The

results show that 900 MHz RF signal radiation from antenna can reduce **cell** viability and proliferation rates of human ADSCs regarding the duration of exposure.

Shahin S, Mishra V, Singh SP, Chaturvedi CM. 2.45-GHz microwave irradiation adversely affects reproductive function in male mouse, Mus musculus by inducing oxidative and nitrosative stress. Free Radic Res. 48(5):511-525, 2014.

Electromagnetic radiations are reported to produce long-term and short-term biological effects, which are of great concern to human health due to increasing use of devices emitting EMR especially microwave (MW) radiation in our daily life. In view of the unavoidable use of MW emitting devices (microwaves oven, mobile phones, Wi-Fi, etc.) and their harmful effects on biological system, it was thought worthwhile to investigate the long-term effects of low-level MW irradiation on the reproductive function of male Swiss strain mice and its mechanism of action. Twelve-week-old mice were exposed to non-thermal low-level 2.45-GHz MW radiation (CW for 2 h/day for 30 days, power density = 0.029812 mW/cm(2) and SAR = 0.018 W/Kg). Sperm count and sperm viability test were done as well as vital organs were processed to study different stress parameters. Plasma was used for testosterone and testis for 3β HSD assay. Immunohistochemistry of 3β HSD and nitric oxide synthase (i-NOS) was also performed in testis. We observed that MW irradiation induced a significant decrease in sperm count and sperm viability along with the decrease in seminiferous tubule diameter and degeneration of seminiferous tubules. Reduction in testicular 3β HSD activity and plasma testosterone levels was also noted in the exposed group of mice. Increased expression of testicular i-NOS was observed in the MW-irradiated group of mice. Further, these adverse reproductive effects suggest that chronic exposure to nonionizing MW radiation may lead to infertility via free radical species-mediated pathway.

Shahin S, Singh VP, Shukla RK, Dhawan A, Gangwar RK, Singh SP, Chaturvedi CM. 2.45 GHz microwave irradiation-induced oxidative stress affects implantation or pregnancy in mice, Mus musculus. Appl Biochem Biotechnol. 169(5):1727-1751, 2013.

The present experiment was designed to study the 2.45 GHz low-level microwave (MW) irradiation-induced stress response and its effect on implantation or pregnancy in female mice. Twelve-week-old mice were exposed to MW radiation (continuous wave for 2 h/day for 45 days, frequency 2.45 GHz, power density=0.033549 mW/cm(2), and specific absorption rate=0.023023 W/kg). At the end of a total of 45 days of exposure, mice were sacrificed, implantation sites were monitored, blood was processed to study stress parameters (hemoglobin, RBC and WBC count, and neutrophil/lymphocyte (N/L) ratio), the brain was processed for comet assay, and plasma was used for nitric oxide (NO), progesterone and estradiol estimation. Reactive oxygen species (ROS) and the activities of ROS-scavenging enzymes- superoxide dismutase, catalase, and glutathione peroxidase-were determined in the liver, kidney and ovary. We observed that implantation sites were affected significantly in MW-irradiated mice as compared to control. Further, in addition to a significant increase in ROS, hemoglobin ($p<0.001$), RBC and WBC counts ($p<0.001$), N/L ratio ($p<0.01$), DNA damage ($p<0.001$) in brain cells, and plasma estradiol

concentration ($p<0.05$), a significant decrease was observed in NO level ($p<0.05$) and antioxidant enzyme activities of MW-exposed mice. Our findings led us to conclude that a low level of MW irradiation-induced oxidative stress not only suppresses implantation, but it may also lead to deformity of the embryo in case pregnancy continues. We also suggest that MW radiation-induced oxidative stress by increasing ROS production in the body may lead to DNA strand breakage in the brain cells and implantation failure/resorption or abnormal pregnancy in mice.

Shallom JM, Di Carlo AL, Ko D, Penafiel LM, Nakai A, Litovitz TA. Microwave exposure induces Hsp70 and confers protection against hypoxia in chick embryos. J Cell Biochem 86(3):490-496, 2002.

To determine if microwave exposure could elicit a biological effect in the absence of thermal stress, studies were designed in which chick embryos were exposed to athermal microwave radiation (915 MHz) to look for induction of Hsp70, a protein produced during times of cellular stress that aids in the protection of cellular components. Levels of Hsp70 were found to increase within 2 h, with maximum expression (approximately 30% higher than controls) typically occurring by 3 h from the start of exposure. Other embryos were exposed to microwave radiation prior to being subjected to hypoxic stress, and were found to have significantly higher survival ($P < 0.05$) following re-oxygenation than non-exposed controls. The results of these studies indicate that not only can athermal microwave exposures activate the stress protein response pathway; they can also enhance survivability following exposure to a subsequent, potentially lethal stress. From a public health standpoint, it is important that more studies be performed to determine if repeated exposures, a condition likely to be found in cell phone use, are still beneficial.

Sharma A, Sisodia R, Bhatnagar D, Saxena VK. Spatial memory and learning performance and its relationship to protein synthesis of Swiss albino mice exposed to 10 GHz microwaves. Int J Radiat Biol. 2013 Aug 19. [Epub ahead of print]

Purpose: To study the possible role of microwave (MW) exposure on spatial memory of Swiss albino mice and its relationship to protein concentration in whole brain. Materials and methods: Mice were exposed to 10 GHz (Giga Hertz) microwaves with the power density of 0.25 mW/cm^2 (milliwatt per centimeter square) with average whole body specific absorption rate (SAR) 0.1790 W/kg daily for 2 hours per day (h/day) for 30 days. After exposure mice were tested for spatial memory performance using Morris water maze test (MWT). For this purpose mice (6-8 weeks old) were divided into two groups (i) sham exposed and, (ii) microwaves exposed. After initial training for two days, MWT was performed for another 6 days. Protein was estimated 48 hours after exposure and immediately after completion of MWT. Results: Both sham exposed and microwave exposed animals showed a significant decrease in escape time with training. Microwave exposed animals had statistically significant higher mean latency to reach the target quadrant compared to sham exposed. A concurrent decrease in protein levels was estimated in whole brain of the exposed mice compared to sham exposed mice. Conclusions: It can be concluded from the current study that exposure to microwave radiation caused decrements in the ability

of mice to learn the special memory task, this may be due to simultaneous decrease in protein levels in the brain of mice.

Sharma A, Kesari KK, Saxena VK, Sisodia R. Ten gigahertz microwave radiation impairs spatial memory, enzymes activity, and histopathology of developing mice brain. Mol Cell Biochem. 2017 May 3. doi: 10.1007/s11010-017-3051-8. [Epub ahead of print]

For decades, there has been an increasing concern about the potential hazards of non-ionizing electromagnetic fields that are present in the environment and alarming as a major pollutant or electro-pollutant for health risk and neuronal diseases. Therefore, the objective of the present study was to explore the effects of 10 GHz microwave radiation on developing mice brain. Two weeks old mice were selected and divided into two groups (i) sham-exposed and (ii) microwave-exposed groups. Animals were exposed for 2 h/day for 15 consecutive days. After the completion of exposure, within an hour, half of the animals were autopsied immediately and others were allowed to attain 6 weeks of age for the follow-up study. Thereafter results were recorded in terms of various biochemical, behavioral, and histopathological parameters. Body weight result showed significant changes immediately after treatment, whereas non-significant changes were observed in mice attaining 6 weeks of age. Several other endpoints like brain weight, lipid peroxidation, glutathione, protein, catalase, and superoxide dismutase were also found significantly ($p < 0.05$) altered in mice whole brain. These significant differences were found immediately after exposure and also in follow-up on attaining 6 weeks of age in microwave exposure group. Moreover, statistically significant ($p < 0.001$) effect was investigated in spatial memory of the animals, in learning to locate the position of platform in Morris water maze test. Although in probe trial test, sham-exposed animals spent more time in searching for platform into the target quadrant than in opposite or other quadrants. Significant alteration in histopathological parameters (qualitative and quantitative) was also observed in CA1 region of the hippocampus, cerebral cortex, and ansiform lobule of cerebellum. Results from the present study concludes that the brain of 2 weeks aged mice was very sensitive to microwave exposure as observed immediately after exposure and during follow-up study at 6 weeks of age

Sharma VP, Singh HP, Batish DR, Kohli RK. Cell phone radiations affect early growth of Vigna radiata (mung bean) through biochemical alterations. Z Naturforsch C. 65(1-2):66-72, 2010.

The indiscriminate use of wireless technologies, particularly of cell phones, has increased the health risks among living organisms including plants. We investigated the impact of cell phone electromagentic field (EMF) radiations (power density, 8.55 microW cm(-2)) on germination, early growth, proteins and carbohydrate contents, and activities of some enzymes in Vigna radiata. Cell phone EMF radiations significantly reduced the seedling length and dry weight of V radiata after exposure for 0.5, 1, 2, and 4 h. Furthermore, the contents of proteins and carbohydrates were reduced in EMF-exposed plants. However, the activities of proteases, alpha-amylases, beta-amylases, polyphenol oxidases, and peroxidases were enhanced in

EMF-exposed radicles indicating their role in providing protection against EMF-induced stress. The study concludes that cell phone EMFs impair early growth of V radiata seedlings by inducing biochemical changes.

Sharma VP, Singh HP, Kohli RK, Batish DR. Mobile phone radiation inhibits Vigna radiata (mung bean) root growth by inducing oxidative stress. Sci Total Environ. 407(21):5543-7, 2009.

During the last couple of decades, there has been a tremendous increase in the use of cell phones. It has significantly added to the rapidly increasing EMF smog, an unprecedented type of pollution consisting of radiation in the environment, thereby prompting the scientists to study the effects on humans. However, not many studies have been conducted to explore the effects of cell **phone** EMFr on growth and biochemical changes in plants. We investigated whether EMFr from cell phones inhibit growth of Vigna radiata (mung bean) through induction of conventional stress responses. Effects of cell **phone** EMFr (power density: 8.55 microW cm(-2); 900 MHz band width; for 1/2, 1, 2, and 4 h) were determined by measuring the generation of reactive oxygen species (ROS) in terms of malondialdehyde and hydrogen peroxide (H(2)O(2)) content, root oxidizability and changes in levels of antioxidant enzymes. Our results showed that cell **phone** EMFr significantly inhibited the germination (at > or =2 h), and radicle and plumule growths (> or =1 h) in mung bean in a time-dependent manner. Further, cell **phone** EMFr enhanced MDA content (indicating lipid peroxidation), and increased H(2)O(2) accumulation and root oxidizability in mung bean roots, thereby inducing oxidative stress and **cellular** damage. In response to EMFr, there was a significant upregulation in the activities of scavenging enzymes, such as superoxide dismutases, ascorbate peroxidases, guaiacol peroxidases, catalases and glutathione reductases, in mung bean roots. The study concluded that cell **phone** EMFr inhibit root growth of mung bean by inducing ROS-generated oxidative stress despite increased activities of antioxidant enzymes.

Shcheglov VS, Alipov ED, Belyaev IY. Cell-to-cell communication in response of E. coli cells at different phases of growth to low-intensity microwaves. Biochim Biophys Acta 1572(1):101-106, 2002.

Effects of millimeter waves (MMW) at the frequency of 51.755 GHz were studied in logarithmic and stationary E. coli cells at various cell densities. The changes in the genome conformational state (GCS) were analyzed by the method of anomalous viscosity time dependence (AVTD). Before lysis, the cells were adjusted to the cell density of 4x10(7) cells/ml and all AVTD measurements were run at this cell density. Stationary cells responded to MMW by increase in AVTD, while the same MMW exposure decreased AVTD in logarithmic cells. MMW effects depended on cell density during exposure and were stronger for stationary cells. The observed dependence on cell density suggested a cell-to-cell communication between cells during exposure to microwaves. Decrease in power density (PD) resulted in more striking differences between responses at different cell densities. The data provided evidence that intercellular communication in response to MMW depended on cell status and PD of microwaves. The MMW effects were studied in more detail at low intensity of 10(-17) W/cm(2) in the range of cell densities 4x10(7) to 8x10(8) cells/ml. The obtained sigmoid-

like dependence of MMW effect on cell density saturated at approximately 5x10(8) cells/ml. The dependence of MMW effect on cell density was very similar in this study and in previous studies with weak extremely low frequency (ELF) electromagnetic fields (EMF). The data suggested that cell-to-cell communication might be involved in response of cells to weak EMF of various frequency ranges.

Shckorbatov YG, Grigoryeva NN, Shakhbazov VG, Grabina VA, Bogoslavsky AM, Microwave irradiation influences on the state of human cell nuclei. Bioelectromagnetics 19(7):414-419, 1998.

Changes of electrokinetic properties of cell nuclei and the quantity of granules of heterochromatin located near the nuclear envelope in nuclei of human buccal epithelium cells were studied under the influence of electromagnetic fields in vitro. Irradiation of cells was realized by means of a semiconductor generator of millimeter radiation (wavelength 7.1 mm, frequency 42.2 GHz), the Yav-1 apparatus for extremely high frequency therapy. It was shown that irradiation of cells induced a decrease in electric charge of native human buccal epithelium cell nuclei and an increase in chromatin condensation in nuclei. The observed effects depend on irradiation dose and individual peculiarities of donors.

Shckorbatov YG, Shakhbazov VG, Navrotskaya VV, Grabina VA, Sirenko SP, Fisun AI, Gorobets NN, Kiyko VI. Application of intracellular microelectrophoresis to analysis of the influence of the low-level microwave radiation on electrokinetic properties of nuclei in human epithelial cells. Electrophoresis 23(13):2074-2079, 2002.

Intracellular microelectrophoresis was applied to investigate the electrokinetic properties of human buccal epithelium cell nuclei after exposure of cells to microwaves of wavelengths of 8 mm (f = 37.5 GHz) and 16 mm (f = 18.75 GHz) at a surface power density of 0.2 mW/cm(2). Irradiated or nonirradiated cells were suspended in a flat microelectrophoretic chamber and exposed to an electric field of 15 V/cm at a current flow of 0.1 mA. The cells, whose nuclei altered their intracellular location towards the anode of the externally applied electric field, were considered to have negatively charged nuclei. The percentage of cells with electrophoretically movable nuclei was determined as the value of electronegativity of cell nuclei (ENN). Microwaves induced changes of ENN during irradiation of 15-60 s. If cells of a donor had an elevated initial level of ENN, it decreased during irradiation. On the contrary, if cells of another donor had a low initial ENN level, irradiation induced ENN increase. No significant difference between the action of microwaves of wavelengths of 8 mm and 16 mm was found. However, microwave irradiation caused an increase in membrane permeability for the in vivo dye indigo Carmine in cells of all donors irrespectively of the initial levels they showed. This suggests that electrokinetic properties of nuclei in cells do not only depend on cell membrane permeability.

Shehu A, Mohammed A, Magaji RA, Muhammad MS. Exposure to mobile phone electromagnetic field radiation, ringtone and vibration affects anxiety-like behaviour and oxidative stress biomarkers in albino wistar rats. Metab Brain Dis. 2015 Nov 7. [Epub ahead of print]

Research on the effects of Mobile phone radio frequency emissions on biological systems has been focused on noise and vibrations as auditory stressors. This study investigated the potential effects of exposure to mobile phone electromagnetic field radiation, ringtone and vibration on anxiety-like behaviour and oxidative stress biomarkers in albino wistar rats. Twenty five male wistar rats were randomly divided into five groups of 5 animals each: group I: exposed to mobile phone in switched off mode (control), group II: exposed to mobile phone in silent mode, group III: exposed to mobile phone in vibration mode, group IV: exposed to mobile phone in ringtone mode, group V: exposed to mobile phone in vibration and ringtone mode. The animals in group II to V were exposed to 10 min call (30 missed calls for 20 s each) per day for 4 weeks. Neurobehavioural studies for assessing anxiety were carried out 24 h after the last exposure and the animals were sacrificed. Brain samples were collected for biochemical evaluation immediately. Results obtained showed a significant decrease ($P < 0.05$) in open arm duration in all the experimental groups when compared to the control. A significant decrease ($P < 0.05$) was also observed in catalase activity in group IV and V when compared to the control. In conclusion, the results of the present study indicates that 4 weeks exposure to electromagnetic radiation, vibration, ringtone or both produced a significant effect on anxiety-like behavior and oxidative stress in young wistar rats.

Shekoohi Shooli F, Mortazavi SA, Jarideh S, Nematollahii S, Yousefi F, Haghani M, Mortazavi SM, Shojaei-Fard MB. Short-Term Exposure to Electromagnetic Fields Generated by Mobile Phone Jammers Decreases the Fasting Blood Sugar in Adult Male Rats. J Biomed Phys Eng. 6(1):27-32, 2016.

BACKGROUND: Substantial evidence indicates that exposure to electromagnetic fields (EMF) above certain levels can affect human health through triggering some biological responses. According to WHO, short-term exposure to EMF at the levels present in the home/environment do not cause any apparent detrimental effects in healthy individuals. However, now, there is a debate on whether long-term exposure to low level EMF can evoke detrimental biological responses. Although based on the Communications Act of 1934, selling, advertising, using, or importing mobile jammers which block cell phone calls and text messages are illegal acts, in some countries these devices are being used for security purpose and for prevention of cheating during examinations. **METHODS:** In this study 30 male Wistar rats were randomly divided into 3 groups of 10 each. The control group received no radiation. The sham exposure group was exposed to a switched-off jammer device. After fasting for 12 hours, the exposure group was exposed to EMFs at a distance of 50 cm from the jammer. Blood samples were collected from the tail vein after 24, 48 and72 hours and fasting blood sugar was measured by using a common blood glucose monitor (BIONIME GM110, Taiwan). The significance level was considered 5% and SPSS Ver. 21 was used for statistical analysis. The data were analyzed by ANOVA followed by Tukey's test. **RESULTS:** A statistically significant difference was observed between blood sugar level in the control and exposure groups after 24, 48 and 72 hours of continuous irradiation (p values were <0.001, <0.001 and 0.002, respectively). No significant difference was found between the level of fasting blood sugar in control and sham groups. **CONCLUSION:** Short-term exposure to electromagnetic field

generated by mobile phone jammer can reduce blood sugar level in adult male rats. These findings, in contrast with our previous results, lead us to this conclusion that the use of these signal blocking devices in very specific circumstances may have some therapeutic effects. However, further studies have to be performed to find out the exact mechanism by which Jammer EMFs reduce fasting blood sugar.

Shen YH, Yu D, Fu YT, Chiang H. [Effects of mobile-phone microwave on dimethylbenz (a) anthracene induced mammary carcinoma development in rats.] Zhonghua Yu Fang Yi Xue Za Zhi. 40(3):164-167, 2006. [Article in Chinese]

OBJECTIVE: To investigate whether exposure to 900 MHz GSM wireless communication signals enhances mammary tumor development and growth induced by low dose dimethylbenz (a) anthracene (DMBA). METHODS: Five hundred female Sprague Dawley (SD) rats were treated with a single dose of 35 mg/kg. DMBA and then divided into 5 groups: one control group without exposure, and 4 groups with exposure in blinded fashion. The specific absorption rates (SAR) were 0, 0.44, 1.33 and 4.00 W/kg for the 4 exposure groups, respectively. Exposure started on the next day after DMBA administration and lasted 4 hours/day, 5 days/week for 26 weeks. Rats were weighted and palpated weekly for the presence of tumors, and killed at the end of 26-week exposure period. All mammary glands were examined histopathologically. RESULTS: The incidence of mammary carcinoma in sham-exposure group was 37% (37/100). And mammary carcinoma incidences in the other groups of the exposure dose (0.44, 1.33 and 4.00 W/kg) were 25% (25/100), 34% (34/99) and 38% (38/100) respectively. There were no statistically significant differences between sham- and mobile phone microwave-exposed groups. In addition, the histopathological morphology of mammary tumor model in SD rats was observed. By microscopical examination two types of mammary tumor in this model were found, that was malignant or benign one. The former included adenocarcinoma and squamous cell carcinoma, and the latter included adenoma, fibroadenoma and cyst. Sometimes the histopathological morphology of mammary tumor appeared various since several kinds of histopathological features existed in the same individual. CONCLUSION: This study does not provide the evidence that 900 MHz GSM microwave exposure might promote DMBA-induced mammary tumor development in rats.

Sherry CJ, Blick DW, Walters TJ, Brown GC, Murphy MR, Lack of behavioral effects in non-human primates after exposure to ultrawideband electromagnetic radiation in the microwave frequency range. Radiat Res 143(1):93-97, 1995.

The effect of acute exposure to ultrawideband (UWB) electromagnetic radiation on the Primate Equilibrium Platform (PEP) task, where the monkey's task is to manipulate a joystick control to compensate for the random perturbations in the pitch plane that are generated by a computer at unpredictable intervals, was examined. The duration of the UWB exposure was 2 min at a pulse repetition rate of 60 Hz (total of 7200 pulses). The bandwidth of the pulse was 100 MHz to 1.5 GHz (peak power between 250-500 MHz) with a peak E-field strength of 250 kV/m. Each monkey was exposed twice. The interval between exposures was 6 days. The exposure to UWB electromagnetic radiation had no effect on PEP performance when tested immediately after exposure.

Shinar D, Tractinsky N, Compton R. Effects of practice, age, and task demands, on interference from a phone task while driving. Accid Anal Prev. 37(2):315-326, 2005.

Experimental research on the effects of cellular phone conversations on driving indicates that the phone task interferes with many driving-related functions, especially with older drivers. Unfortunately in past research (1) the dual task conditions were not repeated in order to test for learning, (2) the 'phone tasks' were not representative of real conversations, and (3) most often both the driving and the phone tasks were experimenter-paced. In real driving drivers learn to time-share various tasks, they can pace their driving to accommodate the demands of a phone conversation, and they can even partially pace the phone conversation to accommodate the driving demands. The present study was designed to better simulate real driving conditions by providing a simulated driving environment with repeated experiences of driving while carrying two different hands-free 'phone' tasks with different proximities to real conversations. In the course of five sessions of driving and using the phone, there was a learning effect on most of the driving measures. In addition, the interference from the phone task on many of the driving tasks diminished over time as expected. Finally, the interference effects were greater when the phone task was the often-used artificial math operations task than when it was an emotionally involving conversation, when the driving demands were greater, and when the drivers were older. Thus, the deleterious effects of conversing on the phone are very real initially, but may not be as severe with continued practice at the dual task, especially for drivers who are not old.

Shirai T, Kawabe M, Ichihara T, Fujiwara O, Taki M, Watanabe SI, Wake K, Yamanaka Y, Imaida K, Asamoto M, Tamano S. Chronic exposure to a 1.439 GHz electromagnetic field used for cellular phones does not promote N-ethylnitrosourea induced central nervous system tumors in F344 rats. Bioelectromagnetics 26:59-68, 2005.

The present study was designed to evaluate whether a 2 year exposure to an electromagnetic field (EMF) equivalent to that generated by cellular phones can accelerate tumor development in the central nervous system (CNS) of rats. Brain tumorigenesis was initiated by an intrauterine exposure to N-ethylnitrosourea (ENU) on gestational day 18. A total of 500 pups were divided into five groups, each composed of 50 males and 50 females: Group 1, untreated control; Group 2, ENU alone; Groups 3-5, ENU + EMF (sham exposure and 2 exposure levels). A 1.439 GHz time division multiple access (TDMA) signal for the Personal Digital Cellular (PDC), Japanese standard cellular system was used for the exposure of the rat head starting from 5 weeks of age, 90 min a day, 5 days a week, for 104 weeks. Brain average specific absorption rate (SAR) was 0.67 and 2.0 W/kg for low and high exposures, respectively: whole body average SAR was less than 0.4 W/kg. There were no inter-group differences in body weights, food consumption, and survival rates. No increase in the incidences or numbers per group of brain and/or spinal cord tumors, either in the males or females, was detected in the EMF exposed groups. In addition, no clear changes in tumor types were evident. Thus, under the present experimental conditions, 1.439 GHz EMF exposure to the heads of rats for a 2 year period was not demonstrated to accelerate or affect ENU initiated brain tumorigenesis.

Shirai T, Ichihara T, Wake K, Watanabe SI, Yamanaka Y, Kawabe M, Taki M, Fujiwara O, Wang J, Takahashi S, Tamano S. Lack of promoting effects of chronic exposure to 1.95-GHz W-CDMA signals for IMT-2000 cellular system on development of N-ethylnitrosourea-induced central nervous system tumors in F344 rats. Bioelectromagnetics.28(7):562-572, 2007.

The present study was performed to evaluate effects of a 2-year exposure to an electromagnetic near-field (EMF) equivalent to that generated by cellular phones on tumor development in the central nervous system (CNS) of rats. For this purpose, pregnant F344 rats were given a single administration of N-ethylnitrosourea (ENU) on gestational day 18. A total of 500 pups were divided into five groups, each composed of 50 males and 50 females: Group 1, untreated controls; Group 2, ENU alone; Groups 3 to 5, ENU + EMF (sham exposure and two exposure levels). A 1.95-GHz wide-band code division multiple access (W-CDMA) signal, which is a feature of the International Mobile Telecommunication 2000 (IMT-2000) cellular system was employed for exposure of the rat head starting from 5 weeks of age, 90 min a day, 5 days a week, for 104 weeks. Brain average specific absorption rates (SARs) were designed to be .67 and 2.0 W/kg for low and high exposures, respectively. The incidence and numbers of brain tumors in female rats exposed to 1.95-GHz W-CDMA signals showed tendencies to increase but without statistical significance. Overall, no significant increase in incidences or numbers, either in the males or females, was detected in the EMF-exposed groups. In addition, no clear changes in tumor types in the brain were evident. Thus, under the present experimental conditions, exposure of heads of rats to 1.95-GHz W-CDMA signals for IMT-2000 for a 2-year period was not demonstrated to accelerate or otherwise affect ENU-initiated brain tumorigenesis.

Shirai T, Imai N, Wang J, Takahashi S, Kawabe M, Wake K, Kawai H, Watanabe S-I, Furukawa F, Fujiwara O. Multigenerational effects of whole body exposure to 2.14 GHz W-CDMA cellular phone signals on brain function in rats. Bioelectromagnetics 35(7):497-511, 2014.

The present experimental study was carried out with rats to evaluate the effects of whole body exposure to 2.14 GHz band code division multiple access (W-CDMA) signals for 20 h a day, over three generations. The average specific absorption rate (SAR, in unit of W/kg) for dams was designed at three levels: high (<0.24 W/kg), low (<0.08 W/kg), and 0 (sham exposure). Pregnant mothers (4 rats/group) were exposed from gestational day (GD) 7 to weaning and then their offspring (F_1 generation, 4 males and 4 females/dam, respectively) were continuously exposed until 6 weeks of age. The F_1 females were mated with F_1 males at 11 weeks old, and then starting from GD 7, they were exposed continuously to the electromagnetic field (EMF; one half of the F1 offspring was used for mating, that is, two of each sex per dam and 8 males and 8 females/group, except for all offspring for the functional development tests). This protocol was repeated in the same manner on pregnant F_2 females and F_3 pups; the latter were killed at 10 weeks of age. No abnormalities were observed in the mother rats (F_0, F_1, and F_2) and in the offspring (F_1, F_2, and F_3) in any biological parameters, including neurobehavioral function. Thus, it was concluded that under the experimental conditions applied, multigenerational whole body exposure to

2.14 GHz W-CDMA signals for 20 h/day did not cause any adverse effects on the F_1, F_2, and F_3 offspring.

Shirai T, Wang J, Kawabe M, Wake K, Watanabe SI, Takahashi S, Fujiwara O. No adverse effects detected for simultaneous whole-body exposure to multiple-frequency radiofrequency electromagnetic fields for rats in the intrauterine and pre- and post-weaning periods. J Radiat Res. 58(1):48-58, 2017.

In everyday life, people are exposed to radiofrequency (RF) electromagnetic fields (EMFs) with multiple frequencies. To evaluate the possible adverse effects of multifrequency RF EMFs, we performed an experiment in which pregnant rats and their delivered offspring were simultaneously exposed to eight different communication signal EMFs (two of 800 MHz band, two of 2 GHz band, one of 2.4 GHz band, two of 2.5 GHz band and one of 5.2 GHz band). Thirty six pregnant Sprague-Dawley (SD) 10-week-old rats were divided into three groups of 12 rats: one control (sham exposure) group and two experimental (low- and high-level RF EMF exposure) groups. The whole body of the mother rats was exposed to the RF EMFs for 20 h per day from Gestational Day 7 to weaning, and F_1 offspring rats (46-48 F1 pups per group) were then exposed up to 6 weeks of age also for 20 h per day. The parameters evaluated included the growth, gestational condition and organ weights of the dams; the survival rates, development, growth, physical and functional development, memory function, and reproductive ability of the F_1 offspring; and the embryotoxicity and teratogenicity in the F_2 rats. No abnormal findings were observed in the dams or F_1 offspring exposed to the RF EMFs or to the F_2 offspring for any of the parameters evaluated. Thus, under the conditions of the present experiment, simultaneous whole-body exposure to eight different communication signal EMFs at frequencies between 800 MHz and 5.2 GHz did not show any adverse effects on pregnancy or on the development of rats.

Shivashankara AR, Joy J, Sunitha V, Rai MP, Rao S, Nambranathayil S, Baliga MS. Effect of cell phone use on salivary total protein, enzymes and oxidative stress markers in young adults: a pilot study. J Clin Diagn Res. 9(2):BC19-22, 2015.

INTRODUCTION: The present study aimed to assess the levels of salivary enzymes, protein and oxidant-antioxidant system in young college-going cell phone users. MATERIALS AND METHODS: The cell users (students) were categorized in to two groups - less mobile users and high mobile users, based on the duration and frequency of cell use. Unstimulated whole saliva samples of the volunteers were analysed for amylase, lactate dehydrogenase (LDH), malondialdehdye (MDA) and glutathione (GSH). RESULTS: High mobile users had significantly higher levels of amylase ($p = 0.001$), LDH ($p = 0.002$) and MDA ($p = 0.002$) in saliva, when compared to less mobile users. The marginal decrease in salivary total proteins, GSH and flow rate were statistically not significant ($p > 0.05$). CONCLUSION: Significant changes in salivary enzymes and MDA suggest adverse effect of high use of cell phones on cell health.

Shokri S, Soltani A, Kazemi M, Sardari D, Mofrad FB. Effects of Wi-Fi (2.45 GHz) Exposure on Apoptosis, Sperm Parameters and Testicular Histomorphometry in

Rats: A Time Course Study. Cell J. 17(2):322-331, 2015.

OBJECTIVE: In today's world, 2.45-GHz radio-frequency radiation (RFR) from industrial, scientific, medical, military and domestic applications is the main part of indoor-outdoor electromagnetic field exposure. Long-term effects of 2.45-GHz Wi-Fi radiation on male reproductive system was not known completely. Therefore, this study aimed to investigate the major cause of male infertility during short- and long-term exposure of Wi-Fi radiation. MATERIALS AND METHODS: This is an animal experimental study, which was conducted in the Department of Anatomical Sciences, Faculty of Medicine, Zanjan University of Medical Sciences, Zanjan, IRAN, from June to August 2014. Three-month-old male Wistar rats (n=27) were exposed to the 2.45 GHz radiation in a chamber with two Wi-Fi antennas on opposite walls. Animals were divided into the three following groups: I. control group (n=9) including healthy animals without any exposure to the antenna, II. 1-hour group (n=9) exposed to the 2.45 GHz Wi-Fi radiation for 1 hour per day during two months and III.7-hour group (n=9) exposed to the 2.45 GHz Wi-Fi radiation for 7 hours per day during 2 months. Sperm parameters, caspase-3 concentrations, histomorphometric changes of testis in addition to the apoptotic indexes were evaluated in the exposed and control animals. RESULTS: Both 1-hour and 7-hour groups showed a decrease in sperm parameters in a time dependent pattern. In parallel, the number of apoptosis-positive cells and caspase-3 activity increased in the seminiferous tubules of exposed rats. The seminal vesicle weight reduced significantly in both1-hour or 7-hour groups in comparison to the control group. CONCLUSION: Regarding the progressive privilege of 2.45 GHz wireless networks in our environment, we concluded that there should be a major concern regarding the time-dependent exposure of whole-body to the higher frequencies of Wi-Fi networks existing in the vicinity of our living places.

Shrestha M, Raitanen J, Salminen T, Lahkola A, Auvinen A. Pituitary tumor risk in relation to mobile phone **use: A case-control study. Acta Oncol. 2015 May 18:1-7. [Epub ahead of print]**

BACKGROUND: The number of **mobile phone** users has grown rapidly, which has generated mounting public concern regarding possible health hazards. This study aims to assess pituitary tumor risk, as it has rarely been investigated. MATERIAL AND METHODS: A case-control study was conducted with 80 eligible cases identified from all five university hospitals in Finland and frequency-matched 240 controls from the national population register. Controls were matched to cases by age, sex, region of residence and date of interview. A detailed history of **mobile phone** use was obtained using a structured interview. Several indicators of **mobile phone** use were assessed using conditional logistic regression. RESULTS: A reduced odds ratio was seen among regular **mobile phone** users [OR 0.39, 95% confidence interval (CI) 0.21, 0.72] relative to never/non-regular users, possibly reflecting methodological limitations. Pituitary tumor risk was not increased after 10 or more years since first use (OR 0.69, 95% CI 0.25, 1.89). The risk was not increased in relation to duration, cumulative hours of use, or cumulative number of calls. The results were similar for analog and digital **phones**. CONCLUSIONS: We found no excess risk associated with self-reported short- or medium-term use of **mobile phones**. This is consistent with most of the published studies. However, uncertainties

remained for longer duration of use, as a very small proportion of study participants reported use beyond 10 years.

Shtemberg AS, Uzbekov MG, Shikhov SN, Bazian AS, Cherniakov GM, [Species specificity, age factors, and various neurochemical correlates of the animal spontaneous behavior after exposure to electromagnetic field of the ultralow intensity]. Zh Vyssh Nerv Deiat Im I P Pavlova 50(4):703-715, 2000. [Article in Russian]

Behavioral and neurochemical reactions of small laboratory animals (mice and rats of different age) under exposure to ultralow-intensity electromagnetic fields (EMF, frequency of 4200 and 970 MHz, modulated by a quasistochastic signal in the range of 20-20,000 Hz, power density 15 microW/cm2, specific body absorption rate up to 4.5 mJ/kg) were studied. The EMF basically inhibited the locomotor and exploratory activity in the "open-field" test. The species- and age-specific features rather than radiation conditions dominated. However, decrease in the EMF frequency considerably intensified the observed effect. Change in animal behavior was accompanied by shifts in neurochemical processes, i.e., sharp activation of serotoninergic and inhibition of morepinephrinergic system.

Sidorenko AV, The analysis of animal bioelectric brain activity influenced by microwaves or by the introduction of strychnine. Bioelectrochem Bioenerg 48(1):223-226, 1999.

The widespread impact made by technology has raised concerns about the safety of human exposure to electromagnetic radiation in the environment. The brain is especially sensitive to the influence of microwaves. The most effective method for estimation of the organism's functional states is an analysis of electroencephalograms. The statistical and spectral methods are usually used for analysis of animal electrocorticograms. The information obtained in such way is the integrated character and it is sometimes insufficient for identification of the brain state charging caused by various factors, especially microwaves altering the ecological situation. The nonlinear dynamics method is used in our work concurrent with the spectral correlation method for animal electrocorticogram processing. The correlation dimensionality represents a numerical criterion allowing for comparative investigation of various dynamic states of the system. In the process of investigation, it has been found that the nonlinear dynamics method may be used to analyze the electrocorticograms of experimental animal in different functional states being confirmed by increasing parameter of the correlation dimensionality in electrocorticograms of animal irradiated by microwaves or subjected to the introduction of strychnine.

Sidorenko A, Tsaryuk V, Effects of microwave radiation and strychnine on cerebral biopotentials in narcotized rats. Bull Exp Biol Med 130(9):835-837, 2000.

Strychnine and microwave radiation produced changes in spectral parameters of electrocorticogram, correlation dimension, and Kolmogorov entropy, parameters calculated by the methods of nonlinear dynamics opposite to those induced by urethane. The modulatory effect of microwaves on bioelectric cerebral activity in narcotized animals

was similar to the effect of strychnine and probably related to enhanced excitability of brain structures and complication of bioelectric processes.

Sienkiewicz ZJ, Blackwell RP, Haylock RG, Saunders RD, Cobb BL, Low-level exposure to pulsed 900 MHz microwave radiation does not cause deficits in the performance of a spatial learning task in mice. Bioelectromagnetics 21(3):151-158, 2000.

There is some concern that short-term memory loss or other cognitive effects may be associated with the use of mobile cellular telephones. In this experiment, the effect of repeated, acute exposure to a low intensity 900 MHz radiofrequency (RF) field pulsed at 217 Hz was explored using an appetitively-motivated spatial learning and working memory task. Adult male C57BL/6J mice were exposed under far field conditions in a GTEM cell for 45 min each day for 10 days at an average whole-body specific energy absorption rate (SAR) of 0.05 W/kg. Their performance in an 8-arm radial maze was compared to that of sham-exposed control animals. All behavioral assessments were performed without handlers having knowledge of the exposure status of the animals. Animals were tested in the maze immediately following exposure or after a delay of 15 or 30 min. No significant field-dependent effects on performance were observed in choice accuracy or in total times to complete the task across the experiment. These results suggest that exposure to RF radiation simulating a digital wireless telephone (GSM) signal under the conditions of this experiment does not affect the acquisition of the learned response. Further studies are planned to explore the effects of other SARs on learned behavior.

Sieroń-Stołtny K, Teister Ł, Cieślar G, Sieroń D, Śliwinski Z, Kucharzewski M, Sieroń A. The influence of electromagnetic radiation generated by a mobile phone on the skeletal system of rats. Biomed Res Int. 2015;2015:896019. doi: 10.1155/2015/896019. Epub 2015 Feb 1.

The study was focused on the influence of electromagnetic field generated by mobile phone on the skeletal system of rats, assessed by measuring the macrometric parameters of bones, mechanical properties of long bones, calcium and phosphorus content in bones, and the concentration of osteogenesis (osteocalcin) and bone resorption (NTX, pyridinoline) markers in blood serum. The study was carried out on male rats divided into two groups: experimental group subjected to 28-day cycle of exposures in electromagnetic field of 900 MHz frequency generated by mobile phone and a control, sham-exposed one. The mobile phone-generated electromagnetic field did not influence the macrometric parameters of long bones and L4 vertebra, it altered mechanical properties of bones (stress and energy at maximum bending force, stress at fracture), it decreased the content of calcium in long bones and L4 vertebra, and it altered the concentration of osteogenesis and bone resorption markers in rats. On the basis of obtained results, it was concluded that electromagnetic field generated by 900 MHz mobile phone does not have a direct impact on macrometric parameters of bones; however, it alters the processes of bone mineralization and the intensity of bone turnover processes and thus influences the mechanical strength of bones.

Sievert U, Eggert S, Pau HW. Can mobile phone emissions affect auditory functions of cochlea or brain stem? Otolaryngol Head Neck Surg. 132(3):451-455, 2005.

Problems addressed Despite their abundant spread, mobile phones are suspected by a major share of the population to cause adverse effects on health and welfare. The ear as the sense organ next to the individual device has rarely been investigated for short-term effects in this regard. In a previous article, we could not prove any impact on the vestibular part of the inner ear. Our present examinations are concerned with the question whether mobile phone emissions could affect cochlear or auditory brain stem functions. Methods and measures In 12 healthy test persons with normal hearing, auditory brain stem reflexes recordings were performed before, during, and after exposure to electromagnetic emissions by standardized mobile phone devices. Two modes of electromagnetic emissions fields were administered: pulsed and continuous. For acoustic stimulation simultaneous to field exposure, special "plug-in" earphones had to be used. Results No impact on auditory brain stem reflexes recordings in terms of absolute and interpeak latencies could be found. Clinical significance Together with the results of a previous article concerned with the vestibular part of the inner ear, we can state that there are no adverse effects of mobile phone emissions on the ear function, at least on a short-term range. Of course, any long-term effects cannot be excluded by our study.

Silva V, Hilly O, Strenov Y, Tzabari C, Hauptman Y, Feinmesser R. Effect of cell phone-like electromagnetic radiation on primary human thyroid cells. Int J Radiat Biol. 2015 Dec 21:1-9. [Epub ahead of print]

Purpose To evaluate the potential carcinogenic effects of radiofrequency energy (RFE) emitted by cell phones on human thyroid primary cells. Materials and methods Primary thyroid cell culture was prepared from normal thyroid tissue obtained from patients who underwent surgery at our department. Subconfluent thyroid cells were irradiated under different conditions inside a cell incubator using a device that simulates cell phone-RFE. Proliferation of control and irradiated cells was assessed by the immunohistochemical staining of antigen Kiel clone-67 (Ki-67) and tumor suppressor p53 (p53) expression. DNA ploidy and the stress biomarkers heat shock protein 70 (HSP70) and reactive oxygen species (ROS) was evaluated by fluorescence-activated cell sorting (FACS). Results Our cells highly expressed thyroglobulin (Tg) and sodium-iodide symporter (NIS) confirming the origin of the tissue. None of the irradiation conditions evaluated here had an effect neither on the proliferation marker Ki-67 nor on p53 expression. DNA ploidy was also not affected by RFE, as well as the expression of the biomarkers HSP70 and ROS. Conclusion Our conditions of RFE exposure seem to have no potential carcinogenic effect on human thyroid cells. Moreover, common biomarkers usually associated to environmental stress also remained unchanged. We failed to find an association between cell phone-RFE and thyroid cancer. Additional studies are recommended.

Silvi A M, Zari A, Licitra G. Assessment of the temporal trend of the exposure of people to electromagnetic fields produced by base stations for mobile telephones. Radiat Prot Dosimetry 97(4):387-390, 2001.

Monitoring of electric field levels produced by base stations (BSs) for mobile telephones

of different typologies (TACS. GSM, DCS) has been carried out. Results show that BSs can be classified as 'business' or 'residential'. The mean value of six minutes averaged E-field value measured between 10 a.m. and 1 p.m. corresponds to the 84% of the maximum daily six minutes averaged value. Comparison between electromagnetic field levels produced by BSs and their phone traffic data, supplied by companies, is shown. Finally, on an hourly average basis, a daily curve has been constructed of the exposure trend produced by such installations.

Silva V, Hilly O, Strenov Y, Tzabari C, Hauptman Y, Feinmesser R. Effect of cell phone-like electromagnetic radiation on primary human thyroid cells. Int J Radiat Biol. 2015 Dec 21:1-9. [Epub ahead of print]

Purpose To evaluate the potential carcinogenic effects of radiofrequency energy (RFE) emitted by cell phones on human thyroid primary cells. Materials and methods Primary thyroid cell culture was prepared from normal thyroid tissue obtained from patients who underwent surgery at our department. Subconfluent thyroid cells were irradiated under different conditions inside a cell incubator using a device that simulates cell phone-RFE. Proliferation of control and irradiated cells was assessed by the immunohistochemical staining of antigen Kiel clone-67 (Ki-67) and tumor suppressor p53 (p53) expression. DNA ploidy and the stress biomarkers heat shock protein 70 (HSP70) and reactive oxygen species (ROS) was evaluated by fluorescence-activated cell sorting (FACS). Results Our cells highly expressed thyroglobulin (Tg) and sodium-iodide symporter (NIS) confirming the origin of the tissue. None of the irradiation conditions evaluated here had an effect neither on the proliferation marker Ki-67 nor on p53 expression. DNA ploidy was also not affected by RFE, as well as the expression of the biomarkers HSP70 and ROS. Conclusion Our conditions of RFE exposure seem to have no potential carcinogenic effect on human thyroid cells. Moreover, common biomarkers usually associated to environmental stress also remained unchanged. We failed to find an association between cell phone-RFE and thyroid cancer. Additional studies are recommended.

Simko M, Hartwig C, Lantow M, Lupke M, Mattsson MO, Rahman Q, Rollwitz J. Hsp70 expression and free radical release after exposure to non-thermal radio-frequency electromagnetic fields and ultrafine particles in human Mono Mac 6 cells. Toxicol Lett. 161(1):73-82, 2006.

The contemporary urban environment has become increasingly complex in its composition, leading to discussions regarding possible novel health effects. Two factors that recently have received considerable attention are ultrafine particles (UFP; <0.1mum) produced by combustion processes and emissions from wireless communication devices like mobile phones that emit in the radio-frequency (RF) part of the spectrum. Several studies have shown biological effects of both these exposures in various cell systems. Here we investigate if exposure to UFP (12-14nm, 100mug/ml) and RF-electromagnetic fields (EMF; 2W/kg specific absorption rate (SAR); continuous wave (CW) or modulated (217Hz or GSM-nonDTX)), alone or in combination influences levels of the superoxide radical anion or the stress protein heat-shock protein (Hsp70) in the human monocyte cell line Mono Mac 6. Heat treatment (42-43 degrees C, 1h) was used as positive control for both stress reaction and for heat development in the RF exposure setup. Our results

clearly show that Mono Mac 6 cells are capable to internalise UFP, and that this phagocytic activity is connected to an increased release of free radicals. This increase (40-45% above negative control) is stronger than the effect of heat treatment. On the other hand, none of the employed RF exposures showed any effects on free radical levels. Co-exposure of RF and UFP did not potentiate the UFP effect either. Our investigations showed a significantly increased Hsp70 expression level by heat treatment in a time-dependent manner, whereas UFP, RF, or UFP+RF were without any effect. Therefore, we conclude that in the investigated Mono Mac 6 cells, RF exposure alone or in combination with UFP cannot influence stress-related responses.

Simon D, Daubos A, Pain C, Fitoussi R, Vié K, Taieb A, de Benetti L, Cario-André M.Exposure to acute electromagnetic radiation of mobile phone exposure range alters transiently skin homeostasis of a model of pigmented reconstructed epidermis.Int J Cosmet Sci. 35(1):27-34, 2013.

Exposure to electromagnetic radiations (EMR) produced by mobile phone concerns half the world's population and raises the problem of their impact on human health. In this study, we looked at the effects of mobile phone exposure (GSM basic, 900MHz, SAR 2 mW g(-1) , 6 h) on a model of pigmented skin. We have analysed the expression and localization of various markers of keratinocyte and melanocyte differentiation 2, 6, 18 and 24 h after EMR exposure of reconstructed epidermis containing either only keratinocytes or a combination of keratinocytes and melanocytes grown on dead de-epidermized dermis, using histology, immunohistochemistry and Western blot. No changes were found in epidermal architecture, localization of epidermal markers, presence of apoptotic cells and the induction of p53 in both types of epidermis (with or without melanocytes) after exposure to EMR. In pigmented reconstructs, no change in the location and dendricity of melanocytes and in melanin transfer to neighbouring keratinocytes was detected after EMR exposure. Loricrin, cytokeratin 14 were significantly decreased at 6 h. The level of all markers increased at 24 h as compared to 6 h post-EMR exposure, associated with a significant decrease of the 20S proteasome activity. Our data indicate that exposure to 900MHz frequency induces a transient alteration of epidermal homoeostasis, which may alter the protective capacity of the skin against external factors. Presence or absence of melanocytes did not modify the behaviour of reconstructs after EMR exposure.

Simsek V, Sahin H, Akay AF, Kaya H, Bircan MK. The effects of cellular telephone use on serum PSA levels in men. Int Urol Nephrol. 35(2):193-196, 2003.

BACKGROUND: The increasing use of cellular telephones is known to have harmful effects on human health. The aim of this prospective study was to determine whether cellular telephone use affected serum PSA levels in men. METHODS: Participants included 20 men with ages ranging from 22 to 65 years who had never previously used cellular telephones. Blood samples were taken prior to and 30 days after the beginning of cellular telephone use. Serum was separated from the blood samples and stored in a deep freezer until the end of the study, at which time serum free and total PSA levels were determined by tandem radioimmunoassay. The results were statistically analyzed by the Wilcoxon Paired Signed Rank Test. RESULTS: Average free and total PSA values were 2.070 ng/ml and 0.500 ng/ml before the study, and 2.0 ng/ml and 0.505 ng/ml at the

end of the study, respectively. No significant difference was determined between the initial and final values ($p > 0.05$). CONCLUSIONS: The results indicate that cellular telephone use does not significantly affect PSA values in the short term. Nevertheless, we think that there is a need for longer-term studies on this subject.

Singh B, Bate LA, Responses of pulmonary intravascular macrophages to 915-MHz microwave radiation: ultrastructural and cytochemical study. Anat Rec 246(3):343-355, 1996.

BACKGROUND: Microwave (MW) radiation is being increasingly used as a source of heat supplementation during early postnatal development of pigs. Although MW radiation does not cause deleterious physiological effects, no specific information exists regarding its impact on immune cells such as macrophages. Pulmonary intravascular macrophages (PIMs) are emerging as important inflammatory cells due to their endocytic and secretory potential. An in vivo study was conducted to evaluate the effects of infrared, and low and high power MW radiation on the PIMs of pigs. METHODS: Pigs were exposed to infrared (IR), low MW (LMW; 6.1mW cm-2), and high MW (HMW; 11.4mW cm-2) radiation at 915 MHz (n = 2 for each treatment) for 24 hr. The controls (n = 2) were exposed to natural light for the same period of time. Lung tissues were processed for ultrastructural examination and acid phosphatase (AcPase) cytochemistry. In addition, rough endoplasmic reticulum (RER) as a fraction of cytosol of the PIMs was counted. RESULTS: Ultrastructural and numerical data suggested enhanced secretory activity in the PIMs of LMW-treated pigs as indicated by the increased RER:cytoplasm ratio, prominent Golgi complex profiles, and accumulation of secretory vesicles in conjunction with microtubules as compared with the control, IR, and HMW-exposed pigs. High MW treatment induced some damage to pulmonary interstitium as deduced from the presence of extracellular AcPase precipitates and disrupted collagen matrix. Intracellular globules were noticed in the PIMs of IR and LMW-treated pigs but not in the control and HMW-radiated animals. CONCLUSIONS: Elaboration of structural signs of secretory activity in the PIMs by LMW radiation in the absence of pulmonary pathological changes indicates its potential for cell activation in addition to the already established role of LMW in heat supplementation. This activation could be due to either increased core body temperature or initiation of intracellular signaling by the LMW radiation. This study also shows that the HMW radiation is capable of inducing pathology in the form of changes in the pulmonary interstitial matrix and may not be a good source of supplementary heat.

Singh HP, Sharma VP, Batish DR, Kohli RK. Cell phone electromagnetic field radiations affect rhizogenesis through impairment of biochemical processes. Environ Monit Assess. 184(4):1813-1821, 2012.

Indiscriminate adoption and use of cell phone technology has tremendously increased the levels of electromagnetic field radiations (EMFr) in the natural environment. It has raised the concerns among the scientists regarding the possible risks of EMFr to living organisms. However, not much has been done to assess the damage caused to plants that are continuously exposed to EMFr present in the environment. The present study investigated the biochemical mechanism of

interference of 900 MHz cell phone EMFr with root formation in mung bean (Vigna radiata syn. Phaseolus aureus) hypocotyls, a model system to study rhizogenesis in plants. Cell phone EMFr enhanced the activities of proteases (by 1.52 to 2.33 times), polyphenol oxidases (by 1.5 to 4.3 times), and peroxidases (by 1.5 to 2.0 times) in mung bean hypocotyls over control. Further, EMFr enhanced malondialdehyde (an indicator of lipid peroxidation), hydrogen peroxide, and proline content, indicating a reactive oxygen species-mediated oxidative damage in hypocotyls. It was confirmed by the upregulation in the activities of antioxidant enzymes (superoxide dismutase, ascorbate peroxidase, guaiacol peroxidase, catalase, and glutathione reductase) suggesting their possible role in providing protection against EMFr-induced oxidative damage. The study concluded that cell phone radiations affect the process of rhizogenesis through biochemical alterations that manifest as oxidative damage resulting in root impairment.

Singh K, Nagaraj A, Yousuf A, Ganta S, Pareek S, Vishnani P. Effect of electromagnetic radiations from mobile phone base stations on general health and salivary function. J Int Soc Prevent Communit Dent 6:54-59, 2016.

Objective: Cell phones use electromagnetic, nonionizing radiations in the microwave range, which some believe may be harmful to human health. The present study aimed to determine the effect of electromagnetic radiations (EMRs) on unstimulated/stimulated salivary flow rate and other health-related problems between the general populations residing in proximity to and far away from mobile phone base stations. Materials and Methods: A total of four mobile base stations were randomly selected from four zones of Jaipur, Rajasthan, India. Twenty individuals who were residing in proximity to the selected mobile phone towers were taken as the case group and the other 20 individuals (control group) who were living nearly 1 km away in the periphery were selected for salivary analysis. Questions related to sleep disturbances were measured using Pittsburgh Sleep Quality Index (PSQI) and other health problems were included in the questionnaire. Chi-square test was used for statistical analysis. Results: It was unveiled that a majority of the subjects who were residing near the mobile base station complained of sleep disturbances, headache, dizziness, irritability, concentration difficulties, and hypertension. A majority of the study subjects had significantly lesser stimulated salivary secretion ($P < 0.01$) as compared to the control subjects. Conclusions: The effects of prolonged exposure to EMRs from mobile phone base stations on the health and well-being of the general population cannot be ruled out. Further studies are warranted to evaluate the effect of electromagnetic fields (EMFs) on general health and more specifically on oral health.

Singh N, Rudra N, Bansal P, Mathur R, Behari J, Nayar U, Poly ADP ribosylation as a possible mechanism of microwave--biointeraction. Indian J Physiol Pharmacol 38(3):181-184, 1994.

Electromagnetic fields (EMFs) affect the metabolism of the body including the nervous, endocrine, cardiovascular, hematological as well as the reproductive system. EMFs are environmental pollutants, thus posing a health hazard which can cause steric changes in the molecule located at the cell surface. Microwaves are

known to cause chromosomal abberations and act as tumor promoters. The process involves a stream of signals from cell membrane to nucleus and other organelles. The present investigations aim to understand the mechanism of biological effects of microwaves (2.45 GHz). The effect was studied on poly ADP-ribosylation, which is a post translational modification of chromatin protein catalysed by the enzyme poly ADPR polymerase using NAD+ as the substrate. Poly ADP-ribosylation has been shown to be involved in several aspects of chromatin structure and function. Twenty-three days old rats weighing 42-48 gms were exposed at a microwave dose level of 1.0 mW/cm2. After exposure for sixty days the animals were sacrificed and an estimation of poly ADPR polymerase activity was undertaken in different organs of these animals. There was an increase of 20% in its activity in liver, 35% in testis, whereas brain showed a 53% decrease in diencephalon and 20% decrease in the cortex in the exposed animals as compared to their respective controls. There was no change in enzyme activity in spleen and kidney. This was accompanied by concomitant changes in NAD+ levels. The above results may be cited as important events in carcinogenesis and tumor promotion related to microwave exposure and the signal transduction mechanism involved. The goal is to shed light on complex ecogenetic interactions leading to cancer modulation of gene expression by epigenetic mechanism.

Sinha RK. Chronic non-thermal exposure of modulated 2450 MHz microwave radiation alters thyroid hormones and behavior of male rats. Int J Radiat Biol. 84(6):505-513, 2008.

Purpose: The purpose of this investigation was to analyze the effects of leakage microwave (2450 MHz) irradiation on thyroid hormones and behavior of male rats. Materials and methods: Experiments were carried out on two groups of male rats (exposure and control, respectively). Radio-immuno assay (RIA) methods were used for estimation of 3,5,3'-triiodothyronine (T(3)), thyroxine (T(4)) and thyrotrophin or thyroid stimulating hormone (TSH). The assessments of behavioral changes were performed in Open-Field (OF) and Elevated Plus-Maze (EPM) apparatuses. Results: Following chronic microwave exposure, rats were found hyperactive and aggressive on the 16th and 21st days. Behavioral changes in OF were analyzed and found to be significantly changed from controls ($p < 0.05$) for immobilization, rearing and ambulation behavior. In EPM, rats showed increased activity with decreased time spent in the open arm and more time spent in the center on the 11th ($p < 0.05$), 16th ($p < 0.05$) and 21st day ($p < 0.01$) after irradiation. Changes in behavioral parameters are also correlated with the trend of changes, compared to control animals, in hormonal blood levels of T3 (decreased on the 16th day, $p < 0.05$ and 21st day, $p < 0.01$) and T4 (increased on the 21st day, $p < 0.05$). Conclusion: Low energy microwave irradiation may be harmful as it is sufficient to alter the levels of thyroid hormones as well as the emotional reactivity of the irradiated compared to control animals.

Singh S, Mani KV, Kapoor N. Effect of occupational EMF exposure from radar at two different frequency bands on plasma melatonin and serotonin levels. Int J Radiat Biol. 2015 Jan 7:1-39. [Epub ahead of print].

Objective: The purpose of the present study was to delineate the effect of chronic electromagnetic field (EMF) exposure from radar on plasma melatonin and serotonin levels in occupationally exposed military personnel. Subjects and Methods: 166 male military personnel participated in the study out of which only 155 joined for blood draw. They were divided into three sets viz control group (n=68), exposure group I (n=40) exposed to 8-12GHz and exposure group II (n=58) working with radar at 12.5-18GHz frequency. All the three groups were further split into two groups according to their years of service (up to 10 years and > 10 years) in order to investigate the effect of years of exposure from radar. Melatonin and serotonin levels were estimated by enzyme immunoassay in fasting blood samples collected during 0600-0700h. EMF measurements were recorded at different locations using Satimo EME Guard 'Personal Exposure Meter' and Narda 'Broad Band Field Meter'. Results: The group I exposed population registered a minor though not significant decrease in plasma melatonin concentration while the other group II exposed population registered statistically significant decline in melatonin concentration when compared with controls. Highly significant increase in plasma serotonin levels was found in exposure group II when compared to control whereas marginal non-significant rise was also registered in exposure group I in comparison to control. Exposure in terms of length of service up to 10 years did not produce any significant effect in the indoleamine levels in both the exposure groups when they were compared with their respective control groups. Whereas, length of service greater than 10 years was observed to decrease and increase respectively the melatonin and serotonin concentration significantly in exposure group II but not in exposure group I. However, correlation test did not yield any significant association between years of service and melatonin or serotonin levels respectively in both the exposure sets I and II. No significant association was observed between melatonin and serotonin levels as well. Conclusion: The study shows the EMF ability to influence plasma melatonin and serotonin concentration in radar workers, significantly in 12.5-18GHz range with service period greater than 10 years.

Siqueira EC, de Souza FT, Ferreira E, Souza RP, Macedo SC, Friedman E, Gomez MV, Gomes CC, Gomez RS. Cell phone use is associated with an inflammatory cytokine profile of parotid gland saliva. J Oral Pathol Med. 2016 Feb 14. doi: 10.1111/jop.12434. [Epub ahead of print]

BACKGROUND: There is controversy on the effects of the non-ionizing radiation emitted by cell phones on cellular processes and the impact of such radiation exposure on health. The purpose of this study was to investigate whether cell phone use alters cytokine expression in the saliva produced by the parotid glands. METHODS: Cytokine expression profile was determined by enzyme linked immuno sorbent assay (ELISA) in the saliva produced by the parotid glands in healthy volunteers, and correlated with self-reported cell phone use and laterality. RESULTS: The following parameters were determined, in 83 Brazilian individuals in saliva produced by the parotid glands comparing the saliva from the gland exposed to cell phone radiation (ipsilateral) to that from the contralateral parotid: salivary flow, total protein concentration, interleukin 1 β (IL-1 β), interleukin 6 (IL-6), interleukin 10 (IL-10), interferon γ (IFN-γ), and tumor necrosis factor α (TNF-α) salivary levels by ELISA. After multiple testing correction, decreased IL-10 and increased IL-1β

salivary levels in the ipsilateral side compared with the contralateral side ($P < 0.05$) were detected. Subjects who used cell phones for more than 10 years presented higher differences between IL-10 levels in ipsilateral versus contralateral parotids ($P = 0.0012$). No difference was observed in any of the tested parameters in correlation with cell phone monthly usage in minutes. CONCLUSION: The exposure of parotid glands to cell phones can alter salivary IL-10 and IL-1β levels, consistent with a pro-inflammatory microenvironment that may be related to heat production.

Sirav B, Seyhan N. Radio frequency radiation (RFR) from TV and radio transmitters at a pilot region in Turkey. Radiat Prot Dosimetry. 136(2):114-117. 2009.

For the last 30 y, the biological effects of non-ionising radiation (NIR: 0-300 GHz) have been a major topic in bioelectromagnetism. Since the number of radiofrequency (RF) systems operating in this frequency range has shown an incredible increase over the last few decades, the dangers of exposure to the fields generated thereby has become an important public health issue. In this study, the aim was to evaluate the level of RF electromagnetic radiation in Yenimahalle Sentepe Dededoruk Hill in Ankara, Turkey that is a multiple-transmitter site hosting 64 different TV and radio towers and one base station for mobile phone communication. The site has been of interest as it is nearby a residential community. Within the technical input data available on 31 of the radio and TV transmitters, the calculated radiation level in this particular region was found to be approximately four times higher than the permitted standards of Turkey, which are the same as the ICNIRP standards. Electromagnetic field measurement is needed in the site.

Sirav B, Seyhan N.Effects of radiofrequency radiation exposure on blood-brain barrier permeability in male and female rats.Electromagn Biol Med. 30(4):253-260, 2011.

During the last several decades, numerous studies have been performed aiming at the question of whether or not exposure to radiofrequency radiation (RFR) influences the permeability of the blood-brain barrier (BBB). The objective of this study was to investigate the effect of RFR on the permeability of BBB in male and female Wistar albino rats. Right brain, left brain, cerebellum, and total brain were analyzed separately in the study. Rats were exposed to 0.9 and 1.8 GHz continuous-wave (CW) RFR for 20 min (at SARs of 4.26 mW/kg and 1.46 mW/kg, respectively) while under anesthesia. Control rats were sham-exposed. Disruption of BBB integrity was detected spectrophotometrically using the Evans-blue dye, which has been used as a BBB tracer and is known to be bound to serum albumin. Right brain, left brain, cerebellum, and total brain were evaluated for BBB permeability. In female rats, no albumin extravasation was found in in the brain after RFR exposure. A significant increase in albumin was found in the brains of the RF-exposed male rats when compared to sham-exposed male brains. These results suggest that exposure to 0.9 and 1.8 GHz CW RFR at levels below the international limits can affect the vascular permeability in the brain of male rats. The possible risk of RFR exposure in humans is a major concern for the society. Thus, this topic should be investigated more thoroughly in the future.

Sırav B, Seyhan N. Effects of GSM modulated radio-frequency electromagnetic radiation on permeability of blood-brain barrier in male & female rats. J Chem Neuroanat. 2015 Dec 23. pii: S0891-0618(15)00106-4. doi: 10.1016/j.jchemneu.2015.12.010. [Epub ahead of print]

With the increased use of mobile phones, their biological and health effects have become more important. Usage of mobile phones near the head increases the possibility of effects on brain tissue. This study was designed to investigate the possible effects of pulse modulated 900MHz and 1800MHz radio-frequency radiation on the permeability of blood-brain barrier of rats. Study was performed with 6 groups of young adult male and female wistar albino rats. The permeability of blood-brain barrier to intravenously injected evans blue dye was quantitatively examined for both control and radio-frequency radiarion exposed groups. For male groups; Evans blue content in the whole brain was found to be 0.08±0.01mg% in the control, 0.13±0.03mg% in 900MHz exposed and 0.26±0.05mg% in 1800MHz exposed animals. In both male radio-frequency radiation exposed groups, the permeability of blood-brain barrier found to be increased with respect to the controls ($p<0.01$). 1800MHz pulse modulated radio-frequency radiation exposure was found more effective on the male animals ($p<0.01$). For female groups; dye contents in the whole brains were 0.14±0.01mg% in the control, 0.24±0.03mg% in 900MHz exposed and 0.14±0.02mg% in 1800MHz exposed animals. No statistical variance found between the control and 1800MHz exposed animals ($p>0.01$). However 900MHz pulse modulated radio-frequency exposure was found effective on the permeability of blood-brain barrier of female animals. Results have shown that 20minutes pulse modulated radio-frequency radiation exposure of 900MHz and 1800MHz induces an effect and increases the permeability of blood-brain barrier of male rats. For females, 900MHz was found effective and it could be concluded that this result may due to the physiological differences between female and male animals. The results of this study suggest that mobile phone radation could lead to increase the permeability of blood-brain barrier under non-thermal exposure levels. More studies are needed to demonstrate the mechanisms of that breakdown.

Smith P, Kuster N, Ebert S, Chevalier HJ. GSM and DCS wireless communication signals: combined chronic toxicity/carcinogenicity study in the Wistar Rat. Radiat Res. 168(4):480-492, 2007.

.A total of 1170 rats comprised of 65 male and 65 female Han Wistar rats per group were exposed for 2 h/day, 5 days/ week for up to 104 weeks to GSM or DCS wireless communication signals at three nominal SARs of 0.44, 1.33 and 4.0 W/kg. A preliminary study confirmed that the highest exposure level was below that which was capable of causing a measurable increase in the core temperature of the rat. Additional groups for each modulation were sham exposed, and there was also an unrestrained, unexposed (cage) control group. Fifteen male and 15 female rats per group were killed after 52 weeks. From the remaining 50 male and 50 female rats per group, surviving animals were killed after 104 weeks. Evaluations during the study included mortality rate, clinical signs, recording of palpable masses, body weight, food consumption, ophthalmoscopic examination, and clinical pathological investigations. Terminal investigations included organ weight measurement and

macroscopic and microscopic pathology examinations. There was no adverse response to the wireless communication signals. In particular, there were no significant differences in the incidence of primary neoplasms, the number of rats with more than one primary neoplasm, the multiplicity and latency of neoplasms, the number of rats with metastases, and the number of benign and malignant neoplasms between the rats exposed to wireless communication signals and rats that were sham exposed.

Smythe JW, Costall B. Mobile phone use facilitates memory in male, but not female, subjects. Neuroreport 14(2):243-246, 2003.

In the present study we report on the effects of mobile phone exposure on short- and long-term memory in male and female subjects. Subjects were university undergraduate students, and consisted of right-handed, males (= 33) and females (= 29). Individuals were randomly assigned to one of three experimental conditions: no phone exposure; inactive phone exposure; and active phone exposure. They were provided with a series of words to learn, structured in a two-dimensional shape, and given 3 min to memorise the words. After a 12 min distraction task, they were then asked to draw the shape (spatial) and place the correct words (semantic) into the appropriate boxes. One week later the same subjects were brought back to again redraw the shape and words. Error scores were determined and analysed by non-parametric techniques. The results show that males exposed to an active phone made fewer spatial errors than those exposed to an active phone condition, while females were largely unaffected. These results further indicate that mobile phone exposure has functional consequences for human subjects, and these effects appear to be sex-dependent.

Soderqvist F, Carlberg M, Hardell L. Use of wireless telephones and self-reported health symptoms: a population-based study among Swedish adolescents aged 15-19 years. Environ Health. 7(1):18, 2008.

ABSTRACT: BACKGROUND: Despite the last years of rapid increase in use of wireless phones little data on the use of these devices has been systematically assessed among young persons. The aim of this descriptive cross-sectional study was to assess use of wireless phones and to study such use in relation to explanatory factors and self-reported health symptoms. METHODS: A postal questionnaire comprising 8 pages of 27 questions with 75 items in total was sent to 2000 Swedish adolescents aged 15-19 years and selected from the population registry using a stratified sampling scheme. RESULTS: The questionnaire was answered by 63.5 % of the study subjects. Most participants reported access to a mobile phone (99.6%) and use increased with age; 55.6% of the 15-year-olds and 82.2% of the 19-year-olds were regular users. Girls generally reported more frequent use than boys. Use of wired hands-free equipment 'anytime' was reported by 17.4%. Cordless phones were used by 81.9%, and 67.3% were regular users. Watching TV increased the odds ratio for use of wireless phones, adjusted for age and gender. Some of the most frequently reported health complaints were tiredness, stress, headache, anxiety, concentration difficulties and sleep disturbances. Regular users of wireless phones had health symptoms more often and reported poorer perceived health than less frequent users. CONCLUSIONS: Almost all adolescence in this

study used a wireless phone, girls more than boys. The most frequent use was seen among the older adolescents and those who watched TV extensively. The study further showed that perceived health and certain health symptoms seemed to be related to the use of wireless phones. However, this part of the investigation was explorative and should therefore be interpreted with caution since bias and chance findings due to multiple testing might have influenced the results. Potentially this study will stimulate more sophisticated studies that may also investigate directions of associations and whether, or to what degree, any mediation factors are involved.

Söderqvist F, Carlberg M, Hardell L. Use of wireless telephones and serum S100B levels: A descriptive cross-sectional study among healthy Swedish adults aged 18-65 years. Sci Total Environ. 407(2):798-805, 2009

BACKGROUND: Since the late 1970s, experimental animal studies have been carried out on the possible effects of low-intensive radiofrequency fields on the blood-brain barrier (BBB), but no epidemiological study has been published to date. OBJECTIVE: Using serum S100B as a putative marker of BBB dysfunction we performed a descriptive cross-sectional study to investigate whether protein levels were higher among frequent than non-frequent users of mobile and cordless desktop phones. METHOD: One thousand subjects, 500 of each sex aged 18-65 years, were randomly recruited using the population registry. Data on wireless phone use were assessed by a postal questionnaire and blood samples were analyzed for S100B. RESULTS: The response rate was 31.4%. The results from logistic and linear regression analyses were statistically insignificant, with one exception: the linear regression analysis of latency for UMTS use, which after stratifying on gender remained significant only for men (p = 0.01; n = 31). A low p-value (0.052) was obtained for use of cordless phone (n = 98) prior to giving the blood samples indicating a weak negative association. Total use of mobile and cordless phones over time yielded odds ratio (OR) 0.8 and 95% confidence interval (CI) 0.3-2.0 and use on the same day as giving blood yielded OR=1.1, CI=0.4-2.8. CONCLUSIONS: This study failed to show that long- or short-term use of wireless telephones was associated with elevated levels of serum S100B as a marker of BBB integrity. The finding regarding latency of UMTS use may be interesting but it is based on small numbers. Generally, S100B levels were low and to determine whether this association - if causal - is clinically relevant, larger studies with sufficient follow-up are needed.

Söderqvist F, Carlberg M, Hansson Mild K, Hardell L. Exposure to an 890-MHz mobile phone-like signal and serum levels of S100B and transthyretin in volunteers. Toxicol Lett. 189(1):63-66, 2009.

Whether low-intensity non-thermal microwave radiation alters the integrity of the blood-brain barrier has been debated since the late 1970s, yet no experimental study has been carried out on humans. The aim of this study was to test, using peripheral markers, whether exposure to a mobile phone-like signal alters the integrity of the human blood-brain and blood-cerebrospinal fluid barriers. A provocation study was carried out that exposed 41 volunteers to a 30 min GSM 890 MHz signal with an average specific energy absorption rate distribution of 1.0 W/kg in the temporal area

of the head as measured over any 1g of contiguous tissue. The outcome was assessed by changes in serum concentrations of two putative markers of brain barrier integrity, S100B and transthyretin. Repeated blood sampling before and after the provocation showed no statistically significant increase in the serum levels of S100B, while for transthyretin a statistically significant increase was seen in the final blood sample 60 min after the end of the provocation as compared to the prior sample taken immediately after provocation (p=0.02). The clinical significance of this finding, if any, is unknown. Further randomized studies with use of additional more brain specific markers are needed.

Soderqvist F, Carlberg M, Hardell L. Mobile and cordless telephones, serum transthyretin and the blood-cerebrospinal fluid barrier: a cross-sectional study. Environ Health. 8(1):19, 2009.

BACKGROUND: Whether low-intensity radiofrequency radiation damages the blood-brain barrier has long been debated, but little or no consideration has been given to the blood-cerebrospinal fluid barrier. In this cross-sectional study we tested whether long-term and/or short-term use of wireless telephones was associated with changes in the serum transthyretin level, indicating altered transthyretin concentration in the cerebrospinal fluid, possibly reflecting an effect of radiation. METHODS: One thousand subjects, 500 of each sex aged 18-65 years, were randomly recruited using the population registry. Data on wireless telephone use were assessed by a postal questionnaire and blood samples were analyzed for serum transthyretin concentrations determined by standard immunonephelometric techniques on a BN Prospec(R) instrument. RESULTS: The response rate was 31.4%. Logistic regression of dichotomized TTR serum levels with a cut-point of 0.31 g/l on wireless telephone use yielded increased odds ratios that were statistically not significant. Linear regression of time since first use overall and on the day that blood was withdrawn gave different results for males and females: for men significantly higher serum concentrations of TTR were seen the longer an analogue telephone or a mobile and cordless desktop telephone combined had been used, and in contrast, significantly lower serum levels were seen the longer an UMTS telephone had been used. Adjustment for fractions of use of the different telephone types did not modify the effect for cumulative use or years since first use for mobile telephone and DECT, combined. For women, linear regression gave a significant association for short-term use of mobile and cordless telephones combined, indicating that the sooner blood was withdrawn after the most recent telephone call, the higher the expected transthyretin concentration. CONCLUSIONS: In this hypothesis-generating descriptive study time since first use of mobile telephones and DECT combined was significantly associated with higher TTR levels regardless of how much each telephone type had been used. Regarding short-term use, significantly higher TTR concentrations were seen in women the sooner blood was withdrawn after the most recent telephone call on that day.

Söderqvist F, Hardell L, Carlberg M, Mild KH. Radiofrequency fields, transthyretin, and Alzheimer's disease.J Alzheimers Dis. 20(2):599-606, 2010.

Radiofrequency field (RF) exposure provided cognitive benefits in an animal study. In Alzheimer's disease (AD) mice, exposure reduced brain amyloid-beta (Abeta) deposition through decreased aggregation of Abeta and increase in soluble Abeta levels. Based on our studies on humans on RF from wireless phones, we propose that transthyretin (TTR) might explain the findings. In a cross-sectional study on 313 subjects, we used serum TTR as a marker of cerebrospinal fluid TTR. We found a statistically significantly positive beta coefficient for TTR for time since first use of mobile phones and desktop cordless phones combined (P=0.03). The electromagnetic field parameters were similar for the phone types. In a provocation study on 41 persons exposed for 30 min to an 890-MHz GSM signal with specific absorption rate of 1.0 Watt/kg to the temporal area of the brain, we found statistically significantly increased serum TTR 60 min after exposure. In our cross-sectional study, use of oral snuff also yielded statistically significantly increased serum TTR concentrations and nicotine has been associated with decreased risk for AD and to upregulate the TTR gene in choroid plexus but not in the liver, another source of serum TTR. TTR sequesters Abeta, thereby preventing the formation of Abeta plaques in the brain. Studies have shown that patients with AD have lowered TTR concentrations in the cerebrospinal fluid and have attributed the onset of AD to insufficient sequestering of Abeta by TTR. We propose that TTR might be involved in the findings of RF exposure benefit in AD mice.

Söderqvist F, Carlberg M, Hardell L. Use of wireless phones and the risk of salivary gland tumours: a case-control study. Eur J Cancer Prev.21(6):576-579, 2012.

The last decades of increasing use of wireless phones, including mobile as well as cordless desktop phones, have led to concerns about the potential carcinogenic effects of radiofrequency electromagnetic fields. Among the most exposed areas of the body when the phone is used for talking are the salivary glands, mainly the parotid gland, located in front of the ear. The objective of this case-control study was to assess whether the use of wireless phones is associated with an increased risk of tumour at this site. Sixty-nine patients with salivary gland tumours (63 with a parotid gland tumour) and 262 randomly recruited controls were included. Unconditional logistic regression - adjusted for age at diagnosis, sex, year of diagnosis and socioeconomic index - was used to produce odds ratios and 95% confidence intervals. The use of wireless phones was not associated with an overall increased risk of salivary gland tumours, odds ratio 0.8, 95% confidence interval 0.4-1.5. Neither was there an increased risk for the different phone types when calculated separately nor was there an increased risk for different latencies or when cumulative use was divided into three groups (1-1000, 1001-2000 and >2000 h). The overall results were similar for the risk of parotid gland tumours. In conclusion, our data add to the evidence against there being an increased risk for parotid gland tumours associated with light-to-moderate use of wireless phones and for less than 10 years of use but offers little information on risk related to more prolonged and/or heavy use.

Söderqvist F, Carlberg M, Zetterberg H, Hardell L. Use of wireless phones and serum β-trace protein in randomly recruited persons aged 18-65 years: a cross-sectional study. Electromagn Biol Med.31(4):416-424, 2012.

Background: There are studies suggesting effects on sleep from pulse-modulated radiofrequency fields used in mobile and cordless phones. So far, reports of adverse effects in observational studies are of limited value for risk assessment while effects from experimental studies seem to be more consistent but unclear as to their importance for health. The aim of this study was to investigate whether use of wireless phones is associated with lower concentrations of β-trace protein (lipocalin-type prostaglandin D synthase), a key enzyme in the synthesis of prostaglandin D(2), an endogenous sleep-promoting neurohormone. Methods: Three hundred and fourteen people, aged 18-65 years and living in the municipality of Örebro, Sweden, were recruited randomly using the population registry. Total and age-specific linear regression analyses adjusted for known covariates were used to calculate associations between levels of β-trace protein and short- and long-term use of wireless phones. Results: Overall, no statistically significant association between use of wireless phones and the serum concentration of β-trace protein was found, neither with respect to short-term nor long-term use. Age-specific analyses, however, yielded negative associations for long-term use (cumulative hours of use) and β-trace protein in the youngest age group (18-30 years). Conclusion: This study provided no overall evidence of an association between wireless phone use and serum concentrations of β-trace protein. While the findings in the 18-30 year age group indicating lower concentrations with more cumulative hours of use should be further investigated, no causal inferences can be made from the results of the present study.

Söderqvist F, Carlberg M, Hardell L. Biomarkers in volunteers exposed to mobile phone radiation. Toxicol Lett. 2015 Mar 31. pii: S0378-4274(15)00119-8. doi: 10.1016/j.toxlet.2015.03.016. [Epub ahead of print]

For some time it has been investigated whether low-intensity non-thermal microwave radiation from mobile phones adversely affects the mammalian blood-brain barrier (BBB). All such studies except one have been either in vitro or experimental animal studies. The one carried out on humans showed a statistically significant increase in serum transthyretin (TTR) 60min after finishing of a 30-min microwave exposure session. The aim of the present study was to follow up on the finding of the previous one using a better study design. Using biomarkers analyzed in blood serum before and after the exposure this single blinded randomized counterbalanced study, including 24 healthy subjects aged 18-30 years that all underwent three exposure conditions (SAR_{10G}=2W/kg, SAR_{10G}=0.2W/kg, sham), tested whether microwaves from an 890-MHz phone-like signal give acute effects on the integrity of brain-shielding barriers. Over time, statistically significant variations were found for two of the three biomarkers (TTR; β-trace protein); however, no such difference was found between the different exposure conditions nor was there any interaction between exposure condition and time of blood sampling. In conclusion this study failed to show any acute clinically or statistically significant effect of short term microwave exposure on the serum levels of S100β, TTR and β-trace protein with a follow up limited to two hours. The study was hampered by the fact that all study persons were regular wireless phone users and thus not naïve as to microwave exposure.

Sokolovic D, Djindjic B, Nikolic J, Bjelakovic G, Pavlovic D, Kocic G, Krstic D, Cvetkovic T, Pavlovic V. Melatonin reduces oxidative stress induced by chronic exposure of microwave radiation from mobile phones in rat brain. J Radiat Res (Tokyo). 49(6):579-586, 2008.

PURPOSE: The aim of the study was to evaluate the intensity of oxidative stress in the brain of animals chronically exposed to mobile phones and potential protective effects of melatonin in reducing oxidative stress and brain injury. MATERIALS AND METHODS: Experiments were performed on Wistar rats exposed to microwave radiation during 20, 40 and 60 days. Four groups were formed: I group (control)- animals treated by saline, intraperitoneally (i.p.) applied daily during follow up, II group (Mel)- rats treated daily with melatonin (2 mg kg(-1) body weight i.p.), III group (MWs)- microwave exposed rats, IV group (MWs + Mel)- MWs exposed rats treated with melatonin (2 mg kg(-1) body weight i.p.). The microwave radiation was produced by a mobile test phone (SAR = 0.043-0.135 W/kg). RESULTS: A significant increase in the brain tissue malondialdehyde (MDA) and carbonyl group concentration was registered during exposure. Decreased activity of catalase (CAT) and increased activity of xanthine oxidase (XO) remained after 40 and 60 days of exposure to mobile phones. Melatonin treatment significantly prevented the increase in the MDA content and XO activity in the brain tissue after 40 days of exposure while it was unable to prevent the decrease of CAT activity and increase of carbonyl group contents. CONCLUSION: We demonstrated two important findings; that mobile phones caused oxidative damage biochemically by increasing the levels of MDA, carbonyl groups, XO activity and decreasing CAT activity; and that treatment with the melatonin significantly prevented oxidative damage in the brain.

Sokolovic D, Djordjevic B, Kocic G, Babovic P, Ristic G, Stanojkovic Z, Sokolovic DM, Veljkovic A, Jankovic A, Radovanovic Z. The effect of melatonin on body mass and behaviour of rats during an exposure to microwave radiation from mobile phone. Bratisl Lek Listy. 113(5):265-269, 2012.

BACKGROUND: Microwave radiation (MW) produced by wireless telecommunications and a number of electrical devices used in household or in healthcare institutions may cause various disorders in human organism. On the other hand, melatonin is a potent antioxidant, immunostimulator and neuromodulator. The aim of this research was to determine body mass and behaviour changes in rats after a chronic microwave exposure, as well as to determine the effects of melatonin on body mass and behaviour in irradiated rats. METHODS: Wistar rats were divided into the four experimental groups: I group (control) - rats treated with 0,9 % saline, II group (Mel) - rats treated with melatonin (2 mg/kg), III group (MW) - rats exposed to MW radiation (4 h/day), IV group (MW+Mel) - rats, which were both exposed to MW radiation and received melatonin premedication (2 mg/kg). RESULTS: A significant body mass reduction was noted in animals exposed to MW radiation when compared to controls after 20, 40 and 60 days ($p<0.001$). Furthermore, body weight was significantly increased ($p<0.05$) in irradiated rats, which received melatonin pretreatment (MW+Mel) in comparison to irradiated group (MW) after 20 days. Microwave radiation exposed animals showed an anxiety related behaviour

(agitation, irritability) after 10 days of exposure. After the radiation source removal, changes in behaviour were less noticeable. Melatonin administration to irradiated rats caused a decrease in the stress induced behaviour. CONCLUSION: Microwave radiation causes body mass decrease and anxiety related behaviour in rats, however melatonin causes a reverse of those effects on both body weight and behaviour of irradiated animals (Fig. 2, Ref. 32).

Sokolovic D, Djordjevic B, Kocic G, Stoimenov TJ, Stanojkovic Z, Sokolovic DM, et al. The Effects of Melatonin on Oxidative Stress Parameters and DNA Fragmentation in Testicular Tissue of Rats Exposed to Microwave Radiation. Adv Clin Exp Med. 24(3):429-436, 2015.

BACKGROUND: Microwaves from mobile phones are one of the environmental toxicants that are capable of compromising male fertility by inducing oxidative stress and apoptosis in the testes. Melatonin is a lipophilic tryptophan indole amine and a potent antioxidant. OBJECTIVES: The aim of the study was to evaluate the effect of melatonin treatment on oxidative stress parameters and DNA fragmentation in the testicular tissue of rats exposed to microwave radiation (4 h/day). MATERIAL AND METHODS: Adult Wistar rats were divided in 4 groups: I - treated with saline; II - treated with melatonin; III - exposed to microwaves; IV - exposed to microwaves and treated with melatonin. The melatonin (2 mg/kg ip) was administered daily. The animals were sacrificed after 20, 40 and 60 days. RESULTS: Melatonin treatment prevented previously registered increases in malondialdehyde after only 20 days. Furthermore, it reversed the effects of microwave exposure on xanthine oxidase (after 40 days) and acid-DNase activity (after 20 days). However, neither protein carbonyl content nor catalase and alkaline Dnase activity were changed due to melatonin treatment. CONCLUSIONS: Melatonin exerts potent antioxidant effects in the testes of rats exposed to microwaves by decreasing the intensity of oxidative stress; it also reduces DNA fragmentation.

Solomentsev GY, English NJ, Mooney DA. Effects of external electromagnetic fields on the conformational sampling of a short alanine peptide. J Comput Chem. 33(9):917-923, 2012.

Non-equilibrium molecular dynamics simulations of a solvated 21-residue polyalanine (A21) peptide, featuring a high propensity for helix formation, have been performed at 300 K and 1 bar in the presence of external electromagnetic (e/m) fields in the microwave region (2.45 GHz) and an r.m.s. electric field intensity range of 0.01-0.05 V/Å. To investigate how the field presence affects transitions between the conformational states of a protein, we report 16 independent 40 ns-trajectories of A21 starting from both extended and fully folded states. We observe folding-behavior of the peptide consistent with prior simulation and experimental studies. The peptide displays a natural tendency to form stable elements of secondary structure which are stabilized by tertiary interactions with proximate regions of the peptide. Consistent with our earlier work, the presence of external e/m fields disrupts this behavior, involving a mechanism of localized dipolar alignment which serves to enhance intra-protein perturbations in hydrogen bonds

(English, et al., J. Chem. Phys. 2010, 133, 091105), leading to more frequent transitions between shorter-lifetime states.

Sommer AM, Streckert J, Bitz AK, Hansen VW, Lerchl A. No effects of GSM-modulated 900 MHz electromagnetic fields on survival rate and spontaneous development of lymphoma in female AKR/J mice. BMC Cancer. 4(1):77, 2004.

BACKGROUND: There are several reports that indicate that non-thermal electromagnetic radiation such as from mobile phones and base stations may promote cancer. Therefore, it was investigated experimentally, whether 900 MHz electromagnetic field exposure influences lymphoma development in a mouse strain that is genetically predisposed to this disease. The AKR/J mice genome carries the AK-virus, which leads within one year to spontaneous development of thymic lymphoblastic lymphoma. METHODS: 48 groups of 6-7 unrestrained female mice were sham-exposed or exposed (each n = 160 animals) to GSM like 900 MHz electromagnetic fields for 24 hours per day, 7 days per week, at an average whole body specific absorption rates (SAR) values of 0.4 W/Kg. Animals were visually checked daily and were weighed and palpated weekly. Starting with an age of 6 months, blood samples were taken monthly from the tail. Animals with signs of disease or with an age of about 42 weeks were sacrificed and a gross necropsy was performed. RESULTS: There was no effect of electromagnetic field exposure on body weight gain or survival rate, and lymphoma incidence did not differ between exposed and sham-exposed animals. CONCLUSION: These data do not support the hypothesis that exposure to 900 MHz electromagnetic fields is a significant risk factor for developing lymphoma in a genetically predisposed species, even at a relatively high exposure level.

Sommer AM, Bitz AK, Streckert J, Hansen VW, Lerchl A. Lymphoma development in mice chronically exposed to UMTS-modulated radiofrequency electromagnetic fields. Radiat Res. 168(1):72-80, 2007.

There are public concerns regarding possible carcinogenic or cancer-promoting effects of electromagnetic fields (EMFs) from mobile phones and base stations. The objective of the present study was to investigate whether chronic exposure to EMFs of the UMTS (Universal Mobile Telecommunication System) influences the development of lymphoma in a lymphoma animal model, the AKR/J mouse. Unrestrained mice were chronically sham-exposed (n = 160) or exposed (n = 160) in identical exposure systems (radial waveguides) to a generic UMTS test signal (24 h per day, 7 days per week, 0.4 W/kg SAR). Additionally, 30 animals were kept as cage controls. Animals were checked visually each day and were weighed and palpated weekly to detect swollen lymph nodes. Starting at the age of 6 months, blood samples were taken from the tail every 2 weeks to perform differential leukocyte counts and to measure the hematocrit. Visibly diseased animals or those older than 43 weeks were killed humanely, and tissue slices were examined for metastatic infiltrations and lymphoma type. The study was performed in a blinded way. Cage control animals had a significantly lower growth rate than those kept in the radial waveguides. The number of ill animals, the mean survival time, and the severity code of the disease did not differ between the experimental groups. Therefore, the data

show no negative effects from exposure and corroborate earlier findings in AKR/J mice exposed to GSM EMF (Sommer et al., BMC Cancer 4, 77-90, 2004).

Sommer, A. M., Grote, K., Reinhardt, T., Streckert, J., Hansen, V. and Lerchl, A. Effects of radiofrequency electromagnetic fields (UMTS) on reproduction and development of mice: A Multi-generation Study. Radiat. Res. 171: 89-95, 2009.

Male and female mice (C57BL) were chronically exposed (life-long, 24 h/day) to mobile phone communication electromagnetic fields at approximately 1966 MHz (UMTS). Their development and fertility were monitored over four generations by investigating histological, physiological, reproductive and behavioral functions. The mean whole-body SARs, calculated for adult animals at the time of mating, were 0 (sham), 0.08, 0.4 and 1.3 W/kg. Power densities were kept constant for each group (0, 1.35, 6.8 and 22 W/m(2)), resulting in varying SARs due to the different numbers of adults and pups over the course of the experiment. The experiment was done in a blind fashion. The results show no harmful effects of exposure on the fertility and development of the animals. The number and the development of pups were not affected by exposure. Some data, albeit without a clear dose-response relationship, indicate effects of exposure on food consumption that is in accordance with some data published previously. In summary, the results of this study do not indicate harmful effects of long-term exposure of mice to UMTS over several generations.

Somosy Z, Thuroczy G, Koteles GJ, Kovacs J, Effects of modulated microwave and X-ray irradiation on the activity and distribution of Ca(2+)-ATPase in small intestine epithelial cells. Scanning Microsc 8(3):613-619; discussion 619-620, 1994.

The distribution and activity of Ca(2+)-ATPase were investigated by histochemical methods in small intestine epithelial cells of mice following total body 2450 MHz low frequency (16 Hz) microwave and X-ray irradiation. In the control animals, enzyme activities were found in the brush border and on lateral membranes, including junctional areas of the cells. The enzyme activity of lateral membranes was inhibited by quercetin, a specific inhibitor of Ca(2+)-ATPase. Immediately after square modulated (16 Hz) 2450 MHz microwave irradiation at 1 mW/cm2 power densities, we observed a decreased activity of Ca(2+)-ATPase on the lateral membrane regions. The X-ray irradiation (1 Gy) induced a similar decrease of Ca(2+)-ATPase activity which was reversible within 24 hours. "5 Gy" doses resulted in a decrease of enzyme activities on both apical and lateral membrane areas persisting up to 24 hours following irradiation

Somosy Z, Thuroczy G, Kovacs J, Effects of modulated and continuous microwave irradiation on pyroantimonate precipitable calcium content in junctional complex of mouse small intestine. Scanning Microsc 7(4):1255-1261, 1993.

The pyroantimonate precipitable calcium content of intestinal epithelial cells was investigated in mice following total body irradiation with 2450 MHz continuous and low frequency (16 Hz) square modulated waves. In the control animals the reaction products appeared in the intercellular space of adjacent cells including intermediate junctions and desmosomes and were absent in the area of tight junctions. Immediately after low frequency modulated microwave irradiation at 0.5 and 1 mW/cm2 power densities, a rapid distribution of pyroantimonate precipitable calcium content was observed. The

pyroantimonate deposits were located on the cytoplasmic side of lateral membrane, in the area of junctional complex, including tight junction, and in other parts of lateral plasma membrane. These changes were reversible and 24 hours after the irradiation the distribution of pyroantimonate deposits was similar to the control. Continuous waves with same energy not altered the distribution of precipitable calcium. We conclude the low frequency modulated microwave irradiation can modify the calcium distribution without heat effects.

Somosy Z, Thuroczy G, Kubasova T, Kovacs J, Szabo LD, Effects of modulated and continuous microwave irradiation on the morphology and cell surface negative charge of 3T3 fibroblasts. Scanning Microsc 5(4):1145-1155, 1991

Mouse embryo 3T3 cells were irradiated with 2450 MHz continuous and low frequency (16 Hz) square modulated waves of absorbed energy ranging from 0.0024 to 2.4 mW/g. The low frequency modulated microwave irradiation yielded more morphological cell changes than did the continuous microwave fields of the same intensity. The amount of free negative charges (cationized ferritin binding) on cell surfaces decreased following irradiation by modulated waves but remained unchanged under the effect of a continuous field of the same dose. Modulated waves of 0.024 mW/g dose increased the ruffling activity of the cells, and caused ultrastructural alteration in the cytoplasm. Similar effects were experienced by continuous waves at higher (0.24 and 2.4 mW/g) doses.

Son Y, Jeong YJ, Kwon JH, Choi HD, Pack JK, Kim N, Lee YS, Lee HJ. 1950 MHz radiofrequency electromagnetic fields do not aggravate memory deficits in 5xFAD mice. Bioelectromagnetics. 37(6):391-399, 2016.

The increased use of mobile phones has generated public concern about the impact of radiofrequency electromagnetic fields (RF-EMF) on health. In the present study, we investigated whether RF-EMFs induce molecular changes in amyloid precursor protein (APP) processing and amyloid beta (Aβ)-related memory impairment in the 5xFAD mouse, which is a widely used amyloid animal model. The 5xFAD mice at the age of 1.5 months were assigned to two groups (RF-EMF- and sham-exposed groups, eight mice per group). The RF-EMF group was placed in a reverberation chamber and exposed to 1950 MHz electromagnetic fields for 3 months (SAR 5 W/kg, 2 h/day, 5 days/week). The Y-maze, Morris water maze, and novel object recognition memory test were used to evaluate spatial and non-spatial memory following 3-month RF-EMF exposure. Furthermore, Aβ deposition and APP and carboxyl-terminal fragment β (CTFβ) levels were evaluated in the hippocampus and cortex of 5xFAD mice, and plasma levels of Aβ peptides were also investigated. In behavioral tests, mice that were exposed to RF-EMF for 3 months did not exhibit differences in spatial and non-spatial memory compared to the sham-exposed group, and no apparent change was evident in locomotor activity. Consistent with behavioral data, RF-EMF did not alter APP and CTFβ levels or Aβ deposition in the brains of the 5xFAD mice. These findings indicate that 3-month RF-EMF exposure did not affect Aβ-related memory impairment or Aβ accumulation in the 5xFAD Alzheimer's disease model.

Sonmez OF, Odaci E, Bas O, Kaplan S. Purkinje cell number decreases in the adult female rat cerebellum following exposure to 900 MHz electromagnetic field. Brain

Res. 1356:95-101, 2010.

The biological effects of electromagnetic field (EMF) exposure from mobile phones have growing concern among scientists since there are some reports showing increased risk for human health, especially in the use of mobile phones for a long duration. In the presented study, the effects on the number of Purkinje cells in the cerebellum of 16-week (16 weeks) old female rats were investigated following exposure to 900 MHz EMF. Three groups of rats, a control group (CG), sham exposed group (SG) and an electromagnetic field exposed group (EMFG) were used in this study. While EMFG group rats were exposed to 900 MHz EMF (1h/day for 28 days) in an exposure tube, SG was placed in the exposure tube but not exposed to EMF (1h/day for 28 days). The specific energy absorption rate (SAR) varied between 0.016 (whole body) and 2 W/kg (locally in the head). The CG was not placed into the exposure tube nor was it exposed to EMF during the study period. At the end of the experiment, all of the female rats were sacrificed and the number of Purkinje cells was estimated using a stereological counting technique. Histopathological evaluations were also done on sections of the cerebellum. Results showed that the total number of Purkinje cells in the cerebellum of the EMFG was significantly lower than those of CG ($p<0.004$) and SG ($p<0.002$). In addition, there was no significant difference at the 0.05 level between the rats' body and brain weights in the EMFG and CG or SG. Therefore, it is suggested that long duration exposure to 900 MHz EMF leads to decreases of Purkinje cell numbers in the female rat cerebellum.

Soran ML, Stan M, Niinemets U, Copolovici L. Influence of microwave frequency electromagnetic radiation on terpene emission and content in aromatic plants.J Plant Physiol. 171(15):1436-1443, 2014

Influence of environmental stress factors on both crop and wild plants of nutritional value is an important research topic. The past research has focused on rising temperatures, drought, soil salinity and toxicity, but the potential effects of increased environmental contamination by human-generated electromagnetic radiation on plants have little been studied. Here we studied the influence of microwave irradiation at bands corresponding to wireless router (WLAN) and mobile devices (GSM) on leaf anatomy, essential oil content and volatile emissions in Petroselinum crispum, Apium graveolens and Anethum graveolens. Microwave irradiation resulted in thinner cell walls, smaller chloroplasts and mitochondria, and enhanced emissions of volatile compounds, in particular, monoterpenes and green leaf volatiles (GLV). These effects were stronger for WLAN-frequency microwaves. Essential oil content was enhanced by GSM-frequency microwaves, but the effect of WLAN-frequency microwaves was inhibitory. There was a direct relationship between microwave-induced structural and chemical modifications of the three plant species studied. These data collectively demonstrate that human-generated microwave pollution can potentially constitute a stress to the plants.

Sorri MJ, Huttunen KH, Valimaa TT, Karinen PJ, Lopponen HJ, Cochllear implants and GSM phone. Scand Audiol Suppl (52):54-56, 2001.

Use of a telephone and GSM phones, in particular, was assessed by means of a postal interview sent to all adult Finnish implantees. The response rate was very high (87%). Fifty-one of the 61 respondents used a telephone and 27/61 also used a mobile phone, usually a digital phone. Two GSM phone models from Nokia (3110 and 6110) were tested with three different cochlear implant systems used by nine patients. Definite differences between the processors were found. Nucleus Spectra (two implantees) could not be used with any of the GSM phones under any test condition. Nucleus SPrint was incompatible with both GSM phone models in a poor field, while GSM phone model 6110 could be used in a good field. The Med-El Combi 40+ processor was compatible with both GSM models tested under any condition.

Souza LD, Cerqueira ED, Meireles JR. Assessment of nuclear abnormalities in exfoliated cells from the oral epithelium of mobile phone users. Electromagn Biol Med. 2013 May 28. [Epub ahead of print]

Transmission and reception of mobile telephony signals take place through electromagnetic wave radiation, or electromagnetic radiofrequency fields, between the mobile terminal and the radio base station. Based on reports in the literature on adverse effects from exposure to this type of radiation, the objective of this study was to evaluate the genotoxic and cytotoxic potential of such exposure, by means of the micronucleus test on exfoliated cells from the oral epithelium. The sample included 45 individuals distributed in 3 groups according to the amount of time in hours per week (t) spent using mobile phones: group I, $t > 5$ h; group II, $t > 1$ h and ≤ 5 h; and group III, $t \leq 1$ h. Cells from the oral mucosa were analyzed to assess the numbers of micronuclei, broken egg structures and degenerative nuclear abnormalities indicative of apoptosis (condensed chromatin, karyorrhexis and pyknosis) or necrosis (karyolysis in addition to these changes). The occurrences of micronuclei and degenerative nuclear abnormalities did not differ between the groups, but the number of broken egg (structures that may be associated with gene amplification) was significantly greater in the individuals in group I ($p < 0.05$).

Sparks PB, Mond HG, Joyner KH, Wood MP, The safety of digital mobile cellular telephones with minute ventilation rate adaptive pacemakers. Pacing Clin Electrophysiol 19(10):1451-1455, 1996.

In vitro tests suggest that rate adaptive pacemakers using changes in transthoracic impedance to vary pacing rate may be affected by digital mobile telephones. Electromagnetic fields generated by digital mobile telephones (Global System for Mobile [GSM]) represent a potential source of electromagnetic interference (EMI) for the Telectronics META rate adaptive pacemakers, which use transthoracic impedance as a sensor to determine changes in minute ventilation. Sixteen implanted Telectronics META pulse generators were exposed to 25-W simulated GSM transmissions (900-MHz carrier pulsed at 2, 8, and 217 Hz with a pulse width of 0.6 ms) and the antenna of a 2-W digital mobile telephone (900-MHz, 217-Hz pulse, 0.6-ms pulse width). The 12 dual and four single chamber devices were programmed to maximum sensitivity and assessed in unipolar and bipolar settings and rate adaptive and nonrate adaptive modes. In all cases of EMI, testing was repeated at lower, more routinely set bipolar sensitivity levels. At

maximum sensitivity, 11 of 16 devices displayed no evidence of EMI. Brief ventricular triggering occurred in 2, a brief pause in 1, a combination of both in 1, and a brief episode of pacemaker-mediated tachycardia in 1. With pulse generators programmed to more routine sensitivities, only one device displayed rare single beat ventricular triggering. No changes in minute ventilation rate adaptive pacing were observed. At maximum unipolar sensitivities, the META series of rate adaptive pacemakers are resistant to clinically important EMI from digital mobile telephones. Set at routine sensitivities, these devices perform reliably in the presence of digital mobile telephones.

Speit G, Schütz P, Hoffmann H. Genotoxic effects of exposure to radiofrequencyelectromagnetic fields (RF-EMF) in cultured mammalian cells are not independently reproducible. Mutat Res. 626(1-2):42-47, 2007.

Conflicting results have been published regarding the induction of genotoxic effects by exposure to radiofrequencyelectromagnetic fields (RF-EMF). Using the comet assay, the micronucleus test and the chromosome aberration test with human fibroblasts (ES1 cells), the EU-funded "REFLEX" project (Risk Evaluation of Potential Environmental Hazards From Low Energy Electromagnetic Field Exposure Using Sensitive in vitro Methods) reported clearly positive effects for various exposure conditions. Because of the ongoing discussion on the biological significance of the effects observed, it was the aim of the present study to independently repeat the results using the same cells, the same equipment and the same exposure conditions. We therefore exposed ES1 cells to RF-EMF (1800 MHz; SAR 2 W/kg, continuous wave with intermittent exposure) for different time periods and then performed the alkaline (pH>13) comet assay and the micronucleus test (MNT). For both tests, clearly negative results were obtained in independently repeated experiments. We also performed these experiments with V79 cells, a sensitive Chinese hamster cell line that is frequently used in genotoxicity testing, and also did not measure any genotoxic effect in the comet assay and the MNT. Appropriate measures of quality control were considered to exclude variations in the test performance, failure of the RF-EMF exposure or an evaluation bias. The reasons for the difference between the results reported by the REFLEX project and our experiments remain unclear.

Spichtig S, Scholkmann F, Chin L, Lehmann H, Wolf M. Assessment of intermittent UMTS electromagnetic field effects on blood circulation in the human auditory region using a near-infrared system.Bioelectromagnetics. 33(1):40-54, 2012.

The aim of the present study was to assess the potential effects of intermittent Universal Mobile Telecommunications System electromagnetic fields (UMTS-EMF) on blood circulation in the human head (auditory region) using near-infrared spectroscopy (NIRS) on two different timescales: short-term (effects occurring within 80 s) and medium-term (effects occurring within 80 s to 30 min). For the first time, we measured potential immediate effects of UMTS-EMF in real-time without any interference during exposure. Three different exposures (sham, 0.18 W/kg, and 1.8 W/kg) were applied in a controlled, randomized, crossover, and double-blind paradigm on 16 healthy volunteers. In addition to oxy-, deoxy-, and total haemoglobin concentrations ([O(2) Hb], [HHb], and [tHb], respectively), the heart rate (HR), subjective well-being, tiredness, and counting speed

were recorded. During exposure to 0.18 W/kg, we found a significant short-term increase in Δ[O(2) Hb] and Δ[tHb], which is small (≈17%) compared to a functional brain activation. A significant decrease in the medium-term response of Δ[HHb] at 0.18 and 1.8 W/kg exposures was detected, which is in the range of physiological fluctuations. The medium-term ΔHR was significantly higher (+1.84 bpm) at 1.8 W/kg than for sham exposure. The other parameters showed no significant effects. Our results suggest that intermittent exposure to UMTS-EMF has small short- and medium-term effects on cerebral blood circulation and HR.

Spiers DE, Baummer SC, Thermal and metabolic responsiveness of Japanese quail embryos following periodic exposure to 2,450 MHz microwaves. Bioelectromagnetics 12(4):225-239, 1991.

Two studies were performed to determine if repeated exposure of the avian egg to microwaves can alter metabolism, temperature, and growth rate of embryos. Another aim was to supplement conventional heating with microwave heating and provide an optimal temperature for growth. Japanese quail (Coturnix coturnix japonica) eggs were exposed from day 1 through 15 of incubation (8 h/day) to sham or microwave (2,450 MHz) irradiation. Microwave exposures were at two power densities, 5 or 20 mW/cm2, and at three ambient temperatures (Tas), 30.0, 33.1, or 35.4 degrees C. Specific absorption rates for unincubated and 15-day-old incubated eggs were, respectively, 0.76 and 0.66 W kg-1 mW-1 cm-2 (i.e., 3.8 and 3.3 W/kg at 5 mW/cm2 and 15.2 and 13.2 W/kg at 20 mW/cm2). Eggs were concurrently sham exposed at each of five Tas, ranging from 27.9 to 37.5 degrees C. Tests were conducted during the 16th day of incubation (i.e., 1 day post-treatment), in the absence of microwaves, to determine metabolic rate of embryos and internal and external egg temperatures at different Tas. Repeated exposures to microwaves at 5 and 20 mW/cm2 at the same Ta (30 degrees C) increased wet-embryo mass on the 16th day by an average, respectively, of 9% and 61% when compared with predicted masses for embryos exposed at the same Ta in the absence of microwave radiation. There was no reliable indication, from post-treatment tests and comparisons with control embryos of similar mass, that repeated exposure to microwave radiation resulted in abnormal physiological development. Microwave radiation can be used to increase egg temperature and embryonic growth rate at Tas below normal incubation level without altering basic metabolic and thermal characteristics of the developing bird.

Stagg RB, Thomas WJ, Jones RA, Adey WR, DNA synthesis and cell proliferation in C6 glioma and primary glial cells exposed to a 836.55 MHz modulated radiofrequency field. Bioelectromagnetics 18(3):230-236, 1997.

We have tested the hypothesis that modulated radiofrequency (RF) fields may act as a tumor-promoting agent by altering DNA synthesis, leading to increased cell proliferation. In vitro tissue cultures of transformed and normal rat glial cells were exposed to an 836.55 MHz, packet-modulated RF field at three power densities: 0.09, 0.9, and 9 mW/cm2, resulting in specific absorption rates (SARs) ranging from 0.15 to 59 muW/g. TEM-mode transmission-line cells were powered by a prototype time-domain multiple-access (TDMA) transmitter that conforms to the North American digital cellular telephone standard. One sham and one energized TEM cell were placed in standard incubators

maintained at 37 degrees C and 5% CO2. DNA synthesis experiments at 0.59-59 muW/g SAR were performed on log-phase and serum-starved semiquiescent cultures after 24 h exposure. Cell growth at 0.15-15 muW/g SAR was determined by cell counts of log-phase cultures on days 0, 1, 5, 7, 9, 12, and 14 of a 2 week protocol. Results from the DNA synthesis assays differed for the two cell types. Sham-exposed and RF-exposed cultures of primary rat glial cells showed no significant differences for either log-phase or serum-starved condition. C6 glioma cells exposed to RF at 5.9 muW/g SAR (0.9 mW/cm2) exhibited small (20-40%) significant increases in 38% of [3H]thymidine incorporation experiments. Growth curves of sham and RF-exposed cultures showed no differences in either normal or transformed glial cells at any of the power densities tested. Cell doubling times of C6 glioma cells [sham (21.9 +/- 1.4 h) vs. field (22.7 +/- 3.2 h)] also demonstrated no significant differences that could be attributed to altered DNA synthesis rates. Under these conditions, this modulated RF field did not increase cell proliferation of normal or transformed cultures of glial origin.

Stagg RB, Hawel LH III, Pastorian K, Cain C, Adey WR, Byus CV, Effect of immobilization and concurrent exposure to a pulse-modulated microwave field on core body temperature, plasma ACTH and corticosteroid, and brain ornithine decarboxylase, Fos and Jun mRNA. Radiat Res 155(4):584-592, 2001.

Effect of Immobilization and Concurrent Exposure to a Pulse-Modulated Microwave Field on Core Body Temperature, Plasma ACTH and Corticosteroid, and Brain Ornithine Decarboxylase, Fos and Jun mRNA. Exposure of humans and rodents to radiofrequency (RF) cell phone fields has been reported to alter a number of stress- related parameters. To study this potential relationship in more detail, tube-restrained immobilized Fischer 344 rats were exposed in the near field in a dose-dependent manner to pulse-modulated (11 packets/s) digital cell phone microwave fields at 1.6 GHz in accordance with the Iridium protocol. Core body temperatures, plasma levels of the stress-induced hormones adrenocorticotrophic hormone (ACTH) and corticosterone, and brain levels of ornithine decarboxylase (Odc), Fos and Jun mRNAs were measured as potential markers of stress responses mediated by RF radiation. We tested the effects of the loose-tube immobilization with and without prior conditioning throughout a 2-h period (required for near-field head exposure to RF fields), on core body temperature, plasma ACTH and corticosteroids. Core body temperature increased transiently (+/-0.3 degrees C) during the initial 30 min of loose- tube restraint in conditioned animals. When conditioned/tube-trained animals were followed as a function of time after immobilization, both the ACTH and corticosterone levels were increased by nearly 10-fold. For example, within 2-3 min, ACTH increased to 83.2 +/- 31.0 pg/dl, compared to 28.1 +/- 7.7 pg/dl for cage controls, reaching a maximum at 15-30 min (254.6 +/- 46.8 pg/dl) before returning to near resting levels by 120 min (31.2 +/- 10.2 pg/dl). However, when non-tube-trained animals were submitted to loose-tube immobilization, these animals demonstrated significantly higher (3-10-fold greater) hormone levels at 120 min than their tube-trained counterparts (313.5 +/- 54.8 compared to 31.2 +/- 10.2 pg/dl; corticosterone, 12.2 +/- 6.2 ?g/dl compared to 37.1 +/- 6.4 ?g/dl). Hormone levels in exposed animals were also compared to those in swim-stressed animals. Swimming stress also resulted in marked elevation in both ACTH and corticosterone levels, which were 10-20 fold higher (541.8 compared to 27.2-59.1 pg/dl for ACTH) and 2-5 fold higher (45.7 compared to 8.4- 20.0 ?g/dl for corticosteroids)

than the cage control animals. Three time-averaged brain SAR levels of 0.16, 1.6 and 5 W/ kg were tested in a single 2-h RF-field exposure to the Iridium cell phone field. When RF-exposed and sham-exposed (immobilized) animals were compared, no differences were seen in core body temperature, corticosterone or ACTH that could be attributed to near-field RF radiation. Levels of Odc, Fos and Jun mRNA were also monitored in brains of animals exposed to the RF field for 2 h, and they showed no differences from sham-exposed (loose-tube immobilized) animals that were due to RF-field exposure. These data suggest that a significant stress response, indicated by a transient increase in core body temperature, ACTH and corticosterone, occurred in animals placed in even the mild loose-tube immobilization required for near-field RF exposure employed here and in our other studies. Failure to adequately characterize and control this immobilization response with appropriate cage control animals, as described previously, could significantly mask any potential effects mediated by the RF field on these and other stress-related parameters. We conclude that the pulse-modulated digital Iridium RF field at SARs up to 5 W/kg is incapable of altering these stress-related responses. This conclusion is further supported by our use of an RF-field exposure apparatus that minimized immobilization stress; the use of conditioned/tube-trained animals and the measurement of hormonal and molecular markers after 2 h RF-field exposure when the stress-mediated effects were complete further support our conclusion.

Stang A, Anastassiou G, Ahrens W, Bromen K, Bornfeld N, Jockel KH, The possible role of radiofrequency radiation in the development of uveal melanoma. Epidemiology 12(1):7-12, 2001.

There are few epidemiologic studies dealing with electromagnetic radiation and uveal melanoma. The majority of these studies are exploratory and are based on job and industry titles only. We conducted a hospital-based and population-based case-control study of uveal melanoma and occupational exposures to different sources of electromagnetic radiation, including radiofrequency radiation. We then pooled these results. We interviewed a total of 118 female and male cases with uveal melanoma and 475 controls matching on sex, age, and study regions. Exposure to radiofrequency-transmitting devices was rated as (a) no radiofrequency radiation exposure, (b) possible exposure to mobile phones, or (c) probable/certain exposure to mobile phones. Exposures were rated independently by two of the authors who did not know case or control status. We used conditional logistic regression to calculate odds ratios (ORs) and 95% confidence intervals (95% CIs). We found an elevated risk for exposure to radiofrequency-transmitting devices (exposure to radio sets, OR = 3.0, 95% CI = 1.4-6.3; probable/certain exposure to mobile phones, OR = 4.2, 95% CI = 1.2-14.5). Other sources of electromagnetic radiation such as high-voltage lines, electrical machines, complex electrical environments, visual display terminals, or radar units were not associated with uveal melanoma. This is the first study describing an association between radiofrequency radiation exposure and uveal melanoma. Several methodologic limitations prevent our results from providing clear evidence on the hypothesized association.

Stang A, Schmidt-Pokrzywniak A, Lash TL, Lommatzsch PK, Taubert G, Bornfeld N, Jöckel KH. Mobile phone use and risk of uveal melanoma: results of the risk factors for uveal melanoma Case-control study. J Natl Cancer Inst. 101(2):120-123, 2009.

We recently reported an increased risk of uveal melanoma among mobile phone users. Here, we present the results of a case-control study that assessed the association between mobile phone use and risk of uveal melanoma. We recruited 459 uveal melanoma case patients at the University of Duisburg-Essen and matched 455 case patients with 827 population control subjects, 133 with 180 ophthalmologist control subjects, and 187 with 187 sibling control subjects. We used a questionnaire to assess mobile phone use and estimated odds ratios (ORs) and 95% confidence intervals (95% CIs) of risk for uveal melanoma using conditional logistic regression. Risk of uveal melanoma was not associated with regular mobile phone use (OR = 0.7, 95% CI = 0.5 to 1.0 vs population control subjects; OR = 1.1, 95% CI = 0.6 to 2.3 vs ophthalmologist control subjects; and OR = 1.2, 95% CI = 0.5 to 2.6 vs sibling control subjects), and we observed no trend for cumulative measures of exposure. We did not corroborate our previous results that showed an increased risk of uveal melanoma among regular mobile phone users.

Stankiewicz W, Dąbrowski MP, Kubacki R, Sobiczewska E, Szmigielski S Immunotropic influence of 900 MHz microwave GSM signal on human blood immune cells activated in vitro. Electromag Biol Med 25(1): 45-51, 2006.

In an earlier study we reported that G_o phase peripheral blood mononulclear cells (PBMC) exposed to low-level (SAR = 0.18 W/kg) pulse-modulated 1300 MHz microwaves and subsequently cultured, demonstrate changed immune activity (Dabrowski et al., 2003). We investigated whether cultured immune cells induced into the active phases of cell cycle (G_1, S) and then exposed to microwaves will also be sensitive to electromagnetic field. An anechoic chamber of our design containing a microplate with cultured cells and an antenna emitting microwaves (900 MHz simulated GSM signal, 27 V/m, SAR 0.024 W/kg) was placed inside the ASSAB incubator. The microcultures of PBMC exposed to microwaves demonstrated significantly higher response to mitogens and higher immunogenic activity of monocytes (LM index) than control cultures. LM index, described in detail elsewhere (Dabrowski et al., 2001), represents the monokine influence on lymphocyte mitogenic response. The results suggest that immune activity of responding lymphocytes and monocytes can be additionally intensified by 900 MHz microwaves.

Stark KD, Krebs T, Altpeter E, Manz B, Griot C, Abelin T, Absence of chronic effect of exposure to short-wave radio broadcast signal on salivary melatonin concentrations in dairy cattle. J Pineal Res 22(4):171-176, 1997.

A pilot study was conducted to investigate the influence of electromagnetic fields in the short-wave range (3-30 MHz) radio transmitter signals on salivary melatonin concentration in dairy cattle. The hypothesis to be tested was whether EMF exposure would lower salivary melatonin concentrations, and whether removal of the EMF source would be followed by higher concentration levels. For this pilot study, a controlled intervention trial was designed. Two commercial dairy herds at two farms were compared, one located at a distance of 500 m (exposed), the other at a distance of 4,000 m (unexposed) from the transmitter. At each farm, five cows were monitored with respect to their salivary melatonin concentrations over a period of ten consecutive days. Saliva samples were collected at two-hour intervals during the dark phase of the night. As an

additional intervention, the short-wave transmitter was switched off during three of the ten days (off phase). The samples were analyzed using a radioimmunoassay. The average nightly field strength readings were 21-fold greater on the exposed farm (1.59 mA/m) than on the control farm (0.076 mA/m). The mean values of the two initial nights did not show a statistically significant difference between exposed and unexposed cows. Therefore, a chronic melatonin reduction effect seemed unlikely. However, on the first night of re-exposure after the transmitter had been off for three days, the difference in salivary melatonin concentration between the two farms (3.89 pg/ml, CI: 2.04, 7.41) was statistically significant, indicating a two- to seven-fold increase of melatonin concentration. Thus, a delayed acute effect of EMF on melatonin concentration cannot completely be excluded. However, results should be interpreted with caution and further trials are required in order to confirm the results.

Stasinopoulou M, Fragopoulou AF, Stamatakis A, Mantziaras G, Skouroliakou K, Papassideri IS, Stylianopoulou F, Lai H, Kostomitsopoulos N, Margaritis LH. Effects of pre- and postnatal exposure to 1880-1900MHz DECT base radiation on development in the rat. Reprod Toxicol. 65:248-262, 2016.

In the present study, to evaluate the effects of wireless 1880-1900MHz Digital Enhanced Communication Telephony (DECT) base radiation on fetal and postnatal development, Wistar rats were exposed at an average electric field intensity of 3.7V/m, 12h/day, during pregnancy. After parturition, a group of dams and offspring were similarly exposed for another 22days. Controls were sham-exposed. The data showed that DECT base radiation exposure caused heart rate increase in the embryos on the 17th day of pregnancy. Moreover, significant changes on the newborns' somatometric characteristics were noticed. Pyramidal cell loss and glia fibrilliary acidic protein (GFAP) over-expression were detected in the CA4 region of the hippocampus of the 22-day old pups that were irradiated either during prenatal life or both pre- and postnatally. Changes in the integrity of the brain in the 22-day old pups could potentially be related to developmental behavioral changes during the fetal period.

Stefanics G, Kellenyi L, Molnar F, Kubinyi G, Thuroczy G, Hernadi I. Short GSM mobile phone exposure does not alter human auditory brainstem response. BMC Public Health.7:325,2007.

ABSTRACT: BACKGROUND: There are about 1.6 billion GSM cellular phones in use throughout the world today. Numerous papers have reported various biological effects in humans exposed to electromagnetic fields emitted by mobile phones. The aim of the present study was to advance our understanding of potential adverse effects of the GSM mobile phones on the human hearing system. METHODS: Auditory Brainstem Response (ABR) was recorded with three non-polarizing Ag-AgCl scalp electrodes in thirty young and healthy volunteers (age 18-26 years) with normal hearing. ABR data were collected before, and immediately after a 10 minute exposure to 900 MHz pulsed electromagnetic field (EMF) emitted by a commercial Nokia 6310 mobile phone. Fifteen subjects were exposed to genuine EMF and fifteen to sham EMF in a double blind and counterbalanced order. Possible effects of irradiation was analyzed by comparing the latency of ABR waves I, III and V before

and after genuine/sham EMF exposure. RESULTS: Paired sample t-test was conducted for statistical analysis. Results revealed no significant differences in the latency of ABR waves I, III and V before and after 10 minutes of genuine/sham EMF exposure. CONCLUSIONS: The present results suggest that, in our experimental conditions, a single 10 minute exposure of 900 MHz EMF emitted by a commercial mobile phone does not produce measurable immediate effects in the latency of auditory brainstem waves I, III and V.

Stefanics G, Thuróczy G, Kellényi L, Hernádi I. Effects of twenty-minute 3G mobile phone irradiation on event related potential components and early gamma synchronization in auditory oddball paradigm. Neuroscience. 157(2):453-462, 2008.

We investigated the potential effects of 20 min irradiation from a new generation Universal Mobile Telecommunication System (UMTS) 3G mobile phone on human event related potentials (ERPs) in an auditory oddball paradigm. In a double-blind task design, subjects were exposed to either genuine or sham irradiation in two separate sessions. Before and after irradiation subjects were presented with a random series of 50 ms tone burst (frequent standards: 1 kHz, P=0.8, rare deviants: 1.5 kHz, P=0.2) at a mean repetition rate of 1500 ms while electroencephalogram (EEG) was recorded. The subjects' task was to silently count the appearance of targets. The amplitude and latency of the N100, N200, P200 and P300 components for targets and standards were analyzed in 29 subjects. We found no significant effects of electromagnetic field (EMF) irradiation on the amplitude and latency of the above ERP components. In order to study possible effects of EMF on attentional processes, we applied a wavelet-based time-frequency method to analyze the early gamma component of brain responses to auditory stimuli. We found that the early evoked gamma activity was insensitive to UMTS RF exposition. Our results support the notion, that a single 20 min irradiation from new generation 3G mobile phones does not induce measurable changes in latency or amplitude of ERP components or in oscillatory gamma-band activity in an auditory oddball paradigm.

Stewart A, Rao JN, Middleton JD, Pearmain P, Evans T. Mobile telecommunications and health: report of an investigation into an alleged cancer cluster in Sandwell, West Midlands.Perspect Public Health. 132(6):299-304, 2012.

Aims: Residents of one street expressed concern about the number of incident cancers, following the installation of a nearby mobile phone base station. The investigation explored whether the base station could be responsible for the cancers. Methods: Data were collected from residents' medical records. GPs and oncologists provided further information. Results: Ward-level cancer incidence and mortality data were also obtained, over four three-year time periods. A total of 19 residents had developed cancer. The collection of cancers did not fulfil the criteria for a cancer cluster. Standardized mortality ratios (SMRs) for all malignant neoplasms (excluding non-melanoma skin cancers) in females (1.38 (95% CI, 1.08-1.74)) and all persons (1.27 (CI, 1.06-1.51)) were significantly higher than in the West Midlands during 2001-3. There were no significant differences for colorectal, female breast and prostate cancers, for any time period. Standardized incidence ratios (SIRs) for non-melanoma skin cancers in males and all persons was significantly lower than in the West Midlands during 1999-2001, and

significantly lower in males, females and all persons during 2002-4. Conclusions: We cannot conclude that the base station was responsible for the cancers. It is unlikely that information around a single base station can either demonstrate or exclude causality.

Stopczyk D, Gnitecki W, Buczynski A, Markuszewski L, Buczynski J. Med Pr 53(4):311-314, 2002. [Article in Polish]

The aim of the study was to assess in vitro the effect of electromagnetic field produced by mobile phones on the activity of superoxide dismutase (SOD-1) and the level of malonyldialdehyde (MDA) in human blood platelets. The suspension of blood platelets was exposed to the electromagnetic field with the frequency of 900 MHz for 1, 3, 5, and 7 min. Our studies demonstrated that microwaves produced by mobiles significantly depleted SOD-1 activity after 1, 5, and 7 min of exposure and increased after 3 min in comparison with the control test. There was a significant increase in the concentration of MDA after 1, 5, and 7 min and decrease after 3 min of exposure as compared with the control test. On the grounds of our results we conclude that oxidative stress after exposure to microwaves may be the reason for many adverse changes in cells and may cause a number of systemic disturbances in the human body.

Stovner LJ, Oftedal G, Straume A, Johnsson A. Nocebo as headache trigger: evidence from a sham-controlled provocation study with RF fields. Acta Neurol Scand Suppl. 188:67-71, 2008.

BACKGROUND: A large proportion of the population in Norway has experienced headache in connection with mobile phone use, but several double-blind provocation studies with radiofrequency (RF) and sham exposures have shown no relation between headache and mobile phone RF fields. AIMS: To investigate the type and location of headache experienced by participants in one provocation study in order to gain insight into possible causes and mechanisms of the headaches. METHOD: Questionnaire about headache, indication on figure of location of headache after exposure, interview with neurologist about headache features to make headache diagnoses. RESULTS: The 17 participants went through 130 trials (sham or RF exposure). No significant difference existed in headache type, laterality or location between the headaches experienced with the two exposures types. In most participants, the headache was compatible with tension-type headache. DISCUSSION: As participants experienced their typical 'mobile phone headache' both with and without RF exposure, and since the experiment did not involve the stress or the arm/head position of mobile phone use, the most likely explanation is that the headache in this situation is caused by negative expectations (nocebo). CONCLUSION: This and other similar studies indicate that headache occurring in connection with mobile phone use is not related to RF fields, and that a nocebo effect is important for this and possibly other headache triggers.

Straume A, Oftedal G, Johnsson A. Skin temperature increase caused by a mobile phone: A methodological infrared camera study. Bioelectromagnetics. 26(6):510-519, 2005.

Mobile phone users often complain about burning sensations or a heating of the ear region. The increase in temperature may be due to thermal insulation by the phone,

heating of the mobile phone resulting from its electrical power dissipation, and radio frequency (RF) exposure. The main objective of this study was to use infrared (IR) camera techniques to find how much each of these factors contributes to the increase in skin temperature resulting from the use of one GSM 900 phone. One subject, a healthy male took part in the study. He was holding the phone in a normal position when the phone was switched off, when it was switched on but with the antenna replaced by a 50 Omega load to eliminate the RF exposure, and when it was transmitting RF fields. The output power could be fixed, and the minimal and the maximal power levels of the phone were used. The study was designed as a double blind experiment. The changes in temperature after 15 and 30 min of mobile phone use were calculated on the exposed side of the head relative to the unexposed side. The insulation and the electrical power dissipation lead to statistically significant rises in the skin temperature, while the RF exposure did not.

Straume A, Johnsson A, Oftedal G, Wilén J. Frequency spectra from current vs. magnetic flux density measurements for mobile phones and other electrical appliances. Health Phys. 93(4):279-287, 2007.

The frequency spectra of electromagnetic fields have to be determined to evaluate human exposure in accordance to ICNIRP guidelines. In the literature, comparisons with magnetic field guidelines have been performed by using the frequency distribution of the current drawn from the battery. In the present study we compared the frequency spectrum in the range 217 Hz to 2.4 kHz of the magnetic flux density measured near the surface of a mobile phone with the frequency spectrum of the supply current. By using the multiple frequency rule, recommended in the ICNIRP guidelines, we estimated the magnetic field exposure in the two cases. Similar measurements and estimations were done for an electric drill, a hair dryer, and a fluorescent desk lamp. All the devices have a basic frequency of 50 Hz, and the frequency spectra were evaluated up to 550 Hz. We also mapped the magnetic field in 3D around three mobile phones. The frequency distributions obtained from the two measurement methods are not equal. The frequency content of the current leads to an overestimation of the magnetic field exposure by a factor up to 2.2 for the mobile phone. For the drill, the hair dryer, and the fluorescent lamp, the supply current signal underestimated the exposure by a factor up to 2.3. In conclusion, an accurate exposure evaluation requires the magnetic flux density spectrum of the device to be measured directly. There was no indication that the devices studied would exceed the reference levels at the working distances normally used.

Strayer DL, Johnston WA. Driven to distraction: dual-Task studies of simulated driving and conversing on a cellular telephone. Psychol Sci 12(6):462-466, 2001.

Dual-task studies assessed the effects of cellular-phone conversations on performance of a simulated driving task. Performance was not disrupted by listening to radio broadcasts or listening to a book on tape. Nor was it disrupted by a continuous shadowing task using a handheld phone, ruling out, in this case, dual-task interpretations associated with holding the phone, listening, or speaking, However significant interference was observed in a word-generation variant of the shadowing task, and this deficit increased with the difficulty of driving. Moreover unconstrained conversations using either a handheld or a hands-free cell phone resulted in a twofold increase in the failure to detect simulated

traffic signals and slower reactions to those signals that were detected. We suggest that cellular-phone use disrupts performance by diverting attention to an engaging cognitive context other than the one immediately associated with driving.

Strayer DL, Drews FA, Johnston WA. Cell phone-induced failures of visual attention during simulated driving. J Exp Psychol Appl 9(1):23-32, 2003.

This research examined the effects of hands-free cell phone conversations on simulated driving. The authors found that these conversations impaired driver's reactions to vehicles braking in front of them. The authors assessed whether this impairment could be attributed to a withdrawal of attention from the visual scene, yielding a form of inattention blindness. Cell phone conversations impaired explicit recognition memory for roadside billboards. Eye-tracking data indicated that this was due to reduced attention to foveal information. This interpretation was bolstered by data showing that cell phone conversations impaired implicit perceptual memory for items presented at fixation. The data suggest that the impairment of driving performance produced by cell phone conversations is mediated, at least in part, by reduced attention to visual inputs.

Strayer DL, Drews FA. Profiles in driver distraction: effects of cell phone conversations on younger and older drivers. Hum Factors. 46(4):640-649, 2004.

Our research examined the effects of hands-free cell phone conversations on simulated driving. We found that driving performance of both younger and older adults was influenced by cell phone conversations. Compared with single-task (i.e., driving-only) conditions, when drivers used cell phones their reactions were 18% slower, their following distance was 12% greater, and they took 17% longer to recover the speed that was lost following braking. There was also a twofold increase in the number of rear-end collisions when drivers were conversing on a cell phone. These cell-phone-induced effects were equivalent for younger and older adults, suggesting that older adults do not suffer a significantly greater penalty for talking on a cell phone while driving than compared with their younger counterparts. Interestingly, the net effect of having younger drivers converse on a cell phone was to make their average reactions equivalent to those of older drivers who were not using a cell phone. Actual or potential applications of this research include providing guidance for recommendations and regulations concerning the use of mobile technology while driving.

Strobos MA, Coenraads PJ, De Jongste MJ, Ubels FL. Dermatitis caused by radio-frequency electromagnetic radiation. Contact Dermatitis 44(5):309, 2001.

A case report of a woman who developed dermatitis to a transmitter placed on the abdomen that sent radio waves to an implanted neurostimulatory receiver for angina. Patch tests with the plastic, rubber and glue of the transmitter were negative, as well as those with various components of the device from the manufacturer. She had skin symptoms only after starting stimulation, with spontaneous improvement in between times.

Stronati L, Testa A, Moquet J, Edwards A, Cordelli E, Villani P, Marino C, Fresegna AM, Appolloni M, Lloyd D. 935 MHz cellular phone radiation. An in vitro study of genotoxicity in human lymphocytes. Int J Radiat Biol. 82(5):339-346, 2006.

Purpose: The possibility of genotoxicity of radiofrequency radiation (RFR) applied alone or in combination with x-rays was investigated in vitro using several assays on human lymphocytes. The chosen specific absorption rate (SAR) values are near the upper limit of actual energy absorption in localized tissue when persons use some cellular telephones. The purpose of the combined exposures was to examine whether RFR might act epigenetically by reducing the fidelity of repair of DNA damage caused by a well-characterized and established mutagen.Methods: Blood specimens from 14 donors were exposed continuously for 24 h to a Global System for Mobile Communications (GSM) basic 935 MHz signal. The signal was applied at two SAR; 1 and 2 W/Kg, alone or combined with a 1-min exposure to 1.0 Gy of 250 kVp x-rays given immediately before or after the RFR. The assays employed were the alkaline comet technique to detect DNA strand breakage, metaphase analyses to detect unstable chromosomal aberrations and sister chromatid exchanges, micronuclei in cytokinesis-blocked binucleate lymphocytes and the nuclear division index to detect alterations in the speed of in vitro cell cycling.Results: By comparison with appropriate sham-exposed and control samples, no effect of RFR alone could be found for any of the assay endpoints. In addition RFR did not modify any measured effects of the x-radiation.Conclusions: This study has used several standard in vitro tests for chromosomal and DNA damage in Go human lymphocytes exposed in vitro to a combination of x-rays and RFR. It has comprehensively examined whether a 24-h continuous exposure to a 935 MHz GSM basic signal delivering SAR of 1 or 2 W/Kg is genotoxic per se or whether, it can influence the genotoxicity of the well-established clastogenic agent; x-radiation. Within the experimental parameters of the study in all instances no effect from the RFR signal was observed.

Stutts J, Feaganes J, Rodgman E, Hamlett C, Reinfurt D, Gish K, Mercadante M, Staplin L. The causes and consequences of distraction in everyday driving. Annu Proc Assoc Adv Automot Med. 47:235-251, 2003.

ABSTRACT To document drivers' exposure to potential distractions and the effects of these distractions on driving performance, inconspicuous video camera units were mounted in the vehicles of 70 volunteer subjects. The camera units automatically recorded a closeup view of the driver's face, a broader view of the interior of the vehicle, and the roadway immediately ahead of the vehicle whenever it was powered on. Three hours of randomly selected data per subject were coded based on a taxonomy of driver distractions (talking on cell phone, eating, tuning radio, etc.), contextual variables (whether vehicle stopped or moving, road type, traffic level, etc.) and observable measures of driver performance (eyes directed inside or outside vehicle, hands on or off steering wheel, and vehicle position in travel lane). Results were analyzed descriptively and using nonparametric bootstrap analysis techniques. The most common distractions in terms of overall event durations were eating and drinking (including preparations to eat or drink), distractions inside the vehicle (reaching or looking for an object, manipulating vehicle controls, etc.), and distractions outside the vehicle (often unidentified). Although many of the distractions were also associated with negative driving performance outcomes, further research is needed to clarify their impact on driving safety.

Su L, Wei X, Xu Z, Chen G. RF-EMF exposure at 1800 MHz did not elicit DNA damage or abnormal cellular behaviors in different neurogenic cells. Bioelectromagnetics. 38(3):175-185, 2017.

Despite many years of studies, the debate on genotoxic effects of radiofrequency electromagnetic fields (RF-EMF) continues. To systematically evaluate genotoxicity of RF-EMF, this study examined effects of RF-EMF on DNA damage and cellular behavior in different neurogenic cells. Neurogenic A172, U251, and SH-SY5Y cells were intermittently (5 min on/10 min off) exposed to 1800 MHz RF-EMF at an average specific absorption rate (SAR) of 4.0 W/kg for 1, 6, or 24 h. DNA damage was evaluated by quantification of γH2AX foci, an early marker of DNA double-strand breaks. Cell cycle progression, cell proliferation, and cell viability were examined by flow cytometry, hemocytometer, and cell counting kit-8 assay, respectively. Results showed that exposure to RF-EMF at an SAR of 4.0 W/kg neither significantly induced γH2AX foci formation in A172, U251, or SH-SY5Y cells, nor resulted in abnormal cell cycle progression, cell proliferation, or cell viability. Furthermore, prolonged incubation of these cells for up to 48 h after exposure did not significantly affect cellular behavior. Our data suggest that 1800 MHz RF-EMF exposure at 4.0 W/kg is unlikely to elicit DNA damage or abnormal cellular behaviors in neurogenic cells.

Sudan M, Kheifets L, Arah O, Olsen J, Zeltzer L. Prenatal and Postnatal Cell Phone Exposures and Headaches in Children. Open Pediatr Med Journal. 6(2012):46-52, 2012.

OBJECTIVE: Children today are exposed to cell phones early in life, and may be at the greatest risk if exposure is harmful to health. We investigated associations between cell phone exposures and headaches in children. STUDY DESIGN: The Danish National Birth Cohort enrolled pregnant women between 1996 and 2002. When their children reached age seven years, mothers completed a questionnaire regarding the child's health, behaviors, and exposures. We used multivariable adjusted models to relate prenatal only, postnatal only, or both prenatal and postnatal cell phone exposure to whether the child had migraines and headache-related symptoms. RESULTS: Our analyses included data from 52,680 children. Children with cell phone exposure had higher odds of migraines and headache-related symptoms than children with no exposure. The odds ratio for migraines was 1.30 (95% confidence interval: 1.01-1.68) and for headache-related symptoms was 1.32 (95% confidence interval: 1.23-1.40) for children with both prenatal and postnatal exposure. CONCLUSIONS: In this study, cell phone exposures were associated with headaches in children, but the associations may not be causal given the potential for uncontrolled confounding and misclassification in observational studies such as this. However, given the widespread use of cell phones, if a causal effect exists it would have great public health impact.

Sudan M, Kheifets L, Arah OA, Olsen J. Cell phone exposures and hearing loss in children in the danish national birth cohort. Paediatr Perinat Epidemiol. 27(3):247-257, 2013.

BACKGROUND: Children today are exposed to cell phones early in life, and may be the most vulnerable if exposure is harmful to health. We investigated the association between

cell phone use and hearing loss in children. **METHODS:** The Danish National Birth Cohort (DNBC) enrolled pregnant women between 1996 and 2002. Detailed interviews were conducted during gestation, and when the children were 6 months, 18 months and 7 years of age. We used multivariable-adjusted logistic regression, marginal structural models (MSM) with inverse-probability weighting, and doubly robust estimation (DRE) to relate hearing loss at age 18 months to cell phone use at age 7 years, and to investigate cell phone use reported at age 7 in relation to hearing loss at age 7. **RESULTS:** Our analyses included data from 52 680 children. We observed weak associations between cell phone use and hearing loss at age 7, with odds ratios and 95% confidence intervals from the traditional logistic regression, MSM and DRE models being 1.21 [95% confidence interval [CI] 0.99, 1.46], 1.23 [95% CI 1.01, 1.49] and 1.22 [95% CI 1.00, 1.49], respectively. **CONCLUSIONS:** Our findings could have been affected by various biases and are not sufficient to conclude that cell phone exposures have an effect on hearing. This is the first large-scale epidemiologic study to investigate this potentially important association among children, and replication of these findings is needed.

Sudan M, Kheifets LI, Arah OA, Divan HA, Olsen J. Complexities of sibling analysis when exposures and outcomes change with time and birth order. Expo Sci Environ Epidemiol. 2013 Sep 25. doi: 10.1038/jes.2013.56. [Epub ahead of print]

In this study, we demonstrate the complexities of performing a sibling analysis with a re-examination of associations between cell phone exposures and behavioral problems observed previously in the Danish National Birth Cohort. Children (52,680; including 5441 siblings) followed up to age 7 were included. We examined differences in exposures and behavioral problems between siblings and non-siblings and by birth order and birth year. We estimated associations between cell phone exposures and behavioral problems while accounting for the random family effect among siblings. The association of behavioral problems with both prenatal and postnatal exposure differed between siblings (odds ratio (OR): 1.07; 95% confidence interval (CI): 0.69-1.66) and non-siblings (OR: 1.54; 95% CI: 1.36-1.74) and within siblings by birth order; the association was strongest for first-born siblings (OR: 1.72; 95% CI: 0.86-3.42) and negative for later-born siblings (OR: 0.63; 95% CI: 0.31-1.25), which may be because of increases in cell phone use with later birth year. Sibling analysis can be a powerful tool for (partially) accounting for confounding by invariant unmeasured within-family factors, but it cannot account for uncontrolled confounding by varying family-level factors, such as those that vary with time and birth order.

Sukhotina I, Streckert JR, Bitz AK, Hansen VW, Lerchl A. 1800 MHz electromagnetic field effects on melatonin release from isolated pineal glands. J Pineal Res. 40(1):86-91, 2006.

Isolated pineal glands of Djungarian hamsters (Phodopus sungorus) were continuously perifused by Krebs-Ringer buffer, stimulated with the beta-adrenergic receptor agonist isoproterenol to induce melatonin synthesis, and exposed for 7 hr to a 1800 MHz continuous wave (CW) or pulsed GSM (Global System for Mobile Communications)-modulated electromagnetic signal at specific absorption rate (SAR) rates of 8, 80, 800, and 2700 mW/kg. Experiments were performed in a blind fashion. Perifusate samples

were collected every hour, and melatonin concentrations were measured by a specific radioimmunoassay. Both types of signal significantly enhanced melatonin release at 800 mW/kg SAR, while at 2700 mW/kg SAR, melatonin levels were elevated in the CW, but suppressed in the GSM-exposed pineal glands. As a temperature rise of approximately 1.2 degrees C was measured at 2700 mW/kg SAR, effects at this level are thermal. With regard to radiofrequency electromagnetic fields, the data do not support the 'melatonin hypothesis,' according to which nonthermal exposure suppresses melatonin synthesis.

Sun C, Wei X, Fei Y, Su L, Zhao X, Chen G, Xu Z. Mobile phone signal exposure triggers a hormesis-like effect in Atm+/+ and Atm-/- mouse embryonic fibroblasts. Sci Rep. 2016 Nov 18;6:37423. doi: 10.1038/srep37423.

Radiofrequency electromagnetic fields (RF-EMFs) have been classified by the International Agency for Research on Cancer as possible carcinogens to humans; however, this conclusion is based on limited epidemiological findings and lacks solid support from experimental studies. In particular, there are no consistent data regarding the genotoxicity of RF-EMFs. Ataxia telangiectasia mutated (ATM) is recognised as a chief guardian of genomic stability. To address the debate on whether RF-EMFs are genotoxic, we compared the effects of 1,800 MHz RF-EMF exposure on genomic DNA in mouse embryonic fibroblasts (MEFs) with proficient ($Atm^{+/+}$) or deficient ($Atm^{-/-}$) ATM. In $Atm^{+/+}$ MEFs, RF-EMF exposure for 1 h at an average special absorption rate of 4.0 W/kg induced significant DNA single-strand breaks (SSBs) and activated the SSB repair mechanism. This effect reduced the DNA damage to less than that of the background level after 36 hours of exposure. In the $Atm^{-/-}$ MEFs, the same RF-EMF exposure for 12 h induced both SSBs and double-strand breaks and activated the two repair processes, which also reduced the DNA damage to less than the control level after prolonged exposure. The observed phenomenon is similar to the hormesis of a toxic substance at a low dose. To the best of our knowledge, this study is the first to report a hormesis-like effect of an RF-EMF.

Sun LX, Yao K, He JL, Lu DQ, Wang KJ, Li HW. [Effect of acute exposure to microwave from mobile phone on DNA damage and repair of cultured human lens epithelial cells in vitro.] Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 24(8):465-467, 2006. [Article in Chinese]

OBJECTIVE: To investigate the DNA damage of human lens epithelial cells (LECs) caused by acute exposure to low-power 217 Hz modulated 1.8 GHz microwave radiation and DNA repair. METHODS: Cultured LECs were exposed to 217 Hz modulated 1.8 GHz microwave radiation at SAR (specific absorption rate) of 0, 1, 2, 3 and 4 W/kg for 2 hours in an sXc-1800 incubator and irradiate system. The DNA single strand breaks were detected with comet assay in sham-irradiated cells and irradiated cells incubated for varying periods: 0, 30, 60, 120 and 240 min after irradiation. Images of comets were digitized and analyzed using an Imagine-pro plus software, and the indexes used in this study were tail length (TL) and tail moment (TM). RESULTS: The difference in DNA-breaks between the exposure and sham exposure groups induced by 1 and 2 W/kg irradiation was not significant at every detect time ($P > 0.05$). As for the dosage of 3 and 4 W/kg there was difference in both

group immediately after irradiation (P < 0.01). At the time of 30 min after irradiation the difference went on at both group (P < 0.01). However, the difference disappeared after one hour's incubation in 3 W/kg group (P > 0.05), and existed in 4 W/kg group. CONCLUSION: No or repairable DNA damage was observed after 2 hour irradiation of 1.8 GHz microwave on LECs when SAR </= 3 W/kg. The DNA damages caused by 4 W/kg irradiation were irreversible.

Sun LX, Yao K, Jiang H, He JL, Lu DQ, Wang KJ, Li HW [DNA damage and repair induced by acute exposure of microwave from mobile phone on cultured human lens epithelial cells] Zhonghua Yan Ke Za Zhi. 42(12):1084-1088, 2006. [Article in Chinese]

OBJECTIVE: To investigate the effects of acute exposure of low-power 217 Hz modulated 1. 8 GHz microwave radiation on the DNA damage of human lens epithelial cells (hLECs) and repair. METHODS: Cultured hLECs were exposed to 217 Hz modulated 1. 8 GHz microwave radiation at SAR (specific absorption rate) of 1. 0, 2. 0, 3. O0 and 4. 0 W/kg for 2 hours in an sXc-1800 incubator and irradiate system, the DNA single strand breaks were detected with comet assay (single-cell gel electrophoresis) in sham-irradiated cells and irradiated cells incubated for varying periods: 0, 30 and 60 minutes after irradiation. Images of comets were digitized and analyzed using an Imagine-pro plus software, and the indexes used in this study were tail length (TL) and tail moment (TM). BrdU was added into the medium with additional one hour incubation after radiation, the cell proliferation rate was determined using a BrdU-kit. RESULTS: The difference of DNA-breaks between the exposure and sham exposure groups induced by 1.0 and 2.0 W/kg irradiation were not significant in each time points (P > 0.05) ; there were significant difference in both groups at the exposure dose of 3. 0 and 4. 0 W/kg immediately and at the time of 30 minutes after irradiation (P <0. 01) ; if the radiation exposure time was beyond one hour no differences were be able to detected in 3.0 W/kg group (P > 0. 05) compared with control, but the evidence of significant DNA damage still existed in 4. 0 W/kg group at the same time point. Cell proliferation rate had no significant difference when the application of SAR was < or = 3. 0 W/kg (P >0. 05) , however the cell proliferation was decreased significantly at the dose of 4. 0 W/kg irradiation (P < 0. 01). CONCLUSIONS: No effective DNA damage was induced using comet assay after 2 hours irradiation of 1. 8 GHz microwave on hLECs at the dose SAR < or = 3.0 W/kg. 4.0 W/kg irradiation caused significantly DNA damage and inhibition of hLECs proliferation.

Sun W, Shen X, Lu D, Lu D, Chiang H. Superposition of an incoherent magnetic field inhibited EGF receptor clustering and phosphorylation induced by a 1.8 GHz pulse-modulated radiofrequency radiation. Int J Radiat Biol. 89:378-383, 2013.

Purpose: The present study was conducted to investigate the effect of a temporally incoherent ('noise') magnetic field (MF) on radiofrequency radiation (RFR)-induced epidermal growth factor (EGF) receptor clustering and phosporylation in cultured cells. Materials and methods: Human amniotic epithelial (FL) cells were exposed for 15 min to either a 1.8 GHz RFR (modulated at 217 Hz), a 2 μT incoherent MF, or concurrently to the RFR and incoherent MF. Epidermal growth factor treatment severed as the positive control. Epidermal growth factor receptor clustering on cellular membrane surface was analyzed using confocal microscopy after indirect

immunofluorescence staining, and phosphorylation of EGF receptors was measured by western blot technology. Results: Exposure of FL cells to the 1.8 GHz RFR at SAR (specific absorption rate) of 0.5, 1.0, 2.0, or 4.0 W/kg for 15 min induced EGF receptor clustering and enhanced phosphorylation on tyrosine-1173 residue, whereas exposure to RFR at SAR of 0.1 W/kg for 15 min did not significantly cause these effects. Exposure to a 2 μT incoherent MF for 15 min did not significantly affect clustering and phosphorylation of EGF receptor in FL cells. When superimposed, the incoherent MF completely inhibited EGF receptor clustering and phosphorylation induced by RFR at SAR of 0.5, 1.0, and 2.0 W/kg, but did not inhibit the effects induced at SAR of 4.0 W/kg. Conclusion: Based on the data of the experiment, it is suggested that membrane receptors could be one of the main targets by which RFR interacts with cells. An incoherent MF could block the interaction to a certain extent

Sun W, Shen X, Lu D, Fu Y, Lu D, Chiang H. A 1.8-GHz radiofrequency radiation induces EGF receptor clustering and phosphorylation in cultured human amniotic (FL) cells. Int J Radiat Biol. 88(3):239-244, 2012.

PURPOSE: Many studies have shown that exposure to radiofrequency radiation (RFR) could activate cellular signal transduction pathways. In the present research, we investigated the effects of exposure to a 1.8-GHz RFR at different intensities on epidermal growth factor (EGF) receptor clustering and phosphorylation in human amniotic (FL) cells.MATERIALS AND METHODS: Receptor clustering on cellular membrane surface was analyzed using immunofluorescence assessed by confocal microscopy, and phosphorylation of EGF receptors was measured by western blot technology. EGF treatment served as a positive control.RESULTS: The results showed that, compared with sham exposure, exposure to RFR at specific absorption rate (SAR) of 0.5, 1.0, 2.0, or 4.0 W/kg for 15 min significantly induced EGF receptor clustering and enhanced phosphorylation on the tyrosine-1173 residue in FL cells, whereas exposure to a SAR 0.1 W/kg radiation for 15 min did not cause a significant effect.CONCLUSION: Based on the results of this experiment, we conclude that membrane receptors could be one of the main targets that RFR interacts with cells, and the dose-rate threshold, in the case of EGF receptors, is between SAR of 0.1 and 0.5 W/kg. The results indicate a sigmoid dependence of RFR effects on intensity.

Sun Y, Zong L, Gao Z, Zhu S, Tong J, Cao Y. Mitochondrial DNA damage and oxidative damage in HL-60 cells exposed to 900MHz radiofrequency fields. Mutat Res. 797-799:7-14, 2017.

HL-60 cells, derived from human promyelocytic leukemia, were exposed to continuous wave 900MHz radiofrequency fields (RF) at 120μW/cm2 power intensity for 4h/day for 5 consecutive days to examine whether such exposure is capable damaging the mitochondrial DNA (mtDNA) mediated through the production of reactive oxygen species (ROS). In addition, the effect of RF exposure was examined on 8-hydroxy-2'-dexoyguanosine (8-OHdG) which is a biomarker for oxidative damage and on the mitochondrial synthesis of adenosine triphosphate (ATP) which is the energy required for cellular functions. The results indicated a significant increase in ROS and significant

decreases in mitochondrial transcription factor A, mtDNA polymerase gamma, mtDNA transcripts and mtDNA copy number in RF-exposed cells compared with those in sham-exposed control cells. In addition, there was a significant increase in 8-OHdG and a significant decrease in ATP in RF-exposed cells. The response in positive control cells exposed to gamma radiation (GR, which is also known to induce ROS) was similar to those in RF-exposed cells. Thus, the overall data indicated that RF exposure was capable of inducing mtDNA damage mediated through ROS pathway which also induced oxidative damage. Prior-treatment of RF- and GR-exposed the cells with melatonin, a well-known free radical scavenger, reversed the effects observed in RF-exposed cells.

Sunohara T, Hirata A, Laakso I, Onishi T. Analysis of in situ electric field and specific absorption rate in human models for wireless power transfer system with induction coupling.Phys Med Biol. 59(14):3721-3735, 2014.

This study investigates the specific absorption rate (SAR) and the in situ electric field in anatomically based human models for the magnetic field from an inductive wireless power transfer system developed on the basis of the specifications of the wireless power consortium. The transfer system consists of two induction coils covered by magnetic sheets. Both the waiting and charging conditions are considered. The transfer frequency considered in this study is 140 kHz, which is within the range where the magneto-quasi-static approximation is valid. The SAR and in situ electric field in the chest and arm of the models are calculated by numerically solving the scalar potential finite difference equation. The electromagnetic modelling of the coils in the wireless power transfer system is verified by comparing the computed and measured magnetic field distributions. The results indicate that the peak value of the SAR averaged over a 10 g of tissue and that of the in situ electric field are 72 nW kg^{-1} and 91 mV m^{-1} for a transmitted power of 1 W, Consequently, the maximum allowable transmitted powers satisfying the exposure limits of the SAR (2 W kg^{-1}) and the in situ electric field (18.9 V m^{-1}) are found to be 28 MW and 43 kW. The computational results show that the in situ electric field in the chest is the most restrictive factor when compliance with the wireless power transfer system is evaluated according to international guidelines.

Suresh S, Sabanayagam C, Kalidindi S, Shankar A. Cell-phone use and self-reported hypertension: national health interview survey 2008.Int J Hypertens.2011:360415, 2011.

Background. Cell-phone usage has increased dramatically over the last decade, along with a rising public concern over the health effects of using this device. The association between cell-phone usage and hypertension has not been examined before. Methods. We analysed data from 21,135 adults aged ≥18 years who participated in the 2008 National Health Interview Survey. Based on reported cell-phone use, participants were categorized as cell-phone nonusers, predominantly landline users, dual users of cell phone and landline, and predominantly cell-phone users. The main outcome of interest was self-reported physician-diagnosed hypertension (n = 6,793). Results. 43.5% of the participants were cell-phone nonusers, while 13.8% were predominantly cell-phone users. We found that cell-phone use was inversely associated with hypertension,

independent of age, sex, race/ethnicity, smoking, alcohol consumption, education, body mass index (BMI), and physical activity. Compared to cell-phone nonusers, the multivariable odds ratio (95% confidence interval) of hypertension was 0.86 (0.75-0.98, P trend = .005) among predominantly cell-phone users. This inverse association between cell-phone use and hypertension was stronger in women, those aged <60 years, whites, and those with BMI <25 kg/m(2). Conclusion. We found that cell-phone usage was protectively associated with self-reported hypertension in a nationally representative sample of US adults.

Susa M, Pavicić I. Djelovanje Radiofrekvencijskog Elektromagnetskog Zracenja na Spermatogenez u Sisavaca. Arh Hig Rada Toksikol. 58(4):449-459, 2007.

This article reviews studies about the effects of radiofrequency electromagnetic (RF EM) fields on male reproductive system and reproductive health in mammals. According to current data, there are almost 4 million active mobile phone lines in Croatia while this number has risen to 2 billion in the world. Increased use of mobile technology raises scientific and public concern about possible hazardous effects of RF fields on human health. The effects of radiofrequencies on reproductive health and consequences for the offspring are still mainly unknown. A number of in vivo and in vitro studies indicated that RF fields could interact with charged intracellular macromolecular structures. Results of several laboratory studies on animal models showed how the RF fields could affect the mammalian reproductive system and sperm cells. Inasmuch as, in normal physiological conditions spermatogenesis is a balanced process of division, maturation and storage of cells, it is particularly vulnerable to the chemical and physical environmental stimuli. Especially sensitive could be the cytoskeleton, composed of charged proteins; actin, intermedial filaments and microtubules. Cytoskeleton is a functional and structural part of the cell that has important role in the sperm motility, and is actively involved in the morphologic changes that occur during mammalian spermiogenesis.

Suzuki S, Okutsu M, Suganuma R, Komiya H, Nakatani-Enomoto S, Kobayashi S, Ugawa YTateno H, Fujimori K. Influence of radiofrequency-electromagnetic waves from 3rd-generation cellular phones on fertilization and embryo development in mice. Bioelectromagnetics. 38(6):466-473, 2017.

The purpose of this study was to evaluate the effects of 3rd-generation (3G) cellular phone radiofrequency-electromagnetic wave (RF-EMW) exposure on fertilization and embryogenesis in mice. Oocytes and spermatozoa were exposed to 3G cellular phone RF-EMWs, 1.95 GHz wideband code division multiple access, at a specific absorption rate of 2 mW/g for 60 min, or to sham exposure. After RF-EMW exposure, in vitro fertilization and intracytoplasmic sperm injection were performed. Rates of fertilization, embryogenesis (8-cell embryo, blastocyst), and chromosome aberration were compared between the combined spermatozoa and oocyte groups: both exposed, both non-exposed, one exposed, and the other non-exposed. Rates of fertilization, embryogenesis, and blastocyst formation did not change significantly across the four groups. Considering that the degree of exposure in the present study was ≥100 times greater than daily

exposure of human spermatozoa and even greater than daily exposure of oocytes, the present results indicate safety of RF-EMW exposure in humans.

Sykes PJ, McCallum BD, Bangay MJ, Hooker AM, Morley AA. Effect of Exposure to 900 MHz Radiofrequency Radiation on Intrachromosomal Recombination in pKZ1 Mice. Radiat Res 156(5):495-502, 2001.

Radiofrequency (RF) radiation emitted from mobile phones is not considered to be directly genotoxic, but it may have downstream effects on cellular DNA. We studied the effect of 4 W/kg pulsed 900 MHz RF radiation on somatic intrachromosomal recombination in the spleen in the pKZ1 recombination mutagenesis model. Somatic intrachromosomal recombination inversion events were detected in spleen tissue of pKZ1 mice by histochemical staining for E. coli beta-galactosidase protein in cells in which the lacZ transgene has undergone an inversion event. pKZ1 mice were exposed daily for 30 min to plane-wave fields of 900 MHz with a pulse repetition frequency of 217 Hz and a pulse width of 0.6 ms for 1, 5 or 25 days. Three days after the last exposure, spleen sections were screened for DNA inversion events. There was no significant difference between the control and treated groups in the 1- and 5-day exposure groups, but there was a significant reduction in inversions below the spontaneous frequency in the 25-day exposure group. This observation suggests that exposure to RF radiation can lead to a perturbation in recombination frequency which may have implications for recombination repair of DNA. The biological significance of a reduction below the spontaneous frequency is not known. The number of mice in each treatment group in this study was small (n = 10 or n = 20). Therefore, repetition of this study with a larger number of animals is required to confirm these observations.

Szmigielski, S, Cancer morbidity in subjects occupationally exposed to high frequency (radiofrequency and microwave) electromagnetic radiation. Sci Total Environ 180(1):9-17, 1996.

Cancer morbidity was registered in the whole population of military career personnel in Poland during a period of 15 years (1971-1985). Subjects exposed occupationally to radiofrequencies (RF) and microwaves (MW) were selected from the population on the basis of their service records and documented exposures at service posts. The population size varied slightly from year to year with a mean count of about 128,000 persons each year; each year about 3700 of them (2.98%) were considered as occupationally exposed to RF/MW. All subjects (exposed and non-exposed to RF/MW) were divided into age groups (20-29, 30-39, 40-49 and 50-59). All newly registered cases of cancer were divided into 12 types based on localisation of the malignancy; for neoplasms of the haemopoietic system and lymphatic organs an additional analysis based on diagnosis was performed. Morbidity rates (per 100,000 subjects annually) were calculated for all of the above localisations and types of malignancies both for the whole population and for the age groups. The mean value of 15 annual rates during 1971-1985 represented the respective morbidity rate for the whole period. Morbidity rates in the non-exposed groups of personnel were used as 'expected' (E) rates for the exposed subjects, while the real morbidity rates counted in the RF/MW-exposed personnel served as 'observed' (O) rates. This allowed the calculation of the observed/expected ratio (OER)

representing the odds ratio for the exposed groups. The cancer morbidity rate for RF/MW-exposed personnel for all age groups (20-59 years) reached 119.1 per 100,000 annually (57.6 in non-exposed) with an OER of 2.07, significant at $P < 0.05$. The difference between observed and expected values results from higher morbidity rates due to neoplasms of the alimentary tract (OER = 3.19-3.24), brain tumours (OER = 1.91) and malignancies of the haemopoietic system and lymphatic organs (OER = 6.31). Among malignancies of the haemopoietic/lymphatic systems, the largest differences in morbidity rates between exposed and non-exposed personnel were found for chronic myelocytic leukaemia (OER = 13.9), acute myeloblastic leukaemia (OER = 8.62) and non-Hodgkin lymphomas (OER = 5.82).

Szmigielski, S, Bortkiewicz, A, Gadzicka, E, Zmyslony, M, Kubacki, R, Alteration of diurnal rhythms of blood pressure and heart rate to workers exposed to radiofrequency electromagnetic fields. Blood Press Monit 3(6):323-330, 1998.

BACKGROUND: In previous studies we found measurable effects on variability of heart rate and on blood-pressure parameters of workers exposed to radiofrequency electromagnetic fields (EMF)compared with a control population, but none of the effects could be assigned clinical significance. In general, the obtained results strongly suggested that dysregulation of the autonomic control of the circulatory system was occurring. Therefore, it seemed logical that analysis of diurnal rhythms of blood pressure and heart rate, on the basis of data from 24 h recordings, might further support the above hypothesis. OBJECTIVE: The aim of this study was to determine the course of diurnal rhythms of blood pressure and heart rate in a group of workers exposed to various intensities of radiofrequency electromagnetic fields. METHODS: In the study we used 61 healthy workers (aged 30-50 years) who had been exposed to radiofrequency EMF of 0.738-1.503 Mhz and 42 healthy workers at radio-line stations (aged 28-49 years), who had not been exposed to EMF occupationally. The work patterns of these two groups were identical (12 h day working shift, 24 h interval, 12 h night shift and then 48 h rest). During the second day of the rest period 24 h ambulatory blood pressure (ABP) was recorded. For analysis of diurnal rhythms the group of exposed workers was divided into two subgroups: group A of 38 subjects exposed to low intensities of radiofrequency EMF (20-180 V/m) and group B of 23 subjects exposed to high intensities of radiofrequency EMF (200-550 V/m). Parameters of diurnal rhythms of blood pressure and heart rate (acrophase, amplitude and mean) were calculated by performing a least-square fit of a 24 h cosinor (single cosinor analysis) at $P < 0.05$. RESULTS: Healthy men aged 28-49 years, working on a pattern of 12-24-12-48 h, exhibited typical, well-preserved diurnal rhythms of blood pressure and heart rate with two maxima (at about 1400 and 1700-1800 h) and one minimum (at about 0200-0400 h). For workers exposed to radiofrequency EMF we noted a significant lowering of the amplitudes of rhythms of blood pressure and heart rate ($P < 0.01$) and a shift of the acrophase to an earlier time (1100-1200 h; $P < 0.05$). These changes were more pronounced among workers exposed to high intensities of radiofrequency EMF. CONCLUSIONS: Occupational exposure to radiofrequency EMF can result in changes of the diurnal rhythms of blood pressure and heart rate with lowering of their amplitudes and a shift of the acrophase. The clinical relevance of the present finding needs to be investigated in further studies.

Szyjkowska A, Bortkiewicz A, Szymczak W, Makowiec-Dabrowska T. [Subjective

symptoms related to mobile phone use--a pilot study] Pol Merkuriusz Lek. 19(112):529-532, 2005. [Article in Polish]

Research findings indicate that the use of mobile phones may lead to a number of symptoms such as headache, impaired concentration and memory, fatigue. In Poland this problem has not as yet been addressed by scientific studies. THE AIM: The present project was undertaken to investigate whether the symptoms of ill health reported by young people may be associated with the use of mobile phone. MATERIAL AND METHODS: A survey using a self-reported questionnaire was conducted among randomly selected university students in Lodz, Central Poland. The questionnaire was designed specifically for this study and contained items on health condition and complaints as well as on frequency of mobile phone use. The number of questionnaires necessary for the study was assessed using the simple random sample method. Out of the 160 copies distributed among the students, 140 (87.5%) were completed. Eventually, 117 questionnaires were subject to analysis; the data from respondents who reported health problems (neck trauma in a car accident, chronic sinusitis and arterial hypertension) were excluded. The following statistical methods were used to analyse questionnaire data: t-Student test for equal and unequal variances or F-Snedecor test for comparing parameters in two study groups, Fisher exact test for comparing frequency, and single and multiple logistic regression models for quantitative risk assessment of negative health outcomes in relation to exposure level and with control for confounders. The subjects were 61 (52.1%) males and 56 females (47.9%). RESULTS: Most of the subjects (62%) assessed their health condition as good, 31% as very good and 7% as fair. 70% complained of headache and 20% of dizziness. Impaired concentration occurred in 56% of respondents. Facial dermatitis was reported by 11%. The most prevalent symptom related to mobile phone use was the thermal sensation within the auricle and behind/around the ear. This was reported by 33 subjects (28.2%). Out of 82 subjects who complained of headache, only 8 (6.8%) related this symptom to mobile phone use. Only 10 subjects of 65 reporting impaired concentration thought it could be associated with their using a mobile phone. The symptoms and health complaints reported by the respondents in no case were the reason for a medical check-up or taking any medication. CONCLUSIONS: The large number of young people complaining of headache and impaired concentration calls for further research to investigate the underlying reasons. It cannot be excluded that one of them may be exposure to EMF emitted by mobile phone. The explanation should be sought through further experimental and epidemiologic studies.

Szyjkowska A, Gadzicka E, Szymczak W, Bortkiewicz A. The risk of subjective symptoms in mobile phone users in Poland - An epidemiological study. Int J Occup Med Environ Health. 2014 Apr 1. [Epub ahead of print]

OBJECTIVES: To assess the type and incidence of subjective symptoms related to the use of mobile phones in Polish users. **MATERIAL AND METHODS:** The study was conducted in 2005 using a questionnaire survey. Although it has been quite a long time, up to now, no such data have been published for Poland. The questionnaire consisted of 53 questions concerning sex, age, education, general health, characteristics of a mobile phone (hand-held, loud-speaking unit) as well as the habits associated with its use

(frequency and duration of calls, text messages, etc.) and complaints associated with using a mobile phone. **RESULTS:** As many as 1800 questionnaires were sent. The response was obtained from 587 subjects aged 32.6±11.3 (48.9% women, 51.1% men); the age did not differ significantly between men and women. The subjects owned a cell phone for an average of 3 years. Majority of the respondents used the phone intensively, i.e. daily (74%) or almost daily (20%). Headaches were reported significantly more often by the people who talked frequently and long in comparison with other users (63.2% of the subjects, p = 0.0029), just like the symptoms of fatigue (45%, p = 0.013). Also, the feeling of warmth around the ear and directly to the auricle was reported significantly more frequently by the intensive mobile phone users, compared with other mobile phone users (47.3%, p = 0.00004 vs. 44.6%, p = 0.00063, respectively). Most symptoms appeared during or immediately after a call and disappeared within 2 h after the call. Continuous headache, persisting for longer than 6 h since the end of a call, was reported by 26% of the subjects. **CONCLUSIONS:** Our results show that the mobile phone users may experience subjective symptoms, the intensity of which depends on the intensity of use of mobile phones.

Taberski K, Klose M, Grote K, El Ouardi A, Streckert J, Hansen VW, Lerchl A. Noninvasive Assessment of Metabolic Effects of Exposure to 900 MHz Electromagnetic Fields on Djungarian Hamsters (Phodopus sungorus). Radiat Res. 181(6):617-622, 2014.

Sixteen male Djungarian hamsters, serving as their own controls, were individually exposed to RF-EMF (900 MHz, GSM modulation) at 0 (sham), 0.08, 0.4 or 4 W/kg specific absorption rate (SAR) in specially constructed rectangular waveguides. Exposure duration was one week per condition, followed by one week without exposure. Once per day, the temperatures of the hamsters' back fur (a surrogate for skin temperature) and the cornea of the eye (a surrogate for body temperature), were measured by infrared thermography. Oxygen, carbon dioxide and humidity were measured continuously in the ambient and exhaled air. Food and water consumption, as well as body weight were recorded once per week. Only at the highest SAR level were the following effects observed: fur temperatures were elevated by approximately 0.5°C ($P < 0.001$), while the temperatures of the eyes' surface were not affected; food consumption was lowered ($P < 0.05$), while water consumption and body weight were not affected; the production of carbon dioxide was lowered during the day ($P < 0.01$) and unaffected during the night, while oxygen consumption levels remained unaffected and finally the respiratory quotient (carbon dioxide production divided by oxygen consumption) was lower during the day ($P < 0.05$) and also somewhat lower during the night (not significant). The results demonstrate the usefulness of our methods for experiments dealing with metabolic effects of RF-EMF exposure in rodents. They also confirm the assumption that even though the metabolism is reduced at high SAR levels, the body core temperature is being kept constant by the energy uptake from the RF-EMF exposure which is able to physiologically compensate for the reduced metabolism.

Tafforeau M, Verdus MC, Norris V, White GJ, Cole M, Demarty M, Thellier M, Ripoll C.Plant sensitivity to low intensity 105 GHz electromagnetic radiation.

Bioelectromagnetics. 25(6):403-407, 2004.

Exposing seedlings of the flax, Linum usitatissimum L., to a variety of weak environmental stresses followed by a 2 day calcium deprivation, triggers the common response of production of epidermal meristems (actively dividing groups of cells) in the hypocotyl, which is the part of the stem between the root and the cotyledons (the pre-existing leaves in the embryo). This production reaches a plateau of 10-20 meristems after a month in the case of mechanical stimulation and cold shock. Recently, we have shown that radiation from a global system for mobile communication (GSM) telephone also triggers production of meristems with a plateau of around six meristems. Here, we show that a single 2 h exposure to radiation emitted at 105 GHz at non-thermal levels by a Gunn oscillator induces meristem production with kinetics similar to that induced by weak environmental stimuli and radiation from GSM telephone.

Tafforeau M, Verdus M-C, Norris V, White G, Demarty M, Thellier M, Ripoll C. SIMS study of the calcium-deprivation step related to epidermal meristem production induced in flax by cold shock or radiation from a GSM telephone. J Trace Microprobe Tech 20(4):611-623, 2002.

Exposing seedlings of the flax, Linum usitatissimum L., to a variety of weak environmental stresses plus a 2-day calcium deprivation triggers the common response of production of epidermal meristems in the hypocotyls. Here, we show that the same response was induced by a 1 min cold shock. Epidemal meristem production was also induced by a single 2-h exposure to radiation emitted at 0.9 GHz at non-thermal levels by a GSM telephone. This flax-based system is therefore well suited to studying the effects of low intensity stimuli, including those of electromagnetic radiation. To begin to determine the underlying mechanisms, in which calcium is implicated, it is desirable to analyse the changes in ions in the tissues affected. We therefore performed a Secondary Ion Mass Spectrometry (SIMS) study of the distribution of the main inorganic cations in the hypocotl of control and calcium-deprived seedlings. This showed decreases in calcium, sodium and potassium and an increase in magnesium that did not alter substantially the overall ratio of divalent to monovalent cations.

Taheri M, Mortazavi SM, Moradi M, Mansouri S, Hatam GR, Nouri F. Evaluation of the Effect of Radiofrequency Radiation Emitted From Wi-Fi Router and Mobile Phone Simulator on the Antibacterial Susceptibility of Pathogenic Bacteria Listeria monocytogenes and Escherichia coli. Dose Response. 2017 Jan 23;15(1):1559325816688527.

Mobile phones and Wi-Fi radiofrequency radiation are among the main sources of the exposure of the general population to radiofrequency electromagnetic fields (RF-EMF). Previous studies have shown that exposure of microorganisms to RF-EMFs can be associated with a wide spectrum of changes ranged from the modified bacterial growth to the alterations of the pattern of antibiotic resistance. Our laboratory at the nonionizing department of the Ionizing and Non-ionizing Radiation Protection Research Center has performed experiments on the health effects of exposure to animal models and humans to different sources of electromagnetic fields such as cellular phones, mobile base

stations, mobile phone jammers, laptop computers, radars, dentistry cavitrons, magnetic resonance imaging, and Helmholtz coils. On the other hand, we have previously studied different aspects of the challenging issue of the ionizing or nonionizing radiation-induced alterations in the susceptibility of microorganisms to antibiotics. In this study, we assessed if the exposure to 900 MHz GSM mobile phone radiation and 2.4 GHz radiofrequency radiation emitted from common Wi-Fi routers alters the susceptibility of microorganisms to different antibiotics. The pure cultures of *Listeria monocytogenes* and *Escherichia coli* were exposed to RF-EMFs generated either by a GSM 900 MHz mobile phone simulator and a common 2.4 GHz Wi-Fi router. It is also shown that exposure to RF-EMFs within a narrow level of irradiation (an exposure window) makes microorganisms resistant to antibiotics. This adaptive phenomenon and its potential threats to human health should be further investigated in future experiments. Altogether, the findings of this study showed that exposure to Wi-Fi and RF simulator radiation can significantly alter the inhibition zone diameters and growth rate for *L monocytogenes* and *E coli.* These findings may have implications for the management of serious infectious diseases.

Tahvanainen K, Niño J, Halonen P, Kuusela T, Laitinen T, Länsimies E, Hartikainen J, Hietanen M, Lindholm H. Cellular phone use does not acutely affect blood pressure or heart rate of humans. Bioelectromagnetics 25:73-83, 2004.

A recent study raised concern about increase of resting blood pressure after a 35 min exposure to the radiofrequency (RF) field emitted by a 900 MHz cellular phone. In this randomized, double blind, placebo controlled crossover trial, 32 healthy subjects were submitted to 900 MHz (2 W), 1800 MHz (1 W) cellular phone exposure, and to sham exposure in separate sessions. Arterial blood pressure (arm cuff method) and heart rate were measured during and after the 35 min RF and sham exposure sessions. We evaluated cardiovascular responses in terms of blood pressure and heart rate during controlled breathing, spontaneous breathing, head-up tilt table test, Valsalva manoeuvre and deep breathing test. Arterial blood pressure and heart rate did not change significantly during or after the 35 min RF exposures at 900 MHz or 1800 MHz, compared to sham exposure. The results of this study indicate that exposure to a cellular phone, using 900 MHz or 1800 MHz with maximal allowed antenna powers, does not acutely change arterial blood pressure and heart rate.

Tahvanainen K, Nino J, Halonen P, Kuusela T, Alanko T, Laitinen T, Lansimies E, Hietanen M, Lindholm H. Effects of cellular phone use on ear canal temperature measured by NTC thermistors. Clin Physiol Funct Imaging. 27(3):162-172, 2007.

The earlier studies using phantom models and human subjects concerning warming effects during cellular phone use have been controversial, partly because radiofrequency (RF) exposures have been variable. In this randomized, double-blind, placebo-controlled crossover trial, 30 healthy subjects were submitted to 900 MHz (2W) and 1800 MHz (1W) cellular phone RF exposure, and to sham exposure in separate study sessions. Temperature signals were recorded continuously in both ear canals before, during and after the 35-min RF exposure and the 35-min sham exposure sessions. Temperature was measured by using small-sized NTC thermistors placed in the ear canals through disposable ear plugs. The mean temperature changes were determined during a set cardiovascular autonomic

function studies: during a 5-min controlled breathing test, during a 5-min spontaneous breathing test, during 7-min head-up tilting, 1-min before, during and after two consecutive Valsalva manoeuvres and during a deep breathing test. Temperatures in the exposed ear were significantly higher during RF exposures compared with sham exposure in both 900 and 1800 MHz studies with maximum differences of 1.2 +/- 0.5 degrees C (900 MHz exposure) and 1.3 +/- 0.7 degrees C (1800 MHz exposure). Temperatures in the RF-exposed ear were also significantly higher during the postexposure period compared with post-sham exposure period with maximum differences of 0.6 +/- 0.3 degrees C for 900 MHz and 0.5 +/- 0.5 degrees C for 1800 MHz. The results of this study suggest that RF exposure to a cellular phone, either using 900 or 1800 MHz with their maximal allowed antenna powers, increases the temperature in the ear canal. The reason for the ear canal temperature rising is a consequence of mobile phone battery warming during maximal antenna power use. The earlier published articles do not indicate that temperature rising in the ear canal has any significant contribution from the RF fields emitted from mobile phones.

Takahashi S, Inaguma S, Cho Y-M, Imaida K, Wang J, Fujiwara O, Shirai T,Lack of Mutation Induction with Exposure to 1.5 GHz Electromagnetic Near Fields Used for Cellular Phones in Brains of Big Blue Mice. Cancer Res 62:1956-1960, 2002.

The possible mutagenic potential of exposure to 1.5 GHz electromagneticnear field (EMF) was investigated using brain tissues of BigBlue mice (BBM). Male BBM were locally exposed to EMF in thehead region at 2.0, 0.67, and 0 W/kg specific absorption ratefor 90 min/day, 5 days/week, for 4 weeks. No gliosis or degenerativelesions were histopathologically noted in brain tissues, andno obvious differences in Ki-67 labeling and apoptotic indicesof glial cells were evident among the groups. There was no significantvariation in the frequency of independent mutations of the lacItransgene in the brains. G:C to A:T transitions at CpG sitesconstituted the most prevalent mutations in all groups and atall time points. Deletion mutations were slightly increasedin both the high and low EMF exposure groups as compared withthe sham-exposed group, but the differences were not statisticallysignificant. These findings suggest that exposure to 1.5 GHzEMF is not mutagenic to mouse brain cells and does not createany increased hazard with regard to brain tumor development.

Takahashi S, Imai N, Nabae K, Wake K, Kawai H, Wang J, Watanabe S, Kawabe M, Fujiwara O, Ogawa K, Tamano S, Shirai T. Lack of adverse effects of whole-body exposure to a mobile telecommunication electromagnetic field on the rat fetus.Radiat Res. 173(3):362-372, 2010.

The recent steep increase in the number of users of cellular phones is resulting in marked increase of exposure of humans to radiofrequency electromagnetic fields (EMFs). Children are of particular concern. Our goal was to evaluate potential adverse effects of long-term whole-body exposure to EMFs simulating those from base stations for cellular phone communication. Pregnant rats were given low, high or no exposure. At the high level, the average specific absorption rate (SAR)for the dams was 0.066-0.093 W/kg. The SAR for the fetuses and the F(1) progeny was 0.068-0.146 W/kg. At the low level, the SARs were about 43% of these. The 2.14 GHz signals were applied for 20 h per day during the gestation and lactation periods. No abnormal findings were observed in either

the dams or the F(1) generation exposed to the EMF or in the F(2) offspring. Parameters evaluated included growth, gestational condition and organ weights for dams and survival rates, development, growth, physical and functional development, hormonal status, memory function and reproductive ability of the F(1) offspring (at 10 weeks of age) along with embryotoxicity and teratogenicity in the F(2) rats. Thus, under our experimental conditions, whole-body exposure to 2.14 GHz for 20 h per day during gestation and lactation did not cause any adverse effects on pregnancy or the development of rats.

Takashima Y, Hirose H, Koyama S, Suzuki Y, Taki M, Miyakoshi J. Effects of continuous and intermittent exposure to RF fields with a wide range of SARs on cell growth, survival, and cell cycle distribution. Bioelectromagnetics.27(5):392-400, 2006.

To examine the biological effects of radio frequency (RF) electromagnetic fields in vitro, we have examined the fundamental cellular responses, such as cell growth, survival, and cell cycle distribution, following exposure to a wide range of specific absorption rates (SAR). Furthermore, we compared the effects of continuous and intermittent exposure at high SARs. An RF electromagnetic field exposure unit operating at a frequency of 2.45 GHz was used to expose cells to SARs from 0.05 to 1500 W/kg. When cells were exposed to a continuous RF field at SARs from 0.05 to 100 W/kg for 2 h, cellular growth rate, survival, and cell cycle distribution were not affected. At 200 W/kg, the cell growth rate was suppressed and cell survival decreased. When the cells were exposed to an intermittent RF field at 300 W/kg(pk), 900 W/kg(pk) and 1500 W/kg(pk) (100 W/kg(mean)), no significant differences were observed between these conditions and intermittent wave exposure at 100 W/kg. When cells were exposed to a SAR of 50 W/kg for 2 h, the temperature of the medium around cells rose to 39.1 degrees C, 100 W/kg exposure increased the temperature to 41.0 degrees C, and 200 W/kg exposure increased the temperature to 44.1 degrees C. Exposure to RF radiation results in heating of the medium, and the thermal effect depends on the mean SAR. Hence, these results suggest that the proliferation disorder is caused by the thermal effect.

Takebayashi T, Akiba S, Kikuchi Y, Taki M, Wake K, Watanabe S, Yamaguchi N. Mobile phone use and acoustic neuroma risk in Japan. Occup Environ Med.63(5):802-807, 2006.

OBJECTIVES: The rapid increase of mobile phone use has increased public concern about its possible health effects in Japan, where the mobile phone system is unique in terms of the characteristics of the signal transmission. To examine the relationship between mobile phone use and acoustic neuroma, a case-control study was initiated. METHODS: The study followed the common, core protocol of the international collaborative study, INTERPHONE study. A prospective case recruitment was done in Japan for 2000-2004. One hundred and one acoustic neuroma cases, who were 30-69 years of age and resided in the Tokyo area, and 339 age-, sex-, and residency-matched controls were interviewed using a common computer-assisted personal interview system. Education- and marital status-adjusted odds ratio was calculated with a conditional logistic regression analysis. RESULTS: Fifty-one cases (52.6%) and 192 controls (58.2%) were regular mobile phone users on the reference date, which was set as 1 year before the diagnosis, and no significant increase of acoustic neuroma risk was observed, with

the odds ratio (OR) being 0.73 (95% confidence interval : 0.43-1.23). No exposure-related increase in the risk of acoustic neuroma was observed when the cumulative length of use (<4 years, 4-8 years, >8years) or cumulative call time (<300 h, 300-900 h, >900h) was used as an exposure index. The OR was 1.09 (95%CI:0.58-2.06) when the reference date was set as 5 years before the diagnosis. Further, laterality of mobile phone use was not associated with tumors. CONCLUSIONS: These results suggest that there is no significant increase in the risk of acoustic neuroma in association with mobile phone use in Japan.

Takebayashi T, Varsier N, Kikuchi Y, Wake K, Taki M, Watanabe S, Akiba S, Yamaguchi N. Mobile phone use, exposure to radiofrequency electromagnetic field, and brain tumour: a case-control study. Br J Cancer. 98(3):652-659, 2008.

In a case-control study in Japan of brain tumours in relation to mobile phone use, we used a novel approach for estimating the specific absorption rate (SAR) inside the tumour, taking account of spatial relationships between tumour localisation and intracranial radiofrequency distribution. Personal interviews were carried out with 88 patients with glioma, 132 with meningioma, and 102 with pituitary adenoma (322 cases in total), and with 683 individually matched controls. All maximal SAR values were below 0.1 W kg(-1), far lower than the level at which thermal effects may occur, the adjusted odds ratios (ORs) for regular mobile phone users being 1.22 (95% confidence interval (CI): 0.63-2.37) for glioma and 0.70 (0.42-1.16) for meningioma. When the maximal SAR value inside the tumour tissue was accounted for in the exposure indices, the overall OR was again not increased and there was no significant trend towards an increasing OR in relation to SAR-derived exposure indices. A non-significant increase in OR among glioma patients in the heavily exposed group may reflect recall bias.

Takeda H, Yasunaga K, Sakuma N, Hirose H, Nojima T, Miyakoshi J. 2-GHz Band CW and W-CDMA modulated radiofrequency fields have no significant effect on cell proliferation and gene expression profile in human cells. J Radiat Res (Tokyo). 51(3):277-284, 2010.

We investigated the mechanisms by which radiofrequency (RF) fields exert their activity, and the changes in both cell proliferation and the gene expression profile in the human cell lines, A172 (glioblastoma), H4 (neuroglioma), and IMR-90 (fibroblasts from normal fetal lung) following exposure to 2.1425 GHz continuous wave (CW) and Wideband Code Division Multiple Access (W-CDMA) RF fields at three field levels. During the incubation phase, cells were exposed at the specific absorption rates (SARs) of 80, 250, or 800 mW/kg with both CW and W-CDMA RF fields for up to 96 h. Heat shock treatment was used as the positive control. No significant differences in cell growth or viability were observed between any test group exposed to W-CDMA or CW radiation and the sham-exposed negative controls. Using the Affymetrix Human Genome Array, only a very small (< 1%) number of available genes (ca. 16,000 to 19,000) exhibited altered expression in each experiment. The results confirm that low-level exposure to 2.1425 GHz CW and W-CDMA RF fields for up to 96 h did not act as an acute cytotoxicant in either cell proliferation or the gene expression profile. These results suggest that RF exposure up to the limit of whole-body average SAR levels as specified in the ICNIRP guidelines is unlikely to elicit a general stress

response in the tested cell lines under these conditions.

Talebnejad MR, Sadeghi-Sarvestani A, Hossein Nowroozzadeh M, Mortazavi SMJ, Khalili MR. The effects of microwave radiation on rabbit's retina. Journal of Current Ophthalmology, Available online 9 October 2017.

Purpose Mobile cell phones are used extensively these days, and their microwave (MW) radiation has been shown to affect the eye. The purpose of the present study was to evaluate the effects of MW radiation on rabbit retina. Methods This experimental study (concluded in 2015) was conducted on 40 adult white New Zealand rabbits. A Global System for Mobile Communications (GSM) cell phone simulator was used for MW irradiation. The rabbits were randomized into five groups (8 in each) and treated as follows: Group 1: no irradiation (sham); Group 2: irradiation at 10 cm for 1 day; Group 3: irradiation at 30 cm for 1 day; Group 4: irradiation at 10 cm for 3 days; and Group 5: irradiation at 30 cm for 3 days. Scotopic and photopic electroretinography (ERG) responses were obtained at baseline and 7 days after the last exposure. Then all the rabbits were euthanized, and their eyes were enucleated and sent for pathology examination. Kruskal–Wallis and Chi-Square tests were used to evaluate intergroup differences in ERG parameters and histological findings, respectively. Results ERG responses obtained 7 days after irradiation did not show any statistically significant difference between the groups ($P > 0.1$, for all tested parameters). There were statistically non-significant trends toward greater changes in the MW irradiated eyes. In pathological examination, retina was normal with no sign of degeneration or infiltration. Ciliary body congestion was observed in greater fraction of those who received higher MW doses. ($P = 0.005$). Conclusions Histopathologically, cell phone simulated MW irradiation had no significant detrimental effect on the retina. However, ciliary body congestion was observed in greater fraction of those who received higher MW doses. Although there was no significant difference between post-treatment mean ERG values, there were statistically non-significant trends toward greater changes in the MW irradiated eyes.

Talei D, Valdiani A, Maziah M, Mohsenkhah M. Germination response of MR 219 rice variety to different exposure times and periods of 2450 MHz microwave frequency. ScientificWorldJournal. 2013 Nov 6;2013:408026. doi: 10.1155/2013/408026. eCollection 2013.

Germination is a key process in plants' phenological cycles. Accelerating this process could lead to improvment of the seedling growth as well as the cultivation efficiency. To achieve this, the effect of microwave frequency on the germination of rice seeds was examined. The physiological feedbacks of the MR 219 rice variety in terms of seed germination rate (GR), germination percentage (GP), and mean germination time (MGT) were analyzed by exposing its seeds to 2450 MHz of microwave frequency for one, four, seven, and ten hours. It was revealed that exposing the seeds to the microwave frequency for 10 hours resulted in the highest GP. This treatment led to 100% of germination after three days with a mean germination time of 2.1 days. Although the other exposure times of microwave frequency caused the moderate effects on germination with a GP(a3) ranged from 93% to 98%, they failed to reduce the MGT(a3). The results

showed that ten-hour exposure times of microwave frequency for six days significantly facilitated and improved the germination indices (primary shoot and root length). Therefore, the technique is expected to benefit the improvement of rice seed germination considering its simplicity and efficacy in increasing the germination percentage and rate as well as the primary shoot and root length without causing any environmental toxicity.

Tamer A, **Gündüz H**, **Ozyildirim S**. **The cardiac effects of a mobile phone positioned closest to the heart. Anadolu Kardiyol Derg. 9(5):380-384, 2009.**

OBJECTIVE: The aim of this study was to evaluate the effect of mobile phone (MP) on cardiac electrical activity by examining the heart rate variability (HRV), QT, P dispersions and blood pressure (BP) while the MP is located on the precordium. METHODS: A total of 24 healthy volunteers were included in this prospective study. In the first step; 12-lead electrocardiogram (ECG) and BP recordings of the subjects without MP, while the MP is off, on, and ringing were recorded. In the second step; rhythm and BP were recorded for 30 minutes with the Holter without MP, and when the MP was "on" at the precordial location. P-wave and QT interval dispersions were measured from 12-lead ECG, while Holter 24-hour recordings were used for HRV analysis. Statistical analysis was performed using paired t test for comparison of hemodynamic and HRV variables without MP and during MP on. ANOVA for repeated measures was used to compare hemodynamic and ECG variables through baseline and 3 experimental settings: MP on, off and ringing. RESULTS: There were no statistically significant differences between the groups in the BP, heart rate, P-wave dispersion, QT dispersion and QT corrected dispersion parameters ($p>0.05$) in the first step of the study. In the second step, there were no significant differences between two groups in the BP, heart rate and HRV parameters ($p>0.05$). CONCLUSION: We conclude that MP has no effect on hemodynamic (heart rate, blood pressure) and cardiac electrical activity (P-wave and QT dispersions) parameters when it is positioned on the chest in immediate proximity to the heart, and it does not cause cardiac autonomic dysfunction examined by HRV analysis in healthy adult subjects.

Tang J, Zhang Y, Yang L, Chen Q, Tan L, Zuo S, Feng H, Chen Z, Zhu G. Exposure to 900 MHz electromagnetic fields activates the mkp-1/ERK pathway and causes blood-brain barrier damage and cognitive impairment in rats. Brain Res. 1601:92-101, 2015.

With the rapid increase in the number of mobile phone users, the potential adverse effects of the electromagnetic field radiation emitted by a mobile phone has become a serious concern. This study demonstrated, for the first time, the blood-brain barrier and cognitive changes in rats exposed to 900 MHz electromagnetic field (EMF) and aims to elucidate the potential molecular pathway underlying these changes. A total of 108 male Sprague-Dawley rats were exposed to a 900 MHz, 1 mW/cm(2) EMF or sham (unexposed) for 14 or 28 days (3h per day). The specific energy absorption rate (SAR) varied between 0.016 (whole body) and 2 W/kg (locally in the head). In addition, the Morris water maze test was used to examine spatial memory performance determination. Morphological changes were investigated by examining ultrastructural changes in the hippocampus and cortex, and the Evans Blue assay was used to assess blood brain

barrier (BBB) damage. Immunostaining was performed to identify heme oxygenase-1 (HO-1)-positive neurons and albumin extravasation detection. Western blot was used to determine HO-1 expression, phosphorylated ERK expression and the upstream mediator, mkp-1 expression. We found that the frequency of crossing platforms and the percentage of time spent in the target quadrant were lower in rats exposed to EMF for 28 days than in rats exposed to EMF for 14 days and unexposed rats. Moreover, 28 days of EMF exposure induced cellular edema and neuronal cell organelle degeneration in the rat. In addition, damaged BBB permeability, which resulted in albumin and HO-1 extravasation were observed in the hippocampus and cortex. Thus, for the first time, we found that EMF exposure for 28 days induced the expression of mkp-1, resulting in ERK dephosphorylation. Taken together, these results demonstrated that exposure to 900 MHz EMF radiation for 28 days can significantly impair spatial memory and damage BBB permeability in rat by activating the mkp-1/ERK pathway.

Tanvir S, Thuróczy G, Selmaoui B, Pires-Antonietti VS, SonnetP, Arnaud-Cormos D, Lévêque P, Pulvin S, de Seze R. Effects of 3G cell phone exposure on the structure and function of the human cytochrome P450 reductase. Bioelectrochemistry Available online 11 May 2016.

Cell phones increase exposure to radiofrequency (RF) electromagnetic fields (EMFs). Whether EMFs exert specific effects on biological systems remains debatable. This study investigated the effect of cell phone exposure on the structure and function of human NADPH-cytochrome P450 reductase (CPR). CPR plays a key role in the electron transfer to cytochrome P450, which takes part in a wide range of oxidative metabolic reactions in various organisms from microbes to humans. Human CPR was exposed for 60 min to 1966-MHz RF inside a transverse electromagnetic cell (TEM-cell) placed in an incubator. The specific absorption rate (SAR) was 5 $W \cdot kg^{-1}$. Conformation changes have been detected through fluorescent spectroscopy of flavin and tryptophan residues, and investigated through circular dichroism, dynamic light scattering and microelectrophoresis. These showed that CPR was narrowed. By using cytochrome C reductase activity to assess the electron flux through the CPR, the Michaelis Menten constant (Km) and the maximum initial velocity (Vmax) decreased by 22% as compared with controls. This change was due to small changes in the tertiary and secondary structures of the protein at 37 °C. The relevance of these findings to an actual RF exposure scenario demands further biochemical and in-vivo confirmation.

Tas M, Dasdag S, Akdag MZ, Cirit U, Yegin K, Seker U, Ozmen MF, Eren LB. Long-term effects of 900 MHz radiofrequency radiation emitted from mobile phone on testicular tissue and epididymal semen quality. Electromagn Biol Med. 2013 Jun 19. [Epub ahead of print]

Abstract The purpose of this study is to bridge this gap by investigating effects of long term 900 MHz mobile phone exposure on reproductive organs of male rats. The study was carried out on 14 adult Wistar Albino rats by dividing them randomly into two groups (n: 7) as sham group and exposure group. Rats were exposed to 900 MHz radiofrequency (RF) radiation emitted from a GSM signal generator. Point, 1 g and

10 g specific absorption rate (SAR) levels of testis and prostate were found as 0.0623 W/kg, 0.0445 W/kg and 0.0373 W/kg, respectively. The rats in the exposure group were subject to RF radiation 3 h per day (7 d a week) for one year. For the sham group, the same procedure was applied, except the generator was turned off. At the end of the study, epididymal sperm concentration, progressive sperm motility, abnormal sperm rate, all-genital organs weights and testis histopathology were evaluated. Any differences were not observed in sperm motility and concentration ($p > 0.05$). However, the morphologically normal spermatozoa rates were found higher in the exposure group ($p < 0.05$). Although histological examination showed similarity in the seminiferous tubules diameters in both groups, tunica albuginea thickness and the Johnsen testicular biopsy score were found lower in the exposure group ($p < 0.05$, $p < 0.0001$). In conclusion, we claim that long-term exposure of 900 MHz RF radiation alter some reproductive parameters. However, more supporting evidence and research is definitely needed on this topic.

Tashiro M, Horikawa E, Mochizuki H, Sakurada Y, Kato M, Inokuchi T, Ridout F, Hindmarch I, Yanai K. Effects of fexofenadine and hydroxyzine on brake reaction time during car-driving with cellular phone use. Hum Psychopharmacol. 20(7):501-509, 2005.

Antihistamines are a mainstay treatment for allergic rhinitis; however, many older agents cause adverse events, including sedation and central nervous system (CNS) impairment. Research has shown sedating effects of antihistamines on driving; currently, no known study has examined whether cellular phone usage while driving further compounds impairment in individuals administered antihistamines. The aim of this study was to examine this endpoint. In a randomized, double-blind, placebo-controlled, three-way crossover study, healthy volunteers received fexofenadine HCl 120 mg, hydroxyzine HCl 30 mg and placebo. Brake reaction time (BRT) was used to examine driving performance across four conditions: driving only; driving while completing simple calculations; complex calculations; and conversing on a cellular phone. Subjective sedation assessments were also conducted. Brake reaction time with and without cellular phone usage in fexofenadine-treated subjects did not differ significantly from placebo in any condition. In contrast, hydroxyzine-treated subjects were significantly more sedated and had slower BRTs, suggesting slower hazard recognition and brake application, compared with the fexofenadine and placebo groups in all conditions. Importantly, cellular phone operation was an additive factor, increasing BRTs in hydroxyzine-treated volunteers. Fexofenadine did not impair CNS function in subjects involved in a divided attention task of driving and cellular phone operation.

Taskinen H, Kyyronen P, Hemminki K, Effects of ultrasound, shortwaves, and physical exertion on pregnancy outcome in physiotherapists. J Epidemiol Community Health 44(3):196-201, 1990.

STUDY OBJECTIVE--The aim of the study was to investigate whether occupational exposure among physiotherapists is associated with spontaneous abortion or congenital malformation in the offspring. DESIGN--The study was a retrospective nested case-control study, where the pregnancy outcome data were based on the medical registers. SETTING--All registered physiotherapists in Finland who had

become pregnant during the study period were included in the study. SUBJECTS--Cases were defined as women who had been treated for spontaneous abortion during 1973-1983 or had delivered a malformed child during 1973-1982. One pregnancy per woman was randomly selected for the study. Three age matched (+/-18 months) controls were selected for each abortion case and five for each malformation case. The final study population was 204 cases and 483 controls in the spontaneous abortion study, and 46 cases and 187 controls in the congenital malformation study. MEASUREMENTS AND MAIN RESULTS--Exposure information was collected by mailed questionnaires from 1329 women. The response rate was 92% in the spontaneous abortion study, and 89% in the congenital malformation study. Heavy lifting (including patient transfers) was associated significantly with spontaneous abortion. Exposure to ultrasound and shortwaves showed about threefold odds ratios for spontaneous abortions occurring after the 10th week of gestation but in analysis where potential confounding variables were controlled, neither reached statistical significance. Deep heat therapies together, and shortwaves alone, were associated significantly with congenital malformations, but the increase was found in the lower exposure category only. From the potential confounding variables, previous abortion (spontaneous or induced) was associated significantly with spontaneous abortion, and febrile disease in early pregnancy was associated with congenital malformation. CONCLUSION--Physical exertion during early pregnancy seems to be a risk factor for spontaneous abortion. The findings raise suspicion of the potential harmful effect of shortwaves and ultrasound on the pregnancy, but no firm conclusion can be drawn on the bases of these results alone.

Tat FH, Wah KC, Hung YH. A follow-up study of electromagnetic interference of cellular phones on electronic medical equipment in the emergency department. Emerg Med (Fremantle) 14(3):315-319, 2002.

OBJECTIVE: Considering the growing use of cellular phones and the fast appearance of new phone models, the electromagnetic interference of currently popular cellular phones on electronic medical equipment was tested. METHODS: Three Personal Communication System cellular phones were put at different distances from multiple electronic medical devices, the interference effect was observed and the electromagnetic field strength measured with a spectrum analyser. RESULTS: Only two small pieces of equipment, the CO2 airway adapter and the haemoglucostix meter were affected and then only when the phone was in very close proximity. CONCLUSION: Compared to the results of our study in 1997 testing Global System for Mobile Communication phones, the Personal Communication System phones generated less electromagnetic interference. However a much larger scaled study and an accurate international electromagnetic interference standard are recommended before any change in the current restrictive hospital policy on mobile phone usage could be recommended.

Tattersall JE, Scott IR, Wood SJ, Nettell JJ, Bevir MK, Wang Z, Somasiri NP, Chen X. Effects of low intensity radiofrequency electromagnetic fields on electrical activity in rat hippocampal slices. Brain Res 904(1):43-53, 2001.

Slices of rat hippocampus were exposed to 700 MHz continuous wave radiofrequency (RF) fields (25.2-71.0 V m(-1), 5-15 min exposure) in a stripline waveguide. At low field

intensities, the predominant effect on the electrically evoked field potential in CA1 was a potentiation of the amplitude of the population spike by up to 20%, but higher intensity fields could produce either increases or decreases of up to 120 and 80%, respectively, in the amplitude of the population spike. To eliminate the possibility of RF-induced artefacts due to the metal stimulating electrode, the effect of RF exposure on spontaneous epileptiform activity induced in CA3 by 4-aminopyridine (50-100 &mgr;M) was investigated. Exposure to RF fields (50.0 V m(-1)) reduced or abolished epileptiform bursting in 36% of slices tested. The maximum field intensity used in these experiments, 71.0 V m(-1), was calculated to produce a specific absorption rate (SAR) of between 0.0016 and 0.0044 W kg(-1) in the slices. Measurements with a Luxtron fibreoptic probe confirmed that there was no detectable temperature change (+/-0.1 degrees C) during a 15 min exposure to this field intensity. Furthermore, imposed temperature changes of up to 1 degrees C failed to mimic the effects of RF exposure. These results suggest that low-intensity RF fields can modulate the excitability of hippocampal tissue in vitro in the absence of gross thermal effects. The changes in excitability may be consistent with reported behavioural effects of RF fields.

Taylor DM, Bennett DM, Carter M, Garewal D. Mobile telephone use among Melbourne drivers: a preventable exposure to injury risk. Med J Aust. 179(3):140-142, 2003.

OBJECTIVE: To determine the rate of handheld mobile telephone use among motor vehicle drivers. DESIGN AND SETTING: Observational study of motor vehicle drivers at three times (10: 00-11: 00; 14: 00-15: 00; 17: 00-18: 00) on three consecutive Fridays in October 2002 at 12 highway sites in metropolitan Melbourne. MAIN OUTCOME MEASURES: Rates of mobile phone use overall and by sex and age group, highway site (major metropolitan road, central business district, freeway exit ramp) and time of day (morning, afternoon, evening). RESULTS: 315 of 17 023 drivers were observed using mobile phones (18.5 users/1000 drivers; 95% CI, 16.5-20.6). Men had a slightly higher rate of use (19.0; 95% CI, 16.5-21.6) than women (17.5; 95% CI, 14.1-20.9), but the difference was not significant. Older drivers (50 years or more) had a significantly lower rate (4.8; 95% CI, 2.5-7.0) than middle-aged (21.9; 95% CI, 18.8-25.1) or young drivers (23.2; 95% CI, 18.9-27.5). Central business district drivers had a slightly, but not significantly, higher rate (20.5; 95% CI, 16.8-24.3) compared with those on major metropolitan roads (16.7; 95% CI, 13.3-20.2) or freeway exit ramps (18.2; 95% CI, 14.8-21.6). The rate of mobile phone use was significantly higher in the evening (23.5; 95% CI, 19.8-27.3) compared with the morning (16.0; 95% CI, 12.6-19.4) and afternoon (15.2; 95% CI, 11.9-18.4). CONCLUSION: Mobile phone use is common among Melbourne metropolitan drivers despite restrictive legislation. This issue needs to be further addressed by Victoria Police and public health and education agencies. Similar research is indicated to determine the extent of mobile phone use in other states.

Teerapot Wessapan, Phadungsak Rattanadecho. Specific absorption rate and temperature increase in the human eye due to electromagnetic fields exposure at different frequencies. International Journal of Heat and Mass Transfer, 64:426-435, September 2013.

This study presents a numerical analysis of the specific absorption rate (SAR) and the

heat transfer in a heterogeneous human eye model exposed to electromagnetic (EM) fields of 900 and 1800 MHz. In this study, the effect of operating frequency on the SAR and temperature distributions in the eye was systematically investigated. The SAR value and the temperature distribution in various tissues in the eye during exposure to EM fields were obtained by numerical simulation of EM wave propagation and a heat transfer model was then developed based on the natural convection and porous media theories. The study highlights two transport phenomena: heat and mass transfer in the eye during exposure to EM fields at different frequencies. This study indicated that when the eye exposed to EM fields at the frequencies of 900 and 1800 MHz, the highest SAR values at two chosen frequencies was in the cornea, and the highest temperature at the frequency of 900 MHz was in the anterior chamber while the highest for the frequency of 1800 MHz was in the vitreous. The temperature distribution in the eye induced by EM fields was not directly related to the SAR distribution due to the effect of the interaction among the dielectric properties, thermal properties, blood perfusion, and penetration depth of the EM power. Moreover, this study also showed that the exposure time had an influence on the temperature increase in the eye.

Teerapot Wessapan, Phadungsak Rattanadecho. Influence of ambient temperature on heat transfer in the human eye during exposure to electromagnetic fields at 900 MHz. International Journal of Heat and Mass Transfer 70: 378-388, 2014.
The topic of temperature increase in human tissue when exposed to EM fields, particularly those radiated to the eye, has been of interest for many years. This study presents a numerical analysis of the specific absorption rate (SAR) and the heat transfer in a heterogeneous two-dimensional human eye model exposed to TM-mode of electromagnetic (EM) fields of 900 MHz at various power densities. In this study, the effects of ambient temperature and power density on the temperature distributions and fluid flow in the eye during exposure to electromagnetic fields were systematically investigated. The electric field, SAR, temperature distribution and fluid flow in various tissues in the eye during exposure to EM fields were obtained by numerical simulation of EM wave propagation and a heat transfer model. The heat transfer model was then developed based on the porous media theories. The study highlights heat transfer and fluid flow in the eye during exposure to EM fields at different ambient temperatures. This study indicated that when the eye exposed to EM fields at the frequency of 900 MHz, the highest electric field intensity and SAR values at the chosen frequency was in the cornea. At the highest power density of 100 mW/cm^2, the absorbed EM energy is converted to heat causes a further increase of 3 °C in corneal temperature in cases of hot, moderate and cold ambient temperatures. The result shows important information related to a complex interaction between ambient temperature, fluid flow and temperature distribution in the eye during exposure to electromagnetic fields. Moreover, this study also showed that the power density had a strong influence on the temperature increase and fluid flow in the eye.

Tell RA, Sias GG, Vazquez A, Sahl J, Turman JP, Kavet RI, Mezei G. RADIOFREQUENCY FIELDS ASSOCIATED WITH THE ITRON SMART METER.Radiat Prot Dosimetry.151(1):17-29, 2012.

This study examined radiofrequency (RF) emissions from smart electric power meters deployed in two service territories in California for the purpose of evaluating potential human exposure. These meters included transmitters operating in a local area mesh network (RF LAN, ~250 mW); a cell relay, which uses a wireless wide area network (WWAN, ~1 W); and a transmitter serving a home area network (HAN, ~70 mW). In all instances, RF fields were found to comply by a wide margin with the RF exposure limits established by the US Federal Communications Commission. The study included specialised measurement techniques and reported the spatial distribution of the fields near the meters and their duty cycles (typically <1 %) whose value is crucial to assessing time-averaged exposure levels. This study is the first to characterise smart meters as deployed. However, the results are restricted to a single manufacturer's emitters.

Tell RA, Kavet R, Mezei G. Characterization of radiofrequency field emissions from smart meters. J Expo Sci Environ Epidemiol. 2012 Nov 7. doi: 10.1038/jes.2012.102. [Epub ahead of print]

This study presents measurement data that describe radiofrequency emission levels and patterns from smart meters (rated nominally at 1 W) currently deployed in Pacific Gas and Electric Company's service territory in northern California. The smart meters in our investigation could not be set to operate continuously and required a Field Service Unit to induce short periods of emitted fields. To obtain peak field data under both laboratory and ambient conditions, a spectrum analyzer scanned across the 83 transmitting channels between 902 and 928 MHz used by the smart meter on a random frequency-hopping basis. To obtain data describing temporal emission patterns, the analyzer operated in scope mode. Duty cycle was estimated using transmit data acquired by the system operator from over 88,000 m. Instantaneous peak fields at 0.3 m in front of the meters were no more than 15% of the US Federal Communications Commission (FCC) exposure limit for the general public, and 99.9% of the meters operated with a duty cycle of 1.12% or less during the sampling period. In a sample of measurements in six single-detached residences equipped with individual smart meters, no interior measurement of peak field exceeded 1% of the FCC's general public exposure limit.

Tell RA, Kavet R. A SURVEY OF THE URBAN RADIOFREQUENCY (RF) ENVIRONMENT. Radiat Prot Dosimetry. 2014 Feb 23. [Epub ahead of print]

In 1980, Tell and Mantiply published a study of radiofrequency (RF) fields measured across 15 major metropolitan areas in the USA. They required a van fully equipped with instrumentation and computing capability for their measurements. This study aimed to assess whether and how hand-held instrumentation available today would facilitate and enhance the efficiency of large-scale surveys of ambient RF fields. In addition, the data would provide a suggestion as to how the profile of ambient RF fields has changed with respect to frequency content and magnitude. Not unexpectedly, the relative power densities were orders of magnitude lower than the Federal Communications Commission's (FCC) maximum permissible exposure (MPE) for the general public, with a maximum time-averaged value across the VHF-FM-UHF-cellular bands of 0.12 % of the MPE (AM's contribution was negligible). In

both the 1980 and the present study, the power density in the FM band was a major contributor to overall power density, but over time, power densities in the VHF and UHF band decreased and increased, respectively. From the perspective of absolute power density, the wideband values in the 1980 study, this study and any number of assessments conducted in European nations are not generally different from one another.

Terao Y, Okano T, Furubayashi T, Ugawa Y. Effects of thirty-minute mobile phone use on visuo-motor reaction time. Clin Neurophysiol.117(11):2504-2511, 2006.

OBJECTIVE: To investigate whether exposure to pulsed high-frequency electromagnetic field (pulsed EMF) emitted by a mobile phone has short-term effects on the visuo-motor choice reaction time (RT) and movement time (MT). METHODS: A double blind, counterbalanced crossover design was employed. In 16 normal subjects, we studied the performance of a visuo-motor precued choice reaction time task (PCRT) before and after exposure to EMF emitted by a mobile phone for 30 minutes or sham exposure. RESULTS: The RTs and MTs under different conditions of precue information were not affected by exposure to pulsed EMF emitted by a mobile phone or by sham phone use. CONCLUSIONS: Thirty minutes of mobile phone use has no significant short-term effect on the cortical visuo-motor processing as studied by the present PCRT task. SIGNIFICANCE: This is the first study to investigate visuo-motor behavior in relation to mobile phone exposure. No significant effect of mobile phone use was demonstrated on the performance of the visuo-motor reaction time task.

Terao Y, Okano T, Furubayashi T, Yugeta A, Inomata-Terada S, Ugawa Y Effects of thirty-minute mobile phone exposure on saccades. Clin Neurophysiol. 118(7):1545-1556, 2007.

OBJECTIVE: To investigate whether exposure to pulsed high-frequency electromagnetic field (pulsed EMF) emitted by a mobile phone has short-term effects on saccade performances. METHODS: A double blind, counterbalanced crossover design was employed. In 10 normal subjects, we studied the performance of visually guided saccade (VGS), gap saccade (GAP), and memory guided saccade (MGS) tasks before and after exposure to EMF emitted by a mobile phone for thirty minutes or sham exposure. We also implemented a hand reaction time (RT) task in response to a visual signal. RESULTS: With the exception of VGS and MGS latencies, the parameters of VGS, GAP and MGS tasks were unchanged before and after real or sham EMF exposure. In addition, the latencies of VGS and MGS did not change differently after real and sham exposure. The hand RT shortened with the repetition of trials, but again this trend was of similar magnitude for real and sham exposures. CONCLUSIONS: Thirty minutes of mobile phone exposure has no significant short-term effect on saccade performances. SIGNIFICANCE: This is the first study to investigate saccade performance in relation to mobile phone exposure. No significant effect of mobile phone use was demonstrated on the performance of various saccade tasks, suggesting that the cortical processing for saccades and attention is not affected by exposure to EMF emitted by a mobile phone.

Tereshin Siu, [The combined action of different forms of iodine and organic iodine compounds and of superhigh-frequency electromagnetic fields on the excitability and accommodative capacity of nervous and muscular tissues in frogs]. Vopr Kurortol Fizioter Lech Fiz Kult (5):31-33, 1999. [Article in Russian]

Experiments on 130 male lake frogs were made to study a combined action of SHF electromagnetic fields (microwaves) and baths KI + I2, DMSO, KI + I2 + DMSO, iodinol, iodinol + DMSO, humic acids, humic acids + KI + I2, humic acids + DMSO, sapropel + DMSO on excitability and accommodation ability of nervous and muscular tissues. The most perspective combinations (by the number of statistically significant shifts of 6 electrophysiological parameters) were selected for screening on warm-blooded animals. These were SHF microwaves + KI + I2, SHF microwaves + iodinol.

Terro F, Magnaudeix A, Crochetet M, Martin L, Bourthoumieu S, Wilson CM, Yardin C, Leveque P. GSM-900MHz at low dose temperature-dependently downregulates α-synuclein in cultured cerebral cells independently of chaperone-mediated-autophagy.Toxicology. 292(2-3):136-144, 2012.

The expanding use of GSM devices has resulted in public concern. Chaperone-mediated autophagy (CMA) is a way for protein degradation in the lysosomes and increases under stress conditions as a cell defense response. α-synuclein, a CMA substrate, is a component of Parkinson disease. Since GSM might constitute a stress signal, we raised the possibility that GSM could alter the CMA process. Here, we analyzed the effects of chronic exposure to a low GSM-900MHz dose on apoptosis and CMA. Cultured cerebral cortical cells were sham-exposed or exposed to GSM-900MHz at specific absorption rate (SAR): 0.25W/kg for 24 h using a wire-patch cell. Apoptosis was analyzed by DAPI stain of the nuclei and western blot of cleaved caspase-3. The expression of proteins involved in CMA (HSC70, HSP40, HSP90 and LAMP-2A) and α-synuclein were analyzed by western blot. CMA was also quantified in situ by analyzing the cell localization of active lysosomes. 24 h exposure to GSM-900MHz resulted in ~0.5°C temperature rise. It did not induce apoptosis but increased HSC70 by 26% and slightly decreased HSP90 (<10%). It also decreased α-synuclein by 24% independently of CMA, since the localization of active lysosomes was not altered. Comparable effects were observed in cells incubated at 37.5°C, a condition that mimics the GSM-generated temperature rise. The GSM-induced changes in HSC70, HSP90 and α-synuclein are most likely linked to temperature rise. We did not observe any immediate effect on cell viability. However, the delayed and long term consequences (protective or deleterious) of these changes on cell fate should be examined.

Testylier G, Tonduli L, Malabiau R, Debouzy JC. Effects of exposure to low level radiofrequency fields on acetylcholine release in hippocampus of freely moving rats. Bioelectromagnetics 23:249-255, 2002.

Some central cholinergic effects have been reported in animals after acute exposure to radiofrequency electromagnetic field at low intensity. We studied acetylcholine (ACh) release in the brain of freely moving rats exposed for 1 h during the day to a 2.45 GHz continuous wave radiofrequency field (RF) (2 or 4 mW/cm^2) or exposed for 1 or 14 h during the night to a 800 MHz field modulated at 32 Hz (AM 200 mW/cm^2).

Measurements were performed by microdialysis using a membrane implanted through the upper CA1 region of the hippocampus. After irradiation with the 2.45 GHz RF, rats exposed at 2 mW/cm^2 did not show a significant modification of Ach release, whereas those exposed at 4 mW/cm^2 showed a significant 40% decrease in mean ACh release from hippocampus. This decrease was maximal at 5 h post exposure. Exposure to the 800 MHz RF for 1 h did not cause any significant effect, but exposure for 14 hrs induced a significant 43% decrease in ACh release during the period 11 p.m.-4 a.m. compared to control rats. In the control group we observed an increase of ACh release at the beginning of the night, which was linked to the waking period of rats. This normal increase was disturbed in rats exposed overnight to the 800 MHz RF. This work indicates that neurochemical modification of the hippocampal cholinergic system can be observed during and after an exposure to low intensity RF.

Teven CM, Greives M, Natale RB, Su Y, Luo Q, He BC, Shenaq D, He TC, Reid RR. Differentiation of osteoprogenitor cells is induced by high-frequency pulsed electromagnetic fields. J Craniofac Surg. 23(2):586-593, 2012.

Craniofacial defect repair is often limited by a finite supply of available autologous tissue (ie, bone) and less than ideal alternatives. Therefore, other methods to produce bony healing must be explored. Several studies have demonstrated that low-frequency pulsed electromagnetic field (PEMF) stimulation (ie, 5-30 Hz) of osteoblasts enhances bone formation. The current study was designed to investigate whether a Food and Drug Administration-approved, high-frequency PEMF-emitting device is capable of inducing osteogenic differentiation of osteoprogenitor cells. Osteoprogenitor cells (commercially available C3H10T1/2 and mouse calvarial) in complete Dulbecco modified Eagle medium were continuously exposed to PEMF stimulation delivered by the ActiPatch at a frequency of 27.1 MHz. Markers of cellular proliferation and early, intermediate, and terminal osteogenic differentiation were measured and compared with unstimulated controls. All experiments were performed in triplicate. High-frequency PEMF stimulation increases alkaline phosphatase activity in both cell lines. In addition, high-frequency PEMF stimulation augments osteopontin and osteocalcin expression as well as mineral nodule formation in C3H10T1/2 cells, indicating late and terminal osteogenic differentiation, respectively. Cellular proliferation, however, was unaffected by high-frequency PEMF stimulation. Mechanistically, high-frequency PEMF-stimulated osteogenic differentiation is associated with elevated mRNA expression levels of osteogenic bone morphogenetic proteins in C3H10T1/2 cells. Our findings suggest that high-frequency PEMF stimulation of osteoprogenitor cells may be explored as an effective tissue engineering strategy to treat critical-size osseous defects of the craniofacial and axial skeleton.

Thielens A, Vermeeren G, Kurup D, Joseph W, Martens L. Compliance boundaries for multiple-frequency base station antennas in three directions. Bioelectromagnetics. 2013 Jan 29. doi: 10.1002/bem.21778. [Epub ahead of print]

In this article, compliance boundaries and allowed output powers are determined for the front, back, and side of multiple-frequency base station antennas, based on the root-mean-squared electric field, the whole-body averaged specific absorption rate (SAR), and

the 10 g averaged SAR in both the limbs and the head and trunk. For this purpose, the basic restrictions and reference levels defined by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) for both the general public and occupational exposure are used. The antennas are designed for Global System for Mobile Communications around 900 MHz (GSM900), GSM1800, High Speed Packet Access (HSPA), and Long Term Evolution (LTE), and are operated with output powers at the individual frequencies up to 300 W. The compliance boundaries are estimated using finite-difference time-domain simulations with the Virtual Family Male and have been determined for three directions with respect to the antennas for 800, 900, 1800, and 2600 MHz. The reference levels are not always conservative when the radiating part of the antenna is small compared to the length of the body. Combined compliance distances, which ensure compliance with all reference levels and basic restrictions, have also been determined for each frequency. A method to determine a conservative estimation of compliance boundaries for multiple-frequency (cumulative) exposure is introduced. Using the errors on the estimated allowed powers, an uncertainty analysis is carried out for the compliance distances. Uncertainties on the compliance distances are found to be smaller than 122%.

Thielens A, Agneessens S, De Clercq H, Lecoutere J, Verloock L, Tanghe E, Aerts S, Puers R, Rogier H, Martens L, Joseph W. On-body calibration and measurements using a personal, distributed exposimeter for wireless fidelity. Health Phys. 2015 Apr;108(4):407-18. doi: 10.1097/HP.0000000000000238.

This paper describes the design, calibration, and measurements with a personal, distributed exposimeter (PDE) for the on-body detection of radio frequency (RF) electromagnetic fields due to Wireless Fidelity (WiFi) networks. Numerical simulations show that using a combination of two RF nodes placed on the front and back of the body reduces the 50% prediction interval (PI50) on the incident free-space electric-field strength (Equation is included in full-text article.). Median reductions of 10 dB and 9.1 dB are obtained compared to the PI50 of a single antenna placed on the body using a weighted arithmetic and geometric average, respectively. Therefore, a simple PDE topology based on two nodes, which are deployed on opposite sides of the human torso, is applied for calibration and measurements. The PDE is constructed using flexible, dual-polarized textile antennas and wearable electronics, which communicate wirelessly with a Universal Serial Bus (USB) connected receiver and can be unobtrusively integrated into a garment. The calibration of the PDE in an anechoic chamber proves that the PI50 of the measured (Equation is included in full-text article.)is reduced to 3.2 dB. To demonstrate the real-life usability of the wireless device, a subject was equipped with the PDE during a walk in the city of Ghent, Belgium. Using a sample frequency of 2 Hz, an average incident power density of 59 nW m was registered in the WiFi frequency band during this walk.

Thomas S, Kühnlein A, Heinrich S, Praml G, von Kries R, Radon K. Exposure to mobile telecommunication networks assessed using personal dosimetry and well-being in children and adolescents: the German MobilEe-study. Environ Health. 7(1):54, 2008.

BACKGROUND: Despite the increase of mobile phone use in the last decade and the

growing concern whether mobile telecommunication networks adversely affect health and well-being, only few studies have been published that focussed on children and adolescents. Especially children and adolescents are important in the discussion of adverse health effects because of their possibly higher vulnerability to radio frequency electromagnetic fields. METHODS: We investigated a possible association between exposure to mobile telecommunication networks and well-being in children and adolescents using personal dosimetry. A population-based sample of 1.498 children and 1.524 adolescents was assembled for the study (response 52%). Participants were randomly selected from the population registries of four Bavarian (South of Germany) cities and towns with different population sizes. During a Computer Assisted Personal Interview data on participants' well-being, socio-demographic characteristics and potential confounder were collected. Acute symptoms were assessed three times during the study day (morning, noon, evening).Using a dosimeter (ESM-140 Maschek Electronics), we obtained an exposure profile over 24 hours for three mobile phone frequency ranges (measurement interval 1 second, limit of determination 0.05 V/m) for each of the participants. Exposure levels over waking hours were summed up and expressed as mean percentage of the ICNIRP (International Commission on Non-Ionizing Radiation Protection) reference level. RESULTS: In comparison to non-participants, parents and adolescents with a higher level of education who possessed a mobile phone and were interested in the topic of possible adverse health effects caused by mobile telecommunication network frequencies were more willing to participate in the study. The median exposure to radio frequency electromagnetic fields of children and adolescents was 0.18% and 0.19% of the ICNIRP reference level respectively. CONCLUSION: In comparison to previous studies this is one of the first to assess the individual level of exposure to mobile telecommunication networks using personal dosimetry, enabling objective assessment of exposure from all sources and longer measurement periods. In total, personal dosimetry was proofed to be a well accepted tool to study exposure to mobile phone frequencies in epidemiologic studies including health effects on children and adolescents.

Thomas S, Heinrich S, von Kries R, Radon K. Exposure to radio-frequency electromagnetic fields and behavioural problems in Bavarian children and adolescents. Eur J Epidemiol. 25(2):135-141, 2010.

Only few studies have so far investigated possible health effects of radio-frequency electromagnetic fields (RF EMF) in children and adolescents, although experts discuss a potential higher vulnerability to such fields. We aimed to investigate a possible association between measured exposure to RF EMF fields and behavioural problems in children and adolescents. 1,498 children and 1,524 adolescents were randomly selected from the population registries of four Bavarian (South of Germany) cities. During an Interview data on participants' mental health, socio-demographic characteristics and potential confounders were collected. Mental health behaviour was assessed using the German version of the Strengths and Difficulties Questionnaire (SDQ). Using a personal dosimeter, we obtained radio-frequency EMF exposure profiles over 24 h. Exposure levels over waking hours were expressed as mean percentage of the reference level. Overall, exposure to radiofrequency electromagnetic fields was far below the reference level. Seven percent of the

children and 5% of the adolescents showed an abnormal mental behaviour. In the multiple logistic regression analyses measured exposure to RF fields in the highest quartile was associated to overall behavioural problems for adolescents (OR 2.2; 95% CI 1.1-4.5) but not for children (1.3; 0.7-2.6). These results are mainly driven by one subscale, as the results showed an association between exposure and conduct problems for adolescents (3.7; 1.6-8.4) and children (2.9; 1.4-5.9). As this is one of the first studies that investigated an association between exposure to mobile telecommunication networks and mental health behaviour more studies using personal dosimetry are warranted to confirm these findings.

Thomas S, Benke G, Dimitriadis C, Inyang I, Sim MR, Wolfe R, Croft RJ, Abramson MJ. Use of mobile phones and changes in cognitive function in adolescents. Occup Environ Med.67(12):861-866, 2010.

Background Several studies have investigated the impact of mobile phone exposure on cognitive function in adults. However, children and adolescents are of special interest due to their developing nervous systems. Methods Data were derived from the Australian Mobile Radiofrequency Phone Exposed Users' Study (MoRPhEUS) which comprised a baseline examination of year 7 students during 2005/2006 and a 1-year follow-up. Sociodemographic and exposure data were collected with a questionnaire. Cognitive functions were assessed with a computerised test battery and the Stroop Color-Word test. Results 236 students participated in both examinations. The proportion of mobile phone owners and the number of voice calls and short message services (SMS) per week increased from baseline to follow-up. Participants with more voice calls and SMS at baseline showed less reductions in response times over the 1-year period in various computerised tasks. Furthermore, those with increased voice calls and SMS exposure over the 1-year period showed changes in response time in a simple reaction and a working memory task. No associations were seen between mobile phone exposure and the Stroop test. Conclusions We have observed that some changes in cognitive function, particularly in response time rather than accuracy, occurred with a latency period of 1 year and that some changes were associated with increased exposure. However, the increased exposure was mainly applied to those who had fewer voice calls and SMS at baseline, suggesting that these changes over time may relate to statistical regression to the mean, and not be the effect of mobile phone exposure.

Thomée S, Härenstam A, Hagberg M. Mobile phone use and stress, sleep disturbances, and symptoms of depression among young adults--a prospective cohort study.BMC Public Health. 11:66, 2011.

BACKGROUND: Because of the quick development and widespread use of mobile phones, and their vast effect on communication and interactions, it is important to study possible negative health effects of mobile phone exposure. The overall aim of this study was to investigate whether there are associations between psychosocial aspects of mobile phone use and mental health symptoms in a prospective cohort of young adults. METHODS: The study group consisted of young adults 20-24 years old (n = 4156), who responded to a questionnaire at baseline and 1-year follow-up. Mobile phone exposure variables included frequency of use, but also more qualitative variables: demands on

availability, perceived stressfulness of accessibility, being awakened at night by the mobile phone, and personal overuse of the mobile phone. Mental health outcomes included current stress, sleep disorders, and symptoms of depression. Prevalence ratios (PRs) were calculated for cross-sectional and prospective associations between exposure variables and mental health outcomes for men and women separately. RESULTS: There were cross-sectional associations between high compared to low mobile phone use and stress, sleep disturbances, and symptoms of depression for the men and women. When excluding respondents reporting mental health symptoms at baseline, high mobile phone use was associated with sleep disturbances and symptoms of depression for the men and symptoms of depression for the women at 1-year follow-up. All qualitative variables had cross-sectional associations with mental health outcomes. In prospective analysis, overuse was associated with stress and sleep disturbances for women, and high accessibility stress was associated with stress, sleep disturbances, and symptoms of depression for both men and women. CONCLUSIONS: High frequency of mobile phone use at baseline was a risk factor for mental health outcomes at 1-year follow-up among the young adults. The risk for reporting mental health symptoms at follow-up was greatest among those who had perceived accessibility via mobile phones to be stressful.Public health prevention strategies focusing on attitudes could include information and advice, helping young adults to set limits for their own and others' accessibility.

Thompson CJ, Anderson V, Rowley JT. Assessment of guidelines for limiting exposures to emf using methods of probabilistic risk analysis. Health Phys 82(4):484-490, 2002.

Allowable limits of human exposure to radiofrequency fields commonly include a "factor of safety," typically between 10 to 50, which is somewhat arbitrary. The broad objective in our work is to assess radiofrequency exposure limits, hazard thresholds, and safety factors using methods of probabilistic risk analysis. We focus our analysis on the variables affecting peak radiofrequency specific energy absorption rate (SAR) values in the brain from digital mobile telephones operating at approximately 900 MHz. As SAR is defined as a product of positive random variables, it is not unreasonable to assume that SAR has a lognormal distribution. Our analysis of component SAR variables such as conductivity and permittivity of grey brain matter and radiated field strengths using experimental and numerical modeling data strongly supports our hypothesis that SAR values are distributed lognormally. It then follows that the probability that the SAR exceeds a certain threshold can be derived directly and is shown to be very low for handset SARs relative to presently allowable standard limits.

Thorlin, T., Rouquette, J.-M., Hamnerius, Y., Hansson, E., Persson, M., Bjorklund, U., Rosengren, L., Ronnback, L. and Persson, M. Exposure of Cultured Astroglial and Microglial Brain Cells to 900 MHz Microwave Radiation. Radiat. Res. 166, 409-421, 2006.

The rapid rise in the use of mobile communications has raised concerns about health issues related to low-level microwave radiation. The head and brain are usually the most exposed targets in mobile phone users. In the brain, two types of glial cells, the astroglial and the microglial cells, are interesting in the context of biological effects

from microwave exposure. These cells are widely distributed in the brain and are directly involved in the response to brain damage as well as in the development of brain cancer. The aim of the present study was to investigate whether 900 MHz radiation could affect these two different glial cell types in culture by studying markers for damage-related processes in the cells. Primary cultures enriched in astroglial cells were exposed to 900 MHz microwave radiation in a temperature-controlled exposure system at specific absorption rates (SARs) of 3 W/kg GSM modulated wave (mw) for 4, 8 and 24 h or 27 W/kg continuous wave (cw) for 24 h, and the release into the extracellular medium of the two pro-inflammatory cytokines interleukin 6 (Il6) and tumor necrosis factor-alpha (Tnfa) was analyzed. In addition, levels of the astroglial cell-specific reactive marker glial fibrillary acidic protein (Gfap), whose expression dynamics is different from that of cytokines, were measured in astroglial cultures and in astroglial cell-conditioned cell culture medium at SARs of 27 and 54 W/kg (cw) for 4 or 24 h. No significant differences could be detected for any of the parameters studied at any time and for any of the radiation characteristics. Total protein levels remained constant during the experiments. Microglial cell cultures were exposed to 900 MHz radiation at an SAR of 3 W/kg (mw) for 8 h, and Il6, Tnfa, total protein and the microglial reactivity marker ED-1 (a macrophage activation antigen) were measured. No significant differences were found. The morphology of the cultured astroglial cells and microglia was studied and appeared to be unaffected by microwave irradiation. Thus this study does not provide evidence for any effect of the microwave radiation used on damage-related factors in glial cells in culture.

Thors B, Thielens A, Fridén J, Colombi D, Törnevik C, Vermeeren G, Martens L, Joseph W. Radio frequency electromagnetic field compliance assessment of multi-band and MIMO equipped radio base stations. Bioelectromagnetics. 35(4):296-308. 2014.

In this paper, different methods for practical numerical radio frequency exposure compliance assessments of radio base station products were investigated. Both multi-band base station antennas and antennas designed for multiple input multiple output (MIMO) transmission schemes were considered. For the multi-band case, various standardized assessment methods were evaluated in terms of resulting compliance distance with respect to the reference levels and basic restrictions of the International Commission on Non-Ionizing Radiation Protection. Both single frequency and multiple frequency (cumulative) compliance distances were determined using numerical simulations for a mobile communication base station antenna transmitting in four frequency bands between 800 and 2600 MHz. The assessments were conducted in terms of root-mean-squared electromagnetic fields, whole-body averaged specific absorption rate (SAR) and peak 10 g averaged SAR. In general, assessments based on peak field strengths were found to be less computationally intensive, but lead to larger compliance distances than spatial averaging of electromagnetic fields used in combination with localized SAR assessments. For adult exposure, the results indicated that even shorter compliance distances were obtained by using assessments based on localized and whole-body SAR. Numerical simulations, using base station products employing MIMO transmission schemes, were performed as well and were in agreement with reference measurements. The applicability of various field combination methods for

correlated exposure was investigated, and best estimate methods were proposed. Our results showed that field combining methods generally considered as conservative could be used to efficiently assess compliance boundary dimensions of single- and dual-polarized multicolumn base station antennas with only minor increases in compliance distances.

Thuroczy G, Kubinyi G, Bodo M, Bakos J, Szabo LD, Simultaneous response of brain electrical activity (EEG) and cerebral circulation (REG) to microwave exposure in rats. Rev Environ Health 10(2):135-148, 1994.

The correlations between physiological modalities in microwave field-activated systemic or localized regulatory mechanisms with changes in the central nervous system (CNS) seem not to be identical. These problems are important because of the increased number of radiating appliances, e.g. portable radios and mobile telephones. In two series of experiments on anaesthetized rats (N = 40) (i) before and after 10 min, whole body exposures to 2.45 GHz CW microwaves, and (ii) during 30 min exposures to 4 GHz amplitude modulated (AM, 16 Hz) microwaves, the effects on the CNS were observed simultaneously with those on the cardiovascular system by quantitative polygraphic measurement. In acute experiments on rats, electroencephalograms (EEG), rheoencephalograms (REG) as an index of cerebral blood flow (CBF), brain tissue DC impedance and temperature and ECG were recorded simultaneously. The total power of EEG spectra increased after whole body 30 mW/cm2 2.45 GHz CW exposure for 10 min. No changes occurred at 10 mW/cm2. The CBF increased after 10 mW/cm2 exposure. The power of EEG delta (0.5-4 Hz) waves was increased by thermal level of brain localized 4 GHz CW exposure at 42 mW/g specific absorption rate (SAR) simultaneously with the REG amplitude as an index of cerebral blood flow. Amplitude modulation at 16 Hz and 8.4 mW/g SAR was associated with increased power of EEG beta (14.5-30 Hz) waves but changes in the CBF were not observed. CW radiation at 8.4 mW/g increased the cerebral blood flow, but did not change EEG spectra.

Tice RR, Hook GG, Donner M, McRee DI, Guy AW. Genotoxicity of radiofrequency signals. I. Investigation of DNA damage and micronuclei induction in cultured human blood cells. Bioelectromagnetics 23:113-126, 2002.

As part of a comprehensive investigation of the potential genotoxicity of radiofrequency (RF) signals emitted by cellular telephones, in vitro studies evaluated the induction of DNA and chromosomal damage in human blood leukocytes and lymphocytes, respectively. The signals were voice modulated 837 MHz produced by an analog signal generator or by a time division multiple access (TDMA) cellular telephone, 837 MHz generated by a code division multiple access (CDMA) cellular telephone (not voice modulated), and voice modulated 1909.8 MHz generated by a global system of mobile communication (GSM)-type personal communication systems (PCS) cellular telephone. DNA damage (strand breaks/alkali labile sites) was assessed in leukocytes using the alkaline (pH>13) single cell gel electrophoresis (SCG) assay. Chromosomal damage was evaluated in lymphocytes mitogenically stimulated to divide postexposure using the cytochalasin B-binucleate cell micronucleus assay. Cells were exposed at 37±1°C, for 3 or 24 h at average specific absorption rates (SARs) of 1.0-10.0 W/kg. Exposure for either 3 or 24 h did not induce a significant increase in DNA damage in leukocytes, nor did

exposure for 3 h induce a significant increase in micronucleated cells among lymphocytes. However, exposure to each of the four RF signal technologies for 24 h at an average SAR of 5.0 or 10.0 W/kg resulted in a significant and reproducible increase in the frequency of micronucleated lymphocytes. The magnitude of the response (approximately four fold) was independent of the technology, the presence or absence of voice modulation, and the frequency (837 vs. 1909.8 MHz). This research demonstrates that, under extended exposure conditions, RF signals at an average SAR of at least 5.0 W/kg are capable of inducing chromosomal damage in human lymphocytes.

Tillmann T, Ernst H, Ebert S, Kuster N, Behnke W, Rittinghausen S, Dasenbrock C. Carcinogenicity study of GSM and DCS wireless communication signals in B6C3F1 mice. Bioelectromagnetics.28(3):173-187, 2007.

The purpose of this study using a total of 1170 B6C3F1 mice was to detect and evaluate possible carcinogenic effects in mice exposed to radio-frequency-radiation (RFR) from Global System for Mobile Communication (GSM) and Digital Personal Communications System (DCS) handsets as emitted by handsets operating in the center of the communication band, that is, at 902 MHz (GSM) and 1747 MHz (DCS). Restrained mice were exposed for 2 h per day, 5 days per week over a period of 2 years to three different whole-body averaged specific absorption rate (SAR) levels of 0.4, 1.3, 4.0 mW/g bw (SAR), or were sham exposed. Regarding the organ-related tumor incidence, pairwise Fisher's test did not show any significant increase in the incidence of any particular tumor type in the RF exposed groups as compared to the sham exposed group. Interestingly, while the incidences of hepatocellular carcinomas were similar in EMF and sham exposed groups, in both studies the incidences of liver adenomas in males decreased with increasing dose levels; the incidences in the high dose groups were statistically significantly different from those in the sham exposed groups. Comparison to published tumor rates in untreated mice revealed that the observed tumor rates were within the range of historical control data. In conclusion, the present study produced no evidence that the exposure of male and female B6C3F1 mice to wireless GSM and DCS radio frequency signals at a whole body absorption rate of up to 4.0 W/kg resulted in any adverse health effect or had any cumulative influence on the incidence or severity of neoplastic and non-neoplastic background lesions, and thus the study did not provide any evidence of RF possessing a carcinogenic potential.

Tillmann T, Ernst H, Streckert J, Zhou Y, Taugner F, Hansen V, Dasenbrock C. Indication of cocarcinogenic potential of chronic UMTS-modulated radiofrequency exposure in an ethylnitrosourea mouse model. nt J Radiat Biol. 86(7):529-541, 2010.

PURPOSE: To evaluate putative effects on tumour susceptibility in mice exposed to a UMTS (universal mobile telecommunications system) test signal for up to 24 months, commencing with embryo-fetal exposure.MATERIAL AND METHODS: Animals were exposed to UMTS fields with intensities of 0, 4.8, and 48 W/m(2), the low-dose group (4.8 W/m(2)) was subjected to additional prenatal ethylnitrosourea treatment (40 mg ENU/kg body weight).RESULTS: The high-level UMTS exposure (48 W/m(2)), the sham exposure, and the cage control groups showed comparable tumour incidences

in the protocol organs. In contrast, the ENU-treated group UMTS-exposed at 4.8 W/m(2) displayed an enhanced lung tumour rate and an increased incidence of lung carcinomas as compared to the controls treated with ENU only. Furthermore, tumour multiplicity of the lung carcinomas was increased and the number of metastasising lung tumours was doubled in the ENU/UMTS group as compared to the ENU control group.CONCLUSION: This pilot study indicates a cocarcinogenic effect of lifelong UMTS exposure (4.8 W/m(2)) in female B6C3F1 descendants subjected to pretreatment with ethylnitrosourea.

Tiwari R, Lakshmi NK, Surender V, Rajesh AD, Bhargava SC, Ahuja YR.Combinative exposure effect of radio frequency signals from CDMA mobile phones and aphidicolin on DNA integrity. Electromagn Biol Med. 27(4):418-425, 2008.

The aim of present study is to assess DNA integrity on the effect of exposure to a radio frequency (RF) signal from Code Division Multiple Access (CDMA) mobile phones. Whole blood samples from six healthy male individuals were exposed for RF signals from a CDMA mobile phone for 1 h. Alkaline comet assay was performed to assess the DNA damage. The combinative exposure effect of the RF signals and APC at two concentrations on DNA integrity was studied. DNA repair efficiency of the samples was also studied after 2 h of exposure. The RF signals and APC (0.2 microg/ml) alone or in synergism did not have any significant DNA damage as compared to sham exposed. However, univariate analysis showed that DNA damage was significantly different among combinative exposure of RF signals and APC at 0.2 microg/ml ($p < 0.05$) and at 2 microg/ml ($p < 0.02$). APC at 2 microg/ml concentration also showed significant damage levels ($p < 0.05$) when compared to sham exposed. DNA repair efficiency also varied in a significant way in combinative exposure sets ($p < 0.05$). From these results, it appears that the repair inhibitor APC enhances DNA breaks at 2 microg/ml concentration and that the damage is possibly repairable. Thus, it can be inferred that the in vitro exposure to RF signals induces reversible DNA damage in synergism with APC.

Tkalec M, Malaric K, Pevalek-Kozlina B. Influence of 400, 900, and 1900 MHz electromagnetic fields on Lemna minor growth and peroxidase activity. Bioelectromagnetics. 26(3):185-193, 2005.

Increased use of radio and microwave frequencies requires investigations of their effects on living organisms. Duckweed (Lemna minor L.) has been commonly used as a model plant for environmental monitoring. In the present study, duckweed growth and peroxidase activity was evaluated after exposure in a Gigahertz Transversal Electromagnetic (GTEM) cell to electric fields of frequencies 400, 900, and 1900 MHz. The growth of plants exposed for 2 h to the 23 V/m electric field of 900 MHz significantly decreased in comparison with the control, while an electric field of the same strength but at 400 MHz did not have such effect. A modulated field at 900 MHz strongly inhibited the growth, while at 400 MHz modulation did not influence the growth significantly. At both frequencies a longer exposure mostly decreased the growth and the highest electric field (390 V/m) strongly inhibited the growth. Exposure of plants to lower field strength (10 V/m) for 14 h caused significant decrease at 400 and 1900 MHz while 900 MHz did not

influence the growth. Peroxidase activity in exposed plants varied, depending on the exposure characteristics. Observed changes were mostly small, except in plants exposed for 2 h to 41 V/m at 900 MHz where a significant increase (41%) was found. Our results suggest that investigated electromagnetic fields (EMFs) might influence plant growth and, to some extent, peroxidase activity. However, the effects of EMFs strongly depended on the characteristics of the field exposure.

Tkalec M, Malarić K, Pevalek-Kozlina B. Exposure to radiofrequency radiation induces oxidative stress in duckweed Lemna minor L. Sci Total Environ. 388(1-3):78-89, 2007.

Widespread use of radiofrequency radiation emitting devices increased the exposure to electromagnetic fields (EMFs) from 300 MHz to 300 GHz. Various biological effects of exposure to these fields have been documented so far, but very little work has been carried out on plants. The aim of the present work was to investigate the physiological responses of the plant Lemna minor after exposure to radiofrequencyEMFs, and in particular, to clarify the possible role of oxidative stress in the observed effects. Duckweed was exposed for 2 h to EMFs of 400 and 900 MHz at field strengths of 10, 23, 41 and 120 V m(-1). The effect of a longer exposure time (4 h) and modulation was also investigated. After exposure, parameters of oxidative stress, such as lipid peroxidation, H(2)O(2) content, activities and isoenzyme pattern of antioxidative enzymes as well as HSP70 expression were evaluated. At 400 MHz, lipid peroxidation and H(2)O(2) content were significantly enhanced in duckweed exposed to EMFs of 23 and 120 V m(-1) while other exposure treatments did not have an effect. Compared to the controls, the activities of antioxidative enzymes showed different behaviour: catalase (CAT) activity increased after most exposure treatments while pyrogallol (PPX) and ascorbate peroxidase (APX) activities were not changed. Exceptions were reduced PPX and APX activity after longer exposure at 23 V m(-1) and increased PPX activity after exposures at 10 and 120 V m(-1). By contrast, at 900 MHz almost all exposure treatments significantly increased level of lipid peroxidation and H(2)O(2) content but mostly decreased PPX activity and did not affect CAT activity. Exceptions were exposures to a modulated field and to the field of 120 V m(-1) which increased PPX and CAT activity. At this frequency APX activity was significantly decreased after exposure at 10 V m(-1) and longer exposure at 23 V m(-1) but it increased after a shorter exposure at 23 V m(-1). At both frequencies no differences in isoenzyme patterns of antioxidative enzymes or HSP70 level were found between control and exposed plants. Our results showed that non-thermal exposure to investigated radiofrequency fields induced oxidative stress in duckweed as well as unspecific stress responses, especially of antioxidative enzymes. However, the observed effects markedly depended on the field frequencies applied as well as on other exposure parameters (strength, modulation and exposure time). Enhanced lipid peroxidation and H(2)O(2) content accompanied by diminished antioxidative enzymes activity caused by exposure to investigated EMFs, especially at 900 MHz, indicate that oxidative stress could partly be due to changed activities of antioxidative enzymes.

Tkalec M, Malarić K, Pavlica M, Pevalek-Kozlina B, Vidaković-Cifrek Z. Effects of radiofrequency electromagnetic fields on seed germination and root meristematic cells of Allium cepa L. Mutat Res. 672(2):76-81, 2009.

The effects of exposure to radiofrequency electromagnetic fields (RF-EMFs) on seed germination, primary root growth as well as mitotic activity and mitotic aberrations in root meristematic cells were examined in Allium cepa L. cv. Srebrnjak Majski. Seeds were exposed for 2h to EMFs of 400 and 900MHz at field strengths of 10, 23, 41 and 120Vm(-1). The effect of longer exposure time (4h) and field modulation was investigated at 23Vm(-1) as well. Germination rate and root length did not change significantly after exposure to radiofrequency fields under any of the treatment conditions. At 900MHz, exposures to EMFs of higher field strengths (41 and 120Vm(-1)) or to modulated fields showed a significant increase of the mitotic index compared with corresponding controls, while the percentage of mitotic abnormalities increased after all exposure treatments. On the other hand, at 400MHz the mitotic index increased only after exposure to modulated EMF. At this frequency, compared with the control higher numbers of mitotic abnormalities were found after exposure to modulated EMF as well as after exposure to EMFs of higher strengths (41 and 120Vm(-1)). The types of aberration induced by the EMFs of both frequencies were quite similar, mainly consisting of lagging chromosomes, vagrants, disturbed anaphases and chromosome stickiness. Our results show that non-thermal exposure to the radiofrequency fields investigated here can induce mitotic aberrations in root meristematic cells of A. cepa. The observed effects were markedly dependent on the field frequencies applied as well as on field strength and modulation. Our findings also indicate that mitotic effects of RF-EMF could be due to impairment of the mitotic spindle.

Tkalec M, Stambuk A, Srut M, Malarić K, Klobučar GI. Oxidative and genotoxic effects of 900 MHz electromagnetic fields in the earthworm Eisenia fetida. Ecotoxicol Environ Saf. 90:7-12, 2013.

Accumulating evidence suggests that exposure to radiofrequency electromagnetic field (RF-EMF) can have various biological effects. In this study the oxidative and genotoxic effects were investigated in earthworms Eisenia fetida exposed in vivo to RF-EMF at the mobile phone frequency (900 MHz). Earthworms were exposed to the homogeneous RF-EMF at field levels of 10, 23, 41 and 120 V m(-1) for a period of 2h using a Gigahertz Transversal Electromagnetic (GTEM) cell. At the field level of 23 V m(-1) the effect of longer exposure (4h) and field modulation (80% AM 1 kHz sinusoidal) was investigated as well. All exposure treatments induced significant genotoxic effect in earthworms coelomocytes detected by the Comet assay, demonstrating DNA damaging capacity of 900 MHz electromagnetic radiation. Field modulation additionally increased the genotoxic effect. Moreover, our results indicated the induction of antioxidant stress response in terms of enhanced catalase and glutathione reductase activity as a result of the RF-EMF exposure, and demonstrated the generation of lipid and protein oxidative damage. Antioxidant responses and the potential of RF-EMF to induce damage to lipids, proteins and DNA differed depending on the field level applied, modulation of the field and duration of E. fetida exposure to 900 MHz electromagnetic radiation. Nature of detected

DNA lesions and oxidative stress as the mechanism of action for the induction of DNA damage are discussed.

Tök L, Nazıroğlu M, Doğan S, Kahya MC, Tök O. Effects of melatonin on Wi-Fi-induced oxidative stress in lens of rats. Indian J Ophthalmol. 62(1):12-15, 2014. doi: 10.4103/0301-4738.126166.

Introduction: Melatonin has been considered a potent antioxidant that detoxifies a variety of reactive oxygen species in many pathophysiological states of eye. The present study was designed to determine the effects of Wi-Fi exposure on the lens oxidant, antioxidant redox systems, as well as the possible protective effects of melatonin on the lens injury induced by electromagnetic radiation (EMR). Materials and Methods: Thirty-two rats were used in the current study and they were randomly divided into four equal groups as follows: First and second groups were cage-control and sham-control rats. Rats in third group were exposed to Wi-Fi (2.45 GHz) for duration of 60 min/day for 30 days. As in the third group, the fourth group was treated with melatonin. The one-hour exposure to irradiation in second, third and fourth took place at noon each day. Results: Lipid peroxidation levels in the lens were slightly higher in third (Wi-Fi) group than in cage and sham control groups although their concentrations were significantly ($P < 0.05$) decreased by melatonin supplementation. Glutathione peroxidase (GSH-Px) activity was significantly ($P < 0.05$) lower in Wi-Fi group than in cage and sham control groups although GSH-Px ($P < 0.01$) and reduced glutathione ($P < 0.05$) values were significantly higher in Wi-Fi + melatonin group than in Wi-Fi group. Conclusions: There are poor oxidative toxic effects of one hour of Wi-Fi exposure on the lens in the animals. However, melatonin supplementation in the lens seems to have protective effects on the oxidant system by modulation of GSH-Px activity.

Tokola K, Kurttio P, Salminen T, Auvinen A. Reducing overestimation in reported mobile phone use associated with epidemiological studies. Bioelectromagnetics. 29(7):559-563, 2008.

Case-control studies of mobile phones are commonly based on retrospective, self-reported exposure information, which are often characterized as involving substantial uncertainty concerning data validity. We assessed the validity of self-reported mobile phone use and developed a statistical model to account for the over-reporting of exposure. We collected information on mobile phone use from 70 volunteers using two sources of data: self-report in an interview and network operator records. We used regression models to obtain bias-corrected estimates of exposure. A correlation coefficient of 0.71 was obtained between the self-reported and the network operators' data on average calling time (log-transformed minutes per month). A simple linear regression model, where the duration of calls acquired from network operators is explained with the self-reported duration fitted the data reasonably well (adjusted R(2) 0.51). The constant term was 2.71 and the regression coefficient 0.49 (logarithmic scale). No significant improvement in the model fit was achieved by including potential predictors of accuracy in self-reported exposure estimates, such as the pattern of mobile phone use, the modality of response to the questionnaire or demographic characteristics. Overestimation in self-reported intensity of mobile phone use can be accounted for by the

use of regression calibration. The estimates obtained in our study may not be applicable in other contexts, but similar methods could be used to reduce bias in other studies.

Tombini M, Pellegrino G, Pasqualetti P, Assenza G, Benvenga A, Fabrizio E, Rossini PMMobile phone emissions modulate brain excitability in patients with focal epilepsy.Brain Stimul. 2012 Aug 9. [Epub ahead of print]

BACKGROUND: Electromagnetic fields (EMFs) emitted by mobile phones had been shown to increase cortical excitability in healthy subjects following 45 min of continuous exposure on the ipsilateral hemisphere. OBJECTIVE: Using Transcranial Magnetic Stimulation (TMS), the current study assessed the effects of acute exposure to mobile phone EMFs on the cortical excitability in patients with focal epilepsy. METHODS: Ten patients with cryptogenic focal epilepsy originating outside the primary motor area (M1) were studied. Paired-pulse TMS were applied to the M1 of both the hemisphere ipsilateral (IH) and contralateral (CH) to the epileptic focus before and immediately after real/sham exposure to the GSM-EMFs (45 min). The TMS study was carried out in all subjects in three different experimental sessions (IH and CH exposure, sham), 1 week apart, according to a crossover, double-blind and counter-balanced paradigm. RESULTS: 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). Both sham and real EMFs exposure of the IH did not affect brain excitability. CONCLUSION: Present results suggest a significant interaction between the brain excitability changes induced by EMFs and the epileptic focus, which eliminated the excitability enhancing effects of EMFs evident only in the CH.

Tomitsch J, **Dechant E**, **Frank W**. **Survey of electromagnetic field exposure in bedrooms of residences in lower Austria. Bioelectromagnetics.31(3):200-208, 2010.**

Previous investigations of exposure to electric, magnetic, or electromagnetic fields (EMF) in households were either about electricity supply EMFs or radio frequency EMFs (RF-EMFs). We report results from spot measurements at the bedside that comprise electrostatic fields, extremely low-frequency electric fields (ELF-EFs), extremely low-frequency magnetic fields (ELF-MFs), and RF-EMFs. Measurements were taken in 226 households throughout Lower Austria. In addition, effects of simple reduction measures (e.g., removal of clock radios or increasing their distance from the bed, turning off Digital Enhanced Cordless Telecommunication (DECT) telephone base stations) were assessed. All measurements were well below International Commission on Non-Ionizing Radiation Protection (ICNIRP) guideline levels. Average night-time ELF-MFs (long-term measurement from 10 pm to 6 am, geometric mean over households) above 100 nT were obtained in 2.3%, and RF-EMFs above 1000 microW/m(2) in 7.1% of households. Highest ELF-EFs were primarily due to lamps beside the bed (max = 166 V/m), and highest ELF-MFs because of transformers of devices (max = 1030 nT) or high current of power lines (max = 380 nT). The highest values of RF-EMFs were caused by DECT telephone base stations (max = 28979 microW/m(2)) and mobile phone base stations

(max = 4872 microW/m(2)). Simple reduction measures resulted in an average decrease of 23 nT for ELF-MFs, 23 V/m for ELF-EFs, and 246 microW/m(2) for RF-EMFs. A small but statistically significant correlation between ELF-MF exposure and overall RF-EMF levels of R = 0.16 (P = 0.008) was computed that was independent of type (flat, single family) and location (urban, rural) of houses.

Tomitsch J, Dechant E. Trends in residential exposure to electromagnetic fields from 2006 to 2009.Radiat Prot Dosimetry. 149(4):384-391, 2012.

After measuring extremely low frequency electric and magnetic fields (ELF-EFs, ELF-MFs) and radio frequency electromagnetic fields (RF-EMFs) in 2006, a follow-up investigation was done in 2009. Overall, 130 measurements in bedrooms at identical and 83 at changed locations within the same or a neighbouring building were performed. The median of ELF-EFs decreased from 25.15 to 17.35 V m(-1) from 2006 to 2009. The median of all-night ELF-MFs from power supply decreased from 16.86 to 12.76 nT, whereas the arithmetic mean was almost unchanged (+0.1%). No difference in the medians of all-night ELF-MFs of railway current was observed. RF-EMFs increased from 41.35 to 59.56 µW m(-2). Increases primarily occurred in the frequency ranges of Global System for Mobile 900 MHz, Universal Mobile Telecommunications System and Wireless Local Area Network. Television changeover from analogue to digital resulted in a reduction within the Ultra-high Frequency-band from 0.47 to 0.35 µW m(-2). The base stations of the recently established terrestrial trunked radio system caused a median of 0.05 µW m(-2).

Tomitsch J, Dechant E. Exposure to electromagnetic fields in households-Trends from 2006 to 2012. Bioelectromagnetics. 2014 Nov 24. doi: 10.1002/bem.21887. [Epub ahead of print]

This article is a follow-up study of extremely low-frequency electric and magnetic fields (ELF-EFs, ELF-MFs) and radiofrequency electromagnetic fields (RF-EMFs) using data collected in 2012 following earlier data sets from 2006 and 2009. Measurements were conducted in 219 bedrooms in Lower Austria. Out of these rooms 113 measurements were done in the same households in 2006, 2009 and 2012, and 106 were conducted in neighbouring buildings added in 2009 and newly recruited buildings in mainly urban areas in 2012. In revisited places the median of the ELF-EFs decreased from 23.20 V/m in 2006 to 13.90 V/m in 2012. The median of all-night measurements of ELF-MFs at 50 Hz decreased from 13.50 to 11.37 nT. The median of total RF-EMFs increased from 28.13 to 52.16 $\mu W/m^2$. Highest increases were found for universal mobile telecommunication system (UMTS) and wireless local area networks (WLAN). The analysis of all households showed higher total RF-EMFs in urban (median = 117.73 $\mu W/m^2$) than in rural (median = 34.52 $\mu W/m^2$) areas. Long-term evolution (LTE) in the 2600 MHz frequency range was detected at 17 locations with a maximum of 38.20 $\mu W/m^2$. Indoor RF-EMF sources resulted in decreased exposure in the frequency range of digital enhanced cordless telecommunications telephones (DECT) and increased exposure in the frequency range of WLAN.

Tong J, Chen S, Liu XM, Hao DM. [Effect of electromagnetic radiation on discharge activity of neurons in the hippocampus CA1 in rats]. Zhongguo Ying Yong Sheng Li Xue Za Zhi. 29(5):423-427, 2013. [Article in Chinese]

OBJECTIVE: In order to explore effect of electromagnetic radiation on learning and memory ability of hippocampus neuron in rats, the changes in discharge patterns and overall electrical activity of hippocampus neuron after electromagnetic radiation were observed. METHODS: Rat neurons discharge was recorded with glass electrode extracellular recording technology and a polygraph respectively. Radiation frequency of electromagnetic wave was 900 MHZ and the power was 10 W/m2. In glass electrode extracellular recording, the rats were separately irradiated for 10, 20, 30, 40, 50 and 60 min, every points repeated 10 times and updated interval of 1h, observing the changes in neuron discharge and spontaneous discharge patterns after electromagnetic radiation. In polygraph recording experiments, irradiation group rats for five days a week, 6 hours per day, repeatedly for 10 weeks, memory electrical changes in control group and irradiation group rats when they were feeding were repeatedly monitored by the implanted electrodes, observing the changes in peak electric digits and the largest amplitude in hippocampal CA1 area, and taking some electromagnetic radiation sampling sequence for correlation analysis. RESULTS: (1) Electromagnetic radiation had an inhibitory role on discharge frequency of the hippocampus CA1 region neurons. After electromagnetic radiation, discharge frequency of the hippocampus CA1 region neurons was reduced, but the changes in scale was not obvious. (2) Electromagnetic radiation might change the spontaneous discharge patterns of hippocampus CA1 region neurons, which made the explosive discharge pattern increased obviously. (3) Peak potential total number within 5 min in irradiation group was significantly reduced, the largest amplitude was less than that of control group. (4) Using mathematical method to make the correlation analysis of the electromagnetic radiation sampling sequence, that of irradiation group was less than that of control group, indicating that there was a tending to be inhibitory connection between neurons in irradiation group after electromagnetic radiation. CONCLUSION: Electromagnetic radiation may cause structure and function changes of transfer synaptic in global, make hippocampal CA1 area neurons change in the overall discharge characteristic and discharge patterns, thus lead to decrease in the ability of learning and memory.

Topal Z, Hanci H, Mercantepe T, Erol HS, Keleş ON, Kaya H, Mungan S, Odaci E. The effects of prenatal long-duration exposure to 900-MHz **electromagnetic field on the 21-day-old newborn male rat liver. Turk J Med Sci. 45(2):291-297, 2015.**

BACKGROUND/AIM: To determine what effect a **900**-**MHz** electromagnetic field (EMF) applied in the prenatal period would have on the liver in the postnatal period. MATERIALS AND METHODS: At the start of the study, adult pregnant rats were divided into two groups, control and experimental. The experimental group was exposed to a **900**-**MHz** EMF for 1 h daily during days 13-21 of pregnancy. After birth, no procedure was performed on either mothers or pups. Male rat pups (n = 6) from the control group mothers (CGMR) and male rat pups (n = 6) from the experimental group mothers (EGMR) were sacrificed on postnatal day 21. RESULTS: Biochemical analyses showed that malondialdehyde and superoxide dismutase values increased and glutathione levels

decreased in the EGMR pups. Marked hydropic degeneration in the parenchyma, particularly in pericentral regions, was observed in light microscopic examination of EGMR sections stained with hematoxylin and eosin. Examinations under transmission electron microscope revealed vacuolization in the mitochondria, expansion in the endoplasmic reticulum, and necrotic hepatocytes. CONCLUSION: The study results show that a **900**-**MHz** EMF applied in the prenatal period caused oxidative stress and pathological alterations in the liver in the postnatal period.

Tornros JE, Bolling AK. Mobile phone use-Effects of handheld and handsfree phones on driving performance. Accid Anal Prev. 37(5):902-909, 2005.

The study was concerned with effects of handsfree and handheld mobile phone dialling and conversation in simulated driving. In the main experiment dealing with conversation, 48 participants drove a distance of about 70km on a route which led through urban and rural environments. In the dialling experiment, the participants drove a distance of 15km on a rural two-lane road. The experimental design was mixed with phone mode as a between-subjects factor and phone use (yes/no) as a within-subjects factor. Performance on a peripheral detection task (PDT) while driving was impaired by dialling and conversation for both phone modes, interpreted as an increase in mental workload. Driving performance was impaired by dialling-lateral position deviation increased in a similar way for both phone modes. Conversation had, however, opposite effects-lateral position deviation decreased in a similar way for both phone modes. Driving speed decreased as an effect of dialling with the greatest effect for handsfree phone mode. Conversation also caused reduced speed, but only for handheld phone mode. The effects on speed can be interpreted as a compensatory effort for the increased mental workload. In spite of the compensatory behaviour, mental workload was still markedly increased by phone use. Subjective effects of dialling and conversation were also analysed. Most participants reported a speed decrease but no effect on lateral position deviation as an effect of dialling or conversation. In the conversation experiment, driving performance was rated better for handsfree than for handheld mode. In the dialling experiment, no difference between the two phone modes appeared.

Tomruk A, Guler G, Dincel AS. The influence of 1800 MHz GSM-like signals on hepatic oxidative DNA and lipid damage in nonpregnant, pregnant, and newly born rabbits. Cell Biochem Biophys. 56(1):39-47, 2010.

The aim of our study is to evaluate the possible biological effects of whole-body 1800 MHz GSM-like radiofrequency (RF) radiation exposure on liver oxidative DNA damage and lipid peroxidation levels in nonpregnant, pregnant New Zealand White rabbits, and in their newly borns. Eighteen nonpregnant and pregnant rabbits were used and randomly divided into four groups which were composed of nine rabbits: (i) Group I (nonpregnant control), (ii) Group II (nonpregnant-RF exposed), (iii) Group III (pregnant control), (iv) Group IV (pregnant-RF exposed). Newborns of the pregnant rabbits were also divided into two groups: (v) Group V (newborns of Group III) and (vi) Group VI (newborns of Group III). 1800 MHz GSM-like RF radiation whole-body exposure (15 min/day for a week) was applied to Group II and Group IV. No significant differences were found in liver 8 OHdG/10(6) dG levels of exposure groups

(Group II and Group IV) compared to controls (Group I and Group III). However, in Group II and Group IV malondialdehyde (MDA) and ferrous oxidation in xylenol orange (FOX) levels were increased compared to Group I ($P < 0.05$, Mann-Whitney). No significant differences were found in liver tissue of 8 OHdG/10(6) dG and MDA levels between Group VI and Group V ($P > 0.05$, Mann-Whitney) while liver FOX levels were found significantly increased in Group VI with respect to Group V ($P < 0.05$, Mann-Whitney). Consequently, the whole-body 1800 MHz GSM-like RF radiation exposure may lead to oxidative destruction as being indicators of subsequent reactions that occur to form oxygen toxicity in tissues.

Tri JL, Hayes DL, Smith TT, Severson RP, Cellular phone interference with external cardiopulmonary monitoring devices. Mayo Clin Proc 76(1):11-15, 2001.

OBJECTIVES: To determine the potential effect (electromagnetic interference) of cellular telephones on external cardiopulmonary monitoring devices. METHODS: For this study, we tested 17 different medical devices with 5 portable telephones (4 digital, 1 analog) to assess the potential for electromagnetic interference. The telephones were tested in a normal operating mode to simulate a typical hospital environment with patients or their families using their cellular phones. The medical devices were connected to the appropriate simulators for proper operation while the tests were under way. The screens and alarms of the medical devices were monitored while the telephones were maneuvered in the y and z planes near the devices. Clinically important interference was defined as interference that may hinder interpretation of the data or cause the equipment to malfunction. RESULTS: Any type of interference occurred in 7 (41%) of the 17 devices tested during 54.7% of the 526 tests. The incidence of clinically important interference was 7.4%. CONCLUSIONS: Cellular telephones may interfere with the operation of external cardiopulmonary monitoring devices. However, most of the test results showed that the interference would rarely be clinically important.

Trigano AJ, Azoulay A, Rochdi M, Campillo, A Electromagnetic interference of external pacemakers by walkie-talkies and digital cellular phones: experimental study. Pacing Clin Electrophysiol 22(4 Pt 1):588-593, 1999.

A number of experimental and clinical studies have documented the risk potential of interference with implanted pacemakers by various types of cellular phones. Radiofrequency susceptibility of external medical equipment has also been reported in experimental studies. The purpose of this experimental study was to evaluate electromagnetic interference of external pacemakers by walkie-talkies and digital cellular telephones. External bipolar pacing was monitored using a digital oscilloscope to record pacemaker pulses and electromagnetic interference separately. Tests with the walkie-talkie, Private Mobile Radio (PMR) (160 MHz, 2.5 W) were conducted during the calling phase. Tests with the cellular phones, global system for mobile communications (GSM) (900 MHz, 2 W) and Digital Cellular System (DCS) (1,800 MHz, 1 W) were conducted in the test mode. Nine widely used external pacemakers from four manufacturers were tested. Various disturbances including pacing inhibition and asynchronous pacing were observed in eight pacemakers by the PMR, in four by the GSM phone, and in two by the DCS phone. The maximum distance that

interference persisted ranged from 10-200 cm. This experimental study shows a potential risk of interference of external pacemakers by walkie-talkies and cellular digital phones. Appropriate warnings should be issued against the potentially serious risks of using communication devices in the vicinity of acutely ill patients treated with temporary transvenous cardiac pacemakers.

Trigano A, Blandeau O, Dale C, Wong MF, Wiart J. Reliability of electromagnetic filters of cardiac pacemakers tested by cellular telephone ringing. Heart Rhythm. 2(8):837-841, 2005.

BACKGROUND: State-of-the art cardiac pacemakers are protected against radiofrequency signals. Although there have been earlier clinical and in vitro reports of cellular phone interference with implantable devices, only a few studies have been performed in recent years. The ringing phase of digital GSM or PCS cellular phones includes a brief period of peak radiated power. OBJECTIVES: This study tested the protection offered by electromagnetic filters of cardiac pacemakers against cellular phone ringing. METHODS: We performed 330 consecutive tests in 158 patients at the time of routine examination in our pacemaker follow-up clinic. The programmed parameters remained unchanged before testing. During electrocardiographic monitoring, 2 single-band digital cellular phones consecutively placed over the pacemaker pocket each received a call. The phone systems tested were 1) GSM at a maximal power output of 2 W, operating on a 900 MHz carrier frequency, and 2) PCS at a maximal output of 1 W, operating on a 1800 MHz carrier frequency. RESULTS: Interference was noted in only 5 tests, due to interaction by the GSM system with 4 unprotected pacemaker models. The GSM test was negative in 12 other tests of identical pulse generator models. The overall incidence of interference was 1.5% of tests. CONCLUSIONS: Interference by cellular phone ringing occurred only with unprotected pacemaker models. Standard programming of these unprotected models was associated with a low incidence of interference.

Trigano A, Blandeau O, Dale C, Wong MF, Wiart J.Risk of cellular phone interference with an implantable loop recorder. Int J Cardiol.116(1):126-130, 2007.

This study examined the risk of cellular phone ringing interference with implantable loop recorders (ILR). The technical manual of ILR warns of potential interference by cellular phone in close proximity to the implanted device, corrupting the data stored in memory or causing inappropriate device operation. The ringing phase of a digital Global System for Mobile Communication (GSM) or Personal Communication Services (PCS) cellular phone includes a brief burst of peak emitted power. To obviate the risk of dysfunction in recipients of implanted ILRs, the testing was performed with externally applied devices. The ILR was positioned in the left parasternal region and the telemetry wand removed after regular programming. Digital cellular telephones were placed over the device at a 1-cm distance and calls were placed. The phone systems tested were single- or dual-band receivers. The GSM used a maximal power output of 2 W, operating on a 900 MHz carrier frequency, and the PCS a maximal output of 1 W, operating on a 1800 MHz carrier frequency. The device activator was used to store the episodes encompassing the tests. Sixty nine tests were performed in 45 patients. In 61 tests, high-frequency polymorphic artifacts were visible on manually activated recordings, beginning a few seconds before the first audible ringing tone and persisting throughout the ringing phase. Cellular phone

ringing in close proximity to an externally applied ILR caused bursts of high-frequency signals during electrocardiogram monitoring, without causing permanent device dysfunction or reprogramming. Cellular telephones are a potential source of electrocardiographic artifacts on ILR recordings.

Trivino Pardo JC, Grimaldi S, Taranta M, Naldi I, Cinti C. Microwave electromagnetic field regulates gene expression in T-lymphoblastoid leukemia CCRF-CEM cell line exposed to 900 MHz. Electromagn Biol Med. 31(1):1-18, 2012.

Electric, magnetic, and electromagnetic fields are ubiquitous in our society, and concerns have been expressed regarding possible adverse effects of these exposures. Research on Extremely Low-Frequency (ELF) magnetic fields has been performed for more than two decades, and the methodology and quality of studies have improved over time. Studies have consistently shown increased risk for childhood leukemia associated with ELFmagnetic fields. There are still inadequate data for other outcomes. More recently, focus has shifted toward Radio Frequencies (RF) exposures from mobile telephony. There are no persuasive data suggesting a health risk, but this research field is still immature with regard to the quantity and quality of available data. This technology is constantly changing and there is a need for continued research on this issue. To investigate whether exposure to high-frequency electromagnetic fields (EMF) could induce adverse health effects, we cultured acute T-lymphoblastoid leukemia cells (CCRF-CEM) in the presence of 900 MHz MW-EMF generated by a transverse electromagnetic (TEM) cell at short and long exposure times. We evaluated the effect of high-frequency EMF on gene expression and we identified functional pathways influenced by 900 MHz MW-EMF exposure.

Trosic I, Matausicpisl M, Radalj Z, Prlic I, Animal study on electromagnetic field biological potency. Arh Hig Rada Toksikol 50(1):5-11, 1999.

This recent basic research study used an animal model protocol to assess specific biomarkers of the effect of non-ionising, non-thermal radiation (2450 MHz microwave radiation at 5-15 mW/cm2) on bone marrow, peripheral blood, and bronchoalveolar free cell populations. Of 40 male Wistar rats taken in the study, 20 animals of the experimental group were irradiated for 2 hours a day, 5 days a week, and subsequently killed on days 1, 8, 16, and 30 of the experiment. The remaining 20 rats served as control. All animals were previously intratracheally instilled with biologically inert microspheres to see the influence of irradiation on lung retention kinetics. The cell response to chosen electromagnetic irradiation was followed quantitatively and qualitatively using the standard laboratory methods. The results of peripheral blood cell response suggested a decreasing tendency in total leukocyte count and in relative lymphocyte count in the treated group. A slight increase was also observed in granulocyte count and in the absolute count of peripheral blood erythrocytes over control animals.

Trosic I. Multinucleated giant cell appearance after whole body microwave irradiation of rats. Int J Hyg Environ Health. 204(2-3):133-138, 2001.

Multinucleated giant cells are common for some chronic inflammatory processes in the

lung. These cells are formed by fusion of macrophages, but how the process relates to the kinetics of alveolar macrophage generation is not clear. This study investigated the influence of 2450 MHz microwave irradiation on alveolar macrophage kinetics and formation of multinucleated giant cells after whole body irradiation of rats. The range of electromagnetic radiation was selected as 2450 MHz microwaves at a power density of 5-15 mW/cm2. A group of experimental animals was divided in four subgroups that received 2, 8, 13 and 22 irradiation treatments of two hours each. The animals were killed on experimental days 1, 8, 16, and 30. Free lung cell population was obtained by bronchoalveolar lavage. Cell response to the selected irradiation level was followed quantitatively, qualitatively and morphologically using standard laboratory methods. Total cell number retrieved by lavage slightly decreased in treated animals showing time- and dose-dependence. Cell viability did not significantly change in the irradiated animal group (G2) as compared with the control group (G1). Multinucleated cells significantly increased ($p < 0.01$) in treated animals. The elevation of the number of nuclei per cell was time- and dose-dependent. Macrophages with two nucleoli were more common in animals treated twice or eight times. Polynucleation, that is three and more nucleoli in a single cell, was frequently observed after 13 or 22 treatments. Binucleation and multinucleation of alveolar macrophages were sensitive time- and dose-dependent morphological indicators of pulmonary stress.

Trosic I, Busljeta I, Kasuba V, Rozgaj R. Micronucleus induction after whole-body microwave irradiation of rats. Mutat Res 521(1-2):73-79, 2002.

Adult male Wistar rats were exposed for 2h a day, 7 days a week for up to 30 days to continuous 2450MHz radiofrequency microwave (rf/MW) radiation at a power density of 5-10mW/cm(2). Sham-exposed rats were used as controls. After ether anesthesia, experimental animals were euthanized on the final irradiation day for each treated group. Peripheral blood smears were examined for the extent of genotoxicity, as indicated by the presence of micronuclei in polychromatic erythrocytes (PCEs). The results for the time-course of PCEs indicated significant differences ($P<0.05$) for the 2nd, the 8th and the 15th day between control and treated subgroups of animals. Increased influx of immature erythrocytes into the peripheral circulation at the beginning of the experiment revealed that the proliferation and maturation of nucleated erythropoietic cells were affected by exposure to the 2450MHz radiofrequency radiation. Such findings are indicators of radiation effects on bone-marrow erythropoiesis and their subsequent effects in circulating red cells. The incidence of micronuclei/1000 PCEs in peripheral blood was significantly increased ($P<0.05$) in the subgroup exposed to rf/MW radiation after eight irradiation treatments of 2h each in comparison with the sham-exposed control group. It is likely that an adaptive mechanism, both in erythrocytopoiesis and genotoxicity appeared in the rat experimental model during the subchronic irradiation treatment.

Trosic I, Busljeta I, Pavicic I. Blood-forming system in rats after whole-body microwave exposure; reference to the lymphocytes. Toxicol Lett. 154(1-2):125-132, 2004.

The influence of 2.45GHz microwave (RF/MW) irradiation on blood-forming cells after whole-body irradiation of rats was investigated. The exposures were conducted with a field power density of 5-10mW/cm(2), and whole-body average specific absorption rate

(SAR) of 1-2W/kg. Four experimental subgroups were created and irradiated 2, 8, 15 or 30 days, for 2h a day, 7 days a week. Concurrent sham-exposed rats were also included in the study. The cell response was assessed by number and type of the bone marrow nuclear cells and peripheral blood white cells using standard laboratory methods. Significant decrease in lymphoblast count was obtained at 15 and 30th experimental day ($P < 0.05$), whereas other examined parameters did not significantly differed in comparison to the sham-exposed controls. The findings point out at stress response in blood-forming system in rats after selected microwave exposure, which could be considered rather as sign of adaptation than malfunction.

Trosic I, Busljeta I, Modlic B. Investigation of the genotoxic effect of microwave irradiation in rat bone marrow cells: in vivo exposure. Mutagenesis. 19(5):361-364, 2004.

An in vivo mammalian cytogenetic test (the erythrocyte micronucleus assay) was used to investigate the extent of genetic damage in bone marrow red cells of rats exposed to radiofrequency/microwave (RF/MW) radiation. Wistar rats (n = 40) were exposed to a 2.45 GHz continuous RF/MW field for 2 h daily, 7 days a week, at a power density of 5-10 mW/cm(2). The whole body average specific absorption rate (SARs) was calculated to be 1.25 +/- 0.36 (SE) W/kg. Four subgroups were irradiated for 4, 16, 30 and 60 h. Sham-exposed controls (n = 24) were included in the study. The animals of each treated subgroup were killed on the final day of irradiation. Bone marrow smears were examined to determine the extent of genotoxicity after particular treatment times. The results were statistically evaluated using non-parametric Mann-Whitney and Kruskal-Wallis tests. In comparison with the sham-exposed subgroups, the findings of polychromatic erythrocytes (PCE) revealed significant differences ($P < 0.05$) for experimental days 8 and 15. The frequency of micronucleated PCEs was also significantly increased on experimental day 15 ($P < 0.05$). Pair-wise comparison of data obtained after 2, 8 and 30 irradiation treatments did not reveal statistically significant differences between sham-exposed and treated subgroups. Under the applied experimental conditions the findings revealed a transient effect on proliferation and maturation of erythropoietc cells in the rat bone marrow and the sporadic appearance of micronucleated immature bone marrow red cells.

Trosic I, Busljeta I. Frequency of micronucleated erythrocytes in rat bone marrow exposure to 2.45 GHz radiation. Physica Scripta T118: 168-170, 2005.

Wistar rats were exposed to 2.45GHz continuous, radiofrequency microwave (RF/MW) field 2 hours daily, 7 days weekly, at power density 5–10mW/cm2. Four subgroups were created in order to be irradiated 4, 16, 30 and 60 hours. Sham exposed controls were included in the study. Animals were euthanized on the final irradiation day of each treated subgroup. Bone marrow smears were examined to determine the extent of genotoxicity after the particular treatment time. Mann- Whitney testwas used for statistical evaluation of data. In comparison to the sham exposed subgroups, the findings of polychromatic erythrocytes revealed significant differences for the 8th and 15th experimental day. Bone marrow erythrocyte maturation and/or proliferation initiated by subthermogenic RF/MW irradiation showed temporary disturbance. Thereafter, the frequency of micronucleated bone marrow red cells was significantly increased after 15 irradiation treatments. Comparison of micronucleus frequency data obtained after 2, 8 and 30 irradiation

treatments did not reveal statistically significant differences between sham and treated subgroups. Under the applied experimental conditions, RF/MWirradiation initiates transitory cytogenetic effect manifested with micronucleus formation in erythropoietic cells.

Trosic I, Busljeta I. Erythropoietic dynamic equilibrium in rats maintained after microwave irradiation. Exp Toxicol Pathol. 57(3):247-251, 2006.

The aim of study was to define influence of radiofrequency microwave (RF/MW) radiation on erythropoiesis in rats. The kinetics of polychromatic erythrocytes (PCEs) and micronucleated (MN) PCEs in the bone marrow (BM) and peripheral blood (PB) of rats during the intermittent subchronic experiment was followed. Rats were exposed 2h/day, 7 days/week to RF/MW of 2.45GHz and whole-body specific absorption rate (SAR) of 1.25+/-0.36W/kg. Control animals were included in the study. Each exposed and control group was killed on the final day of irradiation. Acridine-orange stained BM and blood smears were examined by fluorescence microscope. PCEs were obtained by inspection of 2000BM and 1000PB erythrocytes/slides. BMMNs and PBMNs frequency was obtained by observation of 1000PCEs/slides. BMPCEs were increased on day 8 and 15, and PBPCEs were elevated on days 2 and 8 ($p<0.05$). The BMMN frequency was increased on experimental day 15, and MNPCEs in the PB was increased on day 8 ($p<0.05$). Findings of BM and PBPCEs or MNPCEs declined nearly to the control values until the end of the experiment. Such findings are considered to be indicators of radiation effects on BM erythropoiesis consequently reflected in the PB. Rehabilitated dynamic haemopoietc equilibrium in rats by the end of experiment indicates possibility of activation adaptation process in rats to the selected experimental conditions of subchronic RF/MW exposure.

Trosić I, Pavicić I. Disturbance of cell proliferation in response to mobile phone frequency radiation. Arh Hig Rada Toksikol. 60(1):109-115, 2009.

The aim of study was to determine the influence of mobile phone frequency radiation on the proliferation, cytoskeleton structure, and mitotic index of V79 cells after 1 h, 2 h, and 3 h of exposure. V79 cells were cultured in standard laboratory conditions and exposed to continuous-wave (CW) RF/MW radiation of 935 MHz, electric field strength of (8.2+/-0.3) V m(-1), and specific absorption rate (SAR) of 0.12 W kg(-1). To identify proliferation kinetics, the cells were counted for each hour of exposure 24 h, 48 h, 72 h, and 96 h after respective exposures. Microtubule proteins were determined using specific immunocytochemical methods. Cell smears were analysed under a fluorescent microscope. The study included negative and positive controls. Mitotic index was determined by estimating the number of dividing cells 24 h after exposure and dividing it with the total number of cells. In comparison to the controls, cell proliferation declined in cells exposed for three hours 72 h after irradiation ($p < 0.05$). Microtubule structure was clearly altered immediately after three hours of irradiation ($p < 0.05$). The mitotic index in RF/MW-exposed cells did not differ from negative controls. However, even if exposure did not affect the number of dividing cells, it may have slowed down cell division kinetics as a consequence of microtubule impairment immediately after exposure.

Trosić I, Pavicić I, Milković-Kraus S, Mladinić M, Zeljezić D. Effect of

electromagnetic radiofrequency radiation on the rats' brain, liver and kidney cells measured by comet assay. Coll Antropol. 35(4):1259-1264, 2011.

The goal of study was to evaluate DNA damage in rat's renal, liver and brain cells after in vivo exposure to radiofrequency/microwave (Rf/Mw) radiation of cellular phone frequencies range. To determine DNA damage, a single cell gel electrophoresis/comet assay was used. Wistar rats (male, 12 week old, approximate body weight 350 g) (N = 9) were exposed to the carrier frequency of 915 MHz with Global System Mobile signal modulation (GSM), power density of 2.4 W/m2, whole body average specific absorption rate SAR of 0.6 W/kg. The animals were irradiated for one hour/day, seven days/week during two weeks period. The exposure set-up was Gigahertz Transversal Electromagnetic Mode Cell (GTEM--cell). Sham irradiated controls (N = 9) were apart of the study. The body temperature was measured before and after exposure. There were no differences in temperature in between control and treated animals. Comet assay parameters such as the tail length and tail intensity were evaluated. In comparison with tail length in controls (13.5 +/- 0.7 microm), the tail was slightly elongated in brain cells of irradiated animals (14.0 +/- 0.3 microm). The tail length obtained for liver (14.5 +/- 0.3 microm) and kidney (13.9 +/- 0.5 microm) homogenates notably differs in comparison with matched sham controls (13.6 +/- 0.3 microm) and (12.9 +/- 0.9 microm). Differences in tail intensity between control and exposed animals were not significant. The results of this study suggest that, under the experimental conditions applied, repeated 915 MHz irradiation could be a cause of DNA breaks in renal and liver cells, but not affect the cell genome at the higher extent compared to the basal damage.

Trošić I, Mataušić-Pišl M, Pavičić I, Marjanović AM. Histological and Cytological Examination of Rat Reproductive Tissue After Short-Time Intermittent Radiofrequency Exposure / HISTOLOŠKA I CITOLOŠKA ISTRAŽIVANJA TKIVA REPRODUKTIVNOG SUSTAVA ŠTAKORA NAKON KRATKOTRAJNE ISPREKIDANE IZLOŽENOSTI RADIOFREKVENCIJSKOM ZRAČENJU. Arh Hig Rada Toksikol. 64(4):513-519, 2013. doi: 10.2478/10004-1254-64-2013-2394.

The unfavourable outcomes of mobile phone use on male fertility have still not been fully elaborated. To establish the potentially adverse effects of everyday exposure to radiofrequency radiation (RF) on humans, we performed a controlled animal study that aimed to investigate the influence of RF radiation on rat testis histology as well as the amount, mobility, and structure of epididymal free sperm cell population. Eighteen adult male rats were divided into two groups of nine. One group comprised sham-exposed control animals, while the other group endured total body irradiation for an hour daily during two weeks. A 915 MHz RF field, power density of 2.4 W m-2 and strength of 30 V m-1 was generated in a Gigahertz Transversal Electromagnetic chamber. The specific absorption rate (SAR) was 0.6 W kg-1. Body mass and temperature were measured before and after each exposure treatment. Immediately after the last exposure, the animals were sacrificed and testes removed and prepared for histological analysis. The free sperm cells were collected from the cauda epididymis and their quantity, quality, and morphology were microscopically

determined using a haemocytometer. No statistically significant alteration in any of the endpoints was observed. This study found no evidence of an unfavourable effect of the applied RF radiation on testicular function or structure. Based on these results, we can conclude that short-time intermittent exposure to RF radiation does not represent a significant risk factor for rat reproductive functions.

Troulis SE, Scanlon WG, Evans NE. Effect of a hands-free wire on specific absorption rate for a waist-mounted 1.8 GHz cellular telephone handset. Phys Med Biol. 48(12):1675-1684, 2003.

A common feature of cellular telephony is the use of a 'hands-free' audio extension lead connected to a waist-worn handset. Interaction between the transmitting antenna, the wire and the user's body can occur, with detrimental effects including polar pattern degradation, reduced efficiency and localized increases in specific absorption rate (SAR). Using a realistic full-body model of an adult male, finite difference time domain analysis was employed to investigate the coupling between a hip-mounted 1.8 GHz handset fitted with a monopole antenna and a 1 m long wire representing a hands-free wire. Conduction current densities were computed for three identifiable coupling modes: magnetic-only, conductive-only and combined conductive-and-magnetic. Magnetic-only coupling was dominant. Without the lead, placing the handset at waist height led to a 42.8% increase in the total energy deposited in the body, compared to use at the head. Introducing the lead further increased the body loss, with a reduction in system radiation efficiency from 52% to 43.7%. Without the hands-free lead, the peak 1 g and 10 g SARs were 0.450 W kg(-1) and 0.265 W kg(-1), respectively, for 125 mW transmit power. With the hands-free lead connected, these values increased to 1.14 W kg(-1) and 0.430 W kg(-1), respectively.

Trunk A, Stefanics G, Zentai N, Kovács-Bálint Z, Thuróczy G, Hernádi I. No effects of a single 3G UMTS mobile phone exposure on spontaneous EEG activity, ERP correlates, and automatic deviance detection.Bioelectromagnetics. 2012 Jun 4. doi: 10.1002/bem.21740. [Epub ahead of print]

Potential effects of a 30 min exposure to third generation (3G) Universal Mobile Telecommunications System (UMTS) mobile phone-like electromagnetic fields (EMFs) were investigated on human brain electrical activity in two experiments. In the first experiment, spontaneous electroencephalography (sEEG) was analyzed (n = 17); in the second experiment, auditory event-related potentials (ERPs) and automatic deviance detection processes reflected by mismatch negativity (MMN) were investigated in a passive oddball paradigm (n = 26). Both sEEG and ERP experiments followed a double-blind protocol where subjects were exposed to either genuine or sham irradiation in two separate sessions. In both experiments, electroencephalograms (EEG) were recorded at midline electrode sites before and after exposure while subjects were watching a silent documentary. Spectral power of sEEG data was analyzed in the delta, theta, alpha, and beta frequency bands. In the ERP experiment, subjects were presented with a random series of standard (90%) and frequency-deviant (10%) tones in a passive binaural oddball

paradigm. The amplitude and latency of the P50, N100, P200, MMN, and P3a components were analyzed. We found no measurable effects of a 30 min 3G mobile phone irradiation on the EEG spectral power in any frequency band studied. Also, we found no significant effects of EMF irradiation on the amplitude and latency of any of the ERP components.In summary, the present results do not support the notion that a 30 min unilateral 3G EMF exposure interferes with human sEEG activity, auditory evoked potentials or automatic deviance detection indexed by MMN.

Trunk A, Stefanics G, Zentai N, Bacskay I, Felinger A, Thuróczy G, Hernádi I. Lack of interaction between concurrent caffeine and mobile phone exposure on visual target detection: An ERP study. Pharmacol Biochem Behav. 2014 Jul 26. pii: S0091-3057(14)00215-9. doi: 10.1016/j.pbb.2014.07.011. [Epub ahead of print]

BACKGROUND: Caffeine affects information processing by acting predominantly on cortical activation, arousal and attention. Millions consume caffeine and simultaneously use their mobile phone (MP) during everyday activities. However, it is not known whether and how MP-emitted electromagnetic fields (EMFs) can modulate known psychoactive effects of caffeine. Here we investigated behavioral and neural correlates of caffeine and simultaneous MP exposure in a third generation (3G) Universal Mobile Telecommunication System (UMTS) signal modulation scheme. METHODS: We recorded electroencephalography (EEG) and event related potentials (ERP) in an oddball paradigm to frequent standard (P=0.8) and rare target (P=0.2) stimuli in a placebo controlled, double blind, within-subject protocol in four experimental sessions: 1) no caffeine and no MP, 2) caffeine only, 3) MP only, 4) caffeine and MP. The subjects' task was to discriminate between standard and target stimuli and respond to the latter by pressing a button while reaction time (RT) and EEG were recorded. To provide a complete analysis of any possible caffeine and/or MP treatment effects that may have occurred, we analyzed the P300 ERP wave using four different ERP measures: 1) peak latency, 2) peak amplitude, 3) 50% fractional area latency (FAL) and 4) area under the curve (AUC). RESULTS: Caffeine significantly shortened RT and decreased AUC of the P300 component compared to the control or the UMTS MP alone conditions. However, no effects were observed on RT or P300 in the UMTS MP exposure sessions, neither alone nor in combination with caffeine. CONCLUSION: Overall, the present results did not demonstrate any interactive or synergistic effects of caffeine and UMTS MP like EMF exposure on basic neural or cognitive measures. However, we found that caffeine consistently enhanced behavioral and ERP measures of visual target detection, showing that present results were obtained using a pharmacologically validated, consistent and replicable methodology.

Tseng MC, Lin YP, Hu FC, Cheng TJ. Risks Perception of Electromagnetic Fields in Taiwan: The Influence of Psychopathology and the Degree of Sensitivity to Electromagnetic Fields. Risk Anal. 2013 Mar 28. doi: 10.1111/risa.12041. [Epub ahead of print]

Little is known about the perceived health risks of electromagnetic fields (EMFs) and factors associated with risk perception in non-Western countries. Psychological conditions

and risk perception have been postulated as factors that facilitate the attribution of health complaints to environmental factors. This study investigated people's perceived risks of EMFs and other environmental sources, as well as the relationships between risk perception, psychopathology, and the degree of self-reported sensitivity to EMFs. A total of 1,251 adults selected from a nationwide telephone interviewing system database responded to a telephone survey about the relationships between environmental sources and human health. The interview included questions assessing participants' psychiatric conditions and the presence and degree of sensitivity to EMFs. One hundred and seventy participants were self-identified as having sensitivity to EMFs, and 141 met the criteria for psychiatric conditions without EMF sensitivity. More than half of the survey respondents considered power lines and mobile phone base stations to affect people's health to a big extent. Higher sensitivity to EMFs, psychopathology, being female, being married, more years of education, and having a catastrophic illness had positive associations with perceived risks of EMF-related environmental sources as well as for all environmental sources combined. We observed no moderating effect of psychopathology on the association between degree of sensitivity to EMF and risk perception. Thus, psychopathology had influence on general people's risk perception without having influence on the relationship between people's degree of sensitivity to EMF and risk perception. The plausible explanations are discussed in the text.

Tsurita G, Nagawa H, Ueno S, Watanabe S, Taki M, Biological and morphological effects on the brain after exposure of rats to a 1439 MHz TDMA field. Bioelectromagnetics 21(5):364-371, 2000.

We investigated the effects of exposure to a 1439 MHz TDMA (Time Division Multiple Access) field, as used in cellular phones, on the permeability of the blood-brain barrier (BBB), on the morphological changes of the brain, and on body-mass fluctuations. Male Sprague-Dawley (SD) rats were divided into Three groups of eight rats each. The rats in the EM(+) group, which had their heads arrayed in a circle near the central antenna of an exposure system, were exposed to a 1439 MHz field for one hour a day. The rats in EM(-) group were also in the exposure system, however, without high-frequency electromagnetic wave (HF-EMW) exposure. The animals in the control group were neither placed in the system nor exposed to HF-EMWs. The exposure period was two or four weeks. The energy dose rate peaked at 2 W/kg in the brain; the average over the whole body was 0.25 W/kg. The changes in the permeability of BBB were investigated by Evans blue injection method and by immunostaining of serum albumin. HF-EMWs had no effect on the permeability of BBB. The morphological changes in the cerebellum were investigated by assessing the degeneration of Purkinje cells and the cell concentration in the granular layer. No significant changes were observed in the groups of rats exposed to HF-EMWs for two or four weeks. Averaged body masses were not affected by HF-EMWs exposure. In conclusion, a 1439 MHz TDMA field did not induce observable changes in the permeability of the BBB, morphological changes in the cerebellums, or body mass changes in rats, as evaluated by the conventional methods.

Tsybulin O, Sidorik E, Kyrylenko S, Henshel D, Yakymenko I. GSM 900 MHz microwave radiation affects embryo development of Japanese quails. Electromagn Biol Med. 31(1):75-86, 2012.

A wide range of non thermal biological effects of microwave radiation (MW) was revealed during the last decades. A number of reports showed evident hazardous effects of MW on embryo development in chicken. In this study, we aimed at elucidating the effects of MW emitted by a commercial model of GSM 900 MHz cell phone on embryo development in quails (Coturnix coturnix japonica) during both short and prolonged exposure. For that, fresh fertilized eggs were irradiated during the first 38 h or 14 days of incubation by a cell phone in "connecting" mode activated continuously through a computer system. Maximum intensity of incident radiation on the egg's surface was 0.2 μW/cm2.The irradiation led to a significant ($p<0.001$) increase in numbers of differentiated somites in 38-hour exposed embryos and to a significant ($p<0.05$) increase in total survival of embryos from exposed eggs after 14 days exposure. We hypothesized that observed facilitating effect was due to enhancement of metabolism in exposed embryos provoked via peroxidation mechanisms. Indeed, a level of thiobarbituric acid (TBA) reactive substances was significantly ($p<0.05$-0.001) higher in brains and livers of hatchlings from exposed embryos. Thus, observed effects of radiation from commercial GSM 900 MHz cell phone on developing quail embryos signify a possibility for non-thermal impact of MW on embryogenesis. We suggest that the facilitating effect of low doses of irradiation on embryo development can be explained by a hormesis effect induced by reactive oxygen species (ROS). Future studies need to be done to clarify this assumption.

Tsybulin O, Sidorik E, Brieieva O , Buchynska L, Kyrylenko S, Henshel D, IYakymenko I. GSM 900 MHz cellular phone radiation can either stimulate or depress early embryogenesis in Japanese quails depending on the duration of exposure. Int J Rad Biol. Posted online on April 11, 2013. (doi:10.3109/09553002.2013.791408)

Purpose: Our study was designed to assess the effects of low intensity radiation of a GSM (Global System for Mobile communication) 900 MHz cellular phone on early embryogenesis in dependence on the duration of exposure. *Materials and methods:* Embryos of Japanese Quails were exposed *in ovo* to GSM 900 MHz cellular phone radiation during initial 38 h of brooding or alternatively during 158 h (120 h before brooding plus initial 38 h of brooding) discontinuously with 48 sec ON (average power density 0.25 μW/cm^2, specific absorption rate 3 μW/kg) followed by 12 sec OFF intervals. A number of differentiated somites was assessed microscopically. Possible DNA damage evoked by irradiation was assessed by an alkaline comet assay. *Results:* Exposure to radiation from a GSM 900 MHz cellular phone led to a significantly altered number of differentiated somites. In embryos irradiated during 38 h the number of differentiated somites increased ($p<0.001$), while in embryos irradiated during 158 h this number decreased ($p<0.05$). The lower duration of exposure led to a significant ($p<0.001$) decrease in a level of DNA strand breaks in cells of 38-hour embryos, while the higher duration of exposure resulted in a significant ($p<0.001$) increase in DNA damage as compared to the control. *Conclusion:* Effects of GSM 900 MHz cellular phone radiation on early embryogenesis can be either stimulating or deleterious depending on the duration of exposure.

Tumkaya L, Kalkan Y, Bas O, Yilmaz A. Mobile phone radiation during pubertal development has no effect on testicular histology in rats. Toxicol Ind Health. 2013 Oct 4. [Epub ahead of print]

Mobile phones are extensively used throughout the world. There is a growing concern about the possible public health hazards posed by electromagnetic radiation emitted from mobile phones. Potential health risk applies particularly to the most intensive mobile phone users-typically, young people. The aim of this study was to investigate the effects of mobile phone exposure to the testes, by assessing the histopathological and biochemical changes in the testicular germ cells of rats during pubertal development. A total of 12 male Sprague Dawley rats were used. The study group (n = 6) was exposed to a mobile phone for 1 h a day for 45 days, while the control group (n = 6) remained unexposed. The testes were processed with routine paraffin histology and sectioned. They were stained with hematoxylin-eosin, caspase 3, and Ki-67 and then photographed. No changes were observed between the groups ($p > 0.05$). The interstitial connective tissue and cells of the exposed group were of normal morphology. No abnormalities in the histological appearance of the seminiferous tubules, including the spermatogenic cycle stage, were observed. Our study demonstrated that mobile phones with a low specific absorption rate have no harmful effects on pubertal rat testicles.

Türedi S, Hancı H, Topal Z, Unal D, Mercantepe T, Bozkurt I, Kaya H, Odacı E. The effects of prenatal exposure to a 900-MHz electromagnetic field on the 21-day-old male rat heart. Electromagn Biol Med. 2014 Aug 28:1-8. [Epub ahead of print]

Abstract The growing spread of mobile phone use is raising concerns about the effect on human health of the electromagnetic field (EMF) these devices emit. The purpose of this study was to investigate the effects on rat pup heart tissue of prenatal exposure to a 900 megahertz (MHz) EMF. For this purpose, pregnant rats were divided into experimental and control groups. Experimental group rats were exposed to a 900 MHz EMF (1 h/d) on days 13-21 of pregnancy. Measurements were performed with rats inside the exposure box in order to determine the distribution of EMF intensity. Our measurements showed that pregnant experimental group rats were exposed to a mean electrical field intensity of 13.77 V/m inside the box (0.50 W/m^2). This study continued with male rat pups obtained from both groups. Pups were sacrificed on postnatal day 21, and the heart tissues were extracted. Malondialdehyde, superoxide dismutase and catalase values were significantly higher in the experimental group rats, while glutathione values were lower. Light microscopy revealed irregularities in heart muscle fibers and apoptotic changes in the experimental group. Electron microscopy revealed crista loss and swelling in the mitochondria, degeneration in myofibrils and structural impairments in Z bands. Our study results suggest that exposure to EMF in the prenatal period causes oxidative stress and histopathological changes in male rat pup heart tissue.

Türedi S, Hancı H, Çolakoğlu S, Kaya H, Odacı E. Disruption of the ovarian follicle reservoir of prepubertal rats following prenatal exposure to a continuous 900-MHz electromagnetic field. Int J Radiat Biol. 92(6):329-337, 2016.

The effects on human health of electromagnetic field (EMF) have begun to be seriously questioned with the entry into daily life of devices establishing EMF, such as cell phones, wireless fidelity, and masts. Recent studies have reported that exposure to EMF, particularly during pregnancy, affects the developing embryo/fetus. The aim of this study was therefore to examine the effects of exposure to continuous 900-Megahertz (MHz) EMF applied in the prenatal period on ovarian follicle development and oocyte differentiation. Six pregnant Sprague Dawley rats were divided equally into a non-exposed control group (CNGr) and a group (EMFGr) exposed to continuous 900-MHz EMF for 1 h daily, at the same time every day, on days 13-21 of pregnancy. New groups were established from pups obtained from both groups after birth. One group consisting of female pups from CNGr rats was adopted as newborn CNGr (New-CNGr, n = 6), and another group consisting of female pups from EMFGr rats was adopted as newborn EMFGr (New-EMFGr, n = 6). No procedure was performed on New-CNGr or New-EMFGr rats. All rat pups were sacrificed on the postnatal 34th day, and their ovarian tissues were removed. Follicle count, histological injury scoring and morphological assessment with apoptotic index criteria were performed with sections obtained following routine histological tissue preparation. Follicle count results revealed a statistically significant decrease in primordial and tertiary follicle numbers in New-EMFGr compared to New-CNGr ($p < 0.05$), while atretic follicle numbers and apoptotic index levels increased significantly ($p < 0.05$). Histopathological examination revealed severe follicle degeneration, vasocongestion, a low level of increased stromal fibrotic tissue and cytoplasmic vacuolization in granulosa cell in New-EMFGr. Prenatal exposure to continuous 900-MHz EMF for 1 hour each day from days 13-21 led to a decrease in ovarian follicle reservoirs in female rat pups at the beginning of the prepubertal period.

Türedi S, Kerimoğlu G, Mercantepe T, Odacı E. Biochemical and pathological changes in the male rat kidney and bladder following exposure to continuous 900**-MHz electromagnetic field on postnatal days 22-59. Int J Radiat Biol. 93(9):990-999, 2017.**

PURPOSE: To investigate the effect on male rat kidney and bladder tissues of exposure to **900**-megahertz (MHz) electromagnetic field (EMF) applied on postnatal days 22-59, inclusive.MATERIALS AND METHODS: Twenty-four male Sprague Dawley rats, aged 21 days, were used. These were divided equally into one of three groups, control (CG), sham (SG) or EMF (EMFG). CG was not exposed to any procedure. SG rats were kept inside a cage, without being exposed to the effect of EMF, for 1 h a day on postnatal days 22-59, inclusive. EMFG rats were exposed to continuous **900**-MHz EMF for 1 h a day under the same conditions as those for the SG rats. Rats were sacrificed on postnatal day 60, and the kidney and bladder tissues were removed. Tissues were stained with hematoxylin and eosin (H&E) and Masson trichrome for histomorphological evaluation. The TUNEL method was used to assess apoptosis. Transmission electron microscopy (TEM) was also used for the kidney tissue. Oxidant/antioxidant parameters were studied in terms of biochemical values.RESULTS: The findings showed that tissue malondialdehyde increased in EMFG compared to CG and SG in both kidney ($p = 0.004$ and $p = 0.004$, respectively) and bladder tissue ($p = 0.004$, $p = 0.006$, respectively), while

catalase and glutathione levels decreased compared to CG (p = 0.004; p = 0.004, respectively) and SG (p = 0.004; p = 0.004, respectively). In the EMF group, pathologies such as dilatation and vacuolization in the distal and proximal tubules, degeneration in glomeruli and an increase in cells tending to apoptosis were observed in kidney tissue. In bladder tissue, degeneration in the transitional epithelium and stromal irregularity and an increase in cells tending to apoptosis were observed in EMFG. Additionally, EMFG samples exhibited glomerular capillary degeneration with capillary basement membranes under TEM.CONCLUSIONS: We conclude that continuous exposure to the effect of **900**-MHz EMF for 1 h a day on postnatal days 22-59, inclusive, causes an increase in oxidative stress and various pathological changes in male rat kidney and bladder tissues.

Türker Y, Nazıroğlu M, Gümral N, Celik O, Saygın M, Cömlekçi S, Flores-Arce M. Selenium and L-carnitine reduce oxidative stress in the heart of rat induced by 2.45-GHz radiation from wireless devices. Biol Trace Elem Res. 143(3):1640-1650, 2011.

The aim of this study was to investigate the possible protective role of selenium and L-carnitine on oxidative stress induced by 2.45-GHz radiation in heart of rat. For this purpose, 30 male Wistar Albino rats were equally divided into five groups namely controls, sham controls, radiation-exposed rats, radiation-exposed rats treated with intraperitoneal injections of sodium selenite at a dose of 1.5 mg/kg/day, and radiation-exposed rats treated with intraperitoneal injections of L-carnitine at a dose of 1.5 mg/kg/day. Except for the controls and sham controls, the animals were exposed to 2.45-GHz radiation during 60 min/day for 28 days. The lipid peroxidation (LP) levels were higher in the radiation-exposed groups than in the control and sham control groups. The lipid peroxidation level in the irradiated animals treated with selenium and L-carnitine was lower than in those that were only exposed to 2.45-GHz radiation. The concentrations of vitamins A, C, and E were lower in the irradiated-only group relative to control and sham control groups, but their concentrations were increased in the groups treated with selenium- and L-carnitine. The activity of glutathione peroxidase was higher in the selenium-treated group than in the animals that were irradiated but received no treatment. The erythrocyte-reduced glutathione and β-carotene concentrations did not change in any of the groups. In conclusion, 2.45-GHz electromagnetic radiation caused oxidative stress in the heart of rats. There is an apparent protective effect of selenium and L-carnitine by inhibition of free radical formation and support of the antioxidant redox system.

Tuschl, H, Neubauer, G, Garn, H, Duftschmid, K, Winker, N, Brusl, H, Occupational exposure to high frequency electromagnetic fields and its effect on human immune parameters. Int J Occup Med Environ Health;12(3):239-251, 1999.

The present study recorded a considerable excess of recommended exposure limitsin the vicinity of shortwave diathermy devices used for medical treatment of patients. Different kinds of field probes were used to measure electric and magnetic field strength and the whole body exposure of medical personnel operating shortwave, decimeter wave and microwave units was calculated. To investigate the

influence of chronic exposure on the immune system of operators, blood was sampled from physiotherapists working at the above mentioned devices. Eighteen exposed and thirteen control persons, matched by sex and age, were examined. Total leucocyte and lymphocyte counts were performed and leucocytic subpopulations determined by flow cytometry and monoclonal antibodies against surface antigens. In addition, to quantify subpopulations of immunocompetent cells, the activity of lymphocytes was measured. Lymphocytes were stimulated by mitogen phytohemagglutinin and their proliferation measured by a flow cytometric method. No statistically significant differences between the control and exposed persons were found. In both study groups all immune parameters were within normal ranges.

Tuschl H, Novak W, Molla-Djafari H. In vitro effects of GSM modulated radiofrequency fields on human immune cells. Bioelectromagnetics.27(3):188-196, 2006.

Despite the important role of the immune system in defending the body against infections and cancer, only few investigations on possible effects of radiofrequency (RF) radiation on function of human immune cells have been undertaken. Aim of the present investigation was therefore to assess whether GSM modulated RF fields have adverse effects on the functional competence of human immune cells. Within the frame of the multidisciplinary project "Biological effects of high frequency electromagnetic fields (EMF)" sponsored by the National Occupation Hazard Insurance Association (AUVA) in vitro investigations were carried out on human blood cells. Exposure was performed at GSM Basic 1950 MHz, an SAR of 1 mW/g in an intermittent mode (5 min "ON", 10 min "OFF") and a maximum Delta T of 0.06 degrees C for the duration of 8 h. The following immune parameters were evaluated: (1) the intracellular production of interleukin-2 (IL-2) and interferon (INF) gamma in lymphocytes, and IL-1 and tumor necrosis factor (TNF)-alpha in monocytes were evaluated with monoclonal antibodies. (2) The activity of immune-relevant genes (IL 1-alpha and beta, IL-2, IL-2-receptor, IL-4, macrophage colony stimulating factor (MCSF)-receptor, TNF-alpha, TNF-alpha-receptor) and housekeeping genes was analyzed with real time PCR. (3) The cytotoxicity of lymphokine activated killer cells (LAK cells) against a tumor cell line was determined in a flow cytometric test. For each parameter, blood samples of at least 15 donors were evaluated. No statistically significant effects of exposure were found and there is no indication that emissions from mobile phones are associated with adverse effects on the human immune system.

Tynes T, Hannevik M, Andersen A, Vistnes AI, Haldorsen T, Incidence of breast cancer in Norwegian female radio and telegraph operators. Cancer Causes Control 7(2):197-204, 1996.

Exposure to electromagnetic fields may cause breast cancer in women if it increases susceptibility to sex-hormone-related cancer by diminishing the pineal gland's production of melatonin. We have studied breast cancer incidence in female radio and telegraph operators with potential exposure to light at

night, radio frequency (405 kHz-25 MHz), and, to some extent, extremely low frequency fields (50 Hz). We linked the Norwegian Telecom cohort of female radio and telegraph operators working at sea to the Cancer Registry of Norway to study incident cases of breast cancer. The cohort consisted of 2,619 women who were certified to work as radio and telegraph operators between 1920 and 1980. Cancer incidence was analyzed on the basis of the standardized incidence ratio (SIR), with the Norwegian female population as the comparison group. The incidence of all cancers was close to unity (SIR = 1.2). An excess risk was seen for breast cancer (SIR = 1.5). Analysis of a nested case-control study within the cohort showed an association between breast cancer in women aged 50+ years and shift work. In a model with adjustment for age, calendar year, and year of first birth, the rate ratio for breast cancer associated with being a radio and telegraph operator--in comparison with all Norwegian women born 1935 or later--analyzed with Poisson regression, was 1.5 after adjustment for fertility factors. These results support a possible association between work as a radio and telegraph operator and breast cancer. Future epidemiologic studies on breast cancer in women aged 50 and over, should address possible disturbances of chronobiological parameters by environmental factors.

Tzaphlidou M, Fotiou E. The effects of 910-MHz electromagnetic field on rat cranial arachnoid and dura mater collagen. The axial periodicity of collagen fibrils. ScientificWorldJournal. 4 Suppl 2:70-74, 2004.

The axial periodicity of rat arachnoid and dura mater collagen fibrils exposed to 910 MHz for 2 h/day for 30 consecutive days was measured by means of image analysis of electron-optical data. Such measurements were compared with those from sham-exposed animals. These measurements reveal that on exposure, the intermolecular interactions during collagen fibril assembly are affected.

Ulashchik VS, [Changes in drug pharmacokinetics and pharmacodynamics under the influence of microwaves of different ranges]. Vopr Kurortol Fizioter Lech Fiz Kult 4):1-6, 1993. [Article in Russian]

Human and animal experiments were conducted to compare the effect of microwaves different by their range on drug pharmacodynamics and pharmacokinetics. The response to the microwaves depended on the dose and site of the exposure, on the frequency of the electromagnetic modes. The results suggest that it is possible to use microwaves for potentiating and prolongation of some drugs action.

Uloziene I, Uloza V, Gradauskiene E, Saferis V. Assessment of potential effects of the electromagnetic fields of mobile phones on hearing. BMC Public Health. 5(1):39, 2005.

BACKGROUND: Mobile phones have become indispensable as communication tools; however, to date there is only a limited knowledge about interaction between electromagnetic fields (EMF) emitted by mobile phones and auditory function. The aim of the study was to assess potential changes in hearing function as a consequence of exposure to low-intensity EMF's produced by mobile phones at frequencies of 900 and

1800 MHz. METHODS: The within-subject study was performed on thirty volunteers (age 18-30 years) with normal hearing to assess possible acute effect of EMF. Participants attended two sessions: genuine and sham exposure of EMF. Hearing threshold levels (HTL) on pure tone audiometry (PTA) and transient evoked otoacoustic emissions (TEOAE's) were recorded before and immediately after 10 min of genuine and/or sham exposure of mobile phone EMF. The administration of genuine or sham exposure was double blind and counterbalanced in order. RESULTS: Statistical analysis revealed no significant differences in the mean shift of PTA and TEOAE's values before and after genuine and/or sham mobile phone EMF 10 min exposure. The data collected showed that average TEOAE levels (averaged across a frequency range) changed less than 2 dB between pre- and post-, real and sham exposure. The greatest individual change was 10dB(A), with a decrease in level from pre- to post- real exposure. CONCLUSIONS: It could be concluded that a 10-min close exposure of EMFs emitted from a mobile phone had no immediate after-effect on measurements of HTL of PTA and TEOAEs in young adult human subjects and no measurable hearing deterioration was detected in our study.

Ulubay M, Yahyazadeh A, Deniz OG, Kıvrak EG, Altunkaynak BZ, Erdem G, Kaplan S. Effects of prenatal 900 MHz electromagnetic field exposures on the histology of rat kidney. Int J Radiat Biol. 2014 Aug 1:1-25. [Epub ahead of print]

Purpose: To research the harmful effects of prenatal exposure of 900 megahertz (MHz) electromagnetic field (EMF) on kidneys of four-week-old male rats and to determine protective effects of melatonin (MEL) and omega-3 (ω-3). Materials and methods: Twenty-one Wistar albino rats were randomly placed into seven groups as follows: control (Cont), Sham, MEL, ω-3, EMF, EMF+MEL and EMF+ω-3. After mating, three groups (EMF, EMF+MEL, EMF+ ω-3) were exposed to an EMF. In the fourth week subsequent to parturition, six rats were randomly chosen from each group. Mean volume of kidneys and renal cortices, the total number of glomeruli and basic histological structure of kidney were evaluated by stereological and light microscopical methods, respectively. Results: Stereological results determined the mean volume of the kidneys and cortices were significantly increased in EMF-exposed groups compared to the Cont group. However, EMF-unexposed groups were not significantly modified compared to the Cont group. Additionally, the total number of glomeruli was significantly higher in EMF-unexposed groups compared to the Cont group. Alternatively, the number of glomeruli in EMF-exposed groups was decreased compared to the Cont group. Conclusions: Prenatal exposure of rat kidneys to 900 MHz EMF resulted in increased total kidney volume and decreased the numbers of glomeruli. Moreover, MEL and ω-3 prevented adverse effects of EMF on the kidneys.

Unterlechner M, Sauter C, Schmid G, Zeitlhofer J. No effect of an UMTS mobile phone-like electromagnetic field of 1.97 GHz on human attention and reaction time. Bioelectromagnetics.29(2):145-153, 2008.

Several studies in the past reported influences of electromagnetic emissions of GSM phones on reaction time in humans. However, there are currently only a few studies available dealing with possible effects of the electromagnetic fields emitted by UMTS mobile phones. In our study, 40 healthy volunteers (20 female, 20 male), aged 26.0 years

(range 21-30 years) underwent four different computer tests measuring reaction time and attention under three different UMTS mobile phone-like exposure conditions (two exposure levels plus sham exposure). Exposure of the subjects was accomplished by small helical antennas operated close to the head and fed by a generic signal representing the emissions of a UMTS mobile phone under constant receiving conditions as well as under a condition of strongly varying transmit power. In the high exposure condition the resulting peak spatial average exposure of the test subjects in the cortex of the left temporal lobe of the brain was 0.63 W/kg (min. 0.25 W/kg, max. 1.49 W/kg) in terms of 1 g averaged SAR and 0.37 W/kg (min. 0.16 W/kg, max. 0.84 W/kg) in terms of 10 g averaged SAR, respectively. Low exposure condition was one-tenth of high exposure and sham was at least 50 dB below low exposure. Statistical analysis of the obtained test parameters showed that exposure to the generic UMTS signal had no statistically significant immediate effect on attention or reaction. Therefore, this study does not provide any evidence that exposure of UMTS mobiles interferes with attention under short-term exposure conditions.

Urban, P, Lukas, E, Roth, Z, Does acute exposure to the electromagnetic field emitted by a mobile phone influence visual evoked potentials? A pilot study. Cent Eur J Public Health 6(4):288-290, 1998.

To search for a potential negative influence on the central nervous system (CNS) of the electromagnetic field emitted by a mobile phone, the authors performed a pilot experimental study of the influence of a single short acute exposure to the GSM mobile phone Motorola 8700, using visual evoked potentials (VEP) examination as an electrophysiological marker of CNS dysfunction. The study group consisted of 20 healthy volunteers. The duration of exposure was 5 minutes. The output power of the device was 1.5 W when the antenna was pulled up. Five parameters of VEP were evaluated by means of multifactorial ANOVA. Confounding effects of age, sex, and of the call in itself were taken into consideration. No statistically significant influence of the above-described exposure to the electromagnetic field emitted by the mobile phone on latencies or amplitudes of VEP was observed.

Urbinello D, Röösli M. Impact of one's own mobile phone in stand-by mode on personal radiofrequency electromagnetic field exposure.J Expo Sci Environ Epidemiol. 23:545-548, 2013.

When moving around, mobile phones in stand-by mode periodically send data about their positions. The aim of this paper is to evaluate how personal radiofrequency electromagnetic field (RF-EMF) measurements are affected by such location updates. Exposure from a mobile phone handset (uplink) was measured during commuting by using a randomized cross-over study with three different scenarios: disabled mobile phone (reference), an activated dual-band phone and a quad-band phone. In the reference scenario, uplink exposure was highest during train rides (1.19 mW/m(2)) and lowest during car rides in rural areas (0.001 mW/m(2)). In public transports, the impact of one's own mobile phone on personal RF-EMF measurements was not observable because of high background uplink radiation from other people's mobile phone. In a car, uplink exposure with an activated phone was orders of magnitude higher compared with the reference scenario. This study demonstrates that personal RF-EMF exposure is

affected by one's own mobile phone in stand-by mode because of its regular location update. Further dosimetric studies should quantify the contribution of location updates to the total RF-EMF exposure in order to clarify whether the duration of mobile phone use, the most common exposure surrogate in the epidemiological RF-EMF research, is actually an adequate exposure proxy.

Urbinello D, Huss A, Beekhuizen J, Vermeulen R, Röösli M. Use of portable exposure meters for comparing mobile phone base station radiation in different types of areas in the cities of Basel and Amsterdam. Sci Total Environ. 468-469:1028-1033, 2014.

BACKGROUND: Radiofrequency electromagnetic fields (RF-EMF) are highly variable and differ considerably within as well as between areas. Exposure assessment studies characterizing spatial and temporal variation are limited so far. Our objective was to evaluate sources of data variability and the repeatability of daily measurements using portable exposure meters (PEMs). METHODS: Data were collected at 12 days between November 2010 and January 2011 with PEMs in four different types of urban areas in the cities of Basel (BSL) and Amsterdam (AMS). RESULTS: Exposure from mobile phone base stations ranged from 0.30 to 0.53 V/m in downtown and business areas and in residential areas from 0.09 to 0.41 V/m. Analysis of variance (ANOVA) demonstrated that measurements from various days were highly reproducible (measurement duration of approximately 30 min) with only 0.6% of the variance of all measurements from mobile phone base station radiation being explained by the measurement day and only 0.2% by the measurement time (morning, noon, afternoon), whereas type of area (30%) and city (50%) explained most of the data variability. CONCLUSIONS: We conclude that mobile monitoring of exposure from mobile phone base station radiation with PEMs is useful due to the high repeatability of mobile phone base station exposure levels, despite the high spatial variation.

Urbinello D, Joseph W, Huss A, Verloock L, Beekhuizen J, Vermeulen R, Martens L, Röösli M. Radio-frequency electromagnetic field (RF-EMF) exposure levels in different European outdoor urban environments in comparison with regulatory limits. Environ Int. 2014 Apr 2;68C:49-54. doi: 10.1016/j.envint.2014.03.007. [Epub ahead of print].

BACKGROUND: Concerns of the general public about potential adverse health effects caused by radio-frequency electromagnetic fields (RF-EMFs) led authorities to introduce precautionary exposure limits, which vary considerably between regions. It may be speculated that precautionary limits affect the base station network in a manner that mean population exposure unintentionally increases. AIMS: The objectives of this multicentre study were to compare mean exposure levels in outdoor areas across four different European cities and to compare with regulatory RF-EMF exposure levels in the corresponding areas. METHODS: We performed measurements in the cities of Amsterdam (the Netherlands, regulatory limits for mobile phone base station frequency bands: 41-61V/m), Basel (Switzerland, 4-6V/m), Ghent (Belgium, 3-4.5V/m) and Brussels (Belgium, 2.9-4.3V/m) using a portable measurement device. Measurements were

conducted in three different types of outdoor areas (central and non-central residential areas and downtown), between 2011 and 2012 at 12 different days. On each day, measurements were taken every 4s for approximately 15 to 30min per area. Measurements per urban environment were repeated 12 times during 1year. RESULTS: Arithmetic mean values for mobile phone base station exposure ranged between 0.22V/m (Basel) and 0.41V/m (Amsterdam) in all outdoor areas combined. The 95th percentile for total RF-EMF exposure varied between 0.46V/m (Basel) and 0.82V/m (Amsterdam) and the 99th percentile between 0.81V/m (Basel) and 1.20V/m (Brussels). CONCLUSIONS: All exposure levels were far below international reference levels proposed by ICNIRP (International Commission on Non-Ionizing Radiation Protection). Our study did not find indications that lowering the regulatory limit results in higher mobile phone base station exposure levels.

Urbinello D, Joseph W, Verloock L, Martens L, Röösli M. Temporal trends of radio-frequency electromagnetic field (RF-EMF) exposure in everyday environments across European cities. Environ Res. 2014 Aug 12;134C:134-142. doi: 10.1016/j.envres.2014.07.003. [Epub ahead of print]

BACKGROUND: The rapid development and increased use of wireless telecommunication technologies led to a substantial change of radio-frequency electromagnetic field (RF-EMF) exposure in the general population but little is known about temporal trends of RF-EMF in our everyday environment. OBJECTIVES: The objective of our study is to evaluate temporal trends of RF-EMF exposure levels in different microenvironments of three European cities using a common measurement protocol. METHODS: We performed measurements in the cities of Basel (Switzerland), Ghent and Brussels (Belgium) during one year, between April 2011 and March 2012. RF-EMF exposure in 11 different frequency bands ranging from FM (Frequency Modulation, 88MHz) to WLAN (Wireless Local Area Network, 2.5GHz) was quantified with portable measurement devices (exposimeters) in various microenvironments: outdoor areas (residential areas, downtown and suburb), public transports (train, bus and tram or metro rides) and indoor places (airport, railway station and shopping centers). Measurements were collected every 4s during 10-50min per environment and measurement day. Linear temporal trends were analyzed by mixed linear regression models. RESULTS: Highest total RF-EMF exposure levels occurred in public transports (all public transports combined) with arithmetic mean values of 0.84V/m in Brussels, 0.72V/m in Ghent, and 0.59V/m in Basel. In all outdoor areas combined, mean exposure levels were 0.41V/m in Brussels, 0.31V/m in Ghent and 0.26V/m in Basel. Within one year, total RF-EMF exposure levels in all outdoor areas in combination increased by 57.1% ($p<0.001$) in Basel by 20.1% in Ghent ($p=0.053$) and by 38.2% ($p=0.012$) in Brussels. Exposure increase was most consistently observed in outdoor areas due to emissions from mobile phone base stations. In public transports RF-EMF levels tended also to increase but mostly without statistical significance. DISCUSSION: An increase of RF-EMF exposure levels has been observed between April 2011 and March 2012 in various microenvironments of three European cities. Nevertheless, exposure levels were still far below regulatory limits of each country. A continuous monitoring is needed to identify high

exposure areas and to anticipate critical development of RF-EMF exposure at public places.

Urech, M, Eicher, B, Siegenthaler, J, Effects of microwave and radio frequency electromagnetic fields on lichens. Bioelectromagnetics 17(4):327-334, 1996.

The effects of electromagnetic fields on lichens were investigated. Field experiments of long duration (1-3 years) were combined with laboratory experiments and theoretical considerations. Samples of the lichen species Parmelia tiliacea and Hypogymnia physodes were exposed to microwaves (2.45 GHz; 0.2, 5, and 50 mW/cm2; and control). Both species showed a substantially reduced growth rate at 50 mW/cm2. A differentiation between thermal and nonthermal effects was not possible. Temperature measurements on lichens exposed to microwaves (2.45 GHz, 50 mW/cm2) showed a substantial increase in the surface temperature and an accelerated drying process. The thermal effect of microwave on lichens was verified. The exposure of lichens of both species was repeated near a short-wave broadcast transmitter (9.5 MHz, amplitude modulated; maximum field strength 235 V/m, 332 mA/m). No visible effects on the exposed lichens were detected. At this frequency, no thermal effects were expected, and the experimental results support this hypothesis. Theoretical estimates based on climatic data and literature showed that the growth reductions in the initial experiments could very likely have been caused by drying of the lichens from the heating with microwaves. The results of the other experiments support the hypothesis that the response of the lichens exposed to microwaves was mainly due to thermal effects and that there is a low probability of nonthermal effects.

Ushiyama A, Ohtani S, Suzuki Y, Wada K, Kunugita N, Ohkubo C. Effects of 21-kHz intermediate frequency magnetic fields on blood properties and immune systems of juvenile rats. Int J Radiat Biol. 90(12):1211-1217, 2014.

Purpose: Due to a lack of science-based evidence, we explored the effects of exposure to intermediate frequency magnetic fields (IF-MF) on experimental animals. We assessed several immunological parameters to determine the effect of exposure of the whole body to IF-MF. MATERIALS AND METHODS: Male Sprague-Dawley rats (4-5 weeks old) were divided into three groups: Cage-control, sham, and 3.8-mT (rms) exposure groups. The animals were exposed to IF-MF at 21 kHz under fixed conditions in an acrylic holder. Exposure was performed for 1 h/day for 14 consecutive days. On the 15th day following the exposure, biochemical and hematological parameters in blood were analyzed. The effects of the exposure on immunological functions such as the cytotoxic activity of lymphocytes, chemotactic and phagocytic activity of granulocytes, and T (cluster of differentiation 4 [CD4] and cluster of differentiation 8 [CD8])-cell frequency were also examined. RESULTS: Hematological parameters were not affected by IF-MF exposure. Other immune functions such as the cytotoxic activity and phagocytic activity were not affected. Populations of T cells after exposure also did not show any significant differences. In blood biochemistry, there was significant difference in inorganic phosphorus level between sham and exposure group. However, this will not induce any pathophysiological status, because they were still within physiological range. Overall,

no significant effect by exposure of IF-MF was observed under our experimental conditions. CONCLUSIONS: Our results suggest that exposure to 21-kHz sinusoidal IF-MF at 3.8 mT for 1 h/day for 14 days did not affect immune function in juvenile rats.

Uskalova DV, Igolkina YV, Sarapultseva EI. Intravital Computer Morphometry on Protozoa: A Method for Monitoring of the Morphofunctional Disorders in Cells Exposed in the Cell Phone Communication Electromagnetic Field. Bull Exp Biol Med. 2016 Sep 3. [Epub ahead of print]

Morphofunctional disorders in unicellular aquatic protozoa - Spirostomum ambiguum infusorians after 30-, 60-, and 360-min exposure in electromagnetic field at a radiation frequency of 1 GHz and energy flow density of 50 μW/cm^2 were analyzed by intravital computer morphometry. Significant disorders in morphometric values correlated with low mobility of the protozoa. The results suggested the use of intravital computer morphometry on the protozoa for early diagnosis of radiation-induced effects of the mobile communication electromagnetic field, for example, low mobility of spermatozoa.

Utteridge TD, Gebski V, Finnie JW, Vernon-Roberts B, Kuchel TR. Long-Term Exposure of E μ-Pim1 Transgenic Mice to 898.4 MHz Microwaves does not Increase Lymphoma Incidence. Radiat Res 158(3):357-364, 2002.

A total of 120 E μ-Pim1 heterozygous mice and 120 wild-type mice were exposed for 1 h/day 5 days/week at each of the four exposure levels in "Ferris-wheel" exposure systems for up to 104 weeks to GSM-modulated 898.4 MHz radiation at SARs of 0.25, 1.0, 2.0 and 4.0 W/kg. In addition, 120 heterozygous and 120 wild-type mice were sham-exposed; there was also an unrestrained negative control group. Four exposure levels were used to investigate whether a dose-response effect could be detected. Independent verification confirmed that the exposures in the current study were nonthermal. There was no significant difference in the incidence of lymphomas between exposed and sham-exposed groups at any of the exposure levels. A dose-response effect was not detected. The findings showed that long-term exposures of lymphoma-prone mice to 898.4 MHz GSM radiofrequency (RF) radiation at SARs of 0.25, 1.0, 2.0 and 4.0 W/kg had no significant effects when compared to sham-irradiated animals. A previous study (Repacholi et al., Radiat. Res. 147, 631-640, 1997) reported that long-term exposure of lymphoma-prone mice to one exposure level of 900 MHz RF radiation significantly increased the incidence of non-lymphoblastic lymphomas when compared to sham-irradiated animals.

Vácha M, Puzová T, Kvícalová M. Radio frequency magnetic fields disrupt magnetoreception in American cockroach. J Exp Biol. 212(Pt 21):3473-3477, 2009.

The sense that allows birds to orient themselves by the Earth's magnetic field can be disabled by an oscillating magnetic field whose intensity is just a fraction of the geomagnetic field intensity and whose oscillations fall into the medium or high frequency radio wave bands. This remarkable phenomenon points very clearly at one

of two existing alternative magnetoreception mechanisms in terrestrial animals, i.e. the mechanism based on the radical pair reactions of specific photosensitive molecules. As the first such study in invertebrates, our work offers evidence that geomagnetic field reception in American cockroach is sensitive to a weak radio frequency field. Furthermore, we show that the 'deafening' effect at Larmor frequency 1.2 MHz is stronger than at different frequencies. The parameter studied was the rise in locomotor activity of cockroaches induced by periodic changes in the geomagnetic North positions by 60 deg. The onset of the disruptive effect of a 1.2 MHz field was found between 12 nT and 18 nT whereas the threshold of a doubled frequency field 2.4 MHz fell between 18 nT and 44 nT. A 7 MHz field showed no impact even in maximal 44 nT magnetic flux density. The results indicate resonance effects rather than non-specific bias of procedure itself and suggest that insects may be equipped with the same magnetoreception system as the birds.

Vagdatli E, Konstandinidou V, Adrianakis N, Tsikopoulos I, Tsikopoulos A, Mitsopoulou K. Effects of Electromagnetic Fields on Automated Blood Cell Measurements. J Lab Autom. 2014 Jan 24. [Epub ahead of print]

The aim of this study is to investigate whether the electromagnetic fields associated with mobile phones and/or laptops interfere with blood cell counts of hematology analyzers. Random blood samples were analyzed on an Aperture Impedance hematology analyzer. The analysis was performed in four ways: (A) without the presence of any mobile phone or portable computer in use, (B) with mobile phones in use (B1: one mobile, B4: four mobiles), (C) with portable computers (laptops) in use (C1: one laptop, C3: three laptops), and (D) with four mobile phones and three laptops in use simultaneously. The results obtained demonstrated a statistically significant decrease in neutrophil, erythrocyte, and platelet count and an increase in lymphocyte count, mean corpuscular volume, and red blood cell distribution width, notably in the B4 group. Despite this statistical significance, in clinical practice, only the red blood cell reduction could be taken into account, as the mean difference between the A and B4 group was 60,000 cells/μL. In group D, the analyzer gave odd results after 11 measurements and finally stopped working. The combined and multiple use of mobile phones and computers affects the function of hematology analyzers, leading to false results. Consequently, the use of such electronic devices must be avoided.

Valbonesi P, Franzellitti S, Piano A, Contin A, Biondi C, Fabbri E. Evaluation of HSP70 Expression and DNA Damage in Cells of a Human Trophoblast Cell Line Exposed to 1.8 GHz Amplitude-Modulated Radiofrequency Fields. Radiat Res. 169(3):270-279, 2008.

The aim of this study was to determine whether high-frequency electromagnetic fields (EMFs) could induce cellular effects. The human trophoblast cell line HTR-8/SVneo was used as a model to evaluate the expression of proteins (HSP70 and HSC70) and genes (HSP70A, B, C and HSC70) of the HSP70 family and the primary DNA damage response after nonthermal exposure to pulse-modulated 1817 MHz sinusoidal waves (GSM-217 Hz; 1 h; SAR of 2 W/kg). HSP70 expression was

significantly enhanced by heat, which was applied as the prototypical stimulus. The HSP70A, B and C transcripts were differentially expressed under basal conditions, and they were all significantly induced above basal levels by thermal stress. Conversely, HSC70 protein and gene expression was not influenced by heat. Exposing HTR-8/SVneo cells to high-frequency EMFs did not change either HSP70 or HSC70 protein or gene expression. A significant increase in DNA strand breaks was caused by exposure to H(2)O(2), which was used as a positive stimulus; however, no effect was observed after exposure of cells to high-frequency EMFs. Overall, no evidence was found that a 1-h exposure to GSM-217 Hz induced a HSP70-mediated stress response or primary DNA damage in HTR-8/SVneo cells. Nevertheless, further investigations on trophoblast cell responses after exposure to GSM signals of different types and durations are needed.

Valbonesi P, Franzellitti S, Bersani F, Contin A, Fabbri E. Effects of the exposure to intermittent 1.8 GHz radio frequency electromagnetic fields on HSP70 expression and MAPK signaling pathways in PC12 cells. Int J Radiat Biol. 90(5):382-391, 2014.

Purpose: We previously reported effects on heat shock protein 70 (HSP70) mRNA expression, a cytoprotective protein induced under stressful condition, in human trophoblast cells exposed to amplitude-modulated Global System for Mobile Communication (GSM) signals. In the present work the same experimental conditions were applied to the rat PC12 cells, in order to assess the stress responses mediated by HSP70 and by the Mitogen Activated Protein Kinases (MAPK) in neuronal-like cells, an interesting model to study possible effects of mobile phone frequencies exposure. Materials and methods: HSP70 gene expression level was evaluated by reverse transcriptase polymerase chain reaction, HSP70 protein expression and MAPK phosphorylation were assessed by Western blotting. PC12 cells were exposed for 4, 16 or 24 h to 1.8 GHz continuous wave signal (CW, carrier frequency without modulation) or to two different GSM modulation schemes, GSM-217Hz and GSM-Talk (which generates temporal changes between two different GSM signals, active during talking or listening phases respectively, thus simulating a typical conversation). Specific adsorption rate (SAR) was 2 W/kg. Results: After PC12 cells exposure to the GSM-217Hz signal for 16 or 24 h, HSP70 transcription significantly increased, whereas no effect was observed in cells exposed to the CW or GSM-Talk signals. HSP70 protein expression and three different MAPK signaling pathways were not affected by the exposure to any of the three different 1.8 GHz signals. Conclusion: The positive effect on HSP70 mRNA expression, observed only in cells exposed to the GSM-217Hz signal, is a repeatable response previously reported in human trophoblast cells and now confirmed in PC12 cells. Further investigations towards a possible role of 1.8 GHz signal modulation are therefore advisable.

Valbonesi P, Franzellitti S, Bersani F, Contin A, Fabbri E. Activity and expression of acetylcholinesterase in PC12 cells exposed to intermittent 1.8 GHz 217-GSM mobile phone signal. Int J Radiat Biol. 92(1):1-10.

Purpose Due to its role in learning, memory and in many neurodegenerative diseases, acetylcholinesterase (AChE) represents an interesting endpoint to assess possible

targets of exposure to radiofrequency electromagnetic fields (RF-EMF) generated by mobile phones. We investigated possible alterations of enzymatic activity, gene and protein expression of AChE in neuronal-like cells exposed to a 1.8 GHz Global System for Mobile Communication (GSM) modulated signal (217-GSM). Materials and methods Rat PC12 cells were exposed for 24 h to 1.8 GHz 217-GSM signal. Specific adsorption rate (SAR) was 2 W/kg. AChE enzyme activity was assessed spectrophotometrically by Ellman's method, mRNA expression level was evaluated by real time polymerase chain reaction, and protein expression was assessed by Western blotting. Results AChE enzymatic activity increased of 1.4-fold in PC12 cells exposed to 217-GSM signal for 24 h, whilst AChE transcriptional or translational pathways were not affected. Conclusion Our results provide the first evidence of effects on AChE activity after in vitro exposure of mammalian cells to the RF-EMF generated by GSM mobile phones, at the SAR value 2 W/kg. The obtained evidence promotes further investigations on AChE as a possible target of RF-EMF and confirm the ability of 1.8 GHz 217-GSM signal to induce biological effects in different mammalian cells.

Valentini E, Ferrara M, Presaghi F, De Gennaro L, Curcio G. Republished review: systematic review and meta-analysis of psychomotor effects of mobile phone electromagnetic fields.Postgrad Med J. 87(1031):643-651, 2011.

OBJECTIVES Over the past 10 years there has been increasing concern about the possible behavioural effects of mobile phone use. This systematic review and meta-analysis focuses on studies published since 1999 on the human cognitive and performance effects of mobile phone-related electromagnetic fields (EMF). METHODS PubMed, Biomed, Medline, Biological Sciences, PsychInfo, PsycARTICLES, Environmental Sciences and Pollution Management, Neurosciences Abstracts and Web of Science professional databases were searched and 24 studies selected for meta-analysis. Each study had to have at least one psychomotor measurement result as a main outcome. Data were analysed using standardised mean difference (SMD) as the effect size measure. RESULTS Only three tasks (2-back, 3-back and simple reaction time (SRT)) displayed significant heterogeneity, but after studies with extreme SMD were excluded using sensitivity analysis, the statistical significance disappeared ($\chi(2)(7)=1.63$, $p=0.20$; $\chi(2)(6)=1.00$, $p=0.32$; $\chi(2)(10)=14.04$, $p=0.17$, respectively). Following sensitivity analysis, the effect of sponsorship and publication bias were assessed. Meta-regression indicated a significant effect (b1/40.12, $p<0.05$) only for the 2-back task with mixed funding (industry and public/charity). Funnel plot inspection revealed a significant publication bias only for two cognitive tasks: SRT (Begg's rank correlation r=0.443; Egger's test b=-0.652) and the subtraction task (Egger's test b=-0.687). CONCLUSIONS Mobile phone-like EMF do not seem to induce cognitive and psychomotor effects. Nonetheless, the existence of sponsorship and publication biases should encourage WHO intervention to develop official research standards and guidelines. In addition, future research should address critical and neglected issues such as investigation of repeated, intensive and chronic exposures, especially in highly sensitive populations such as children.

Valič B, Kos B, Gajšek P. TYPICAL EXPOSURE OF CHILDREN TO EMF: EXPOSIMETRY AND DOSIMETRY. Radiat Prot Dosimetry. 2014 Apr 10. [Epub ahead of print]

A survey study with portable exposimeters, worn by 21 children under the age of 17, and detailed measurements in an apartment above a transformer substation were carried out to determine the typical individual exposure of children to extremely low- and radio-frequency (RF) electromagnetic field. In total, portable exposimeters were worn for >2400 h. Based on the typical individual exposure the in situ electric field and specific absorption rate (SAR) values were calculated for an 11-y-old female human model. The average exposure was determined to be low compared with ICNIRP reference levels: 0.29 μT for an extremely low-frequency (ELF) magnetic field and 0.09 V m^{-1} for GSM base stations, 0.11 V m^{-1} for DECT and 0.10 V m^{-1} for WiFi; other contributions could be neglected. However, some of the volunteers were more exposed: the highest realistic exposure, to which children could be exposed for a prolonged period of time, was 1.35 μT for ELF magnetic field and 0.38 V m^{-1} for DECT, 0.13 V m^{-1} for WiFi and 0.26 V m^{-1} for GSM base stations. Numerical calculations of the in situ electric field and SAR values for the typical and the worst-case situation show that, compared with ICNIRP basic restrictions, the average exposure is low. In the typical exposure scenario, the extremely low frequency exposure is <0.03 % and the RF exposure <0.001 % of the corresponding basic restriction. In the worst-case situation, the extremely low frequency exposure is <0.11 % and the RF exposure <0.007 % of the corresponding basic restrictions. Analysis of the exposures and the individual's perception of being exposed/unexposed to an ELF magnetic field showed that it is impossible to estimate the individual exposure to an ELF magnetic field based only on the information provided by the individuals, as they do not have enough knowledge and information to properly identify the sources in their vicinity.

Van de Kamer JB, Lagendijk, JJW, Computation of high-resolution SAR distributions in a head due to a radiating dipole antenna representing a hand-held mobile phone. Phys. Med. Biol. 47:1827-1835, 2002.

SAR distributions in a healthy female adult head as a result of a radiating vertical dipole antenna (frequency 915 MHz) representing a hand-held mobile phone have been computed for three different resolutions: 2 mm, 1 mm and 0.4 mm. The extremely high resolution of 0.4 mm was obtained with our quasistatic zooming technique, which is briefly described in this paper.For an effectively transmitted power of 0.25 W, the maximum averaged SAR values in both cubic- and arbitrary-shaped volumes are, respectively, about 1.72 and 2.55 W kg-1 for 1 g and 0.98 and 1.73 W kg-1 for 10 g of tissue. These numbers do not vary much (<8%) for the different resolutions, indicating that SAR computations at a resolution of 2 mm are sufficiently accurate to describe the large-scale distribution. However, considering the detailed SAR pattern in the head, large differences may occur if high-resolution computations are performed rather than low-resolution ones. These deviations are caused by both increased modelling accuracy and improved anatomical description in higher resolution simulations. For example, the SAR profile across a boundary between tissues with high dielectric contrast is much more accurately described at higher resolutions. Furthermore, low-resolution dielectric geometries may

suffer from loss of anatomical detail, which greatly affects small-scale SAR distributions. Thus, for strongly inhomogeneous regions high-resolution SAR modelling is an absolute necessity.

Van Den Bossche M, Verloock L, Aerts S, Joseph W, Martens L. IN SITU EXPOSURE ASSESSMENT OF INTERMEDIATE FREQUENCY FIELDS OF DIVERSE DEVICES. Radiat Prot Dosimetry. 2014 Aug 14. pii: ncu257. [Epub ahead of print]

In this study, in situ exposure assessment of both electric and magnetic fields of different intermediate frequency (IF) sources is investigated. The authors investigated smart boards and touchscreens, energy-saving bulbs, fluorescent lamps, a portable hearing unit and an electrosurgical unit (ESU). For most of these sources, the electric field is the dominating quantity. International Commission on Non-Ionizing Radiation Protection reference levels are exceeded for touchscreens (44 kHz: up to 155.7 V m^{-1} at 5 cm), energy-saving bulbs (38-52 kHz: up to 117.3 V m^{-1}), fluorescent lamps (52 kHz: up to 471 V m^{-1} at 5 cm) and ESUs (up to 920 kHz: 792 V m^{-1} at 0.5 cm). Magnetic field strengths up to 1.8 and 10.5 A m^{-1} were measured close to the ESU and portable hearing unit (69 V m^{-1}), respectively. Large differences of measured field values exist among the various operating modes of the IF equipment. Compliance distances for general public range from 15.3 cm (touchscreen) to 25 cm (fluorescent lamps).

van Kleef E, Fischer AR, Khan M, Frewer LJ. Risk and Benefit Perceptions of Mobile Phone and Base Station Technology in Bangladesh. Risk Anal.30(6):1002-1015, 2010.

Research in developed countries showed that many citizens perceive that radio signals transmitted by mobile phones and base stations represent potential health risks. Less research has been conducted in developing countries focused on citizen perceptions of risks and benefits, despite the recent and rapid introduction of mobile communication technologies. This study aims to identify factors that are influential in determining the tradeoffs that Bangladeshi citizens make between risks and benefits in terms of mobile phone technology acceptance and health concerns associated with the technology. Bangladesh was selected as representative of many developing countries inasmuch as terrestrial telephone infrastructure is insubstantial, and mobile phone use has expanded rapidly over the last decade, even among the poor. Issues of importance were identified in a small-scale qualitative study among Bangladeshi citizens (n = 13), followed by a survey within a sample of Bangladeshi citizens (n = 500). The results demonstrate that, in general, the perceived benefits of mobile phone technology outweigh the risks. The perceived benefits are primarily related to the social and personal advantages of mobile phone use, including the ability to receive emergency news about floods, cyclones, and other natural disasters. Base stations were seen as a symbol of societal advance. The results furthermore suggest that overall risk perceptions are relatively low, in particular health risks, and are primarily driven by perceptions that related to crime and social inconvenience. Perceived health risks are relatively small. These findings show that risk communication and management may be particularly effective when contextual factors of the society where the system is implemented are taken into consideration.

Vanderwaal RP, Cha B, Moros EG, Roti Roti JL. HSP27 phosphorylation increases after 45 degrees C or 41 degrees C heat shocks but not after non-thermal TDMA or GSM exposures. Int J Hyperthermia. 22(6):507-519, 2006.

Purpose: Experiments with cultured HeLa, S3 and E.A. Hy296 cells were performed to determine if exposure to acute (30 min at 45 degrees C) or chronic (2 h at 41 degrees C) heat shocks or to non-thermal exposures of radiofrequency radiation (RF) induce changes in HSP27 phosphorylation.Materials and methods: The radiofrequency (RF) exposures used in this study were 847 MHz time division multiple access modulated (TDMA) at a specific absorption rate (SAR) of 5 W kg-1 for 1, 2 or 24 h or 900 MHz GSM modulated (GSM) at a SAR of 3.7 W kg-1 for 1, 2 or 5 h. HSP27 phosphorylation was evaluated by resolving the various phosphorylation forms using two-dimensional gel electrophoresis measuring the relative amount of each by densitometry. Alternatively, an antibody specific for phosphorylated HSP27 was used to detect changes in HSP27 phosphorylation levels. All heat shock and RF exposure conditions were analysed simultaneously along with a matched incubator control sample. Each experiment was repeated three times.Results: Following heat shock, the degree of phosphorylation of HSP27 varied with the heat dose, with acute hyperthermia (45 degrees C) having an increased proportion of higher phosphorylated forms. Exposure of HeLa S3 cells to 5 W kg-1 TDMA for 1, 2 or 24 h did not induce significant differences in the levels of HSP27 phosphorylation compared to incubator control or sham. Exposure of E.A. Hy926 cells to 3.7 W kg-1 900 MHz GSM for 1, 2 or 5 h did not induce significant differences in the levels of HSP27 phosphorylation compared to sham exposed.Conclusions: Acute and moderate hyperthermia significantly increase HSP27 phosphorylation, but there was no significant change in the levels of HSP27 following non-thermal exposure to TDMA and GSM modulated RF radiations.

Van Leeuwen GM, Lagendijk JJ, Van Leersum BJ, Zwamborn AP, Hornsleth SN, Kotte AN, Calculation of change in brain temperatures due to exposure to a mobile phone. Phys Med Biol 44(10):2367-2379, 1999.

In this study we evaluated for a realistic head model the 3D temperature rise induced by a mobile phone. This was done numerically with the consecutive use of an FDTD model to predict the absorbed electromagnetic power distribution, and a thermal model describing bioheat transfer both by conduction and by blood flow. We calculated a maximum rise in brain temperature of 0.11 degrees C for an antenna with an average emitted power of 0.25 W, the maximum value in common mobile phones, and indefinite exposure. Maximum temperature rise is at the skin. The power distributions were characterized by a maximum averaged SAR over an arbitrarily shaped 10 g volume of approximately 1.6 W kg(-1). Although these power distributions are not in compliance with all proposed safety standards, temperature rises are far too small to have lasting effects. We verified our simulations by measuring the skin temperature rise experimentally. Our simulation method can be instrumental in further development of safety standards.

Vangelova K, Israel M, Mihaylov S. The effect of low level radiofrequency electromagnetic radiation on the excretion rates of stress hormones in operators during 24-hour shifts. Cent Eur J Public Health 10(1-2):24-28, 2002.

The aim of the study was to investigate the effect of long term exposure to low level radiofrequency (RF) electromagnetic (EM) radiation on the excretion rates of stress hormones in satellite station operators during 24-hour shifts. Twelve male operators at a satellite station for TV communications and space research were studied during 24-hour shifts. Dosimetric evaluation of the exposure was carried out and showed low level exposure with specific absorption of 0.1127 J.kg-1. A control group of 12 unexposed male operators with similar job task and the same shift system were studied, too. The 11-oxycorticosteroids (11-OCS), adrenaline and noradrenaline were followed by spectrofluorimetric methods on 3-hour intervals during the 24-hour shifts. The data were analyzed by tests for interindividual analysis, Cosinor analysis and analysis of variance (ANOVA). Significant increase in the 24-hour excretion of 11-OCS and disorders in its circadian rhythm, manifested by increase in the mesor, decrease in the amplitude and shift in the acrophase were found in the exposed operators. The changes in the excretion rates of the catecholamines were significant and showed greater variability of both variables. The long term effect of the exposure to low-level RF EM radiation evoked pronounced stress reaction with changes in the circadian rhythm of 11-OCS and increased variability of catecholamines secretion. The possible health hazards associated with observed alteration in the stress system need to be clarified by identification of their significance and prognostic relevance.

Vangelova KK, Israel MS. Variations of melatonin and stress hormones under extended shifts and radiofrequency electromagnetic radiation. Rev Environ Health. 20(2):151-161, 2005.

We studied the time-of-day variations in urinary levels of 6-sulphatoxy-melatonin and three stress hormones in operators working fast-rotating extended shifts under radiofrequency electromagnetic radiation (EMR). The excretion rate of the hormones was monitored by radioimmunoassay and spectrofluorimetry at 4-hour intervals in a group of 36 male operators comprising 12 broadcasting station operators, 12 TV station operators, and a control group of 12 satellite station operators. Measuring the time-weighted average (TWA) of EMR exposure revealed a high-level of exposure in broadcasting station operators (TWAmean= 3.10 microW/ cm2, TWAmax = 137.00 microW/cm2), a low-level in TV station operators (TWAmean = 1.89 microW/cm2, TWAmax = 5.24 microW/cm2), and a very low level in satellite station operators. The differences among the groups remained the same after confounding factors were taken into account. Radiofrequency EMR had no effect on the typical diurnal pattern of 6-sulphatoxymelatonin. High-level radiofrequency EMR exposure significantly increased the excretion rates of cortisol ($p < 0.001$), adrenaline ($p = 0.028$), and noradrenaline ($p < 0.000$), whereas changes under low-level exposure did not reach significance. The 24-hour excretion of cortisol and noradrenaline correlated with TWAmean and TWAmax. In conclusion, the excretion of 6-sulphatoxymelatonin retained a typical diurnal pattern under fast-rotating extended shifts and radiofrequency EMR, but showed an exposure-effect relation with stress hormones.

Vangelova K, Deyanov C, Israel M.Cardiovascular risk in operators under radiofrequency electromagnetic radiation.Int J Hyg Environ Health. 209(2):133-138, 2006.

The aim of the study was to assess the long-term effects of radiofrequency electromagnetic radiation (EMR) on the cardiovascular system. Two groups of exposed operators (49 broadcasting (BC) station and 61 TV station operators) and a control group of 110 radiorelay station operators, matched by sex and age, with similar job characteristics except for the radiofrequency EMR were studied. The EMR exposure was assessed and the time-weighted average (TWA) was calculated. The cardiovascular risk factors arterial pressure, lipid profile, body mass index, waist/hip ratio, smoking, and family history of cardiovascular disease were followed. The systolic and diastolic blood pressure (SBP and DBP), total cholesterol (TC) and low-density lipoprotein cholesterol (LDL-C) were significantly higher in the two exposed groups. It was found that the radiofrequency EMR exposure was associated with greater chance of becoming hypertensive and dyslipidemic. The stepwise multiple regression equations showed that the SBP and TWA predicted the high TC and high LDL-C, while the TC, age and abdominal obesity were predictors for high SBP and DBP. In conclusion, our data show that the radiofrequency EMR contributes to adverse effects on the cardiovascular system.

van Wyk MJ, Bingle M, Meyer FJ. Antenna modeling considerations for accurate SAR calculations in human phantoms in close proximity to GSM cellular base station antennas. Bioelectromagnetics. 26(6):502-509, 2005.

International bodies such as International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the Institute for Electrical and Electronic Engineering (IEEE) make provision for human exposure assessment based on SAR calculations (or measurements) and basic restrictions. In the case of base station exposure this is mostly applicable to occupational exposure scenarios in the very near field of these antennas where the conservative reference level criteria could be unnecessarily restrictive. This study presents a variety of critical aspects that need to be considered when calculating SAR in a human body close to a mobile phone base station antenna. A hybrid FEM/MoM technique is proposed as a suitable numerical method to obtain accurate results. The verification of the FEM/MoM implementation has been presented in a previous publication; the focus of this study is an investigation into the detail that must be included in a numerical model of the antenna, to accurately represent the real-world scenario. This is accomplished by comparing numerical results to measurements for a generic GSM base station antenna and appropriate, representative canonical and human phantoms. The results show that it is critical to take the disturbance effect of the human phantom (a large conductive body) on the base station antenna into account when the antenna-phantom spacing is less than 300 mm. For these small spacings, the antenna structure must be modeled in detail. The conclusion is that it is feasible to calculate, using the proposed techniques and methodology, accurate occupational compliance zones around base station antennas based on a SAR profile and basic restriction guidelines.

Varghese R, Majumdar A, Kumar G, Shukla A. Rats exposed to 2.45GHz of non-ionizing radiation exhibit behavioral changes with increased brain expression of

apoptotic caspase 3. Pathophysiology. 2017 Nov 14. pii: S0928-4680(17)30052-4. doi: 10.1016/j.pathophys.2017.11.001.

In recent years there has been a tremendous increase in use of Wi-Fi devices along with mobile phones, globally. Wi-Fi devices make use of 2.4 GHz frequency. The present study evaluated the impact of 2.45 GHz radiation exposure for 4h/day for 45 days on behavioral and oxidative stress parameters in female Sprague Dawley rats. Behavioral tests of anxiety, learning and memory were started from day 38. Oxidative stress parameters were estimated in brain homogenates after sacrificing the rats on day 45. In morris water maze, elevated plus maze and light dark box test, the 2.45 GHz radiation exposed rats elicited memory decline and anxiety behavior. Exposure decreased activities of super oxide dismutase, catalase and reduced glutathione levels whereas increased levels of brain lipid peroxidation was encountered in the radiation exposed rats, showing compromised anti-oxidant defense. Expression of caspase 3 gene in brain samples were quantified which unraveled notable increase in the apoptotic marker caspase 3 in 2.45 GHz radiation exposed group as compared to sham exposed group. No significant changes were observed in histopathological examinations and brain levels of TNF-α. Analysis of dendritic arborization of neurons showcased reduction in number of dendritic branching and intersections which corresponds to alteration in dendritic structure of neurons, affecting neuronal signaling. The study clearly indicates that exposure of rats to microwave radiation of 2.45GHz leads to detrimental changes in brain leading to lowering of learning and memory and expression of anxiety behavior in rats along with fall in brain antioxidant enzyme systems.

Varsier N, Dahdouh S, Serrurier A, De la Plata JP, Anquez J, Angelini ED, Bloch I, Wiart J. Influence of pregnancy stage and fetus position on the whole-body and local exposure of the fetus to RF-EMF. Phys Med Biol. 2014 Aug 7;59(17):4913-4926. [Epub ahead of print]

This paper analyzes the influence of pregnancy stage and fetus position on the whole-body and brain exposure of the fetus to radiofrequency electromagnetic fields. Our analysis is performed using semi-homogeneous pregnant woman models between 8 and 32 weeks of amenorrhea. By analyzing the influence of the pregnancy stage on the environmental whole-body and local exposure of a fetus in vertical position, head down or head up, in the 2100 MHz frequency band, we concluded that both whole-body and average brain exposures of the fetus decrease during the first pregnancy trimester, while they advance during the pregnancy due to the rapid weight gain of the fetus in these first stages. From the beginning of the second trimester, the whole-body and the average brain exposures are quite stable because the weight gains are quasi proportional to the absorbed power increases.The behavior of the fetus whole-body and local exposures during pregnancy for a fetus in the vertical position with the head up were found to be of a similar level, when compared to the position with the head down they were slightly higher, especially in the brain.

Vecchio F, Babiloni C, Ferreri F, Curcio G, Fini R, Del Percio C, Rossini PM. Mobile

phone emission modulates interhemispheric functional coupling of EEG alpha rhythms. Eur J Neurosci. 25(6):1908-1913, 2007.

We tested the working hypothesis that electromagnetic fields from mobile phones (EMFs) affect interhemispheric synchronization of cerebral rhythms, an important physiological feature of information transfer into the brain. Ten subjects underwent two electroencephalographic (EEG) recordings, separated by 1 week, following a crossover double-blind paradigm in which they were exposed to a mobile phone signal (global system for mobile communications; GSM). The mobile phone was held on the left side of the subject head by a modified helmet, and orientated in the normal position for use over the ear. The microphone was orientated towards the corner of the mouth, and the antenna was near the head in the parietotemporal area. In addition, we positioned another similar phone (but without battery) on the right side of the helmet, to balance the weight and to prevent the subject localizing the side of GSM stimulation (and consequently lateralizing attention). In one session the exposure was real (GSM) while in the other it was Sham; both sessions lasted 45 min. Functional interhemispheric connectivity was modelled using the analysis of EEG spectral coherence between frontal, central and parietal electrode pairs. Individual EEG rhythms of interest were delta (about 2-4 Hz), theta (about 4-6 Hz), alpha 1 (about 6-8 Hz), alpha 2 (about 8-10 Hz) and alpha 3 (about 10-12 Hz). Results showed that, compared to Sham stimulation, GSM stimulation modulated the interhemispheric frontal and temporal coherence at alpha 2 and alpha 3 bands. The present results suggest that prolonged mobile phone emission affects not only the cortical activity but also the spread of neural synchronization conveyed by interhemispherical functional coupling of EEG rhythms.

Vecchio F, Babiloni C, Ferreri F, Buffo P, Cibelli G, Curcio G, Dijkman SV, Melgari JM, Giambattistelli F, Rossini PM. Mobile phone emission modulates inter-hemispheric functional coupling of EEG alpha rhythms in elderly compared to young subjects. Clin Neurophysiol. 121(2):163-171, 2010.

OBJECTIVE: It has been reported that GSM electromagnetic fields (GSM-EMFs) of mobile phones modulate - after a prolonged exposure - inter-hemispheric synchronization of temporal and frontal resting electroencephalographic (EEG) rhythms in normal young subjects [Vecchio et al., 2007]. Here we tested the hypothesis that this effect can vary on physiological aging as a sign of changes in the functional organization of cortical neural synchronization. METHODS: Eyes-closed resting EEG data were recorded in 16 healthy elderly subjects and 5 young subjects in the two conditions of the previous reference study. The GSM device was turned on (45min) in one condition and was turned off (45min) in the other condition. Spectral coherence evaluated the inter-hemispheric synchronization of EEG rhythms at the following bands: delta (about 2-4Hz), theta (about 4-6Hz), alpha 1 (about 6-8Hz), alpha 2 (about 8-10Hz), and alpha 3 (about 10-12Hz). The aging effects were investigated comparing the inter-hemispheric EEG coherence in the elderly subjects vs. a young group formed by 15 young subjects (10 young subjects of the reference study; Vecchio et al., 2007). RESULTS: Compared with the young subjects, the elderly subjects showed a statistically significant ($p<0.001$) increment of the inter-hemispheric coherence of frontal and temporal alpha rhythms (about 8-12Hz) during

the GSM condition. CONCLUSIONS: These results suggest that GSM-EMFs of a mobile phone affect inter-hemispheric synchronization of the dominant (alpha) EEG rhythms as a function of the physiological aging. SIGNIFICANCE: This study provides further evidence that physiological aging is related to changes in the functional organization of cortical neural synchronization.

Vecchio F, Buffo P, Sergio S, Iacoviello D, Rossini PM, Babiloni C. Mobile phone emission modulates event-related desynchronization of α rhythms and cognitive-motor performance in healthy humans.Clin Neurophysiol. 123(1):121-128, 2012.

OBJECTIVES: It has been shown that electromagnetic fields of Global System for Mobile Communications phone (GSM-EMFs) affect human brain rhythms (Vecchio et al., 2007, 2010), but it is not yet clear whether these effects are related to alterations of cognitive functions.**METHODS:** Eleven healthy adults underwent two electroencephalographic (EEG) sessions separated by 1 week, following a cross-over, placebo-controlled, double-blind paradigm. In both sessions, they performed a visual go/no-go task before real exposure to GSM-EMFs or after a sham condition with no EMF exposure. In the GSM real session, temporal cortex was continuously exposed to GSM-EMFs for 45 min. In the sham session, the subjects were not aware that the EMFs had been switched off for the duration of the experiment. In the go/no-go task, a central fixation stimulus was followed by a green (50% of probability) or red visual stimulus. Subjects had to press the mouse button after the green stimuli (go trials). With reference to a baseline period, power decrease of low- (about 8-10 Hz) and high-frequency (about 10-12 Hz) alpha rhythms indexed the cortical activity.**RESULTS:** It was found less power decrease of widely distributed high-frequency alpha rhythms and faster reaction time to go stimuli in the post- than pre-exposure period of the GSM session. No effect was found in the sham session.**CONCLUSIONS:** These results suggest that the peak amplitude of alpha ERD and the reaction time to the go stimuli are modulated by the effect of the GSM-EMFs on the cortical activity.**SIGNIFICANCE:** Exposure to GSM-EMFs for 45 min may enhance human cortical neural efficiency and simple cognitive-motor processes in healthy adults.

Vecchio F, Tombini M, Buffo P, Assenza G, Pellegrino G, Benvenga A, Babiloni C, Rossini PM. Mobile phone emission increases inter-hemispheric functional coupling of electroencephalographic alpha rhythms in epileptic patients. Int J Psychophysiol.84(2):164-171, 2012.

It has been reported that GSM electromagnetic fields (GSM-EMFs) of mobile phones modulate - after a prolonged exposure - inter-hemispheric synchronization of temporal and frontal resting electroencephalographic (EEG) rhythms in normal young and elderly subjects (Vecchio et al., 2007, 2010). Here we tested the hypothesis that this can be even more evident in epileptic patients, who typically suffer from abnormal mechanisms governing synchronization of rhythmic firing of cortical neurons. Eyes-closed resting EEG data were recorded in ten patients affected by focal epilepsy in real and sham exposure conditions. These data were compared with those obtained from 15 age-matched normal subjects of the previous reference studies. The GSM device was turned on (45min) in the "GSM" condition and was turned off (45min) in the other condition ("sham"). The mobile phone was always positioned on the left

side in both patients and control subjects. Spectral coherence evaluated the inter-hemispheric synchronization of EEG rhythms at the following frequency bands: delta (about 2-4Hz), theta (about 4-6Hz), alpha1 (about 6-8Hz), alpha2 (about 8-10Hz), and alpha3 (about 10-12Hz). The effects on the patients were investigated comparing the inter-hemispheric EEG coherence in the epileptic patients with the control group of subjects evaluated in the previous reference studies. Compared with the control subjects, epileptic patients showed a statistically significant higher inter-hemispheric coherence of temporal and frontal alpha rhythms (about 8-12Hz) in the GSM than "Sham" condition. These results suggest that GSM-EMFs of mobile phone may affect inter-hemispheric synchronization of the dominant (alpha) EEG rhythms in epileptic patients. If confirmed by future studies on a larger group of epilepsy patients, the modulation of the inter-hemispheric alpha coherence due to the GSM-EMFs could have clinical implications and be related to changes in cognitive-motor function.

Vecsei Z, Csathó A, Thuróczy G, Hernádi I. Effect of a single 30 min UMTS mobile phone-like exposure on the thermal pain threshold of young healthy volunteers. Bioelectromagnetics. 2013 Jun 20. doi: 10.1002/bem.21801. [Epub ahead of print]

One of the most frequently investigated effects of radiofrequency electromagnetic fields (RF EMFs) on the behavior of complex biological systems is pain sensitivity. Despite the growing body of evidence of EMF-induced changes in pain sensation, there is no currently accepted experimental protocol for such provocation studies for the healthy human population. In the present study, therefore, we tested the effects of third generation Universal Mobile Telecommunications System (UMTS) RF EMF exposure on the thermal pain threshold (TPT) measured on the surface of the fingers of 20 young adult volunteers. The protocol was initially validated with a topical capsaicin treatment. The exposure time was 30 min and the genuine (or sham) signal was applied to the head through a patch antenna, where RF EMF specific absorption rate (SAR) values were controlled and kept constant at a level of 1.75 W/kg. Data were obtained using randomized, placebo-controlled trials in a double-blind manner. Subjective pain ratings were tested blockwise on a visual analogue rating scale (VAS). Compared to the control and sham conditions, the results provide evidence for intact TPT but a reduced desensitization effect between repeated stimulations within the individual blocks of trials, observable only on the contralateral side for the genuine UMTS exposure. Subjective pain perception (VAS) data indicated marginally decreased overall pain ratings in the genuine exposure condition only. The present results provide pioneering information about human pain sensation in relation to RF EMF exposure and thus may contribute to cover the existing gap between safety research and applied biomedical science targeting the potential biological effects of environmental RF EMFs.

Velayutham P, Govindasamy GK, Raman R, Prepageran N, Ng KH. High-frequency hearing loss among mobile phone users. Indian J Otolaryngol Head Neck Surg. 66(Suppl 1):169-172, 2014.

The objective of this study is to assess high frequency hearing (above 8 kHz) loss among prolonged mobile phone users is a tertiary Referral Center. Prospective single blinded study. This is the first study that used high-frequency audiometry. The wide usage of mobile phone is so profound that we were unable to find enough non-users as a control group. Therefore we compared the non-dominant ear to the dominant ear using audiometric measurements. The study was a blinded study wherein the audiologist did not know which was the dominant ear. A total of 100 subjects were studied. Of the subjects studied 53% were males and 47% females. Mean age was 27. The left ear was dominant in 63%, 22% were dominant in the right ear and 15% did not have a preference. This study showed that there is significant loss in the dominant ear compared to the non-dominant ear ($P < 0.05$). Chronic usage mobile phone revealed high frequency hearing loss in the dominant ear (mobile phone used) compared to the non dominant ear.

Velizarov, S, Raskmark, P, Kwee, S, The effects of radiofrequency fields on cell proliferation are non-thermal. Bioelectrochem Bioenerg 48(1):177-180, 1999.

The number of reports on the effects induced by radiofrequency (RF) electromagnetic fields and microwave (MW) radiation in various cellular systems is still increasing. Until now no satisfactory mechanism has been proposed to explain the biological effects of these fields. One of the current theories is that heat generation by RF/MW is the cause, in spite of the fact that a great number of studies under isothermal conditions have reported significant cellular changes after exposure to RF/MW. Therefore, this study was undertaken to investigate which effect MW radiation from these fields in combination with a significant change of temperature could have on cell proliferation. The experiments were performed on the same cell line, and with the same exposure system as in a previous work [S. Kwee, P. Raskmark, Changes in cell proliferation due to environmental non-ionizing radiation: 2. Microwave radiation, Bioelectrochem. Bioenerg., 44 (1998), pp. 251-255]. The field was generated by signal simulation of the Global System for Mobile communications (GSM) of 960 MHz. Cell cultures, growing in microtiter plates, were exposed in a specially constructed chamber, a Transverse Electromagnetic (TEM) cell. The Specific Absorption Rate (SAR) value for each cell well was calculated for this exposure system. However, in this study thecells were exposed to the field at a higher or lower temperature than the temperature in the field-free incubator i.e., the temperature in the TEM cell was either 39 or 35 +/- 0.1 degrees C. The corresponding sham experiments were performed under exactly the same experimental conditions. The results showed that there was a significant change in cell proliferation in the exposed cells in comparison to the non-exposed (control) cells at both temperatures. On the other hand, no significant change in proliferation rate was found in the sham-exposed cells at both temperatures. This shows that biological effects due to RF/MW cannot be attributed only to a change of temperature. Since the RF/MW induced changes were of the same order of magnitude at both temperatures and also comparable to our previous results under isothermal conditions at 37 degrees C, cellular stress caused by electromagnetic fields could initiate the changes in cell cycle reaction rates. It is widely accepted that certain classes of heat-shock proteins are involved in

these stress reactions.

Vereshchako GG, Chueshova NV, Gorokh GA, Naumov AD. State of the reproductive system in male rats of 1st generation obtained from irradiated parents and exposed to electromagnetic radiation (897 MHz) during embryogenesis and postnatal development. Radiats Biol Radioecol. 54(2):186-192, 2014.

The consequences of prolonged exposure to electromagnetic radiation from cellular phone (897 MHz, daily 8 h/day) in male rats of the 1st generation obtained from irradiated parents and subjected to prolonged exposure to electromagnetic radiation of the range of mobile communications during ontogeny and postnatal development were studied. It has been found that irradiation causes a decrease in the number of births of animals, changing the sex ratio towards the increase in the number of males. It had a significant impact on the reproductive system of males, accelerating their sexual development, revealed at the age of two months. Radiation from cell phones led to significant disproportions in the cell number at different stages of spermatogenesis. It increased the number of mature spermatozoa which decreased viability.

Vergassola R, Borgioli A, Chiodi L, Rossi D, Fazi A, Lebrun E, Vaccari M, [Changes in pacemakers and the wearers of pacemakers as a result of the use of different electromagnetic energy sources]. Minerva Cardioangiol 42(1-2):27-32, 1994.

[Over the past decade there have been considerable advances in cardiac electrostimulation technologies. However, there are still reports of electromagnetic interference with pacemakers and pacemaker patients. We have studied the effects of various electromagnetic sources (short-wave diathermy, electrosurgical knives, electrotherapy and radiofrequencies) on both humans and animals. The results of the studies were completely negative and, therefore, we are convinced that today's pacemakers are much more reliable and hence less subject to interference from external electromagnetic sources. We performed the following tests: (a) Short-wave diathermy: various electrode positions in pigs and 8 patients with pacemakers. (b) Electrosurgical knives: several tests on pigs with unipolar electrosurgical knife; 6 tests on humans during automatic defibrillator implantation using two-pole electrosurgical knives; 23 pacemaker patients underwent abdominal surgery (3 inguinal hernias, 12 gastric resections; 6 cholecystotomies, 2 aortic aneurysms-with two-pole electrosurgical knives). (c) Electrotherapy (TENS): on pigs. (d) Radiofrequency (RF) for transcatheter ablation-several tests on pigs.

Verloock L, Joseph W, Vermeeren G, Martens L. Procedure for assessment of general public exposure from WLAN in offices and in wireless sensor network testbed.Health Phys. 98(4):628-638, 2010.

A fast and accurate measurement procedure to determine experimentally wireless local area network (WLAN) radiofrequency (RF) exposure and to test compliance with international guidelines for the general public is proposed. This is the first paper where all optimal settings for the measurement equipment (sweep time, resolution bandwidth, etc.)

are investigated, selected, and validated. The exposure to WLAN access points is determined for 222 locations with 7 WLAN networks present in office environments. The WLAN exposure is also characterized for the first time in a wireless sensor lab environment (WiLab) at IBBT-Ghent University in Belgium. Average background exposure to WLAN (WiLab off) is 0.12 V m(-1), with a 95 percentile of 0.90 V m(-1). With the WiLab in operation, average exposure increases to 1.9 V m(-1), with a 95 percentile of 4.7 V m(-1). All values are well below the International Commission on Non Ionizing Radiation Protection guidelines of 61 V m(-1) in the 2.4 GHz band (at least 9.1 times for distances of more than 1 m from the access points) but a significant increase of exposure is possible in WiLabs due to high duty cycles. By applying the proposed measurement method a relevant reduction in measurement time is obtained.

Verloock L, Joseph W, Goeminne F, Martens L, Verlaek M, Constandt K. Assessment of Radio Frequency Exposures in Schools, Homes, and Public Places in Belgium. Health Phys. 107(6):503-513, 2014.

Characterization of exposure from emerging radio frequency (RF) technologies in areas where children are present is important. Exposure to RF electromagnetic fields (EMF) was assessed in three "sensitive" microenvironments; namely, schools, homes, and public places located in urban environments and compared to exposure in offices. In situ assessment was conducted by performing spatial broadband and accurate narrowband measurements, providing 6-min averaged electric-field strengths. A distinction between internal (transmitters that are located indoors) and external (outdoor sources from broadcasting and telecommunication) sources was made. Ninety-four percent of the broadband measurements were below 1 V m. The average and maximal total electric-field values in schools, homes, and public places were 0.2 and 3.2 V m (WiFi), 0.1 and 1.1 V m (telecommunication), and 0.6 and 2.4 V m (telecommunication), respectively, while for offices, average and maximal exposure were 0.9 and 3.3 V m (telecommunication), satisfying the ICNIRP reference levels. In the schools considered, the highest maximal and average field values were due to internal signals (WiFi). In the homes, public places, and offices considered, the highest maximal and average field values originated from telecommunication signals. Lowest exposures were obtained in homes. Internal sources contributed on average more indoors (31.2%) than outdoors (2.3%), while the average contributions of external sources (broadcast and telecommunication sources) were higher outdoors (97.7%) than at indoor positions (68.8%). FM, GSM, and UMTS dominate the total downlink exposure in the outdoor measurements. In indoor measurements, FM, GSM, and WiFi dominate the total exposure. The average contribution of the emerging technology LTE was only 0.6%.

Verma M, Dutta SK. Microwave induced alteration in the neuron specific enolase gene expression. Cancer Biochem Biophys. 13(4):239-244, 1993.

Exposure of pNGE7, a recombinant clone containing the coding and regulatory sequences for the expression of neuron specific enolase gene, cells to electromagnetic radiations (915 MHz, 16 Hz AM, SAR 0.05 mW/kg) resulted in the elevation of neuron specific enolase (NSE), a diagnostic marker for neuron and lung cancer. Using ion-exchange chromatography we separated the neuron specific enolase activity from the

non-neuronal enolase (NNE) activity and observed an alteration in the expression of neuron specific enolase and non-neuronal enolase. The clinical applications of the present studies have been discussed.

Vermeeren G, Gosselin MC, Kühn S, Kellerman V, Hadjem A, Gati A, Joseph W, Wiart J, Meyer F, Kuster N, Martens L. The influence of the reflective environment on the absorption of a human male exposed to representative base station antennas from 300 MHz to 5 GHz. Phys Med Biol. 55(18):5541-5555, 2010.

The environment is an important parameter when evaluating the exposure to radio-frequency electromagnetic fields. This study investigates numerically the variation on the whole-body and peak spatially averaged-specific absorption rate (SAR) in the heterogeneous virtual family male placed in front of a base station antenna in a reflective environment. The SAR values in a reflective environment are also compared to the values obtained when no environment is present (free space). The virtual family male has been placed at four distances (30 cm, 1 m, 3 m and 10 m) in front of six base station antennas (operating at 300 MHz, 450 MHz, 900 MHz, 2.1 GHz, 3.5 GHz and 5.0 GHz, respectively) and in three reflective environments (a perfectly conducting wall, a perfectly conducting ground and a perfectly conducting ground + wall). A total of 72 configurations are examined. The absorption in the heterogeneous body model is determined using the 3D electromagnetic (EM) finite-difference time-domain (FDTD) solver Semcad-X. For the larger simulations, requirements in terms of computer resources are reduced by using a generalized Huygens' box approach. It has been observed that the ratio of the SAR in the virtual family male in a reflective environment and the SAR in the virtual family male in the free-space environment ranged from -8.7 dB up to 8.0 dB. A worst-case reflective environment could not be determined. ICNIRP reference levels not always showed to be compliant with the basic restrictions.

Verschaeve, L., Heikkinen, P., Verheyen, G., Van Gorp, U., Boonen, F., Vander Plaetse, F., Maes, A., Kumlin, T., Maki-Paakkanen, J., Puranen, L. and Juutilainen, J. Investigation of Co-genotoxic Effects of Radiofrequency Electromagnetic Fields In Vivo. Radiat. Res. 165, 598-607, 2006.

We investigated the possible combined genotoxic effects of radiofrequency (RF) electromagnetic fields (900 MHz, amplitude modulated at 217 Hz, mobile phone signal) with the drinking water mutagen and carcinogen 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX). Female rats were exposed to RF fields for a period of 2 years for 2 h per day, 5 days per week at average whole-body specific absorption rates of 0.3 or 0.9 W/kg. MX was given in the drinking water at a concentration of 19 mug/ml. Blood samples were taken at 3, 6 and 24 months of exposure and brain and liver samples were taken at the end of the study (24 months). DNA damage was assessed in all samples using the alkaline comet assay, and micronuclei were determined in erythrocytes. We did not find significant genotoxic activity of MX in blood and liver cells. However, MX induced DNA damage in rat brain. Co-exposures to MX and RF radiation did not significantly increase the response of blood, liver and brain cells compared to MX exposure only. In conclusion, this 2-year animal study involving long-term exposures to RF radiation and MX did not

provide any evidence for enhanced genotoxicity in rats exposed to RF radiation.

Veyret B, Bouthet C, Deschaux P, de Seze R, Geffard M, Joussot-Dubien J, le Diraison M, Moreau JM, Caristan A, Antibody responses of mice exposed to low-power microwaves under combined, pulse-and-amplitude modulation. Bioelectromagnetics 12(1):47-56, 1991.

Irradiation by pulsed microwaves (9.4 GHz, 1 microsecond pulses at 1,000/s), both with and without concurrent amplitude modulation (AM) by a sinusoid at discrete frequencies between 14 and 41 MHz, was assessed for effects on the immune system of Balb/C mice. The mice were immunized either by sheep red blood cells (SRBC) or by glutaric-anhydride conjugated bovine serum albumin (GA-BSA), then exposed to the microwaves at a low rms power density (30 microW/cm2; whole-body-averaged SAR approximately 0.015 W/kg). Sham exposure or microwave irradiation took place during each of five contiguous days, 10 h/day. The antibody response was evaluated by the plaque-forming cell assay (SRBC experiment) or by the titration of IgM and IgG antibodies (GA-BSA experiment). In the absence of AM, the pulsed field did not greatly alter immune responsiveness. In contrast, exposure to the field under the combined-modulation condition resulted in significant, AM-frequency-dependent augmentation or weakening of immune responses.

Vian A, Roux D, Girard S, Bonnet P, Paladian F, Davies E, Ledoigt G. Microwave irradiation affects gene expression in plants. *Plant Signal Behav.* 1(2):67-70, 2006.

The physiological impact of nonionizing radiation has long been considered negligible. However, here we use a carefully calibrated stimulation system that mimics the characteristics (isotropy and homogeneity) of electromagnetic fields present in the environment to measure changes in a molecular marker (mRNA encoding the stress-related bZIP transcription factor), and show that low amplitude, short duration, 900 MHz EMF evokes the accumulation of this mRNA. Accumulation is rapid (peaking 5-15 min after stimulation) and strong (3.5-fold), and is similar to that evoked by mechanical stimulations.

Vian A, Davies E, Gendraud M, Bonnet P. Plant Responses to High Frequency Electromagnetic Fields. Biomed Res Int. 2016;2016:1830262. doi: 10.1155/2016/1830262. Epub 2016 Feb 14.

High frequency nonionizing electromagnetic fields (HF-EMF) that are increasingly present in the environment constitute a genuine environmental stimulus able to evoke specific responses in plants that share many similarities with those observed after a stressful treatment. Plants constitute an outstanding model to study such interactions since their architecture (high surface area to volume ratio) optimizes their interaction with the environment. In the present review, after identifying the main exposure devices (transverse and gigahertz electromagnetic cells, wave guide, and mode stirred reverberating chamber) and general physics laws that govern EMF interactions with plants, we illustrate some of the observed responses after exposure to HF-EMF at the

cellular, molecular, and whole plant scale. Indeed, numerous metabolic activities (reactive oxygen species metabolism, α- and β-amylase, Krebs cycle, pentose phosphate pathway, chlorophyll content, terpene emission, etc.) are modified, gene expression altered (calmodulin, calcium-dependent protein kinase, and proteinase inhibitor), and growth reduced (stem elongation and dry weight) after low power (i.e., nonthermal) HF-EMF exposure. These changes occur not only in the tissues directly exposed but also systemically in distant tissues. While the long-term impact of these metabolic changes remains largely unknown, we propose to consider nonionizing HF-EMF radiation as a noninjurious, genuine environmental factor that readily evokes changes in plant metabolism.

Viel JF, Cardis E, Moissonnier M, de Seze R, Hours M. Radiofrequency exposure in the French general population: band, time, location and activity variability. Environ Int. 35(8):1150-1154, 2009.

Information on the exposure of individual persons to radiofrequency (RF) fields is scarce, although such data are crucial in order to develop a suitable exposure assessment method, and frame the hypothesis and design of future epidemiological studies. The main goal of this survey is to assess individual RF exposure on a population basis, while clarifying the relative contribution of different sources to the total exposure. A total of 377 randomly selected people were analyzed. Each participant was supplied with a personal exposure meter for 24-hour measurements (weekday), and kept a time-location-activity diary. Electric field strengths were recorded in 12 different RF bands every 13s. Summary statistics were calculated with the robust regression on order statistics method. Most of the time, recorded field strengths were not detectable with the exposure meter. Total field, cordless phones, WiFi-microwave, and FM transmitters stood apart with a proportion above the detection threshold of 46.6%, 17.2%, 14.1%, and 11.0%, respectively. The total field mean value was 0.201V/m, higher in urban areas, during daytime, among adults, and when moving. When focusing on specific channels, the highest mean exposure resulted from FM sources (0.044V/m), followed by WiFi-microwaves (0.038V/m), cordless phones (0.037V/m), and mobile phones (UMTS: 0.036V/m, UMTS: 0.037V/m). Various factors, however, contributed to a high variability in RF exposure assessment. These population-based estimates should therefore be confirmed by further surveys to better characterize the exposure situation in different microenvironments.

Viel JF, Clerc S, Barrera C, Rymzhanova R, Moissonnier M, Hours M, Cardis E. Residential exposure to radiofrequency fields from mobile phone base stations, and broadcast transmitters: a population-based survey with personal meter. Occup Environ Med. 66(8):550-556, 2009.

OBJECTIVES: Both the public perceptions, and most published epidemiologic studies, rely on the assumption that the distance of a particular residence from a base station or a broadcast transmitter is an appropriate surrogate for exposure to radiofrequency fields, although complex propagation characteristics affect the beams from antennas. The main goal of this study was to characterise the distribution of residential exposure from antennas using personal exposure meters. METHODS: A

total of 200 randomly selected people were enrolled. Each participant was supplied with a personal exposure meter for 24 h measurements, and kept a time-location-activity diary. Two exposure metrics for each radiofrequency were then calculated: the proportion of measurements above the detection limit (0.05 V/m), and the maximum electric field strength. Residential address was geocoded, and distance from each antenna was calculated. RESULTS: Much of the time, the recorded field strength was below the detection level (0.05 V/m), the FM band standing apart with a proportion above the detection threshold of 12.3%. The maximum electric field strength was always lower than 1.5 V/m. Exposure to GSM and DCS waves peaked around 280 m and 1000 m from the antennas. A downward trend was found within a 10 km range for FM. Conversely, UMTS, TV 3, and TV 4&5 signals did not vary with distance. CONCLUSIONS: Despite numerous limiting factors entailing a high variability in radiofrequency exposure assessment, but owing to a sound statistical technique, we found that exposures from GSM and DCS base stations increase with distance in the near source zone, to a maximum where the main beam intersects the ground. We believe these results will contribute to the ongoing public debate over the location of base stations and their associated emissions.

Vijayalaxmi, Mohan, N, Meltz, ML, Wittler, MA, Proliferation and cytogenetic studies in human blood lymphocytes exposed in vitro to 2450 MHz radiofrequency radiation. Int J Radiat Biol 72(6):751-757, 1997.

Aliquots of human peripheral blood collected from two healthy human volunteers were exposed in vitro to continuous wave 2450 MHz radiofrequency radiation (RFR), either continuously for a period of 90 min or intermittently for a total exposure period of 90 min (30 min on and 30 min off, repeated three times). Blood aliquots which were sham-exposed or exposed in vitro to 150 cGy gamma radiation served as controls. The continuous wave 2450 MHz RFR was generated with a net forward power of 34.5 W and transmitted from a standard gain rectangular antenna horn in a vertically downward direction. The mean power density at the position of the cells was 5.0 mW/cm2. The mean specific absorption rate calculated by Finite Difference Time Domain analysis was 12.46 W/kg. Immediately after exposure, lymphocytes were cultured for 48 and 72 h to determine the incidence of chromosomal aberrations and micronuclei, respectively. Proliferation indices were also recorded. There were no significant differences between RFR-exposed and sham-exposed lymphocytes with respect to; (a) mitotic indices; (b) incidence of cells showing chromosome damage; (c) exchange aberrations; (d) acentric fragments; (e) binucleate lymphocytes, and (f) micronuclei, for either the continuous or intermittent RFR exposures. In contrast, the response of positive control cells exposed to 150 cGy gamma radiation was significantly different from RFR-exposed and sham-exposed lymphocytes. Thus, there is no evidence for an effect on mitogen-stimulated proliferation kinetics or for excess genotoxicity within 72 h in human blood lymphocytes exposed in vitro to 2450 MHz RFR.

Vijayalaxmi, Frei, MR, Dusch, SJ, Guel, V, Meltz, ML, Jauchem, JR, Frequency of micronuclei in the peripheral blood and bone marrow of cancer-prone mice chronically exposed to 2450 MHz radiofrequency radiation. Radiat Res 147(4):495-500, 1997.

C3H/HeJ mice, which are prone to mammary tumors, were exposed for 20 h/day, 7 days/week, over 18 months to continuous-wave 2450 MHz radiofrequency (RF) radiation in circularly polarized wave guides at a whole-body average specific absorption rate of 1.0 W/kg. Sham-exposed mice were used as controls. The positive controls were the sentinel mice treated with mitomycin C during the last 24 h before necropsy. At the end of the 18 months, all mice were necropsied. Peripheral blood and bone marrow smears were examined for the extent of genotoxicity as indicated by the presence of micronuclei in polychromatic erythrocytes (PCEs). The results indicate that the incidence of micronuclei/1,000 PCEs was not significantly different between groups exposed to RF radiation (62 mice) and sham-exposed groups (58 mice), and the mean frequencies were 4.5 +/- 1.23 and 4.0 +/- 1.12 in peripheral blood and 6.1 +/- 1.78 and 5.7 +/- 1.60 in bone marrow, respectively. In contrast, the positive controls (7 mice) showed a significantly elevated incidence of micronuclei/1,000 PCEs in peripheral blood and bone marrow, and the mean frequencies were 50.9 +/- 6.18 and 55.2 +/- 4.65, respectively. When the animals with mammary tumors were considered separately, there were no significant differences in the incidence of micronuclei/1,000 PCEs between the group exposed to RF radiation (12 mice) and the sham-exposed group (8 mice), and the mean frequencies were 4.6 +/- 1.03 and 4.1 +/- 0.89 in peripheral blood and 6.1 +/- 1.76 and 5.5 +/- 1.51 in bone marrow, respectively. Thus there was no evidence for genotoxicity in mice prone to mammary tumors that were exposed chronically to 2450 MHz RF radiation compared with sham-exposed controls.

A correction was published in a subsequent issue of the journal, stating that there was actually a significant increase in micronucleus formation in peripheral blood and bone marrow cells after chronic exposure to the radiofrequency radiation. “Vijayalaxmi, Frei ,MR, Dusch, SJ, Guel, V, Meltz, ML, Jauchem, JR, Correction of an error in calculation in the article "Frequency of micronuclei in the peripheral blood and bone marrow of cancer-prone mice chronically exposed to 2450 MHz radiofrequency radiation" (Radiat. Res. 147, 495-500, 1997). Radiat Res 149(3):308, 1998 “

Vijayalaxmi, Leal BZ, Szilagyi M, Prihoda TJ, Meltz ML, Primary DNA Damage in Human Blood Lymphocytes Exposed In Vitro to 2450 MHz Radiofrequency Radiation. Radiat Res 153(4):479-486, 2000.

Human peripheral blood samples collected from three healthy human volunteers were exposed in vitro to pulsed-wave 2450 MHz radiofrequency (RF) radiation for 2 h. The RF radiation was generated with a net forward power of 21 W and transmitted from a standard gain rectangular antenna horn in a vertically downward direction. The average power density at the position of the cells in the flask was 5 mW/cm(2). The mean specific absorption rate, calculated by finite difference time domain analysis, was 2.135 (+/-0.005 SE) W/kg. Aliquots of whole blood that were sham-exposed or exposed in vitro to 50 cGy of ionizing radiation from a (137)Cs gamma-ray source were used as controls. The lymphocytes were examined to determine the extent of primary DNA damage (single-strand breaks and alkali-labile lesions) using the alkaline comet assay with three different slide-processing schedules. The assay was performed on the cells immediately after the exposures and at 4 h after incubation of the exposed blood at 37 +/- 1 degrees C to allow time for rejoining of any strand breaks present immediately after exposure, i.e. to assess

the capacity of the lymphocytes to repair this type of DNA damage. At either time, the data indicated no significant differences between RF-radiation- and sham-exposed lymphocytes with respect to the comet tail length, fluorescence intensity of the migrated DNA in the tail, and tail moment. The conclusions were similar for each of the three different comet assay slide-processing schedules examined. In contrast, the response of lymphocytes exposed to ionizing radiation was significantly different from RF-radiation- and sham-exposed cells. Thus, under the experimental conditions tested, there is no evidence for induction of DNA single-strand breaks and alkali-labile lesions in human blood lymphocytes exposed in vitro to pulsed-wave 2450 MHz radiofrequency radiation, either immediately or at 4 h after exposure.

Vijayalaxmi, Seaman RL, Belt ML, Doyle JM, Mathur SP, Prihoda TJ, Frequency of micronuclei in the blood and bone marrow cells of mice exposed to ultra-wideband electromagnetic radiation. Int J Radiat Biol 75(1):115-120, 1999.

PURPOSE: To investigate the extent of genetic damage in the peripheral bloodand bone marrow cells of mice exposed to ultra-wideband electromagnetic radiation (UWBR). MATERIALS AND METHODS: CF-1 male mice were exposed to UWBRfor 15 min at an estimated whole-body average specific absorption rate of 37 mWx kg(-1). Groups of untreated control and positive control mice injected with mitomycin C were also included in the study. After various treatments, half of the mice were killed at 18 h, and the other half at 24 h. Peripheral blood and bone marrow smears were examined to determine the extent of genotoxicity, as assessed by the presence of micronuclei (MN) in polychromatic erythrocytes (PCE). RESULTS: The percentages of PCE and the incidence of MN per 2000 PCE inboth tissues in mice killed at 18 h were similar to the frequencies observed in mice terminated at 24 h. There were no significant differences in the percentage of PCE between control and the mice with or without UWBR exposure; the group mean values (+/- standard deviation) were in the range of 3.1+/-0.14 to 3.2+/-0.23 in peripheral blood, and 49.0+/-3.56 to 52.3+/-4.02 in bone marrow. The mean incidence of MN per 2000 PCE in control and in mice with or without UWBR exposure ranged from 7.7+/-2.00 to 9.7+/-2.54 in peripheral blood and 7.4+/-2.32 to 10.0+/-3.27 in bone marrow. Pairwise comparison of the data did not reveal statistically significant differences between the control and mice with or without UWBR exposure groups (excluding positive controls). CONCLUSION: Under the experimental conditions tested, there was no evidence for excess genotoxicity in peripheral blood or bone marrow cells of mice exposed to UWBR.

Vijayalaxmi , Leal BZ, Meltz ML, Pickard WF, Bisht KS, Roti Roti JL , Straube WL, Moros EG, Cytogenetic Studies in Human Blood Lymphocytes Exposed In Vitro to Radiofrequency Radiation at a Cellular Telephone Frequency (835.62 MHz, FDMA). Radiat Res 155(1):113-121, 2001.

Vijayalaxmi, Pickard, W. F., Bisht, K. S., Leal, B. Z., Meltz, M. L., Roti Roti, J. L., Straube, W. L. and Moros, E. G. Cytogenetic Studies in Human Blood Lymphocytes Exposed In Vitro to Radiofrequency Radiation at a Cellular Telephone Frequency (835.62 MHz, FDMA). Freshly collected peripheral blood samples from four healthy human volunteers were diluted with RPMI 1640 tissue culture medium and exposed in sterile T-75 tissue culture flasks in vitro for 24 h to 835.62 MHz radiofrequency (RF) radiation, a frequency employed for customer-to-base station transmission of cellular telephone

communications. An analog signal was used, and the access technology was frequency division multiple access (FDMA, continuous wave). A nominal net forward power of 68 W was used, and the nominal power density at the center of the exposure flask was 860 W/m(2). The mean specific absorption rate in the exposure flask was 4.4 or 5.0 W/kg. Aliquots of diluted blood that were sham-exposed or exposed in vitro to an acute dose of 1.50 Gy of gamma radiation were used as negative or positive controls. Immediately after the exposures, the lymphocytes were stimulated with a mitogen, phytohemagglutinin, and cultured for 48 or 72 h to determine the extent of genetic damage, as assessed from the frequencies of chromosomal aberrations and micronuclei. The extent of alteration in the kinetics of cell proliferation was determined from the mitotic indices in 48-h cultures and from the incidence of binucleate cells in 72-h cultures. The data indicated no significant differences between RF-radiation- and sham-exposed lymphocytes with respect to mitotic indices, incidence of exchange aberrations, excess fragments, binucleate cells, and micronuclei. In contrast, the response of the lymphocytes exposed to gamma radiation was significantly different from both RF-radiation- and sham-exposed cells for all of these indices. Thus, under the experimental conditions tested, there is no evidence for the induction of chromosomal aberrations and micronuclei in human blood lymphocytes exposed in vitro for 24 h to 835.62 MHz RF radiation at SARs of 4.4 or 5.0 W/kg.

Vijayalaxmi, Bisht KS, Pickard WF, Meltz ML, Roti Roti JL, Moros EG. Chromosome damage and micronucleus formation in human blood lymphocytes exposed in vitro to radiofrequency radiation at a cellular telephone frequency (847.74 MHz, CDMA). Radiat Res 156(4):430-432, 2001.

Peripheral blood samples collected from four healthy nonsmoking human volunteers were diluted with tissue culture medium and exposed in vitro for 24 h to 847.74 MHz radiofrequency (RF) radiation (continuous wave), a frequency employed for cellular telephone communications. A code division multiple access (CDMA) technology was used with a nominal net forward power of 75 W and a nominal power density of 950 W/m(2) (95 mW/cm(2)). The mean specific absorption rate (SAR) was 4.9 or 5.5 W/kg. Blood aliquots that were sham-exposed or exposed in vitro to an acute dose of 1.5 Gy of gamma radiation were included in the study as controls. The temperatures of the medium during RF-radiation and sham exposures in the Radial Transmission Line facility were controlled at 37 +/- 0.3 degrees C. Immediately after the exposures, lymphocytes were cultured at 37 +/- 1 degrees C for 48 or 72 h. The extent of genetic damage was assessed from the incidence of chromosome aberrations and micronuclei. The kinetics of cell proliferation was determined from the mitotic indices in 48-h cultures and from the incidence of binucleate cells in 72-h cultures. The data indicated no significant differences between RF-radiation-exposed and sham-exposed lymphocytes with respect to mitotic indices, frequencies of exchange aberrations, excess fragments, binucleate cells, and micronuclei. The response of gamma-irradiated lymphocytes was significantly different from that of both RF-radiation-exposed and sham-exposed cells for all of these indices. Thus there was no evidence for induction of chromosome aberrations and micronuclei in human blood lymphocytes exposed in vitro for 24 h to 847.74 MHz RF radiation (CDMA) at SARs of 4.9 or 5.5 W/kg.

Vijayalaxmi, Pickard WF, Bisht KS, Prihoda TJ, Meltz ML, LaRegina MC, Roti Roti JL, Straube WL, Moros EG. Micronuclei in the peripheral blood and bone marrow

cells of rats exposed to 2450 MHz radiofrequency radiation. Int J Radiat Biol 77(11):1109-1115, 2001.

PURPOSE: To determine the incidence of micronuclei in peripheral blood and bone marrow cells of rats exposed continuously for 24h to 2450 MHz continuous wave radiofrequency radiation (RFR) at an average whole-body specific absorption rate (SAR) of 12W/kg. MATERIALS AND METHODS: Eight adult male Sprague-Dawley rats were exposed to 2450 MHz RFR in circularly polarized waveguides. Eight sham-exposed rats were kept in similar waveguides without the transmission of RFR. Four rats were treated with mitomycin-C (MMC) and used as positive controls. All rats were necropsied 24h after the end of RFR and sham exposures, and after the 24h treatment with MMC. Peripheral blood and bone marrow smears were examined to determine the frequency of micronuclei (MN) in polychromatic erythrocytes (PCE). RESULTS: The results indicated that the incidence of MN/2000 PCE were not significantly different between RFR- and sham-exposed rats. The group mean frequencies of MN in the peripheral blood were 2.3+/-0.7 in RFR-exposed rats and 2.1+/-0.6 in sham-exposed rats. In bone marrow cells, the average MN incidence was 3.8+/-1.0 in RFR-exposed rats and 3.4+/-0.7 in sham-exposed rats. The corresponding values in positive control rats treated with MMC were 23.5+/-4.7 in the peripheral blood and 33.8+/-7.4 in bone marrow cells. CONCLUSION: There was no evidence for the induction of MN in peripheral blood and bone marrow cells of rats exposed for 24h to 2450 MHz continuous wave RFR at a whole body average SAR of 12 W/kg.

Vijayalaxmi, Sasser LB, Morris JE, Wilson BW, Anderson LE. Genotoxic Potential of 1.6 GHz Wireless Communication Signal: In Vivo Two-Year Bioassay. Radiat Res 159(4):558-564, 2003.

Timed-pregnant Fischer 344 rats (from nineteenth day of gestation) and their nursing offspring (until weaning) were exposed to a far-field 1.6 GHz Iridium wireless communication signal for 2 h/day, 7 days/week. Far-field whole-body exposures were conducted with a field intensity of 0.43 mW/cm(2) and whole-body average specific absorption rate (SAR) of 0.036 to 0.077 W/kg (0.10 to 0.22 W/kg in the brain). This was followed by chronic, head-only exposures of male and female offspring to a near-field 1.6 GHz signal for 2 h/day, 5 days/week, over 2 years. Near-field exposures were conducted at an SAR of 0.16 or 1.6 W/kg in the brain. Concurrent sham-exposed and cage control rats were also included in the study. At the end of 2 years, all rats were necropsied. Bone marrow smears were examined for the extent of genotoxicity, assessed from the presence of micronuclei in polychromatic erythrocytes. The results indicated that the incidence of micronuclei/2000 polychromatic erythrocytes were not significantly different between 1.6 GHz-exposed, sham-exposed and cage control rats. The group mean frequencies were 5.6 +/- 1.8 (130 rats exposed to 1.6 GHz at 0.16 W/kg SAR), 5.4 +/- 1.5 (135 rats exposed to 1.6 GHz at 1.6 W/kg SAR), 5.6 +/- 1.7 (119 sham-exposed rats), and 5.8 +/- 1.8 (100 cage control rats). In contrast, positive control rats treated with mitomycin C exhibited significantly elevated incidence of micronuclei/2000 polychromatic erythrocytes in bone marrow cells; the mean frequency was 38.2 +/- 7.0 (five rats). Thus there was no evidence for excess genotoxicity in rats that were chronically exposed to 1.6 GHz compared to sham-exposed and cage controls.

Vijayalaxmi, Cytogenetic Studies in Human Blood Lymphocytes Exposed In Vitro to 2.45 GHz or 8.2 GHz Radiofrequency Radiation. Radiat. Res. 166, 532–538, 2006.

Peripheral blood samples collected from healthy human volunteers were exposed in vitro to 2.45 GHz or 8.2 GHz pulsed-wave radiofrequency (RF) radiation. The net forward power, average power density, mean specific absorption rate, and the temperature maintained during the 2-h exposure of the cells to 2.45 GHz or 8.2 GHz were, respectively, 21 W or 60 W, 5 mW/cm^2 or 10 mW/cm^2, 2.13 W/kg or 20.71 W/kg, and 36.9 ± 0.1°C or 37.5 ± 0.2°C. Aliquots of the same blood samples that were either sham-exposed or exposed in vitro to an acute dose of 1.5 Gy γ radiation were used as unexposed and positive controls, respectively. Cultured lymphocytes were examined to determine the extent of cytogenetic damage assessed from the incidence of chromosomal aberrations and micronuclei. Under the conditions used to perform the experiments, the levels of damage in RF-radiation-exposed and sham-exposed lymphocytes were not significantly different. Also, there were no significant differences in the response of unstimulated lymphocytes and lymphocytes stimulated with phytohemagglutinin when exposed to 8.2 GHz RF radiation. In contrast, the positive control cells that had been subjected to γ irradiation exhibited significantly more damage than RF-radiation- and sham-exposed lymphocytes.

Vijayalaxmi, Prihoda TJ. Mobile phones, non-ionizing radiofrequency fieldsand brain cancer: is there an adaptive response? Dose Response. 2014 Apr 22;12(3):509-514, 2014.

There is widespread concern among the general public regarding the ever increasing use of mobile phones. The concern is mainly because the antenna which transmits nonionizing radiofrequency fields is held close to the head during use and thus might cause brain cancer. By far, the largest epidemiological study was conducted by the INTER-PHONE study group and the results were published in 2011. The author's conclusions were (i) no increased risk of meningioma and glioma in mobile phone users and (ii) there were suggestions of an increased risk for glioma at the highest exposure levels but, bias and error prevented a causal interpretation. We have carefully examined all of the odd ratios presented in the INTERPHONE study publication: our results showed 24.3% decreased and 0.7% increased risk for meningioma and 22.1% decreased and 6.6% increased risk for glioma. Hence, we hypothesize that the overwhelming evidence for the decreased risk for both diseases may be due to the induction of 'adaptive response' which is well-documented in scientific literature.

Vijver MG, Bolte JF, Evans TR, Tamis WL, Peijnenburg WJ, Musters CJ, de Snoo GR. Investigating short-term exposure to electromagnetic fields on reproductive capacity of invertebrates in the field situation. Electromagn Biol Med. 2013 Jun 19. [Epub ahead of print]

Abstract Organisms are exposed to electromagnetic fields from the introduction of wireless networks that send information all over the world. In this study we examined the impact of exposure to the fields from mobile phone base stations (GSM 900 MHz)

on the reproductive capacity of small, virgin, invertebrates. A field experiment was performed exposing four different invertebrate species at different distances from a radiofrequency electromagnetic fields (RF EMF) transmitter for a 48-h period. The control groups were isolated from EMF exposure by use of Faraday cages. The response variables as measured in the laboratory were fecundity and number of offspring. Results showed that distance was not an adequate proxy to explain dose-response regressions. No significant impact of the exposure matrices, measures of central tendency and temporal variability of EMF, on reproductive endpoints was found. Finding no impact on reproductive capacity does not fully exclude the existence of EMF impact, since mechanistically models hypothesizing non-thermal-induced biological effects from RF exposure are still to be developed. The exposure to RF EMF is ubiquitous and is still increasing rapidly over large areas. We plea for more attention toward the possible impacts of EMF on biodiversity.

Violanti JM, Cellular phones and traffic accidents. Public Health 111(6):423-428, 1997.

Cellular phone use in motor vehicles is becoming an increasing world-wide phenomenon. Using data obtained from traffic accidents reported between 1992 and 1995 in the state of Oklahoma, USA, this study examined statistical rate-ratios of accident characteristics between drivers with or without cellular phones. Rates were calculated between cellular phone involvement and reported accident causes, types of collision, driver actions immediately prior to the accident, location of the accident, the extent of fatalities, and age and gender of drivers. Results indicated a significant increased rate among drivers with cellular phones for inattention, unsafe speed, driving on wrong side of road, striking a fixed object, overturning their vehicle, swerving prior to the accident, and running off the roadway. People with phones stood an increased risk of being killed in an accident over persons without phones. Males with phones had a significantly higher rate than females for many of accident characteristics mentioned above. Rate-ratios of some accident characteristics and fatalities increased as age increased, with the exception of drivers under age 20 yrs, who had the highest fatality rate. *Limitations* of the study and possible prevention alternatives are discussed.

Violanti JM, Cellular phones and fatal traffic collisions. Accid Anal Prev 30(4):519-524, 1998.

A case-control study was conducted to determine statistical associations between traffic fatalities and the use or presence of a cellular phone, given involvement in a collision. The hypothesis of this study does not imply that cellular phones directly affect fatalities, but that phones increase the risk of certain accident characteristics in fatal collisions more than those same characteristics in non-fatal collisions. Analysis employed data from 223,137 traffic accidents occurring between 1992 and 1995. Information on collision characteristics and cellular phone involvement for each fatality was compared with the same information for each non-fatality (controls). Statistically

adjusting for other collision variables (age, gender, alcohol use, speed, inattention and driving left of center), an approximate nine-fold increased risk was found for a fatality given the use of a cellular phone. An approximate two-fold increased risk for a fatality was found given the presence of a cellular phone in the vehicle. Combined effects of reported phone use, driving to the left of center and inattention increased the risk of a fatal collision more than phone use did by itself. This analysis implies a statistical, but not necessarily a causal, relationship. A multitude of factors are involved in any traffic collision, and the exact cause of an accident and its severity level is difficult to disentangle.

Violanti JM, Marshall JR, Cellular phones and traffic accidents: an epidemiological approach. Accid Anal Prev 28(2):265-270, 1996.

Using epidemiological case-control design and logistic regression techniques, this study examined the association of cellular phone use in motor vehicles and traffic accident risk. The amount of time per month spent talking on a cellular phone and 18 other driver inattention factors were examined. Data were obtained from: (1) a case group of 100 randomly selected drivers involved in accidents within the past 2 years, and (2) a control group of 100 randomly selected licensed drivers not involved in accidents within the past 10 years. Groups were matched on geographic residence. Approximately 13% (N = 7) of the accident and 9% (N = 7) of the non-accident group reported use of cellular phones while driving. Data was obtained from Department of Motor Vehicles accident reports and survey information from study subjects. We hypothesized that increased use of cellular phones while driving was associated with increased odds of a traffic accident. Results indicated that talking more than 50 minutes per month on cellular phones in a vehicle was associated with a 5.59-fold increased risk in a traffic accident. The combined use of cellular phones and motor and cognitive activities while driving were also associated with increased traffic accident risk. Readers should be cautioned that this study: (1) consists of a small sample, (2) reveals statistical associations and not causal relationships, and (3) does not conclude that talking on cellular phones while driving is inherently dangerous.

Virtanen H, Keshvari J, Lappalainen R. The effect of authentic metallic implants on the SAR distribution of the head exposed to 900, 1800 and 2450 MHz dipole near field. Phys Med Biol. 52(5):1221-1236, 2007

As the use of radiofrequency (RF) electromagnetic (EM) fields has increased along with increased use of wireless communication, the possible related health risks have also been widely discussed. One safety aspect is the interaction of medical implants and RF devices like mobile phones. In the literature, effects on active implants like pacemakers have been discussed but the studies of passive metallic (i.e. conductive) implants are rare. However, some studies have shown that the EM power absorption in tissues may be enhanced due to metallic implants. In this study, the effect of authentic passive metallic implants in the head region was examined. A half-wave

dipole antenna was used as an exposure source and the specific absorption rate (SAR, W kg(-1)) in the near field was studied numerically. The idea was to model the presumably worst cases of most common implants in an accurate MRI-based phantom. As exposure frequencies GSM (900 and 1800 MHz) and UMTS (2450 MHz) regions were considered. The implants studied were skull plates, fixtures, bone plates and ear rings. The results indicate that some of the implants, under very rare exposure conditions, may cause a notable enhancement in peak mass averaged SAR.

Vitulli WF, Nemeth YM, Conte CT, Ibuprofen effects on behavioral thermoregulation with microwave radiation in albino rats. Percept Mot Skills 92(2):391-394, 2001.

This study determined whether ibuprofen causes a disruptive behavior pattern similar to aspirin yet contrary to acetaminophen regarding thermoregulatory effects. 8 Sprague-Dawley rats (3 males and 5 females) were drawn from a population of rats which had been conditioned to press a lever for food reinforcement in an undergraduate course in operant conditioning. Animals were conditioned in a refrigerated Skinner Box on a fixed-interval 2-min. (FI-2 min.) schedule of microwave radiation (5 sec. of radiation per exposure occasion) in a repeated-measures reversal (within-subjects) design. The rats were injected intraperitoneally with doses of ibuprofen in amounts of 10-50 mg/kg or methyl-cellulose control vehicle of equal volume over 8-hr. daily sessions. A multivariate analysis of variance showed significant differences due to doses (mg/kg) of ibuprofen for number of microwave heat reinforcers per hour and rate of responding (ns) both measures of which were significantly higher during the first 2 hours of the session. Comparative differences in behavioral thermoregulation in humans reflect the likelihood of underlying biochemical mechanisms based on research by Murphy, Badia, Myers, Boecker, and Wright in 1994.

Vlasova II, Mikhalchik EV, Gusev AA, Balabushevich NG, Gusev SA, Kazarinov KD. Extremely high-frequency electromagnetic radiation enhances neutrophil response to particulate agonists. Bioelectromagnetics. 2017 Nov 30. doi: 10.1002/bem.22103.

The growing use of extremely high-frequency electromagnetic radiation (EHF EMR) in information and communication technology and in biomedical applications has raised concerns regarding the potential biological impact of millimeter waves (MMWs). Here, we elucidated the effects of MMW radiation on neutrophil activation induced by opsonized zymosan or E. coli in whole blood ex vivo. After agonist addition to blood, two samples were prepared. A control sample was incubated at ambient conditions without any treatment, and a test sample was exposed to EHF EMR (32.9-39.6 GHz, 100 W/m2). We used methods that allowed us to assess the functional status of neutrophils immediately after exposure: oxidant production levels were measured by luminol-dependent chemiluminescence, and morphofunctional changes to neutrophils were observed in blood smears. Results revealed that the response of neutrophils to both agonists was intensified if blood was exposed to MMW radiation for 15 min. Neutrophils were intact in both the control and irradiated samples if no agonist was added to blood before incubation. Similarly, exposing suspensions of isolated neutrophils in plasma to MMW radiation.

Volkow ND, Tomasi D, Wang GJ, Vaska P, Fowler JS, Telang F, Alexoff D, Logan J, Wong C.Effects of cell phone radiofrequency signal exposure on brain glucose metabolism.JAMA. 305(8):808-813, 2011.

CONTEXT: The dramatic increase in use of cellular telephones has generated concern about possible negative effects of radiofrequency signals delivered to the brain. However, whether acute cell phone exposure affects the human brain is unclear.**OBJECTIVE:** To evaluate if acute cell phone exposure affects brain glucose metabolism, a marker of brain activity.**DESIGN, SETTING, AND PARTICIPANTS:** Randomized crossover study conducted between January 1 and December 31, 2009, at a single US laboratory among 47 healthy participants recruited from the community. Cell phones were placed on the left and right ears and positron emission tomography with ((18)F)fluorodeoxyglucose injection was used to measure brain glucose metabolism twice, once with the right cell phone activated (sound muted) for 50 minutes ("on" condition) and once with both cell phones deactivated ("off" condition). Statistical parametric mapping was used to compare metabolism between on and off conditions using paired t tests, and Pearson linear correlations were used to verify the association of metabolism and estimated amplitude of radiofrequency-modulated electromagnetic waves emitted by the cell phone. Clusters with at least 1000 voxels (volume >8 cm(3)) and P < .05 (corrected for multiple comparisons) were considered significant.**MAIN OUTCOME MEASURE:** Brain glucose metabolism computed as absolute metabolism (μmol/100 g per minute) and as normalized metabolism (region/whole brain).**RESULTS:** Whole-brain metabolism did not differ between on and off conditions. In contrast, metabolism in the region closest to the antenna (orbitofrontal cortex and temporal pole) was significantly higher for on than off conditions (35.7 vs 33.3 μmol/100 g per minute; mean difference, 2.4 [95% confidence interval, 0.67-4.2]; P = .004). The increases were significantly correlated with the estimated electromagnetic field amplitudes both for absolute metabolism (R = 0.95, P < .001) and normalized metabolism (R = 0.89; P < .001).**CONCLUSIONS:** In healthy participants and compared with no exposure, 50-minute cell phone exposure was associated with increased brain glucose metabolism in the region closest to the antenna. This finding is of unknown clinical significance.

Vollrath L, Spessert R, Kratzsch T, Keiner M, Hollmann H, No short-term effects of high-frequency electromagnetic fields on the mammalian pineal gland. Bioelectromagnetics 18(5):376-387, 1997.

There is ample experimental evidence that changes of earth-strength static magnetic fields, pulsed magnetic fields, or alternating electric fields (60 Hz) depress the nocturnally enhanced melatonin synthesis of the pineal gland of certain mammals. No data on the effects of high-frequency electromagnetic fields on melatonin synthesis is available. In the present study, exposure to 900 MHz electromagnetic fields [0.1 to 0.6 mW/cm2, approximately 0.06 to 0.36 W/kg specific absorption rate (SAR) in rats and 0.04 W/kg in Djungarian hamsters; both continuous and/or pulsed at 217 Hz, for 15 min to 6 hr at day or night had no notable short-term effect on pineal melatonin synthesis in male and female Sprague-Dawley rats and Djungarian hamsters. Pineal synaptic ribbon

profile numbers (studied in rats only) were likewise not affected. The 900 MHz electromagnetic fields, unpulsed or pulsed at 217 Hz, as applied in the present study, have no short-term effect on the mammalian pineal gland.

Von Klitzing, L, Low-frequency pulsed electromagnetic fields influence EEG of man. Phys. Medica 11:77-80, 1995.

New techniques using low-frequency puled electromagnetic fields (e.g., digital telecommunication) have raised the question for interference with the biological system of man. EEG data of man sampled under the influence of these electromagnetic fields are altered extremely in the range of alpha-activity as well as during after exposure for some hours. The biological effect is induced by field intensities lower than the given international limiting values.

Vorobyov VV, Galchenko AA, Kukushkin NI, Akoev IG, Effects of weak microwave fields amplitude modulated at ELF on EEG of symmetric brain areas in rats. Bioelectromagnetics 18(4):293-298, 1997.

Averaged electroencephalogram (EEG) frequency spectra were studied in eight unanesthetized and unmyorelaxed adult male rats with chronically implanted carbon electrodes in symmetrical somesthetic areas when a weak (0.1-0.2 mW/cm2) microwave (MW, 945 MHz) field, amplitude-modulated at extremely low frequency (ELF) (4 Hz), was applied. Intermittent (1 min "On," 1 min "Off") field exposure (10-min duration) was used. Hemispheric asymmetry in frequency spectra (averaged data for 10 or 1 min) of an ongoing EEG was characterized by a power decrease in the 1.5-3 Hz range on the left hemisphere and by a power decrease in the 10-14 and 20-30 Hz ranges on the right hemisphere. No differences between control and exposure experiments were shown under these routines of data averaging. Significant elevations of EEG asymmetry in 10-14 Hz range were observed during the first 20 s after four from five onsets of the MW field, when averaged spectra were obtained for every 10 s. Under neither control nor pre- and postexposure conditions was this effect observed. These results are discussed with respect to interaction of MW fields with the EEG generators.

Vorobyov V, Pesic V, Janac B, Prolic Z. Repeated exposure to low-level extremely low frequency-modulated microwaves affects baseline and scopolamine-modified electroencephalograms in freely moving rats. Int J Radiat Biol. 80(9):691-698, 2004.

PURPOSE: To compare in the electroencephalogram of rats the effects of scopolamine (an acetylcholine receptor antagonist) alone and after repeated exposure to low-level microwaves modulated at extremely low frequency. MATERIALS AND METHODS: Averaged frequency spectra (0.5-30 Hz) of the electroencephalogram were studied in freely moving rats with carbon electrodes implanted into the somatosensory cortex. The rats were repeatedly (3 days, 30 min day(-1)) exposed to low-intensity (approximately = 0.3 mW cm(-2)) microwaves (915 MHz, 20-ms pulse duration), amplitude modulated (square-wave) at extremely low frequency (4 Hz). RESULTS: The exposure to extremely low frequency microwaves alone significantly enhanced the fast electroencephalographic rhythms (18-30 Hz). This effect was observed neither in subsequent sham-exposure

experiment nor in radiation-naive animals. In the microwave-exposed rats, scopolamine (0.1 mg kg(-1), subcutaneously) did not cause a slowing in the electroencephalogram that was shown in non-exposed rats. A similarity between the scopolamine-induced electroencephalogram effect in the microwave-exposed rats and that of physostigmine (enhancing the acetylcholine level in the brain) in radiation-naive animals was noted. This paradoxical phenomenon stimulates new experimentation for understanding its mechanism(s). CONCLUSIONS: The data obtained provide additional evidence that repeated low-level exposure to extremely low frequency microwaves can modify an activity of cholinergic system in the brain.

Vorobyov V, Janać B, Pesić V, Prolić Z. Repeated exposure to low-level extremely low frequency-modulated microwaves affects cortex-hypothalamus interplay in freely moving rats: EEG study. Int J Radiat Biol. 86(5):376-383, 2010.

PURPOSE: To compare the effects of repeated exposure to extremely low frequency-modulated microwaves (ELF-MW) on cortical and hypothalamic electroencephalograms (EEG). MATERIALS AND METHODS: In 10 freely moving rats with carbon electrodes implanted into the cortex and dorsomedial hypothalamus, averaged frequency spectra (0.5-30 Hz) of the EEG were studied for five consecutive days either under sham exposures (five rats) or under mixed sham/MW-exposures (five rats). The rats were exposed to ELF-MW (915 MHz, 20-ms pulse duration, approximately 0.3 mW/cm(2), 4 Hz) intermittently (1-min 'On', 1-min 'Off') for 10 min (specific absorption rate, SAR, approximately 0.7 mW/g on average) several times per day, with 10-min pre- and post-exposure periods. RESULTS: In baseline EEG, the activities of 3.2-6.0 Hz and 17.8-30.5 Hz dominated in the cortex and of 6.0-17.8 Hz in the hypothalamus. This cortical-hypothalamic imbalance was relatively stable at sham-exposures and insensitive to ELF-MW in all frequency ranges but one. ELF-MW increased the beta(2) (17.8-30.5 Hz) level in the hypothalamus to a greater extent than in the cortex, causing significant diminishing of the initial EEG bias between them. Moreover, a cumulative phenomenon under repeated exposures to ELF-MW was revealed. CONCLUSIONS: These results are in line with evidence that repeated low-level exposure to ELF-MW affects brain functioning and provide an additional approach when analysing underlying mechanisms.

Vrijheid M, Cardis E, Armstrong BK, Auvinen A, Berg G, Blaasaas KG, Brown J, Carroll M, Chetrit A, Christensen HC, Deltour I, Feychting M, Giles GG, Hepworth SJ, Hours M, Iavarone I, Johansen C, Klaeboe L, Kurttio P, Lagorio S, Lonn S, McKinney PA, Montestrucq L, Parslow RC, Richardson L, Sadetzki S, Salminen T, Schuz J, Tynes T, Woodward A; Interphone Study Group. Validation of short term recall of mobile phone use for the Interphone study. Occup Environ Med. 63(4):237-243, 2006.

AIM: To validate short term recall of mobile phone use within Interphone, an international collaborative case control study of tumours of the brain, acoustic nerve, and salivary glands related to mobile telephone use. METHODS: Mobile phone use of 672 volunteers in 11 countries was recorded by operators or through the use of software modified phones, and compared to use recalled six months later using the Interphone study

questionnaire. Agreement between recalled and actual phone use was analysed using both categorical and continuous measures of number and duration of phone calls. RESULTS: Correlations between recalled and actual phone use were moderate to high (ranging from 0.5 to 0.8 across countries) and of the same order for number and duration of calls. The kappa statistic demonstrated fair to moderate agreement for both number and duration of calls (weighted kappa ranging from 0.20 to 0.60 across countries). On average, subjects underestimated the number of calls per month (geometric mean ratio of recalled to actual = 0.92, 95% CI 0.85 to 0.99), whereas duration of calls was overestimated (geometric mean ratio = 1.42, 95% CI 1.29 to 1.56). The ratio of recalled to actual use increased with level of use, showing underestimation in light users and overestimation in heavy users. There was substantial heterogeneity in this ratio between countries. Inter-individual variation was also large, and increased with level of use. CONCLUSIONS: Volunteer subjects recalled their recent phone use with moderate systematic error and substantial random error. This large random error can be expected to reduce the power of the Interphone study to detect an increase in risk of brain, acoustic nerve, and parotid gland tumours with increasing mobile phone use, if one exists.

Vrijheid M, Deltour I, Krewski D, Sanchez M, Cardis E. The effects of recall errors and of selection bias in epidemiologic studies of mobile phone use and cancer risk. J Expo Sci Environ Epidemiol.16(4):371-384, 2006.

This paper examines the effects of systematic and random errors in recall and of selection bias in case-control studies of mobile phone use and cancer. These sensitivity analyses are based on Monte-Carlo computer simulations and were carried out within the INTERPHONE Study, an international collaborative case-control study in 13 countries. Recall error scenarios simulated plausible values of random and systematic, non-differential and differential recall errors in amount of mobile phone use reported by study subjects. Plausible values for the recall error were obtained from validation studies. Selection bias scenarios assumed varying selection probabilities for cases and controls, mobile phone users, and non-users. Where possible these selection probabilities were based on existing information from non-respondents in INTERPHONE. Simulations used exposure distributions based on existing INTERPHONE data and assumed varying levels of the true risk of brain cancer related to mobile phone use. Results suggest that random recall errors of plausible levels can lead to a large underestimation in the risk of brain cancer associated with mobile phone use. Random errors were found to have larger impact than plausible systematic errors. Differential errors in recall had very little additional impact in the presence of large random errors. Selection bias resulting from underselection of unexposed controls led to J-shaped exposure-response patterns, with risk apparently decreasing at low to moderate exposure levels. The present results, in conjunction with those of the validation studies conducted within the INTERPHONE study, will play an important role in the interpretation of existing and future case-control studies of mobile phone use and cancer risk, including the INTERPHONE study

Vrijheid M, Richardson L, Armstrong BK, Auvinen A, Berg G, Carroll M, Chetrit A, Deltour I, Feychting M, Giles GG, Hours M, Iavarone I, Lagorio S, Lönn S, McBride M, Parent ME, Sadetzki S, Salminen T, Sanchez M, Schlehofer B, Schüz J, Siemiatycki J, Tynes T, Woodward A, Yamaguchi N, Cardis E. Quantifying the impact of selection bias caused by nonparticipation in a case-control study of

mobile phone use. Ann Epidemiol. 19(1):33-41, 2009.

PURPOSE: To quantitatively assess the impact of selection bias caused by nonparticipation in a multinational case-control study of mobile phone use and brain tumor. METHODS: Non-response questionnaires (NRQ) were completed by a subset of nonparticipants. Selection bias factors were calculated based on the prevalence of mobile phone use reported by nonparticipants with NRQ data, and on scenarios of hypothetical exposure prevalence for other nonparticipants. RESULTS: Regular mobile phone use was reported less frequently by controls and cases who completed the NRQ (controls, 56%; cases, 50%) than by those who completed the full interview (controls, 69%; cases, 66%). This relationship was consistent across study centers, sex, and age groups. Lower education and more recent start of mobile phone use were associated with refusal to participate. Bias factors varied between 0.87 and 0.92 in the most plausible scenarios. CONCLUSIONS: Refusal to participate in brain tumor case-control studies seems to be related to less prevalent use of mobile phones, and this could result in a downward bias of around 10% in odds ratios for regular mobile phone use. The use of simple selection bias estimation methods in case-control studies can give important insights into the extent of any bias, even when nonparticipant information is incomplete.

Vrijheid M, Mann S, Vecchia P, Wiart J, Taki M, Ardoino L, Armstrong BK, Auvinen A, Bédard D, Berg-Beckhoff G, Brown J, Chetrit A, Collatz-Christensen H, Combalot E, Cook A, Deltour I, Feychting M, Giles GG, Hepworth SJ, Hours M, Iavarone I, Johansen C, Krewski D, Kurttio P, Lagorio S, Lönn S, McBride M, Montestruq L, Parslow R, Sadietzki S, Schüz J, Tynes T, Woodward A, Cardis E. Determinants of mobile phone output power in a multinational study - implications for exposure assessment. Occup Environ Med.66(10):664-671, 2009.

OBJECTIVES: The output power of a mobile phone is directly related to its radiofrequency (RF) electromagnetic field strength, and may theoretically vary substantially in different networks and phone use circumstances due to power control technologies. To improve indices of RF exposure for epidemiological studies, we assessed determinants of mobile phone output power in a multi-national study. METHODS: More than 500 volunteers in twelve countries used software-modified GSM phones (SMPs) for approximately one month each. The SMPs recorded date, time, and duration of each call, and the frequency band and output power at fixed sampling intervals throughout each call. Questionnaires provided information on the typical circumstances of an individual's phone use. Linear regression models were used to analyse the influence of possible explanatory variables on the average output power and the percentage call-time at maximum power for each call. RESULTS: Measurements of over 60,000 phone calls showed that the average output power was approximately 50% of the maximum, and that output power varied by a factor of up to 2 to 3 between study centres and network operators. Maximum power was used during a considerable proportion of call-time (39% on average). Output power decreased with increasing call duration, but showed little variation in relation to reported frequency of use whilst in a moving vehicle or inside buildings. Higher output powers for rural compared with urban use of the SMP were observed principally in Sweden where the study covered very sparsely populated areas. CONCLUSIONS: Average power levels are substantially

higher than the minimum levels theoretically achievable in GSM networks. Exposure indices could be improved by accounting for average power levels of different telecommunications systems. There appears to be little value in gathering information on circumstances of phone use other than use in very sparsely populated regions.

Vrijheid M, Martinez D, Forns J, Guxens M, Julvez J, Ferrer M, Sunyer J. Prenatal Exposure to Cell Phone Use and Neurodevelopment at 14 Months. Epidemiology. 21: 259-262, 2010.

BACKGROUND:: Recently, an association was reported between prenatal and postnatal exposure to cell phones and neurobehavioral problems in children at the age of 7 years. METHODS:: A birth cohort was established in Sabadell, Spain between 2004 and 2006. Mothers completed questions about cell phone use in week 32 of the pregnancy (n = 587). Neurodevelopment of their children was tested at age 14 months using the Bayley Scales of Infant Development (n = 530). RESULTS:: We observed only small differences in neurodevelopment scores between the offspring of cell phone users and nonusers. Those of users had higher mental development scores and lower psychomotor development scores, which may be due to unmeasured confounding. There was no trend with amount of cell phone use within users. CONCLUSION:: This study gives little evidence for an adverse effect of maternal cell phone use during pregnancy on the early neurodevelopment of offspring.

Wagner, P, Roschke, J, Mann, K, Hiller, W, Frank, C, Human sleep under the influence of pulsed radiofrequency electromagnetic fields: a polysomnographic study using standardized conditions. Bioelectromagnetics 19(3):199-202, 1998.

To investigate the influence of radiofrequency electromagnetic fields (EMFs) of cellular phone GSM signals on human sleep electroencephalographic (EEG) pattern, all-night polysomnographies of 24 healthy male subjects were recorded, both with and without exposure to a circular polarized EMF (900 MHz, pulsed with a frequency of 217 Hz, pulse width 577 micros, power flux density 0.2 W/m2. Suppression of rapid eye movement (REM) sleep as well as a sleep-inducing effect under field exposure did not reach statistical significance, so that previous results indicating alterations of these sleep parameters could not be replicated. Spectral power analysis also did not reveal any alterations of the EEG rhythms during EMF exposure. The failure to confirm our previous results might be due to dose-dependent effects of the EMF on the human sleep profile.

Wagner P, Roschke J, Mann K, Fell J, Hiller W, Frank C, Grozinger M, Human sleep EEG under the influence of pulsed radio frequency electromagnetic fields. results from polysomnographies using submaximal high power flux densities. Neuropsychobiology 42(4):207-212, 2000.

Former exploratory investigations of sleep alterations due to global system for mobile communications (GSM) signals have shown a hypnotic and REM-suppressive effect under field exposure. This effect was observed in a first study using a power flux density of 0.5 W/m(2), and the same trend occurred in a second study with a power flux density of 0.2 W/m(2). For the present study, we applied a submaximal power flux density of 50 W/m(2). To investigate putative effects of radio frequency electromagnetic fields (EMFs)

of cellular GSM phones on human sleep EEG pattern, all-night polysomnographies of 20 healthy male subjects both with and without exposure to a circularly polarized EMF (900 MHz, pulsed with a frequency of 217 Hz, pulse duration 577 &mgr;s) were recorded. The results showed no significant effect of the field application either on conventional sleep parameters or on sleep EEG power spectra.

Wake K, **Varsier N**, **Watanabe S**, **Taki M**, **Wiart J**, **Mann S**, **Deltour I**, **Cardis E**. **The estimation of 3D SAR distributions in the human head from mobile phone compliance testing data for epidemiological studies. Phys Med Biol. 54(19):5695-5706, 2009.**

A worldwide epidemiological study called 'INTERPHONE' has been conducted to estimate the hypothetical relationship between brain tumors and mobile phone use. In this study, we proposed a method to estimate 3D distribution of the specific absorption rate (SAR) in the human head due to mobile phone use to provide the exposure gradient for epidemiological studies. 3D SAR distributions due to exposure to an electromagnetic field from mobile phones are estimated from mobile phone compliance testing data for actual devices. The data for compliance testing are measured only on the surface in the region near the device and in a small 3D region around the maximum on the surface in a homogeneous phantom with a specific shape. The method includes an interpolation/extrapolation and a head shape conversion. With the interpolation/extrapolation, SAR distributions in the whole head are estimated from the limited measured data. 3D SAR distributions in the numerical head models, where the tumor location is identified in the epidemiological studies, are obtained from measured SAR data with the head shape conversion by projection. Validation of the proposed method was performed experimentally and numerically. It was confirmed that the proposed method provided good estimation of 3D SAR distribution in the head, especially in the brain, which is the tissue of major interest in epidemiological studies. We conclude that it is possible to estimate 3D SAR distributions in a realistic head model from the data obtained by compliance testing measurements to provide a measure for the exposure gradient in specific locations of the brain for the purpose of exposure assessment in epidemiological studies. The proposed method has been used in several studies in the INTERPHONE.

Wainwright P, Thermal effects of radiation from cellular telephones. Phys Med Biol 45(8):2363-2372, 2000.

A finite element thermal model of the head has been developed to calculate temperature rises generated in the brain by radiation from cellular telephones and similar electromagnetic devices. A 1 mm resolution MRI dataset was segmented semiautomatically, assigning each volume element to one of ten tissue types. A finite element mesh was then generated using a fully automatic tetrahedral mesh generator developed at NRPB. There are two sources of heat in the model: firstly the natural metabolic heat production; and secondly the power absorbed from the electromagnetic field. The SAR was derived from a finite difference time domain model of the head, coupled to a model 'mobile phone', namely a quarter-wavelength antenna mounted on a metal box. The steady-state temperature distribution was calculated using the standard Pennes 'bioheat equation'. In the normal cerebral cortex the high blood perfusion rate

serves to provide an efficient cooling mechanism. In the case of equipment generally available to the public, the maximum temperature rise found in the brain was about 0.1 degrees C. These results will help in the further development of criteria for exposure guidelines, and the technique developed may be used to assess temperature rises associated with SARs for different types of RF exposure.

Waldmann P, Bohnenberger S, Greinert R, Hermann-Then B, Heselich A, Klug SJ, Koenig J, Kuhr K, Kuster N, Merker M, Murbach M, Pollet D, Schadenboeck W, Scheidemann-Wesp U, Schwab B, Volkmer B, Weyer V, Blettner M. Influence of GSM Signals on Human Peripheral Lymphocytes: Study of Genotoxicity. Radiat Res. 2013 Jan 14. [Epub ahead of print]

Exposure to radiofrequency (RF) electromagnetic fields (EMF) is continuously increasing worldwide. Yet, conflicting results of a possible genotoxic effect of RF EMF continue to be discussed. In the present study, a possible genotoxic effect of RF EMF (GSM, 1,800 MHz) in human lymphocytes was investigated by a collaboration of six independent institutes (institutes a, b, c, d, e, h). Peripheral blood of 20 healthy, nonsmoking volunteers of two age groups (10 volunteers 16-20 years old and 10 volunteers 50-65 years old) was taken, stimulated and intermittently exposed to three specific absorption rates (SARs) of RF EMF (0.2 W/kg, 2 W/kg, 10 W/kg) and sham for 28 h (institute a). The exposures were performed in a setup with strictly controlled conditions of temperature and dose, and randomly and automatically determined waveguide SARs, which were designed and periodically maintained by ITIS (institute h). Four genotoxicity tests with different end points were conducted (institute a): chromosome aberration test (five types of structural aberrations), micronucleus test, sister chromatid exchange test and the alkaline comet assay (Olive tail moment and % DNA). To demonstrate the validity of the study, positive controls were implemented. The genotoxicity end points were evaluated independently by three laboratories blind to SAR information (institute c = laboratory 1; institute d = laboratory 2; institute e = laboratory 3). Statistical analysis was carried out by institute b. Methods of primary statistical analysis and rules to adjust for multiple testing were specified in a statistical analysis plan based on a data review before unblinding. A linear trend test based on a linear mixed model was used for outcomes of comet assay and exact permutation test for linear trend for all other outcomes. It was ascertained that only outcomes with a significant SAR trend found by at least two of three analyzing laboratories indicated a substantiated suspicion of an exposure effect. On the basis of these specifications, none of the nine end points tested for SAR trend showed a significant and reproducible exposure effect. Highly significant differences between sham exposures and positive controls were detected by each analyzing laboratory, thus validating the study. In conclusion, the results show no evidence of a genotoxic effect induced by RF EMF (GSM, 1,800 MHz).

Waldmann-Selsam C, Balmori-de la Puente A, Breunig H, Balmori A. Radiofrequency radiation injures trees around mobile phone base stations. Sci Total Environ. 572:554-569, 2016.

In the last two decades, the deployment of phone masts around the world has taken place and, for many years, there has been a discussion in the scientific community about the possible environmental impact from mobile phone base stations. Trees have several advantages over animals as experimental subjects and the aim of this study was to verify whether there is a connection between unusual (generally unilateral) tree damage and radiofrequency exposure. To achieve this, a detailed long-term (2006-2015) field monitoring study was performed in the cities of Bamberg and Hallstadt (Germany). During monitoring, observations and photographic recordings of unusual or unexplainable tree damage were taken, alongside the measurement of electromagnetic radiation. In 2015 measurements of RF-EMF (Radiofrequency Electromagnetic Fields) were carried out. A polygon spanning both cities was chosen as the study site, where 144 measurements of the radiofrequency of electromagnetic fields were taken at a height of 1.5m in streets and parks at different locations. By interpolation of the 144 measurement points, we were able to compile an electromagnetic map of the power flux density in Bamberg and Hallstadt. We selected 60 damaged trees, in addition to 30 randomly selected trees and 30 trees in low radiation areas (n=120) in this polygon. The measurements of all trees revealed significant differences between the damaged side facing a phone mast and the opposite side, as well as differences between the exposed side of damaged trees and all other groups of trees in both sides. Thus, we found that side differences in measured values of power flux density corresponded to side differences in damage. The 30 selected trees in low radiation areas (no visual contact to any phone mast and power flux density under 50μW/m^2) showed no damage. Statistical analysis demonstrated that electromagnetic radiation from mobile phone masts is harmful for trees. These results are consistent with the fact that damage afflicted on trees by mobile phone towers usually start on one side, extending to the whole tree over time.

Wallace D, Eltiti S, Ridgewell A, Garner K, Russo R, Sepulveda F, Walker S, Quinlan T, Dudley S, Maung S, Deeble R, Fox E. Cognitive and physiological responses in humans exposed to a TETRA base station signal in relation to perceived electromagnetic hypersensitivity.Bioelectromagnetics. 33(1):23-39, 2012.

Terrestrial Trunked Radio (TETRA) technology ("Airwave") has led to public concern because of its potential interference with electrical activity in the brain. The present study is the first to examine whether acute exposure to a TETRA base station signal has an impact on cognitive functioning and physiological responses. Participants were exposed to a 420 MHz TETRA signal at a power flux density of 10 mW/m(2) as well as sham (no signal) under double-blind conditions. Fifty-one people who reported a perceived sensitivity to electromagnetic fields as well as 132 controls participated in a double-blind provocation study. Forty-eight sensitive and 132 control participants completed all three sessions. Measures of short-term memory, working memory, and attention were administered while physiological responses (blood volume pulse, heart rate, skin conductance) were monitored. After applying exclusion criteria based on task performance for each aforementioned cognitive measure, data were analyzed for 36, 43, and 48 sensitive participants for these respective tasks and, likewise, 107,125, and 129 controls. We observed no differences in cognitive performance between sham and TETRA exposure in either group; physiological response also did not differ between the

exposure conditions. These findings are similar to previous double-blind studies with other mobile phone signals (900-2100 MHz), which could not establish any clear evidence that mobile phone signals affect health or cognitive function.

Wallace D, Eltiti S, Ridgewell A, Garner K, Russo R, Sepulveda F, Walker S, Quinlan T, Dudley S, Maung S, Deeble R, Fox E. Do TETRA (Airwave) base station signals have a short-term impact on health and well-being? A randomized double-blind provocation study.Environ Health Perspect. 118(6):735-741, 2012.

BACKGROUND: "Airwave" is the new communication system currently being rolled out across the United Kingdom for the police and emergency services,based on the Terrestrial Trunked Radio Telecommunications System (TETRA). Some police officers have complained about skin rashes, nausea, headaches, and depression as a consequence of using their Airwave handsets. In addition, a small subgroup in the population self-report being sensitive to electromagnetic fields (EMFs) in general. OBJECTIVES: We conducted a randomized double-blind provocation study to establish whether short-term exposure to a TETRA base station signal has an impact on the health and well-being of individuals with self-reported "electrosensitivity" and of participants who served as controls. METHODS: Fifty-one individuals with self-reported electrosensitivity and 132 age- and sex-matched controls participated in an open provocation test; 48 sensitive and 132 control participants went on to complete double-blind tests in a fully screened semianechoic chamber. Heart rate, skin conductance, and blood pressure readings provided objective indices of short-term physiological response. Visual analog scales and symptom scales provided subjective indices of well-being. RESULTS: We found no differences on any measure between TETRA and sham (no signal) under double-blind conditions for either controls or electrosensitive participants, and neither group could detect the presence of a TETRA signal at rates greater than chance (50%). When conditions were not double blind, however, the self-reported electrosensitive individuals did report feeling worse and experienced more severe symptoms during TETRA compared with sham.CONCLUSIONS: Our findings suggest that the adverse symptoms experienced by electrosensitive individuals are due to the belief of harm from TETRA base stations rather than to the low-level EMF exposure itself.

Wallin MK, Marve T, Hakansson PK. Modern wireless telecommunication technologies and their electromagnetic compatibility with life-supporting equipment. Anesth Analg. 101(5):1393-1400, 2005.

Hospitals rely on pagers and ordinary telephones to reach staff members in emergency situations. New telecommunication technologies such as General Packet Radio Service (GPRS), the third generation mobile phone system Universal Mobile Telecommunications System (UMTS), and Wireless Local Area Network (WLAN) might be able to replace hospital pagers if they are electromagnetically compatible with medical devices. In this study, we sought to determine if GPRS, UMTS (Wideband Code Division Multiple Access-Frequency Division Duplex [WCDMA FDD]), and WLAN (IEEE 802.11b) transmitted signals interfere with life-supporting equipment in the intensive care and operating room environment. According to United States standard, ANSI C63.18-1997,

laboratory tests were performed on 76 medical devices. In addition, clinical tests during 11 operations and 100 h of intensive care were performed. UMTS and WLAN signals caused little interference. Devices using these technologies can be used safely in critical care areas and during operations, but direct contact between medical devices and wireless communication devices ought to be avoided. In the case of GPRS, at a distance of 50 cm, it caused an older infusion pump to alarm and stop infusing; the pump had to be reset. Also, 10 cases of interference with device displays occurred. GPRS can be used safely at a distance of 1 m. Terminals/cellular phones using these technologies should be allowed without restriction in public areas because the risk of interference is minimal.

Walsh SP, White KM, Hyde MK, Watson B. Dialling and driving: factors influencing intentions to use a mobile phone while driving. Accid Anal Prev. 40(6):1893-1900, 2008.

Despite being identified as an unsafe (and, in some jurisdictions, illegal) driving practice, the psychological factors underlying people's decision to use their mobile phone while driving have received little attention. The present study utilised the theory of planned behaviour (TPB) to examine the role of attitudes, norms, control factors, and risk perceptions, in predicting people's intentions to use their mobile phone while driving. We examined the predictors of intentions to use a mobile phone while driving in general, and for calling and text messaging in 4 scenarios differing in descriptions of vehicle speed and time pressure. There was some support for the TPB given that attitudes consistently predicted intentions to drive while using a mobile phone and that pressure from significant others (norms) determined some phone use while driving intentions, although less support was found for the role of perceptions of control. Risk was not generally predictive of safer driving intentions. These findings indicate that different factors influence each form of mobile phone use while driving and, hence, a multi-strategy approach is likely to be required to address the issue.

Walters TJ, Blick DW, Johnson LR, Adair ER, Foster KR, Heating and pain sensation produced in human skin by millimeter waves: comparison to a simple thermal model. Health Phys 78(3):259-267, 2000.

Cutaneous thresholds for thermal pain were measured in 10 human subjects during 3-s exposures at 94 GHz continuous wave microwave energy at intensities up to approximately 1.8 W cm(-2). During each exposure, the temperature increase at the skin's surface was measured by infrared thermography. The mean (+/- s.e.m.) baseline temperature of the skin was 34.0+/-0.2 degrees C. The threshold for pricking pain was 43.9+/-0.7 degrees C, which corresponded to an increase in surface temperature of approximately 9.9 degrees C (from 34.0 degrees C to 43.9 degrees C). The measured increases in surface temperature were in good agreement with a simple thermal model that accounted for heat conduction and for the penetration depth of the microwave energy into tissue. Taken together, these results support the use of the model for predicting thresholds of thermal pain at other millimeter wave (length) frequencies.

Walters TJ, Ryan KL, Belcher JC, Doyle JM, Tehrany MR, Mason PA,

Regional brain heating during microwave exposure (2.06 GHz), warm-water immersion, environmental heating and exercise. Bioelectromagnetics 19(6):341-353,1998.

Nonuniform heating may result from microwave (MW) irradiation of tissues and is therefore important to investigate in terms of health and safety issues. Hypothalamic (Thyp), cortical (Tctx), tympanic (Tty), and rectal (Tre) temperatures were measured in rats exposed in the far field, k-polarization (i.e., head pointed toward the transmitter horn and E-field in vertical direction) to two power densities of 2.06 GHz irradiation. The high-power density (HPM) was 1700 mW/cm2 [specific absorption rate (SAR): hypothalamus 1224 W/kg; cortex 493 W/kg]; the low-power density (LPM) was 170 mW/cm2 (SAR: hypothalamus 122.4 W/kg; cortex 49.3 W/kg). The increase (rate-of-rise, in degrees C/s) in Thyp was significantly greater than those in Tctx or Tre when rats were exposed to HPM. LPM produced more homogeneous heating. Quantitatively similar results were observed whether rats were implanted with probes in two brain sites or a single probe in one or the other of the two sites. The qualitative difference between regional brain heating was maintained during unrestrained exposure to HPM in the h-polarization (i.e., body parallel to magnetic field). To compare the temperature changes during MW irradiation with those produced by other modalities of heating, rats were immersed in warm water (44 degrees C, WWI); exposed to a warm ambient environment (50 degrees C, WSED); or exercised on a treadmill (17 m/min 8% grade) in a warm ambient environment (35 degrees C, WEX). WWI produced uniform heating in the regions measured. Similar rates-of-rise occurred among regions following WSED or WEX, thus maintaining the pre-existing gradient between Thyp and Tctx These data indicate that HPM produced a 2-2.5-fold difference in the rate-of-heating within brain regions that were separated by only a few millimeters. In contrast, more homogeneous heating was recorded during LPM or nonmicrowave modalities of heating.

Wang, BM, Lai, H, Acute exposure to pulsed 2450-MHz microwaves affects water maze learning in the rat. Bioelectromagnetics 21:52-56, 2000.

Rats were trained in six sessions to locate a submerged platform in a circular water maze. They were exposed to pulsed 2450-MHz microwaves (pulse width 2 μs, 500 pulses/s, power density 2 mW/cm2, average whole body specific absorption rate 1.2 W/kg) for 1 hr in a circular waveguide system immediately before each training session. One hour after the last training session, they were tested in a probe trial during which the platform was removed and the time spent in the quadrant of the maze in which the platform had been located during the 1-min trial was scored. Three groups of animals: microwave-exposed, sham-exposed, and cage control were studied. Data show that 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. During the probe trial, microwave-exposed animals spent significantly less time in the quadrant that had contained the platform, and their swim

patterns were different from those of the sham-exposed and cage control animals. The latter observation indicates that microwave-exposed rats used a different strategy in learning the location of the platform. These results show that acute exposure to pulsed microwaves caused a deficit in spatial "reference" memory in the rat.

Wang C, Wang X, Zhou H, Dong G, Guan X, Wang L, Xu X, Wang S, Chen P, Peng R, Hu X. Effects of Pulsed 2.856 GHz Microwave Exposure on BM-MSCs Isolated from C57BL/6 Mice. PLoS One. 2015 Feb 6;10(2):e0117550. doi: 10.1371/journal.pone.0117550. eCollection 2015.

The increasing use of microwave devices over recent years has meant the bioeffects of microwave exposure have been widely investigated and reported. However the exact biological fate of bone marrow MSCs (BM-MSCs) after microwave radiation remains unknown. In this study, the potential cytotoxicity on MSC proliferation, apoptosis, cell cycle, and in vitro differentiation were assayed following 2.856 GHz microwave exposure at a specific absorption rate (SAR) of 4 W/kg. Importantly, our findings indicated no significant changes in cell viability, cell division and apoptosis after microwave treatment. Furthermore, we detected no significant effects on the differentiation ability of these cells in vitro, with the exception of reduction in mRNA expression levels of osteopontin (OPN) and osteocalcin (OCN). These findings suggest that microwave treatment at a SAR of 4 W/kg has undefined adverse effects on BM-MSCs. However, the reduced-expression of proteins related to osteogenic differentiation suggests that microwave can the influence at the mRNA expression genetic level.

Wang D, Li B, Liu Y, Ma YF, Chen SQ, Sun HJ, Dong J, Ma XH, Zhou J, Wang XH. [Impact of mobile phone **radiation on the quality and DNA methylation of human sperm in vitro]. Zhonghua Nan Ke Xue. 21(6):515-520, 2015. [Article in Chinese]**
OBJECTIVE: To investigate the influences of mobile phone radiation on the quality and DNA methylation of human sperm in vitro. METHODS: According to the fifth edition of the WHO Laboratory Manual for the Examination and Processing of Human Semen, we randomly selected 97 male volunteers with normal semen parameters and divided each semen sample from the subjects into two equal parts, one exposed to mobile phone radiation at 1950 M Hz, SAR3. 0 W/kg for 3 hours while the other left untreated as the control. We obtained routine semen parameters as well as the acrosomal reaction ability, apoptosis and DNA methylation of sperm, and compared them between the two groups. RESULTS: Compared with the control, the radiation group showed significantly decreased progressive sperm motility ([36.64 ± 16.93] vs [27.56 ± 16.92]%, P < 0.01) and sperm viability ([63.72 ± 16.35] vs [54.31 ± 17.35]%, P < 0.01) and increased sperm head defects ([69.92 ± 4.46] vs [71.17 ± 4.89]%, P < 0.05), but no significant differences in sperm acrosomal reaction ([66.20 ± 6.75] vs [64.50 ± 3.47]%, P > 0.05). The early apoptosis rate of sperm cells was remarkably higher in the radiation group ([6.89 ± 9.84]%) than in the control ([4.44 ± 5.89]%) (P < 0.05). However, no statistically significant differences were found between the control and radiation groups in the DNA methylation patterns of the paternal imprinting gene H19 ICR ([0.60 ± 0.02] vs [1.40 ± 0.03]%, P > 0.05) or the maternal imprinting gene KvDMR1 ([0.00 ± 0.00] vs [1.80 ± 0.031%, P > 0.05). CONCLUSION: Mobile phone radiation reduces the progressive motility and

viability of human sperm and increases sperm head defects and early apoptosis of sperm cells.

Wang H, Peng R, Zhou H, Wang S, Gao Y, Wang L, Yong Z, Zuo H, Zhao L, Dong J, Xu X, Su Z. Impairment of long-term potentiation induction is essential for the disruption of spatial memory after microwave exposure. Int J Radiat Biol. 2013 Jul 24. [Epub ahead of print]

Purpose: To assess the impact of microwave exposure on learning and memory and to explore the underlying mechanisms. Materials and methods: 100 Wistar rats were exposed to a 2.856 GHz pulsed microwave field at average power densities of 0 mW/cm^2, 5 mW/cm^2, 10 mW/cm^2 and 50 mW/cm^2 for 6 min. The spatial memory was assessed by the Morris Water Maze (MWM) task. An in vivo study was conducted soon after microwave exposure to evaluate the changes of population spike (PS) amplitudes of long-term potentiation (LTP) in the medial perforant path (MPP)-dentate gyrus (DG) pathway. The structure of the hippocampus was observed by the light microscopy and the transmission electron microscopy (TEM) at 7 d after microwave exposure. Results: Our results showed that the rats exposed in 10 mW/cm^2 and 50 mW/cm^2 microwave displayed significant deficits in spatial learning and memory at 6 h, 1 d and 3 d after exposure. Decreased PS amplitudes were also found after 10 mW/cm^2 and 50 mW/cm^2 microwave exposure. In addition, varying degrees of degeneration of hippocampal neurons, decreased synaptic vesicles and blurred synaptic clefts were observed in the rats exposed in 10 mW/cm^2 and 50 mW/cm^2 microwave. Compared with the sham group, the rats exposed in 5 mW/cm^2 microwave showed no difference in the above experiments. Conclusions: This study suggested that impairment of LTP induction and the damages of hippocampal structure, especially changes of synapses, might contribute to cognitive impairment after microwave exposure.

Wang H, Peng R, Zhao L, Wang S, Gao Y, Wang L, Zuo H, Dong J, Xu X, Zhou H, Su Z. The relationship between NMDA receptors and microwave induced learning and memory impairment: a long term observation on Wistar rats. Int J Radiat Biol. 2014 Nov 26:1-25. [Epub ahead of print]

Purpose: In the present study, we intended to investigate whether the high power microwave could cause the continuous disorders of learning and memory in Wistar rats and to explore the underlying mechanisms. Materials and methods: 80 Wistar rats were exposed to a 2.856 GHz pulsed microwave source at a power density of 0 mW/cm^2 and 50 mW/cm^2 microwave for 6 min. The spatial memory ability, the structure of the hippocampus, contents of amino acids neurotransmitters in hippocampus and the expression of N-methyl-D-aspartic acid receptors (NMDAR) subunit 1, 2A and 2B (NR1, NR2A and NR2B) were detected at 1 m, 3 m, 6 m, 9 m, 12 m and 18 m after microwave exposure. Results: Our results showed that the microwave exposed rats showed consistent deficiencies in spatial learning and memory. The level of amino acid neurotransmitters also decreased after microwave radiation. The ratio of glutamate (Glu) and gammaaminobutyric acid (GABA) significantly decreased at 6 m. Besides, the

hippocampus showed varying degrees of degeneration of neurons, increased postsynaptic density and blurred synaptic clefts in the exposure group. The NR1 and NR2B expression showed a significant decrease, especially the NR2B expression. Conclusions: This study indicated that the content of amino acids neurotransmitters, the expression of NMDAR subunits and the variation of hippocampal structure might contribute to the long term cognitive impairment after microwave exposure.

Wang J, Koyama S, Komatsubara Y, Suzuki Y, Taki M, Miyakoshi J. Effects of a 2450 MHz high-frequency electromagnetic field with a wide range of SARs on the induction of heat-shock proteins in A172 cells. Bioelectromagnetics. 27(6):479-486, 2006.

In this study, we investigated whether exposure to 2450 MHz high-frequency electromagnetic fields (HFEMFs) could act as an environmental insult to evoke a stress response in A172 cells, using HSP70 and HSP27 as stress markers. The cells were exposed to a 2450 MHz HFEMF with a wide range of specific absorption rates (SARs: 5-200 W/kg) or sham conditions. Because exposure to 2450 MHz HFEMF at 50-200 W/kg SAR causes temperature increases in culture medium, appropriate heat control groups (38-44 degrees C) were also included. The expression of HSP 70 and HSP 27, as well as the level of phosphorylated HSP 27 ((78)Ser) (p-HSP27), was determined by Western blotting. Our results showed that the expression of HSP 70 increased in a time and dose-dependent manner at >50 W/kg SAR for 1-3 h. A similar effect was also observed in corresponding heat controls. There was no significant change in HSP 27 expression caused by HFEMF at 5-200 W/kg or by comparable heating for 1-3 h. However, HSP 27 phosphorylation increased transiently at 100 and 200 W/kg to a greater extent than at 40-44 degrees C. Phosphorylation of HSP 27 reached a maximum after 1 h exposure at 100 W/kg HFEMF. Our results suggest that exposure to a 2450 MHz HFEMF has little or no apparent effect on HSP70 and HSP27 expression, but it may induce a transient increase in HSP27 Phosphorylation in A172 cells at very high SAR (>100 W/kg).

Wang J, Su H, Xie W, Yu S. Mobile Phone Use and The Risk of Headache: A Systematic Review and Meta-analysis of Cross-sectional Studies. Sci Rep. 7(1):12595, 2017.

Headache is increasingly being reported as a detrimental effect of mobile phone (MP) use. However, studies aimed to investigate the association between MP use and headache yielded conflicting results. To assess the consistency of the data on the topic, we performed a systematic review and meta-analysis of the available cross-sectional studies. Published literature from PubMed and other databases were retrieved and screened, and 7 cross-sectional studies were finally included in this meta-analysis. The pooled odds ratio (OR) and 95% confidence interval (CI) were calculated. We found that the risk of headache was increased by 38% in MP user compared with non-MP user (OR, 1.38; 95% CI, 1.18-1.61, $p < 0.001$). Among MP users, the risk of headache was also increased in those who had longer daily call duration (2-15 min vs. <2 min: OR, 1.62; 95% CI, 1.34-1.98, $p < 0.001$; >15 min vs. <2 min: OR, 2.50; 95% CI, 1.76-3.54, $p < 0.001$) and higher daily call frequency (2-4 calls vs. <2 calls: OR, 1.37; 95% CI, 1.07-1.76, $p < 0.001$;

>4 calls vs. <2 calls: OR, 2.52; 95% CI, 1.78-3.58, p < 0.001). Our data indicate that MP use is significantly associated with headache, further epidemiologic and experimental studies are required to affirm and understand this association.

Wang K, Lu JM, Xing ZH, Zhao QR, Hu LQ, Xue L, Zhang J, Mei YA. Effect of 1.8 GHz radiofrequency electromagnetic radiation on novel object associative recognition memory in mice. Sci Rep. 2017 Mar 17;7:44521. doi: 10.1038/srep44521.

Mounting evidence suggests that exposure to radiofrequency electromagnetic radiation (RF-EMR) can influence learning and memory in rodents. In this study, we examined the effects of single exposure to 1.8 GHz RF-EMR for 30 min on subsequent recognition memory in mice, using the novel object recognition task (NORT). RF-EMR exposure at an intensity of >2.2 W/kg specific absorption rate (SAR) power density induced a significant density-dependent increase in NORT index with no corresponding changes in spontaneous locomotor activity. RF-EMR exposure increased dendritic-spine density and length in hippocampal and prefrontal cortical neurons, as shown by Golgi staining. Whole-cell recordings in acute hippocampal and medial prefrontal cortical slices showed that RF-EMR exposure significantly altered the resting membrane potential and action potential frequency, and reduced the action potential half-width, threshold, and onset delay in pyramidal neurons. These results demonstrate that exposure to 1.8 GHz RF-EMR for 30 min can significantly increase recognition memory in mice, and can change dendritic-spine morphology and neuronal excitability in the hippocampus and prefrontal cortex. The SAR in this study (3.3 W/kg) was outside the range encountered in normal daily life, and its relevance as a potential therapeutic approach for disorders associated with recognition memory deficits remains to be clarified.

Wang KJ, Yao K, Lu DQ. [Effects of different dose microwave radiation on protein components of cultured rabbit lens] Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 25(4):208-210, 2007.[Article in Chinese]

OBJECTIVE: To study the effects of different dose microwave radiation on protein components of cultured rabbit lens, and analyze the mechanisms of lens injury caused by microwave radiation. METHODS: Cultured rabbit lens were exposed to microwave radiation with frequency of 2450 MHz and power density of 0.25, 0.50, 1.00, 2.00, 5.00 mW/cm(2) for 8 hours in vitro. The transparency of lens was observed. Changes of protein concentration were detected after different lens protein components were extracted, including water-soluble protein (WSP), urea soluble protein (USP), alkali soluble protein (ASP) and sonicated protein (SP). The influence of microwave radiation on WSP was analyzed using SDS-PAGE electrophoresis and coomassie-blue staining. RESULTS: Transparency of lens decreased after radiation. There was obvious opacification of lens cortex after 5.00 mW/cm(2) microwave radiation for 8 hours. After 1.00, 2.00 and 5.00 mW/cm(2) radiation, the percentage of WSP decreased while USP increased obviously. There was no change of ASP. The percentage of SP decreased when the power of microwave was 5.00 mW/cm(2). The low molecular weight protein of WSP decreased while high molecular weight protein increased after microwave radiation. CONCLUSION: Microwave radiation higher than

1.00 mW/cm(2) can affect the proportion of WSP and USP in cultured rabbit lens, and cause changes of lens transparency and refractive power, which leads to lens opacity.

Wang LF, Li X, Gao YB, Wang SM, Zhao L, Dong J, Yao BW, Xu XP, Chang GM, Zhou HM, Hu XJ, Peng RY. Activation of VEGF/Flk-1-ERK Pathway Induced Blood-Brain Barrier Injury After Microwave Exposure. Mol Neurobiol. 2014 Sep 9. [Epub ahead of print]

Microwaves have been suggested to induce neuronal injury and increase permeability of the blood-brain barrier (BBB), but the mechanism remains unknown. The role of the vascular endothelial growth factor (VEGF)/Flk-1-Raf/MAPK kinase (MEK)/extracellular-regulated protein kinase (ERK) pathway in structural and functional injury of the blood-brain barrier (BBB) following microwave exposure was examined. An in vitro BBB model composed of the ECV304 cell line and primary rat cerebral astrocytes was exposed to microwave radiation (50 mW/cm2, 5 min). The structure was observed by scanning electron microscopy (SEM) and the permeability was assessed by measuring transendothelial electrical resistance (TEER) and horseradish peroxidase (HRP) transmission. Activity and expression of VEGF/Flk-1-ERK pathway components and occludin also were examined. Our results showed that microwave radiation caused intercellular tight junctions to broaden and fracture with decreased TEER values and increased HRP permeability. After microwave exposure, activation of the VEGF/Flk-1-ERK pathway and Tyr phosphorylation of occludin were observed, along with down-regulated expression and interaction of occludin with zonula occludens-1 (ZO-1). After Flk-1 (SU5416) and MEK1/2 (U0126) inhibitors were used, the structure and function of the BBB were recovered. The increase in expression of ERK signal transduction molecules was muted, while the expression and the activity of occludin were accelerated, as well as the interactions of occludin with p-ERK and ZO-1 following microwave radiation. Thus, microwave radiation may induce BBB damage by activating the VEGF/Flk-1-ERK pathway, enhancing Tyr phosphorylation of occludin, while partially inhibiting expression and interaction of occludin with ZO-1.

Wang LL, Chen GD, Lu DQ, Chiang H, Xu ZP. [Global gene response to GSM 1800 MHz radiofrequency electromagnetic field in MCF-7 cells.] Zhonghua Yu Fang Yi Xue Za Zhi. 40(3):159-163, 2006. [Article in Chinese]

OBJECTIVE: To investigate whether GSM 1800 MHz radiofrequency electromagnetic field (RF EMF) can change the gene expression profile in MCF-7 cells and to screen RF EMF responsive genes. METHODS: Subcultured MCF-7 cells were intermittently (5-minute fields on/10-minute fields off) exposed or sham-exposed to GSM 1800 MHz RF EMF, which was modulated by 217 Hz EMF, for 24 hours at an average specific absorption rate (SAR) of 2.0 W/kg or 3.5 W/kg. Immediately after RF EMF exposure or sham-exposure, total RNA was isolated from MCF-7 cells and then purified. Affymetrix Human Genome U133A Genechip was applied to examine the change of gene expression profile according to the manufacturer's instruction. Data was analyzed by Affymetrix Microarray Suite 5.0 (MAS 5.0) and Affymetrix Data Mining Tool 3.0 (DMT 3.0). Quantitative reverse transcription polymerase chain reaction (RT-PCR) was used to

validate the differentially expressed genes identified by Genechip analysis. RESULTS: A small number of differential expression genes were found in each comparison after RF EMF exposure. Through reproducible and consistent analysis, no gene or five up-regulated genes were screened out after exposure to RF EMF at SAR of 2.0 W/kg or 3.5 W/kg, respectively. However, these five genes could not be further confirmed by RT-PCR. CONCLUSION: The present study did not provide clear evidence that RF EMF exposure might distinctly change the gene expression profile in MCF-7 cells under current experimental conditions, implying that the exposure might not affect the MCF-7 cell physiology, or this cell line might be less sensitive to the RF EMF exposure.

Wang Q, Cao ZJ, Bai XT. [Effect of 900 MHz electromagnetic fields on the expression of GABA receptor of cerebral cortical neurons in postnatal rats] Wei Sheng Yan Jiu. 34(5):546-548, 2005.

OBJECTIVE: To investigate the effects of 900 MHz microwave electromagnetic fields (EMF) on the expression of neurotransmitter GABA receptor of cerebral cortical neurons in postnatal rats. METHODS: Neurons were exposed to 900 MHz continuous microwave EMF (SAR = 1.15 - 3.22mW/g) for 2 hours per day in 6 consecutive days and for 12 hours at one time. GABA receptor was chosen to be the biological end. RESULTS: Significant changes had been observed in exposed neurons in the expression of GABA receptor. ($P < 0.01$) . CONCLUSION: The expression of GABA receptor of neurons were significantly regulated by 900 MHz microwave, and a power "window" effect was observed in the exposed neurons.

Wang J, Sakurai T, Koyama S, Komatubara Y, Suzuki Y, Taki M, Miyakoshi J. Effects of 2450 MHz electromagnetic fields with a wide range of SARs on methylcholanthrene-induced transformation in C3H10T1/2 cells. J Radiat Res (Tokyo). 46(3):351-361, 2005.

This study examined whether 2450 MHz continuous wave high frequency electromagnetic fields (HFEMF) could induce cancer-like changes in mouse C3H10T1/2 cells, and whether HFEMF could initiate malignant or synergistic transformation. Transformed foci, Type II and Type III, were independently counted as the experiment endpoint. The cells were exposed to HFEMF alone at a wide range of specific absorption rates (SARs) of 5 to 200 W/kg for 2 h and/or were treated with a known initiating chemical, methylcholanthrene (MC) (2.5 microg/ml). No significant differences were observed in the malignant transformation (Type II + Type III) frequency between the controls and HFEMF with or without 12-O-tetradecanoylphorbol-13-acetate (TPA) (0.5 ng/ml), a tumor promoter that could enhance transformation frequency initiated by MC in multistage carcinogenesis. However, the transformation frequency for HFEMF at SAR of more than 100 W/kg with MC or MC plus TPA was increased compared with MC alone or MC plus TPA. On the other hand, the corresponding heat groups (heat alone, heat + MC, and heat + MC + TPA) did not increase transformation compared with each control level in C3H10T1/2 cells. This result suggests that 2450 MHz HFEMF could not contribute to the initiation stage of tumor formation, but it may contribute to the promotion stage at the extremely high SAR (100 W/kg).

Wang PW, Liu TL, Ko CH, Lin HC, Huang MF, Yeh YC, Yen CF. Association between Problematic Cellular Phone Use and Suicide: The Moderating Effect of

Family Function and Depression. Compr Psychiatry. 2013 Oct 19. pii: S0010-440X(13)00282-4. doi: 10.1016/j.comppsych.2013.09.006. [Epub ahead of print]

BACKGROUND: Suicidal ideation and attempt among adolescents are risk factors for eventual completed suicide. Cellular phone use (CPU) has markedly changed the everyday lives of adolescents. Issues about how cellular phone use relates to adolescent mental health, such as suicidal ideation and attempts, are important because of the high rate of cellular phone usage among children in that age group. This study explored the association between problematic CPU and suicidal ideation and attempts among adolescents and investigated how family function and depression influence the association between problematic CPU and suicidal ideation and attempts. METHODS: A total of 5051 (2872 girls and 2179 boys) adolescents who owned at least one cellular phone completed the research questionnaires. We collected data on participants' CPU and suicidal behavior (ideation and attempts) during the past month as well as information on family function and history of depression. RESULTS: Five hundred thirty-two adolescents (10.54%) had problematic CPU. The rates of suicidal ideation were 23.50% and 11.76% in adolescents with problematic CPU and without problematic CPU, respectively. The rates of suicidal attempts in both groups were 13.70% and 5.45%, respectively. Family function, but not depression, had a moderating effect on the association between problematic CPU and suicidal ideation and attempt. CONCLUSION: This study highlights the association between problematic CPU and suicidal ideation as well as attempts and indicates that good family function may have a more significant role on reducing the risks of suicidal ideation and attempts in adolescents with problematic CPU than in those without problematic CPU.

Wang X, Liu C, Ma Q, Feng W, Yang L, Lu Y, Zhou Z, Yu Z, Li W, Zhang L. 8-oxoG DNA Glycosylase-1 Inhibition Sensitizes Neuro-2a Cells to Oxidative DNA Base Damage Induced by 900 MHz Radiofrequency Electromagnetic Radiation. Cell Physiol Biochem. 2015 Sep 25;37(3):1075-1088. [Epub ahead of print]

BACKGROUND/AIMS: The purpose of this study was to explore the in vitro putative genotoxicity during exposure of Neuro-2a cells to radiofrequency electromagnetic fields (RF-EMFs) with or without silencing of 8-oxoG DNA glycosylase-1 (OGG1). METHODS: Neuro-2a cells treated with or without OGG1 siRNA were exposed to 900 MHz Global System for Mobile Communication (GSM) Talk signals continuously at a specific absorption rate (SAR) of 0, 0.5, 1 or 2 W/kg for 24 h. DNA strand breakage and DNA base damage were measured by the alkaline comet assay and a modified comet assay using formamidopyrimidine DNA glycosylase (FPG), respectively. Reactive oxygen species (ROS) levels and cell viability were monitored using the non-fluorescent probe 2, 7-dichlorofluorescein diacetate (DCFH-DA) and CCK-8 assay. RESULTS: Exposure to 900 MHz RF-EMFs with insufficient energy could induce oxidative DNA base damage in Neuro-2a cells. These increases were concomitant with similar increases in the generation of reactive oxygen species (ROS). Without OGG1 siRNA, 2 W/kg RF-EMFs induced oxidative DNA base damage in Neuro-2a cells. Interestingly, with OGG1 siRNA, RF-EMFs could cause DNA base damage in Neuro-2a cells as low as 1 W/kg. However, neither DNA strand breakage nor altered cell viability was observed. CONCLUSION:

Even if further studies remain conducted we support the hypothesis that OGG1 is involved in the process of DNA base repair and may play a pivotal role in protecting DNA bases from RF-EMF induced oxidative damage.

Wang XW, Ding GR, Shi CH, Zeng LH, Liu JY, Li J, Zhao T, Chen YB, Guo GZ. Mechanisms involved in the blood-testis barrier increased permeability induced by EMP. Toxicology. 276(1):58-63, 2010.

The blood-testis barrier (BTB) plays an important role in male reproductive system. Lots of environmental stimulations can increase the permeability of BTB and then result in antisperm antibody (AsAb) generation, which is a key step in male immune infertility. Here we reported the results of male mice exposed to electromagneticpulse (EMP) by measuring the expression of tight-junction-associated proteins (ZO-1 and Occludin), vimentin microfilaments, and transforming growth factor-beta (TGF-beta3) as well as AsAb level in serum. Male BALB/c mice were sham exposed or exposed to EMP at two different intensities (200kV/m and 400kV/m) for 200 pulses. The testes were collected at different time points after EMP exposure. Immunofluorescence histocytochemistry, western blotting, laser confocal microscopy and RT-PCR were used in this study. Compared with sham group, the expression of ZO-1 and TGF-beta3 significantly decreased accompanied with unevenly stained vimentin microfilaments and increased serum AsAb levels in EMP-exposed mice. These results suggest a potential BTB injury and immune infertility in male mice exposed to a certain intensity of EMP.

Warren HG, Prevatt AA, Daly KA, Antonelli PJ. Cellular telephone use and risk of intratemporal facial nerve tumor. Laryngoscope 113(4):663-667, 2003.

OBJECTIVES/HYPOTHESISMicrowave radiation exposure from cellular telephone use has been implicated in the development of intracranial tumors. The intratemporal facial nerve (IFN) is exposed to higher levels of cellular telephone radiation than intracranial tissues. The purpose of the study was to determine whether cellular telephone use is associated with an increased risk of IFN tumors. STUDY DESIGNCase-control using a structured telephone survey at an academic, tertiary-care referral center. METHODS Patients with IFN tumors (n = 18) were case-matched with patients treated for acoustic neuroma (n = 51), rhinosinusitis (n = 72), and dysphonia or gastroesophageal reflux disease (n = 69). Risk of facial nerve tumorigenesis was compared by extent of cellular telephone use and other risk factors.RESULTSThe odds ratio of developing an IFN tumor was 0.6 (95% CI, 0.2-1.9) with any handheld cellular telephone use and 0.4 (95% CI, 0.1-2.1) with regular cellular telephone use. No factors were associated with an increased risk for IFN tumor development. CONCLUSIONS Regular cellular telephone use does not appear to be associated with a higher risk of IFN tumor development. The short duration of widespread cellular telephone use precludes definite exclusion as a risk for IFN tumor development.

Watilliaux A, Edeline JM, Lévêque P, Jay TM, Mallat M. Effect of exposure to 1,800 MHz electromagnetic fields on heat shock proteins and glial cells in the brain of developing rats. Neurotox Res. 20(2):109-119, 2011.

The increasing use of mobile phones by children raise issues about the effects of electromagnetic fields (EMF) on the immature Central Nervous System (CNS). In the present study, we quantified cell stress and glial responses in the brain of developing rats one day after a single exposure of 2 h to a GSM 1,800 MHz signal at a brain average Specific Absorption Rate (SAR) in the range of 1.7 to 2.5 W/kg. Young rats, exposed to EMF on postnatal days (P) 5 (n = 6), 15 (n = 5) or 35 (n = 6), were compared to pseudo-exposed littermate rats (n = 6 at all ages). We used western blotting to detect heat shock proteins (HSPs) and cytoskeleton- or neurotransmission-related proteins in the developing astroglia. The GSM signal had no significant effect on the abundance of HSP60, HSC70 or HSP90, of serine racemase, glutamate transporters including GLT1 and GLAST, or of glial fibrillary acid protein (GFAP) in either total or soluble tissue extracts. Imunohistochemical detection of CD68 antigen in brain sections from pseudo-exposed and exposed animals did not reveal any differences in the morphology or distribution of microglial cells. These results provide no evidence for acute cell stress or glial reactions indicative of early neural cell damage, in developing brains exposed to 1,800 MHz signals in the range of SAR used in our study.

Wdowiak A, Wdowiak L, Wiktor H. Evaluation of the effect of using mobile phones on male fertility. Ann Agric Environ Med. 14(1):169-172, 2007.

The problem of the lack of offspring is a phenomenon concerning approximately 15% of married couples in Poland. Infertility is defined as inability to conceive after a year of sexual intercourses without the use of contraceptives. In half of the cases the causative factor is the male. Males are exposed to the effect of various environmental factors, which may decrease their reproductive capabilities. A decrease in male fertility is a phenomenon which occurs within years, which may suggest that one of the reasons for the decrease in semen parameters is the effect of the development of techniques in the surrounding environment. A hazardous effect on male fertility may be manifested by a decrease in the amount of sperm cells, disorders in their mobility, as well as structure. The causative agents may be chemical substances, ionizing radiation, stress, as well as electromagnetic waves. The objective of the study was the determination of the effect of the usage of cellular phones on the fertility of males subjected to marital infertility therapy. The following groups were selected from among 304 males covered by the study: Group A: 99 patients who did not use mobile phones, Group B: 157 males who have used GSM equipment sporadically for the period of 1-2 years, and Group C: 48 people who have been regularly using mobile phone for more than 2 years. In the analysis of the effect of GSM equipment on the semen it was noted that an increase in the percentage of sperm cells of abnormal morphology is associated with the duration of exposure to the waves emitted by the GSM phone. It was also confirmed that a decrease in the percentage of sperm cells in vital progressing motility in the semen is correlated with the frequency of using mobile phones.

Weisbrot D, Lin H, Ye L, Blank M, Goodman R. Effects of mobile phone radiation on reproduction and development in Drosophila melanogaster. J Cell Biochem 89(1):48-55, 2003.

In this report we examined the effects of a discontinuous radio frequency (RF) signal produced by a GSM multiband mobile phone (900/1,900 MHz; SAR approximately 1.4 W/kg) on Drosophila melanogaster, during the 10-day developmental period from egg laying through pupation. As found earlier with low frequency exposures, the non-thermal radiation from the GSM mobile phone increased numbers of offspring, elevated hsp70 levels, increased serum response element (SRE) DNA-binding and induced the phosphorylation of the nuclear transcription factor, ELK-1. The rapid induction of hsp70 within minutes, by a non-thermal stress, together with identified components of signal transduction pathways, provide sensitive and reliable biomarkers that could serve as the basis for realistic mobile phone safety guidelines.

Westermark A, Wisten A. Miniplate osteosynthesis and cellular phone create disturbance of infraorbital nerve. J Craniofac Surg 12(5):475-478, 2001.

A 37-year-old man with a zygomatic fracture underwent surgical treatment with reduction of the fracture and osteosynthesis with a miniplate on the infraorbital rim. Postoperatively, he had numbness in the distribution area of the infraorbital nerve, but he also suffered from dysesthesia in the same area during periods when he was using his hand-held mobile phone. After surgical removal of the osteosynthesis plate, the dysesthesia associated with his mobile phone was no longer present. The plate was examined in a setup where we measured the electric current that developed on the surface of the plate under the influence of the magnetic field between the phone antenna and the metal plate. The highest currents measured on the actual plate were 141 mV in air, and 21 mV in saline. These findings indicate that there might have been a correlation between the presence of the miniplate close to the infraorbital nerve, and the dysesthesia experienced by the patient, under the influence of the energy emitted from the cellular phone.

Whitehead TD, Brownstein BH, Parry JJ, Thompson D, Cha BA, Moros EG, Rogers BE, Roti Roti JL. Expression of the Proto-oncogene Fos after Exposure to Radiofrequency Radiation Relevant to Wireless Communications. Radiat Res. 164(4):420-430, 2005.

In this study the expression levels of the proto-oncogene Fos were measured after exposure to radiofrequency (RF) radiation at two relatively high specific absorption rates (SARs) of 5 and 10 W/kg for three types of modulated signals: 847.74 MHz code division multiple access (CDMA), 835.62 MHz frequency division multiple access (FDMA), and 836.55 MHz time division multiple access (TDMA). This work was undertaken to confirm a previous report by Goswami et al. (Radiat. Res. 151, 300-309, 1999) that CDMA and FDMA radiation caused small but statistically significant increases in Fos levels as cells entered plateau phase during exposure. No effects on Myc or Jun levels were observed in that study. Therefore, in the present study, analyses were restricted to Fos expression during the transition from exponential growth to plateau phase. Fos expression was measured using the real-time polymerase chain reaction (RT-PCR) technique. Serum-stimulated C3H 10T(1/2) cells were used as a positive control for Fos expression. Possible influences of final cell number or pH variability on Fos expression were

evaluated. Expression of Fos mRNA in C3H 10T(1/2) cells was not significantly different from that found after sham exposure at either SAR level for any signal modulation. Therefore, the results of Goswami et al. could not be confirmed.

Whitehead TD, Moros EG, Brownstein BH, Roti Roti JLGene expression does not change significantly in C3H 10T(1/2) cells after exposure to 847.74 CDMA or 835.62 FDMA radiofrequency radiation. Radiat Res. 165(6):626-635, 2006.

.In vitro experiments with C3H 10T(1/2) mouse cells were performed to determine whether Frequency Division Multiple Access (FDMA) or Code Division Multiple Access (CDMA) modulated radiofrequency (RF) radiations induce changes in gene expression. After the cells were exposed to either modulation for 24 h at a specific absorption rate (SAR) of 5 W/ kg, RNA was extracted from both exposed and sham-exposed cells for gene expression analysis. As a positive control, cells were exposed to 0.68 Gy of X rays and gene expression was evaluated 4 h after exposure. Gene expression was evaluated using the Affymetrix U74Av2 GeneChip to detect changes in mRNA levels. Each exposure condition was repeated three times. The GeneChip data were analyzed using a two-tailed t test, and the expected number of false positives was estimated from t tests on 20 permutations of the six sham RF-field-exposed samples. For the X-ray-treated samples, there were more than 90 probe sets with expression changes greater than 1.3-fold beyond the number of expected false positives. Approximately one-third of these genes had previously been reported in the literature as being responsive to radiation. In contrast, for both CDMA and FDMA radiation, the number of probe sets with an expression change greater than 1.3-fold was less than or equal to the expected number of false positives. Thus the 24-h exposures to FDMA or CDMA RF radiation at 5 W/kg had no statistically significant effect on gene expression.

Whitehead TD, Moros EG, Brownstein BH, Roti Roti JL. The number of genes changing expression after chronic exposure to Code Division Multiple Access or Frequency DMA radiofrequency radiation does not exceed the false-positive rate. Proteomics. 6(17):4739-4744, 2006.

Experiments with cultured C3H 10T 1/2 cells were performed to determine if exposure to cell phone radiofrequency (RF) radiations induce changes in gene expression. Following a 24 h exposure of 5 W/kg specific adsorption rate, RNA was extracted from the exposed and sham control cells for microarray analysis on Affymetrix U74Av2 Genechips. Cells exposed to 0.68 Gy of X-rays with a 4-h recovery were used as positive controls. The number of gene expression changes induced by RF radiation was not greater than the number of false positives expected based on a sham versus sham comparison. In contrast, the X-irradiated samples showed higher numbers of probe sets changing expression level than in the sham versus sham comparison.

Weyandt, TB, Schrader, SM, Turner, TW, Simon, SD, Semen analysis of military personnel associated with military duty assignments. Reprod Toxicol 10(6):521-528, 1996.

A collaborative study between the U.S. Army Biomedical Research and DevelopmentLaboratory (USABRDL) and the National Institute for Occupational Safety

and Health (NIOSH) was designed to assess fecundity of male artillery soldiers with potential exposures to airborne lead aerosols. Potential exposure assessment was based upon information provided in an interactive questionnaire. It became apparent from extensive questionnaire data that many soldiers in the initial control population had potentially experienced microwave exposure as radar equipment operators. As a result, a third group of soldiers without potential for lead or microwave exposures, but with similar environmental conditions, was selected as a comparison population. Blood hormone levels and semen analyses were conducted on artillerymen (n = 30), radar equipment operators (n = 20), and the comparison group (n = 31). Analysis of the questionnaire information revealed that concern about fertility problems motivated participation of some soldiers with potential artillery or microwave exposures. Although small study population size and the confounding variable of perceived infertility limit the reliability of the study, several statistically significant findings wereidentified. Artillerymen who perceived a possible fertility concern demonstrated lower sperm counts/ejaculate (P = 0.067) and lower sperm/mL (P = 0.014) than the comparison group. The group of men with potential microwave exposures demonstrated lower sperm counts/mL (P = 0.009) and sperm/ejaculate (P = 0.027) than the comparison group. Variables used to assess endocrine, accessory sex gland, and sperm cell function were not different than the comparison group. Additional studies, incorporating larger numbers of individuals, should be performed in order to more optimally characterize potential lead and microwave exposure effects on male fecundity.

Wiholm C, Lowden A, Kuster N, Hillert L, Arnetz BB, Akerstedt T, Moffat SD Mobile phone exposure and spatial memory. Bioelectromagnetics.30(1):59-65, 2009.

Radiofrequency (RF) emission during mobile phone use has been suggested to impair cognitive functions, that is, working memory. This study investigated the effects of a 2 1/2 h RF exposure (884 MHz) on spatial memory and learning, using a double-blind repeated measures design. The exposure was designed to mimic that experienced during a real-life mobile phone conversation. The design maximized the exposure to the left hemisphere. The average exposure was peak spatial specific absorption rate (psSAR10g) of 1.4 W/kg. The primary outcome measure was a "virtual" spatial navigation task modeled after the commonly used and validated Morris Water Maze. The distance traveled on each trial and the amount of improvement across trials (i.e., learning) were used as dependent variables. The participants were daily mobile phone users, with and without symptoms attributed to regular mobile phone use. Results revealed a main effect of RF exposure and a significant RF exposure by group effect on distance traveled during the trials. The symptomatic group improved their performance during RF exposure while there was no such effect in the non-symptomatic group. Until this new finding is further investigated, we can only speculate about the cause.

Wilen J, Sandstrom M, Hansson Mild K. Subjective symptoms among mobile phone users-A consequence of absorption of radiofrequency fields? Bioelectromagnetics 24(3):152-159, 2003.

In a previous epidemiological study, where we studied the prevalence of subjective symptoms among mobile phone (MP) users, we found as an interesting side finding that the prevalence of many of the subjective symptoms increased with increasing calling time

and number of calls per day. In this extrapolative study, we have selected 2402 people from the epidemiological study who used any of the four most common GSM MP. We used the information about the prevalence of symptoms, calling time per day, and number of calls per day and combined it with measurements of the Specific Absorption Rate (SAR). We defined three volumes in the head and measured the maximum SAR averaged over a cube of 1 g tissue (SAR(1g)) in each volume. Two new exposure parameters Specific Absorption per Day (SAD) and Specific Absorption per Call (SAC) have been devised and are obtained as combinations of SAR, calling time per day, and number of calls per day, respectively. The results indicates that SAR values >0.5 W/kg may be an important factor for the prevalence of some of the symptoms, especially in combination with long calling times per day.

Wilen J, Hornsten R, Sandstrom M, Bjerle P, Wiklund U, Stensson O, Lyskov E, Mild KH. Electromagnetic field exposure and health among RF plastic sealer operators. Bioelectromagnetics. 25(1): 5-15, 2004.

Operators of RF plastic sealers (RF operators) are an occupational category highly exposed to radiofrequency electromagnetic fields. The aim of the present study was to make an appropriate exposure assessment of RF welding and examine the health status of the operators. In total, 35 RF operators and 37 controls were included. The leakage fields (electric and magnetic field strength) were measured, as well as induced and contact current. Information about welding time and productivity was used to calculate time integrated exposure. A neurophysiological examination and 24 h ECG were also carried out. The participants also had to answer a questionnaire about subjective symptoms. The measurements showed that RF operators were exposed to rather intense electric and magnetic fields. The mean values of the calculated 6 min, spatially averaged E and H field strengths, in line with ICNIRP reference levels, are 107 V/m and 0.24 A/m, respectively. The maximum measured field strengths were 2 kV/m and 1.5 A/m, respectively. The induced current in ankles and wrists varied, depending on the work situation, with a mean value of 101 mA and a maximum measured value of 1 A. In total, 11 out of 46 measured RF plastic sealers exceeded the ICNIRP reference levels. RF operators, especially the ready made clothing workers had a slightly disturbed two-point discrimination ability compared to a control group. A nonsignificant difference between RF operators and controls was found in the prevalence of subjective symptoms, but the time integrated exposure parameters seem to be of importance to the prevalence of some subjective symptoms: fatigue, headaches, and warmth sensations in the hands. Further, RF operators had a significantly lower heart rate (24 h registration) and more episodes of bradycardia compared to controls.

Wilen J, Johansson A, Kalezic N, Lyskov E, Sandstrom M. Psychophysiological tests and provocation of subjects with mobile phone related symptoms. Bioelectromagnetics.27(3):204-214, 2006.

The aim of the present study was to investigate the effect of exposure to a mobile phone-like radiofrequency (RF) electromagnetic field on persons experiencing subjective symptoms when using mobile phones (MP). Twenty subjects with MP-related symptoms were recruited and matched with 20 controls without MP-related symptoms. Each subject participated in two experimental sessions, one with true exposure and one with sham

exposure, in random order. In the true exposure condition, the test subjects were exposed for 30 min to an RF field generating a maximum SAR(1g) in the head of 1 W/kg through an indoor base station antenna attached to a 900 MHz GSM MP. The following physiological and cognitive parameters were measured during the experiment: heart rate and heart rate variability (HRV), respiration, local blood flow, electrodermal activity, critical flicker fusion threshold (CFFT), short-term memory, and reaction time. No significant differences related to RF exposure conditions were detected. Also no differences in baseline data were found between subject groups, except for the reaction time, which was significantly longer among the cases than among the controls the first time the test was performed. This difference disappeared when the test was repeated. However, the cases differed significantly from the controls with respect to HRV as measured in the frequency domain. The cases displayed a shift in low/high frequency ratio towards a sympathetic dominance in the autonomous nervous system during the CFFT and memory tests, regardless of exposure condition. This might be interpreted as a sign of differences in the autonomous nervous system regulation between persons with MP related subjective symptoms and persons with no such symptoms.

Wilén J, Wiklund U, Hörnsten R, Sandström M. Changes in heart rate variability among RF plastic sealer operators. Bioelectromagnetics. 28(1):76-79, 2007.

In a previous study, we showed that operators of radiofrequency (RF) plastic sealers, RF operators (n = 35) had a lower heart rate during nighttime compared to a control group (n = 37). We have analyzed the heart rate variability (HRV) on the same group of people to better understand the possible underlying rhythm disturbances. We found a significantly increased total HRV and very low frequency (VLF) power during nighttime among the RF operators compared to a control group. Together with our previous finding of a significantly lower heart rate during nighttime among the RF operators compared to the controls, this finding indicates a relative increase in parasympathetic cardiac modulation in RF operators. This could in turn be due to an adaptation of the thermoregulatory system and the cardiac autonomic modulation to a long-term low-level thermal exposure in the RF operators.

Wilke A, Grimm W, Funck R, Maisch B, Influence of D-net (European GSM -Standard) cellular phones on pacemaker function in 50 patients with permanent pacemakers. Pacing Clin Electrophysiol 19(10):1456-1458, 1996.

The widespread use of cellular phones in the last years has prompted some recent studies to suggest an interference of pacemaker function by cellular phone usage. To determine the risk of pacemaker patients using D-net cellular phones, we tested 50 patients with permanent pacemakers after routine pacemaker check by short phone calls using a cellular phone (Ericsson, D-net, frequency 890-915 MHz, digital information coding, equivalent to the European Groupe Systemes Mobiles standard). A six-channel surface ECG was continuously recorded from each patient to detect any interactions between pacemakers and cellular phones. Phone calls were repeated during the following pacemaker settings: (1) preexisting setting; (2) minimum ventricular rate of 90 beats/min and preexisting sensitivity; and (3) minimum ventricular rate of 90 beats/min and

maximum sensitivity without T wave oversensing. Only 2 (4%) of 50 patients repeatedly showed intermittent pacemaker inhibition during calls with the cellular phone. Both pacemakers had unipolar sensing. Therefore, although interactions between cellular phone use and pacemaker function appear to be rare in our study, pacemaker dependent patients in particular should avoid the use of cellular phones.

Wolf R, Wolf D. Increased incidence of cancer near a cell-phone transmitter station. Inter J Cancer Prev 1(2):123-128, 2004.

Significant concern has been raised about possible health effects from exposure to radiofrequency (RF) electromagnetic fields, especially after the rapid introduction of mobile telecommunication systems. Parents are especially concerned with the possibility that children might develop cancer after exposure to the RF emissions from mobile telephone base stations erected in or near schools. The few epidemiologic studies that did report on cancer incidence in relation to RF radiation have generally presented negative or inconsistent results, and thus emphasized the need for more studies that should investigate cohorts with high RF exposure for changes in cancer incidence. The aim of this study is to investigate whether there is an increased cancer incidence in populations, living in a small area, and exposed to RF radiation from a cell-phone transmitter station.

This is an epidemiologic assessment, to determine whether the incidence of cancer cases among individuals exposed to a cell-phone transmitter station is different from that expected in Israel, in Netanya, or as compared to people who lived in a nearby area. Participants are people (n=622) living in the area near a cell-phone transmitter station for 3-7 years who were patients of one health clinic (of DW). The exposure began 1 year before the start of the study when the station first came into service. A second cohort of individuals (n=1222) who get their medical services in a clinic located nearby with very closely matched, environment, workplace and occupational characteristics was used for comparison.

In the area of exposure (area) eight cases of different kinds of cancer were diagnosed in a period of only one year. This rate of cancers was compared both with the rate of 31 cases per 10,000 per year in the general population and the 2/1222 rate recorded in the nearby clinic (area B). Relative cancer rates for female were 10.5 for area A. 0.6 for area B and 1 for the whole town of Netanya. Cancer incidence of women in area A was thus significantly higher ($p<0.0001$) compared with that of area B and the whole city. A comparison of the relative risk revealed that there were 4.15 times more cases in area than in the entire population. The study indicates an association between increased incidence of cancer and living in proximity to a cell-phone transmitter station.

Wolke S, Neibig U, Elsner R, Gollnick F, Meyer R, Calcium homeostasis of isolated heart muscle cells exposed to pulsed high-frequency electromagnetic fields. Bioelectromagnetics 17(2):144-153, 1996.

The intracellular calcium concentration ([Ca(2+)]i) of isolated ventricular cardiac myocytes of the guinea pig was measured during the application of pulsed high-frequency electromagnetic fields. The high-frequency fields were applied in a transverse

electromagnetic cell designed to allow microscopic observation of the myocytes during the presence of the high-frequency fields. The [Ca(2+)]i was measured as fura-2 fluorescence by means of digital image analysis. Both the carrier frequency and the square-wave pulse-modulation pattern were varied during the experiments (carrier frequencies: 900, 1,300, and 1,800 MHz pulse modulated at 217Hz with 14 percent duty cycle; pulsation attern at 900 MHz: continuous wave, 16 Hz, and 50 Hz modulation with 50 percent duty cycle and 30 kHz modulation with 80 percent duty cycle). The mean specific absorption rate (SAR) values in the solution were within one order of magnitude of **1 mW/kg**. They varied depending on the applied carrier frequency and pulse pattern. The experiments were designed in three phases: 500 s of sham exposure, followed by 500 s of field exposure, then chemical stimulation without field. The chemical stimulation (K+ -depolarization) indicated the viability of the cells. The K+ depolarization yielded a significant increase in [Ca(2+)]i. Significant differences between sham exposure and high-frequency field exposure were not found except when a very small but statistically significant difference was detected in the case of 900 MHz/50 Hz. However, this small difference was not regarded as a relevant effect of the exposure.

Wood A, Loughran S, Stough C, Does evening exposure to mobile phone radiation affect subsequent melatonin production? Int. J. Rad. Biol 82:69-76, 2006.

Purpose: To test whether exposure to the emissions from a digital mobile phone handset prior to sleep alters the secretion of melatonin. Materials and methods: In a double-blind cross-over design, 55 adult volunteers were both actively exposed or sham-exposed (in random order on successive Sunday nights) to mobile phone emissions for 30 min (0.25 W average power). Urine collection occurred immediately prior to retiring to bed and on rising the next morning. Melatonin output was estimated from principal metabolite concentrations (6-sulphatoxymelatonin (aMT6s) via radioimmunoassay), urine volumes and creatinine concentrations. Results: Total melatonin metabolite output (concentration×urine volume) was unchanged between the two exposure conditions (active 14.1±1.1 µg; sham 14.6±1.3 µg). The pre- and post-bedtime outputs considered separately were also not significantly different, although the pre-bedtime value was less for active versus sham exposure. When melatonin metabolite output was estimated from the ratio of aMT6s to creatinine concentrations, the pre-bedtime value was significantly less (p = 0.037) for active compared to sham. Examination of individual responses is suggestive of a small group of `responders'. Conclusions: Total nighttime melatonin output is unchanged by mobile phone handset emissions, but there could be an effect on melatonin onset time.

Wu RY, Chiang H, Shao BJ, Li NG, Fu YD, Effects of 2.45-GHz microwave radiation and phorbol ester 12-O-tetradecanoylphorbol-13-acetate on dimethylhydrazine-induced colon cancer in mice. Bioelectromagnetics 15(6):531-538, 1994.

The purpose of this study was to investigate the effects of 2.45 GHz microwave (MW) radiation on dimethylhydrazine (DMH)-induced colon cancer in mice. The subjects were 115 Balb/c mice 4 weeks of age. The animals were divided into group A (control), group B (DMH), group C (DMH+MW), and group D [DMH + 12-O-tetradecanoylphorbol-13-acetate (TPA)]. Radiation (10 mW/cm2) was delivered dorsally with the E field parallel to the mouse's long body axis in an anechoic chamber. Radiations were administered 3 hr

daily, 6 days per week, over a period of 5 months. The average SAR was estimated to be 10-12 W/kg. During the course of radiation treatments, DMH was injected once per week. The tumor promoter TPA was administered once per week for 10 weeks, from the third week on, after the initial treatment. The incidence of tumors did not significantly differ between the three test groups (groups B, C, and D; $P > 0.25$). However, the number of tumors, the size of the tumors, and the incidence of protuberant and infiltrative types in tumor-bearing animals were higher in group D compared to groups B and C ($P < 0.05$). No difference was found between groups B and C ($P > 0.25$). The study indicates that 2.45 GHz microwave radiation at 10 mW/cm2 power density did not promote DMH-induced colon cancers in young mice. The study also showed that TPA could accelerate colon tumor production if a tumor was initiated.

Wu T, Shao Q, Yang L, Qi D, Lin J, Lin X, Yu Z. A large-scale measurement of electromagnetic fields near GSM base stations in Guangxi, China for risk communication. Radiat Prot Dosimetry. 155(1):25-31, 2013.

Radiofrequency (RF) electromagnetic field (EMF) exposure from wireless telecommunication base station antennae can lead to debates, conflicts or litigations among the adjacent residents if inappropriately managed. This paper presents a measurement campaign for the GSM band EMF exposure in the vicinity of 827 base station sites (totally 6207 measurement points) in Guangxi, China. Measurement specifications are designed for risk communication with the residents who previously complained of over-exposure. The EMF power densities with the global positioning system coordinate at each measured point were recorded. Compliance with the International Commission on Non-Ionizing Radiation Protection guidelines and Chinese environmental EMF safety standards was studied. The results show that the GSM band EMF level near the base stations is very low. The measurement results and the EMF risk communication procedures positively influence public perception of the RF EMF exposure from the base stations and promote the exchange of EMF exposure-related knowledge.

Wu W, Yao K, Wang KJ, Lu DQ, He JL, Xu LH, Sun WJ. [Blocking 1800 MHz mobile phone radiation-induced reactive oxygen species production and DNA damage in lens epithelial cells by noise magnetic fields.] Zhejiang Da Xue Xue Bao Yi Xue Ban. 37(1):34-38, 2008. [Article in Chinese]

OBJECTIVE: To investigate whether the exposure to the electromagnetic noise can block reactive oxygen species (ROS) production and DNA damage of lens epithelial cells induced by 1800 MHz mobile phone radiation. METHODS: The DCFH-DA method and comet assay were used respectively to detect the intracellular ROS and DNA damage of cultured human lens epithelial cells induced by 4 W/kg 1800 MHz mobile phone radiation or/and 2microT electromagnetic noise for 24 h intermittently. RESULT: 1800 MHz mobile phone radiation at 4 W/kg for 24 h increased intracellular ROS and DNA damage significantly ($P<0.05$). However, the ROS level and DNA damage of mobile phone radiation plus noise group were not significant enhanced ($P>0.05$) as compared to sham exposure group. Conclusion: Electromagnetic noise can block intracellular ROS production and DNA damage of human lens epithelial

cells induced by 1800 MHz mobile phone radiation.

Wu Y, Jia Y, Guo Y, Zheng Z, Influence of EMP on the nervous system of rats. ACTA Biophysica Sinica 15:152-157, 1999.

To explore the effects of electromagnetic pulse (EMP) exposure on the nervous system of rats, Wistar rats were divided into four groups: three exposure groups and one normal control group. The measurement of ability of learning of rats was carried out with a y-maze, followed by the detection of the content of neurotransmitters in different areas of cerebrum. Compared with control group, in the following three days of EMP exposure, the ability of learning of exposed groups was decreased (P< 0.05). For one day group, in hippocampus, the content of 5-HT and DOPAC increased (P< 0.05), and in hypothalamus, the content of dopamine increased (P< 0.05), while the content of Adr decreased (p< 0.05). the content of Adr and 5-HT in hippocampus of the second day group was reduced (P< 0.05). the content of Adr in hippocampus of the third day group was still lower than that of control group (P< 0.05). According to the results above, we can conclude that EMP exposure results in changes of the content of neurotransmitters in different cerebral areas of rats, lowering their ability of learning.

Xiong L, Sun CF, Zhang J, Gao YB, Wang LF, Zuo HY, Wang SM, Zhou HM, Xu XP, Dong J, Yao BW, Zhao L, Peng RY. Microwave Exposure Impairs Synaptic Plasticity in the Rat Hippocampus and PC12 Cells through Over-activation of the NMDA Receptor Signaling Pathway. Biomed Environ Sci. 28(1):13-24, 2015.

OBJECTIVE: The aim of this study is to investigate whether microwave exposure would affect the N-methyl-D-aspartate receptor (NMDAR) signaling pathway to establish whether this plays a role in synaptic plasticity impairment. METHODS: 48 male Wistar rats were exposed to 30 mW/cm2 microwave for 10 min every other day for three times. Hippocampal structure was observed through H&E staining and transmission electron microscope. PC12 cells were exposed to 30 mW/cm2 microwave for 5 min and the synapse morphology was visualized with scanning electron microscope and atomic force microscope. The release of amino acid neurotransmitters and calcium influx were detected. The expressions of several key NMDAR signaling molecules were evaluated. RESULTS: Microwave exposure caused injury in rat hippocampal structure and PC12 cells, especially the structure and quantity of synapses. The ratio of glutamic acid and gamma-aminobutyric acid neurotransmitters was increased and the intracellular calcium level was elevated in PC12 cells. A significant change in NMDAR subunits (NR1, NR2A, and NR2B) and related signaling molecules (Ca2+/calmodulin-dependent kinase II gamma and phosphorylated cAMP-response element binding protein) were examined. CONCLUSION: 30 mW/cm2 microwave exposure resulted in alterations of synaptic structure, amino acid neurotransmitter release and calcium influx. NMDAR signaling molecules were closely associated with impaired synaptic plasticity.

Xu Q, Tong J, Jin ZD, Lu MX, DU HB, Cao Y. [Radiation protection and possible mechanisms for low intensity microwave.] Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 27(9):520-524, 2009. [Article in Chinese]

OBJECTIVE: To investigate radiation protection and possible mechanisms of low

intensity microwave on gamma-ray exposed mice. METHODS: 96 healthy Kunming mice were randomly divided into the following four groups: normal control, microwave (120 microW/cm(2), 900 MHz), gamma-ray irradiation (5 Gy), combined exposure of microwave and gamma-ray (120 microW/cm(2) + 5 Gy). The microwave group and combined group were exposed to 120 microW/cm(2) microwave firstly, 1 h/d, for 14 days. Then the ionization and combined group were exposed to 5 Gy (60)Co gamma-ray irradiation on the 15th day. Animals were sacrificed on the third, 6th, 9th and 12th day after irradiation. The sternum and spleen paraffin section were produced, and the histological changes were observed. Apoptosis rate of mice splenic cells in each group was examined by flow cytometry, and serum concentration of antioxidase and lipid peroxide was detected at the same time. RESULTS: Bone marrow was obviously injured either by radiation or microwave exposure, characterized by undergoing four-phase lesions, namely apoptosis-necrosis, void, regeneration and recovery phase. Compared with the gamma-ray group, the pathological changes in combined group were slighter and the recovery was quicker. The pathological injuries of spleen were similar to that of bone marrow. Injuries in the combined group were slighter than gamma-ray group. It showed that apoptosis rate of splenic cells in combined group was significantly lower on the 6th and 9th day after gamma-ray radiation (23.02% +/- 15.18%, 25.37% +/- 11.62% respectively) from FCM results. Assays of oxidative damages suggested that serum superoxide dismutase (SOD) level in combined group increased while lipid peroxide level decreased significantly ($P < 0.05$). CONCLUSION: Low intensity microwave may exert protection effects on injuries induced by ionizing radiation. The underlying mechanisms might be related with suppression on the hematopoietic cells apoptosis induced by gamma-ray radiation, inhibition of oxidative damages, and thus enhanced reconstruction of the hematopoietic system.

Xu S, Ning W, Xu Z, Zhou S, Chiang H, Luo J. Chronic exposure to GSM 1800-MHz microwaves reduces excitatory synaptic activity in cultured hippocampal neurons. Neurosci Lett.398(3):253-257,2006.

The world wide proliferation of mobile phones raises the concern about the health effects of 1800-MHz microwaves on the brain. The present study assesses the effects of microwave exposure on the function of cultured hippocampal neurons of rats using whole cell patch-clamp analysis combined with immunocytochemistry. We showed that chronic exposure (15min per day for 8 days) to Global System for Mobile Communication (GSM) 1800-MHz microwaves at specific absorption rate (SAR) of 2.4W/kg induced a selective decrease in the amplitude of alpha-amino-3-hydroxy-5-methyl-4-soxazole propionic acid (AMPA) miniature excitatory postsynaptic currents (mEPSCs), whereas the frequency of AMPA mEPSCs and the amplitude of N-methyl-d-aspartate (NMDA) mEPSCs did not change. Furthermore, the GSM microwave treatment decreased the expression of postsynaptic density 95 (PSD95) in cultured neurons. Our results indicated that 2.4W/kg GSM 1800-MHz microwaves may reduce excitatory synaptic activity and the number of excitatory synapses in cultured rat hippocampal neurons.

Xu S, Zhou Z, Zhang L, Yu Z, Zhang W, Wang Y, Wang X, Li M, Chen Y, Chen C, He M, Zhang G, Zhong M. Exposure to 1800 MHz radiofrequency radiation

induces oxidative damage to mitochondrial DNA in primary cultured neurons. Brain Res. 1311:189-196. 2010.

Increasing evidence indicates that oxidative stress may be involved in the adverse effects of radiofrequency (RF) radiation on the brain. Because mitochondrial DNA (mtDNA) defects are closely associated with various nervous system diseases and mtDNA is highly susceptible to oxidative stress, the purpose of this study was to determine whether radiofrequency radiation can cause oxidative damage to mtDNA. In this study, we exposed primary cultured cortical neurons to pulsed RF electromagnetic fields at a frequency of 1800 MHz modulated by 217 Hz at an average special absorption rate (SAR) of 2 W/kg. At 24h after exposure, we found that RF radiation induced a significant increase in the levels of 8-hydroxyguanine (8-OHdG), a common biomarker of DNA oxidative damage, in the mitochondria of neurons. Consistent with this finding, the copy number of mtDNA and the levels of mitochondrial RNA (mtRNA) transcripts showed an obvious reduction after RF exposure. Each of these mtDNA disturbances could be reversed by pretreatment with melatonin, which is known to be an efficient in the brain. Together, these results suggested that 1800 MHz RF radiation could cause oxidative damage to mtDNA in primary cultured neurons. Oxidative damage to mtDNA may account for the neurotoxicity of RF radiation in the brain.

Xu S, Chen G, Chen C, Sun C, Zhang D, Murbach M, Kuster N, Zeng Q, Xu Z. Cell Type-Dependent Induction of DNA Damage by 1800 MHz Radiofrequency Electromagnetic Fields Does Not Result in Significant Cellular Dysfunctions. PLoS One. 2013;8(1):e54906.

BACKGROUND: Although IARC clarifies radiofrequency electromagnetic fields (RF-EMF) as possible human carcinogen, the debate on its health impact continues due to the inconsistent results. Genotoxic effect has been considered as a golden standard to determine if an environmental factor is a carcinogen, but the currently available data for RF-EMF remain controversial. As an environmental stimulus, the effect of RF-EMF on cellular DNA may be subtle. Therefore, more sensitive method and systematic research strategy are warranted to evaluate its genotoxicity. **OBJECTIVES:** To determine whether RF-EMF does induce DNA damage and if the effect is cell-type dependent by adopting a more sensitive method γH2AX foci formation; and to investigate the biological consequences if RF-EMF does increase γH2AX foci formation. **METHODS:** Six different types of cells were intermittently exposed to GSM 1800 MHz RF-EMF at a specific absorption rate of 3.0 W/kg for 1 h or 24 h, then subjected to immunostaining with anti-γH2AX antibody. The biological consequences in γH2AX-elevated cell type were further explored with comet and TUNEL assays, flow cytometry, and cell growth assay. **RESULTS:** Exposure to RF-EMF for 24 h significantly induced γH2AX foci formation in Chinese hamster lung cells and Human skin fibroblasts (HSFs), but not the other cells. However, RF-EMF-elevated γH2AX foci formation in HSF cells did not result in detectable DNA fragmentation, sustainable cell cycle arrest, cell proliferation or viability change. RF-EMF exposure slightly but not significantly increased the cellular ROS level. **CONCLUSIONS:** RF-EMF induces DNA damage in a cell type-dependent manner, but

the elevated γH2AX foci formation in HSF cells does not result in significant cellular dysfunctions.

Yadav AS, Sharma MK. Increased frequency of micronucleated exfoliated cells among humans exposed in vivo to mobile telephone radiations. Mutat Res. 650(2):175-180, 2008.

The health concerns have been raised following the enormous increase in the use of wireless mobile telephones throughout the world. This investigation had been taken, with the motive to find out whether mobile phone radiations cause any in vivo effects on the frequency of micronucleated exfoliated cells in the exposed subjects. A total of 109 subjects including 85 regular mobile phone users (exposed) and 24 non-users (controls) had participated in this study. Exfoliated cells were obtained by swabbing the buccal-mucosa from exposed as well as sex-age-matched controls. One thousand exfoliated cells were screened from each individual for nuclear anomalies including micronuclei (MN), karyolysis (KL), karyorrhexis (KH), broken egg (BE) and binucleated (BN) cells. The average daily duration of exposure to mobile phone radiations is 61.26min with an overall average duration of exposure in term of years is 2.35 years in exposed subjects along with the 9.84+/-0.745 micronucleated cells (MNCs) and 10.72+/-0.889 total micronuclei (TMN) as compared to zero duration of exposure along with average 3.75+/-0.774 MNC and 4.00+/-0.808 TMN in controls. The means are significantly different in case of MNC and TMN at 0.01% level of significance. The mean of KL in controls is 13.17+/-2.750 and in exposed subjects is 13.06+/-1.793. The value of means of KH in exposed subjects (1.84+/-0.432) is slightly higher than in controls (1.42+/-0.737). Mean frequency of broken egg is found to be more in exposed subjects (0.65+/-0.276) as compared to controls (0.50+/-0.217). Frequency of presence of more than one nucleus in a cell (binucleated) is also higher in exposed (2.72+/-0.374) in comparison to controls (0.67+/-0.231). Although there is a slight increase in mean frequency of KH, BE and BN in exposed subjects but the difference is not found statistically significant. Correlation between 0-1, 1-2, 2-3 and 3-4 years of exposure and the frequency of MNC and TMN has been calculated and found to be positively correlated.

Yakymenko I, Sidorik E, Kyrylenko S, Chekhun V. Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems.Exp Oncol. 33(2):62-70, 2011.

In this review we discuss alarming epidemiological and experimental data on possible carcinogenic effects of long term exposure to low intensity microwave (MW) radiation. Recently, a number of reports revealed that under certain conditions the irradiation by low intensity MW can substantially induce cancer progression in humans and in animal models. The carcinogenic effect of MW irradiation is typically manifested after long term (up to 10 years and more) exposure. Nevertheless, even a year of operation of a powerful base transmitting station for mobile communication reportedly resulted in a dramatic increase of cancer incidence among population living nearby. In addition, model studies in rodents unveiled a significant increase in carcinogenesis after 17-24 months of MW exposure both in tumor-prone and intact animals. To that, such metabolic changes, as

overproduction of reactive oxygen species, 8-hydroxi-2-deoxyguanosine formation, or ornithine decarboxylase activation under exposure to low intensity MW confirm a stress impact of this factor on living cells. We also address the issue of standards for assessment of biological effects of irradiation. It is now becoming increasingly evident that assessment of biological effects of non-ionizing radiation based on physical (thermal) approach used in recommendations of current regulatory bodies, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines, requires urgent reevaluation. We conclude that recent data strongly point to the need for re-elaboration of the current safety limits for non-ionizing radiation using recently obtained knowledge. We also emphasize that the everyday exposure of both occupational and general public to MW radiation should be regulated based on a precautionary principles which imply maximum restriction of excessive exposure.

Yamaguchi H, Tsurita G, Ueno S, Watanabe S, Wake K, Taki M, Nagawa H. 1439 MHz pulsed TDMA fields affect performance of rats in a T-maze task only when body temperature is elevated. Bioelectromagnetics 24(4):223-230, 2003.

This study sought to clarify the effects of exposure to electromagnetic waves (EMW) used in cellular phones on learning and memory processes. Sprague-Dawley rats were exposed for either 1 h daily for 4 days or for 4 weeks to a pulsed 1439 MHz time division multiple access (TDMA) field in a carousel type exposure system. At the brain, average specific absorption rate (SAR) was 7.5 W/kg, and the whole body average SAR was 1.7 W/kg. Other subjects were exposed at the brain average SAR of 25 W/kg and the whole body average SAR of 5.7 W/kg for 45 min daily for 4 days. Learning and memory were evaluated by reversal learning in a food rewarded T-maze, in which rats learned the location of food (right or left) by using environmental cues. The animals exposed to EMW with the brain average SAR of 25 W/kg for 4 days showed statistically significant decreases in the transition in number of correct choices in the reversal task, compared to sham exposed or cage control animals. However, rats exposed to the brain average SAR of 7.5 W/kg for either 4 days or for 4 weeks showed no T-maze performance impairments. Intraperitoneal temperatures, as measured by a fiber optic thermometer, increased in the rats exposed to the brain average SAR of 25 W/kg but remained the same for the brain average SAR of 7.5 W/kg. The SAR of a standard cellular phone is restricted to a maximum of 2 W/kg averaged over 10 g tissue. These results suggest that the exposure to a TDMA field at levels about four times stronger than emitted by cellular phones does not affect the learning and memory processes when there are no thermal effects.

Yan JG, Agresti M, Bruce T, Yan YH, Granlund A, Matloub HS. Effects of cellular phone emissions on sperm motility in rats. Fertil Steril.88(4):957-64, 2007.

OBJECTIVE: To evaluate the effects of cellular phone emissions on rat sperm cells. DESIGN: Classic experimental. SETTING: Animal research laboratory. SUBJECTS: Sixteen 3-month-old male Sprague-Dawley rats, weighing 250-300 g. INTERVENTION(S): Rats in the experimental group were exposed to two 3-hour periods of daily cellular phone emissions for 18 weeks; sperm samples were then collected for evaluation. MAIN OUTCOME MEASURE(S): Evaluation of sperm motility, sperm cell morphology, total sperm cell number, and mRNA levels for two

cell surface adhesion proteins. RESULT(S): Rats exposed to 6 hours of daily cellular phone emissions for 18 weeks exhibited a significantly higher incidence of sperm cell death than control group rats through chi-squared analysis. In addition, abnormal clumping of sperm cells was present in rats exposed to cellular phone emissions and was not present in control group rats. CONCLUSION(S): These results suggest that carrying cell phones near reproductive organs could negatively affect male fertility.

Yan JG, Agresti M, Zhang LL, Yan Y, Matloub HS. Upregulation of specific mRNA levels in rat brain after cell phone exposure. Electromagn Biol Med. 27(2):147-154, 2008.

Adult Sprague-Dawley rats were exposed to regular cell phones for 6 h per day for 126 days (18 weeks). RT-PCR was used to investigate the changes in levels of mRNA synthesis of several injury-associated proteins. Calcium ATPase, Neural Cell Adhesion Molecule, Neural Growth Factor, and Vascular Endothelial Growth Factor were evaluated. The results showed statistically significant mRNA up-regulation of these proteins in the brains of rats exposed to cell phone radiation. These results indicate that relative chronic exposure to cell phone microwave radiation may result in cumulative injuries that could eventually lead to clinically significant neurological damage.

Yang L, Hao D, Wang M, Zeng Y, Wu S, Zeng Y. Cellular Neoplastic Transformation Induced by 916 MHz Microwave Radiation. Cell Mol Neurobiol.32(6):1039-1046, 2012.

There has been growing concern about the possibility of adverse health effects resulting from exposure to microwave radiations, such as those emitted by mobile phones. The purpose of this study was to investigate the cellular neoplastic transformation effects of electromagnetic fields. 916 MHz continuous microwave was employed in our study to simulate the electromagnetic radiation of mobile phone. NIH/3T3cells were adopted in our experiment due to their sensitivity to carcinogen or cancer promoter in environment. They were divided randomly into one control group and three microwave groups. The three microwave groups were exposed to 916 MHz EMF for 2 h per day with power density of 10, 50, and 90 w/m(2), respectively, in which 10 w/m(2) was close to intensity near the antenna of mobile phone. The morphology and proliferation of NIH/3T3cells were examined and furthermore soft agar culture and animal carcinogenesis assay were carried out to determine the neoplastic promotion. Our experiments showed NIH/3T3cells changed in morphology and proliferation after 5-8 weeks exposure and formed clone in soft agar culture after another 3-4 weeks depending on the exposure intensity. In the animal carcinogenesis study, lumps developed on the back of SCID mice after being inoculated into exposed NIH/3T3cells for more than 4 weeks. The results indicate that microwave radiation can promote neoplastic transformation of NIH/3T3cells.

Yang L, Hao D, Wu S, Zhong R, Zeng Y. SAR and temperature distribution in the rat head model exposed to electromagnetic field radiation by 900 MHz dipole antenna. Australas Phys Eng Sci Med. 2013 Jun 6. [Epub ahead of print]

Rats are often used in the electromagnetic field (EMF) exposure experiments. In the study for the effect of 900 MHz EMF exposure on learning and memory in SD rats, the specific absorption rate (SAR) and the temperature rise in the rat head are numerically evaluated. The digital anatomical model of a SD rat is reconstructed with the MRI images. Numerical method as finite difference time domain has been applied to assess the SAR and the temperature rise during the exposure. Measurements and simulations are conducted to characterize the net radiated power of the dipole to provide a precise dosimetric result. The whole-body average SAR and the localized SAR averaging over 1, 0.5 and 0.05 g mass for different organs/tissues are given. It reveals that during the given exposure experiment setup, no significant temperature rise occurs. The reconstructed anatomical rat model could be used in the EMF simulation and the dosimetric result provides useful information for the biological effect studies.

Yang L, Chen Q, Lv B, Wu T. Long-Term Evolution Electromagnetic Fields Exposure Modulates the Resting State EEG on Alpha and Beta Bands. Clin EEG Neurosci. 2016 Apr 25. pii: 1550059416644887. [Epub ahead of print]

Long-term evolution (LTE) wireless telecommunication systems are widely used globally, which has raised a concern that exposure to electromagnetic fields (EMF) emitted from LTE devices can change human neural function. To date, few studies have been conducted on the effect of exposure to LTE EMF. Here, we evaluated the changes in electroencephalogram (EEG) due to LTE EMF exposure. An LTE EMF exposure system with a stable power emission, which was equivalent to the maximum emission from an LTE mobile phone, was used to radiate the subjects. Numerical simulations were conducted to ensure that the specific absorption rate in the subject's head was below the safety limits. Exposure to LTE EMF reduced the spectral power and the interhemispheric coherence in the alpha and beta bands of the frontal and temporal brain regions. No significant change was observed in the spectral power and the inter-hemispheric coherence in different timeslots during and after the exposure. These findings also corroborated those of our previous study using functional magnetic resonant imaging.

Yang M, Guo W, Yang C, Tang J, Huang Q, Feng S, Jiang A, Xu X, Jiang G. Mobile phone **use and glioma risk: A systematic review and meta-analysis. PLoS One. 12(5):e0175136, 2017.**

OBJECTIVE: Many studies have previously investigated the potential association between **mobile phone** use and the risk of glioma. However, results from these individual studies are inconclusive and controversial. The objective of our study was to investigate the potential association between **mobile phone** use and subsequent glioma risk using meta-analysis.METHODS: We performed a systematic search of the Science Citation Index Embase and PubMed databases for studies reporting relevant data on **mobile phone** use and glioma in 1980-2016. The data were extracted and measured in terms of the odds ratio (OR) and 95% confidence interval (CI) using the random effects model. Subgroup analyses were also carried out. This meta-analysis eventually included 11 studies comprising a total 6028 cases and 11488 controls.RESULTS: There was a

significant positive association between long-term **mobile phone** use (minimum, 10 years) and glioma (OR = 1.44, 95% CI = 1.08-1.91). And there was a significant positive association between long-term ipsilateral **mobile phone** use and the risk of glioma (OR = 1.46, 95% CI = 1.12-1.92). Long-term **mobile phone** use was associated with 2.22 times greater odds of low-grade glioma occurrence (OR = 2.22, 95% CI = 1.69-2.92). **Mobile phone** use of any duration was not associated with the odds of high-grade glioma (OR = 0.81, 95% CI = 0.72-0.92). Contralateral **mobile phone** use was not associated with glioma regardless of the duration of use. Similarly, this association was not observed when the analysis was limited to high-grade glioma.CONCLUSIONS: Our results suggest that long-term **mobile phone** use may be associated with an increased risk of glioma. There was also an association between **mobile phone** use and low-grade glioma in the regular use or long-term use subgroups. However, current evidence is of poor quality and limited quantity. It is therefore necessary to conduct large sample, high quality research or better characterization of any potential association between long-term ipsilateral **mobile phone** use and glioma risk.

Yang R, Chen J, Deng Z, Liu X, [Effect of vitamin E on morphological variation of retinal ganglion cells after microwave radiation]. Wei Sheng Yan Jiu 30(1):31-33, 2001. [Article in Chinese]

To determine the morphological variation in the primary cultured pig retinal ganglion cells induced by microwave and the protection of VE can supply some experiment foundation for study of effect of microwave and its protection. Retinal ganglion cells of pig were cultured in vitro and added VE of different concentration, Each group was taken after 30 mW/cm2 microwave intensity radiated for 1 h in shielded room by 2450 MHz continuous wave physiotherapy machine. Immediately after radiation, the morphological variation of cells was observed by optics microscope and transmission electronic microscope. The result showed that a portion of cells congregated, with their axon disappeared after radiation. Mitochondria and endoplasmic reticulum are detected swelling by transmission electronic microscope. The results showed that A poptosis cells can be observed. Cells of VE added groups had not obvious changes with optics microscope, but could be found that mitochondria swelling lightly and integrate mitochondria cristae by transmission electronic microscope. The results showed that microwave induced the morphological damage in primary cultured retinal ganglion cells, VE could reduced the damage of retina ganglion cells by microwave in some extent.

Yang X, He G, Hao Y, Chen C, Li M, Wang Y, Zhang G, Yu Z. The role of the JAK2-STAT3 pathway in pro-inflammatory responses of EMF-stimulated N9 microglial cells. J Neuroinflammation. 7:54, 2010.

BACKGROUND: In several neuropathological conditions, microglia can become overactivated and cause neurotoxicity by initiating neuronal damage in response to pro-inflammatory stimuli. Our previous studies have shown that exposure to electromagnetic fields (EMF) activates cultured microglia to produce tumor necrosis factor (TNF)-α and nitric oxide (NO) through signal transduction involving the activator of transcription

STAT3. Here, we investigated the role of STAT3 signaling in EMF-induced microglial activation and pro-inflammatory responses in more detail than the previous study. **METHODS:** N9 microglial cells were treated with EMF exposure or a sham treatment, with or without pretreatment with an inhibitor (Pyridone 6, P6) of the Janus family of tyrosine kinases (JAK). The activation state of microglia was assessed via immunoreaction using the microglial marker CD11b. Levels of inducible nitric oxide synthase (iNOS), TNF-α and NO were measured using real-time reverse transcription-polymerase chain reaction (RT-PCR), enzyme-linked immunosorbent assay (ELISA) and the nitrate reductase method. Activation of JAKs and STAT3 proteins was evaluated by western blotting for specific tyrosine phosphorylation. The ability of STAT3 to bind to DNA was detected with an electrophoresis mobility shift assay (EMSA). **RESULTS:** EMF was found to significantly induce phosphorylation of JAK2 and STAT3, and DNA-binding ability of STAT3 in N9 microglia. In addition, EMF dramatically increased the expression of CD11b, TNF-α and iNOS, and the production of NO. P6 strongly suppressed the phosphorylation of JAK2 and STAT3 and diminished STAT3 activity in EMF-stimulated microglia. Interestingly, expression of CD11b as well as gene expression and production of TNF-α and iNOS were suppressed by P6 at 12 h, but not at 3 h, after EMF exposure. **CONCLUSIONS:** EMF exposure directly triggers initial activation of microglia and produces a significant pro-inflammatory response. Our findings confirm that the JAK2-STAT3 pathway may not mediate this initial microglial activation but does promote pro-inflammatory responses in EMF-stimulated microglial cells. Thus, the JAK2-STAT3 pathway might be a therapeutic target for reducing pro-inflammatory responses in EMF-activated microglia.

Yang XS, He GL, Hao YT, Xiao Y, Chen CH, Zhang GB, Yu ZP. Exposure to 2.45 GHz electromagnetic fields elicits an HSP-related stress response in rat hippocampus. Brain Res Bull. 88(4):371-378, 2012.

The issue of possible neurobiological effects of the electromagnetic field (EMF) exposure is highly controversial. To determine whether electromagnetic field exposure could act as an environmental stimulus capable of producing stress responses, we employed the hippocampus, a sensitive target of electromagnetic radiation, to assess the changes in its stress-related gene and protein expression after EMF exposure. Adult male Sprague-Dawley rats with body restrained were exposed to a 2.45 GHz EMF at a specific absorption rate (SAR) of 6 W/kg or sham conditions. cDNA microarray was performed to examine the changes of gene expression involved in the biological effects of electromagnetic radiation. Of 2048 candidate genes, 23 upregulated and 18 downregulated genes were identified. Of these differential expression genes, two heat shock proteins (HSP), HSP27 and HSP70, are notable because expression levels of both proteins are increased in the rat hippocampus. Result from immunocytochemistry revealed that EMF caused intensive staining for HSP27 and HSP70 in the hippocampus, especially in the pyramidal neurons of cornu ammonis 3 (CA3) and granular cells of dentate gyrus (DG). The gene and protein expression profiles of HSP27 and HSP70 were further confirmed by reverse transcription polymerase chain reaction (RT-PCR) and Western blot. Our data provide direct evidence that exposure to electromagnetic fields elicits a stress response in the rat hippocampus.

Yao K, Wang KJ, Sun ZH, Tan J, Xu W, Zhu LJ, Lu de Q. Low power microwave radiation inhibits the proliferation of rabbit lens epithelial cells by upregulating P27Kip1 expression. Mol Vis. 10:138-143, 2004.

PURPOSE: The goal of this study was to examine the effects of low power microwave radiation (<10 mW/cm2) on the proliferation of cultured rabbit lens epithelial cells (RLEC). METHODS: Cultured RLEC were exposed to continuous microwave radiation at a frequency of 2,450 MHz and power densities of 0.10, 0.25, 0.50, 1.00, and 2.00 mW/cm2 for 8 h. Cell morphologic changes were observed under a phase-contrast microscope. Cell viability was measured using the MTT assay and cell cycle analysis was measured using flow cytometry. After exposure to 2.00 mW/cm2 microwave radiation for 4, 6, and 8 h, the expression of cell cycle-regulatory proteins, P21WAF1 and P27Kip1, was examined using western blot analysis. Finally, the levels of P21WAF1 and P27Kip1 mRNA were analyzed by reverse transcription-polymerase chain reaction (RT-PCR). RESULTS: After 8 h of radiation treatment, cells treated with 0.50, 1.00, and 2.00 mW/cm2 microwave radiation exhibited decreased cell viability, increased cell condensation and an inhibition of DNA synthesis. RLEC showed significant G0/G1 arrest. No obvious changes could be detected in the 0.10 and 0.25 mW/cm2 microwave treatment groups. Protein expression of P27Kip1 was markedly increased after microwave radiation. However, the mRNA levels were unchanged. On the other hand, there were no detectable differences in P21WAF1 protein expression and mRNA levels between microwave treatment and control groups. CONCLUSIONS: This study suggests that low power microwave radiation higher than 0.50 mW/cm2 can inhibit lens epithelial cell proliferation, and increase the expression of P27Kip1. These effects may account for the decline of lens epithelial proliferation after exposure to microwave radiation.

Yao K, Wu W, Wang K, Ni S, Ye P, Yu Y, Ye J, Sun L. Electromagnetic noise inhibits radiofrequency radiation-induced DNA damage and reactive oxygen species increase in human lens epithelial cells. Mol Vis. 14:964-969, 2008.

PURPOSE: The goal of this study was to investigate whether superposing of electromagnetic noise could block or attenuate DNA damage and intracellular reactive oxygen species (ROS) increase of cultured human lens epithelial cells (HLECs) induced by acute exposure to 1.8 GHz radiofrequency field (RF) of the Global System for Mobile Communications (GSM). METHODS: An sXc-1800 RF exposure system was used to produce a GSM signal at 1.8 GHz (217 Hz amplitude-modulated) with the specific absorption rate (SAR) of 1, 2, 3, and 4 W/kg. After 2 h of intermittent exposure, the ROS level was assessed by the fluorescent probe, 2',7'-dichlorodihydrofluorescein diacetate (DCFH-DA). DNA damage to HLECs was examined by alkaline comet assay and the phosphorylated form of histone variant H2AX (gammaH2AX) foci formation assay. RESULTS: After exposure to 1.8 GHz RF for 2 h, HLECs exhibited significant intracellular ROS increase in the 2, 3, and 4 W/kg groups. RF radiation at the SAR of 3 W/kg and 4 W/kg could induce significant DNA damage, examined by alkaline comet assay, which was used to detect mainly single strand breaks (SSBs), while no statistical difference in double strand breaks (DSBs), evaluated by gammaH2AX foci, was found between RF exposure (SAR: 3 and 4 W/kg) and sham exposure groups. When RF was superposed with 2 muT electromagnetic noise could block RF-induced ROS increase and DNA