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 3

Edward B. Myers
Law Office of Edward B. Myers
14613 Dehaven Court
North Potomac, MD 20878
Phone: 717-752-2032
edwardbmyers@yahoo.com

Counsel for Petitioners 20-1025

Robert F. Kennedy, Jr.
Children's Health Defense
1227 North Peachtree Pkwy #202
Peachtree City, GA 30269
Phone: 845-377-0211
rfk.fcc@childrenshealthdefense.org

W. Scott McCollough
McCollough Law Firm, P.C.
2290 Gatlin Creek Rd.
Dripping Springs, TX 78620
Phone: 512-888-1112
wsmc@dotlaw.biz

Counsel for Petitioners 20-1138

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

Similarly, the NMR study also failed to show any effect of RF.

Curcio G, Ferrara M, De Gennaro L, Cristiani R, D'Inzeo G, Bertini M. Time-course of electromagnetic field effects on human performance and tympanic temperature. Neuroreport. 15(1):161-164, 2004.

The study aimed to investigate the time-course of electromagnetic field (EMF)-induced effects on human cognitive and behavioral performance and on tympanic temperature. Subjects were randomly assigned to two groups, exposed to a 902.40 MHz EMF before the testing session, or to the same signal during the data collecting session. Following a double-blind paradigm, subjects were tested on four performance tasks: an acoustic simple-reaction time task, a visual search task, an arithmetic descending subtraction task and an acoustic choice-reaction time task. Moreover, tympanic temperature was collected five times during each session. Results indicated an improvement of both simple- and choice-reaction times and an increase of local temperature on the exposed region under the active exposure. There was a clear time-course of the reaction time and temperature data, indicating that performance and physiological measures need a minimum of 25 min of EMF exposure to show appreciable changes.

Curcio G, Ferrara M, Moroni F, D'Inzeo G, Bertini M, De Gennaro L. Is the brain influenced by a phone call? An EEG study of resting wakefulness. Neurosci Res. 53(3):265-270, 2005.

We recorded the resting electroencephalogram of 20 healthy subjects in order to investigate the effect of electromagnetic field (EMF) exposure on EEG waking activity and its temporal development. The subjects were randomly assigned to two groups and exposed, in double-blind conditions, to a typical mobile phone signal (902.40MHz, modulated at 217Hz, with an average power of 0.25W) before or during the EEG recording session. The results show that, under real exposure as compared to baseline and sham conditions, EEG spectral power was influenced in some bins of the alpha band. This effect was greater when the EMF was on during the EEG recording session than before it. The present data lend further support to the idea that pulsed high-frequency electromagnetic fields can affect normal brain functioning, also if no conclusions can be drawn about the possible health effects.

Curcio G, Valentini E, Moroni F, Ferrara M, De Gennaro L, Bertini M Psychomotor performance is not influenced by brief repeated exposures to mobile phones. Bioelectromagnetics.29(3):237-241,2008.

The present study investigated the presence of a cumulative effect of brief and repeated exposures to a GSM mobile phone (902.40 MHz, 217 Hz modulated; peak power of 2 W; average power of 0.25 W; SAR = 0.5 W/kg) on psychomotor functions. To this end, after each of 3 15-min exposures, both an acoustic simple reaction time task (SRTT) and a sequential finger tapping task (SFTT) were administered to 24 subjects. The present study was unable to detect the cumulative effects of brief and repeated EMF exposure on human psychomotor performance, although there was a non-statistical trend to shorter reaction times. In summary, these data show an absence of effects with these particular exposure conditions; however, possible cognitive effects induced by different signal characteristics cannot be excluded.

Curcio G, Ferrara M, Limongi T, Tempesta D, Di Sante G, De Gennaro L, Quaresima V, Ferrari M. Acute mobile phones exposure affects frontal cortex hemodynamics as evidenced by functional near-infrared spectroscopy. J Cereb Blood Flow Metab.29(5):903-910, 2009.

This study aimed to evaluate by functional near-infrared spectroscopy (fNIRS), the effects induced by an acute exposure (40 mins) to a GSM (Global System for Mobile Communications) signal emitted by a mobile phone (MP) on the oxygenation of the frontal cortex. Eleven healthy volunteers underwent two sessions (Real and Sham exposure) after a crossover, randomized, double-blind paradigm. The whole procedure lasted 60 mins: 10-mins baseline (Bsl), 40-mins (Exposure), and 10-mins recovery (Post-Exp). Together with frontal hemodynamics, heart rate, objective and subjective vigilance, and self-evaluation of subjective symptoms were also assessed. The fNIRS results showed a slight influence of the GSM signal on frontal cortex, with a linear increase in [HHb] as a function of time in the Real exposure condition ($F(4,40)=2.67$; $P=0.04$). No other measure showed any GSM exposure-dependent changes. These results suggest that fNIRS is a convenient tool for safely and noninvasively investigating the cortical activation in MP exposure experimental settings. Given the short-term effects observed in this study, the results should be confirmed on a larger sample size and using a multichannel instrument that allows the investigation of a wider portion of the frontal cortex.

Curcio G, Mazzucchi E, Marca GD, Vollono C, Rossini PM. Electromagnetic fields and EEG spiking rate in patients with focal epilepsy. Clin Neurophysiol. 2014 Aug 11. pii: S1388-2457(14)00404-0. doi: 10.1016/j.clinph.2014.07.013. [Epub ahead of print]

OBJECTIVE: Despite the increase in mobile telephone technology use and possible effects on brain excitability, no studies have investigated the impact of GSM like (Global System for Mobile Communications) signal on the ongoing spiking activity in human epileptic patients. METHODS: Brain electrical (electroencephalogram, EEG) activity of 12 patients with focal epilepsy has been recorded under both Real and Sham exposure following a double-blind, crossover, counterbalanced design: before the exposure (pre-exposure/baseline session), during the Real or Sham 45min exposure (during-exposure session), and after the exposure (post-exposure session). As dependent variables both spiking activity (spikes count) and EEG quantitative indices (spectral power and coherence data) have been considered. RESULTS: Spiking activity tended to be lower under Real than under Sham exposure. EEG spectral content analysis indicated a significant increase of Gamma band under Real exposure, mainly evident in Parieto-occipital and Temporal areas. Connectivity data indicated increased interhemispheric (left temporal to right frontal Regions of Interest, ROIs) instantaneous coherence, in the Beta frequency band during-exposure with respect to baseline session. No significant modification of lagged coherence was observed. CONCLUSIONS: Acute GSM exposure in epileptic patients slightly influences their EEG properties, without reaching any clinical relevance. SIGNIFICANCE: No signs were found of an increased risk of incoming seizures for these patients as a consequence of using mobile phones.

Czerska EM, Elson EC, Davis CC, Swicord ML, Czerski P, Effects of continuous and pulsed 2450-MHz radiation on spontaneous lymphoblastoid transformation of human lymphocytes in vitro. Bioelectromagnetics 13(4):247-259, 1992.

Normal human lymphocytes were isolated from the peripheral blood of healthy donors. One-ml samples containing (10(6)) cells in chromosome medium 1A were exposed for 5 days to conventional heating or to continuous wave (CW) or pulsed wave (PW) 2450-MHz radiation at non-heating (37 degrees C) and various heating levels (temperature increases of 0.5, 1.0, 1.5, and 2 degrees C). The pulsed exposures involved 1-microsecond pulses at pulse repetition frequencies from 100 to 1,000 pulses per second at the same average SAR levels as the CW exposures. Actual average SARs ranged to 12.3 W/kg. Following termination of the incubation period, spontaneous lymphoblastoid transformation was determined with an image analysis system. The results were compared among each of the experimental conditions and with sham-exposed cultures. At non-heating levels, CW exposure did not affect transformation. At heating levels both conventional and CW heating enhanced transformation to the same extent and correlate with the increases in incubation temperature. PW exposure enhanced transformation at non-heating levels. This finding is significant (P less than .002). At heating levels PW exposure enhanced transformation to a greater extent than did conventional or CW heating. This finding is significant at the .02 level. We conclude that PW 2450-MHz radiation acts differently on the process of lymphoblastoid transformation in vitro compared with CW 2450-MHz radiation at the same average SARs.

Czyz J, GuanK, ZengQ, NikolovaT, MeisterA, SchönbornF, SchudererJ, KusterN, WobusAM, High frequency electromagnetic fields (GSM signals) affect gene expression levels in tumor suppressor p53-deficient embryonic stem cells. Bioelectromagnetics 25:296-307, 2004.

Effects of electromagnetic fields (EMF) simulating exposure to the Global System for Mobile Communications (GSM) signals were studied using pluripotent embryonic stem (ES) cells in vitro. Wild-type ES cells and ES cells deficient for the tumor suppressor p53 were exposed to pulse modulated EMF at 1.71 GHz, lower end of the uplink band of GSM 1800, under standardized and controlled conditions, and transcripts of regulatory genes were analyzed during in vitro differentiation. Two dominant GSM modulation schemes (GSM-217 and GSM-Talk), which generate temporal changes between GSM-Basic (active during talking phases) and GSM-DTX (active during listening phases thus simulating a typical conversation), were applied to the cells at and below the basic safety limits for local exposures as defined for the general public by the International Commission on Nonionizing Radiation Protection (ICNIRP). GSM-217 EMF induced a significant upregulation of mRNA levels of the heat shock protein, hsp70 of p53-deficient ES cells differentiating in vitro, paralleled by a low and transient increase of c-jun, c-myc, and p21 levels in p53-deficient, but not in wild-type cells. No responses were observed in either cell type after EMF exposure to GSM-Talk applied at similar slot-averaged specific absorption rates (SAR), but at lower time-averaged SAR values. Cardiac differentiation and cell cycle characteristics were not affected in embryonic stem and embryonic carcinoma cells after exposure to GSM-217 EMF signals. Our data indicate that the genetic background determines cellular responses to GSM modulated EMF.

Dabouis V, Arvers P, Debouzy JC, Sebbah C, Crouzier D, Perrin A.First epidemiological study on occupational radar exposure in the French Navy: a 26-year cohort study. Int J Environ Health Res. 2015 Jul 28:1-14. [Epub ahead of print]

This retrospective cohort study deals with the causes of death among 57,000 military personnel who served in the French Navy surface vessels and were observed over the period 1975-2000. We successively compared the mortality rate and the specific causes of death between two groups differing in their potential exposure levels to radar. Occupational exposure was defined according to the on-board workplace (radar and control groups). The age-adjusted death ratios of the navy personnel were compared. For all causes of death, the results showed that 885 deaths in the radar group and 299 in the control group occurred (RR = 1.00 (95 % CI: 0.88-1.14)). RRs were 0.92 (95 % CI: 0.69-1.24) for neoplasms. For the duration of follow-up, the results did not show an increased health risk for military personnel exposed to higher levels of radio frequencies in the radar group, but the number of deaths was very small for some cancer sites.

Dabrowski MP, Stankiewicz W, Kubacki R, Sobiczewska E, Szmigielski S. Immunotropic Effects in Cultured Human Blood Mononuclear Cells Pre-exposed to Low-Level 1300 MHz Pulse-Modulated Microwave Field Electromag. Biol. Med. 22:1-13, 2003.

The samples of mononuclear cells isolated from peripheral blood of healthy donors (N = 16) were exposed to 1300 MHz pulse-modulated microwaves at 330 pps with 5 □s pulse width. The samples were exposed in an anechoic chamber at the average value of power density of S = 10 W/m^2 (1 mW/cm^2). The average specific absorption rate (SAR) was measured in rectangular waveguide and the value of SAR = 0.18 W/kg was recorded. Subsequently, the exposed and control cells were assessed in the microculture system for several parameters characterizing their proliferative and immunoregulatory properties. Although the irradiation decreased the spontaneous incorporation of 3H-thymidine, the proliferative response of lymphocytes to phytohemagglutinin (PHA) and to Con A as well as the T-cell suppressive activity (SAT index) and the saturation of IL-2 receptors did not change. Nevertheless, the lymphocyte production of interleukin (IL)-10 increased (P < .001) and the concentration of IFN□ remained unchanged or slightly decreased in the culture supernatants. Concomitantly, the microwave irradiation modulated the monokine production by monocytes. The production of IL-1□ increased significantly (P < .01), the concentration of its antagonist (IL-1ra) dropped by half (P < .01) and the tumor necrosis factor (TNF-□) concentration remained unchanged. These changes of monokine proportion (IL-1β vs. IL-1ra) resulted in significant increase of the value of LM index (P < .01), which reflects the activation of monocyte immunogenic function. The results indicate that pulse-modulated microwaves represent the potential of immunotropic influence, stimulating preferentially the immunogenic and proinflammatory activity of monocytes at relatively low levels of exposure.

Dahmen N, Ghezel-Ahmadi D, Engel A. Blood laboratory findings in patients suffering from self-perceived electromagnetic hypersensitivity (EHS). Bioelectromagnetics. 30(4):299-306, 2009.

Risks from electromagnetic devices are of considerable concern. Electrohypersensitive (EHS) persons attribute a variety of rather unspecific symptoms to exposure to electromagnetic fields. The pathophysiology of EHS is unknown and therapy remains a challenge. We hypothesized that some electrosensitive individuals are suffering from common somatic health problems. Toward this end we analysed clinical laboratory parameters including thyroid-stimulating hormone (TSH), alanine transaminase (ALT), aspartate transaminase (AST), creatinine, hemoglobine, hematocrit and c-reactive protein (CRP) in subjects suffering from EHS and in controls that are routinely used in clinical medicine to identify or screen for common somatic disorders. One hundred thirty-two patients (n = 42 males and n = 90 females) and 101 controls (n = 34 males and n = 67 females) were recruited. Our results identified laboratory signs of thyroid dysfunction, liver dysfunction and chronic inflammatory processes in small but remarkable fractions of EHS sufferers as potential sources of symptoms that merit further investigation in future studies. In the cases of TSH and ALT/AST there were significant differences between cases and controls. The hypotheses of anaemia or kidney dysfunction playing a major role in EHS could be unambiguously refuted. Clinically it is recommended to check for signs of treatable somatic conditions when caring for individuals suffering from self-proclaimed EHS.

d'Ambrosio G, MassaR, Scarfi MR, Zeni O, Cytogenetic damage in human lymphocytes following GMSK phase modulated microwave exposure. Bioelectromagnetics 23:7-13, 2002.

The present study investigated, using in vitro experiments on human lymphocytes, whether exposure to a microwave frequency used for mobile communication, either unmodulated or in presence of phase only modulation, can cause modification of cell proliferation kinetics and/or genotoxic effects, by evaluating the cytokinesis block proliferation index and the micronucleus frequency. In the GSM 1800 mobile communication systems the field is both phase (Gaussian minimum shift keying, GMSK) and amplitude (time domain multiple access, TDMA) modulated. The present study investigated only the effects of phase modulation, and no amplitude modulation was applied. Human peripheral blood cultures were exposed to 1.748 GHz, either continuous wave (CW) or phase only modulated wave (GMSK), for 15 min. The maximum specific absorption rate (□5 W/kg) was higher than that occurring in the head of mobile phone users; however, no changes were found in cell proliferation kinetics after exposure to either CW or GMSK fields. As far as genotoxicity is concerned, the micronucleus frequency result was not affected by CW exposure; however, a statistically significant micronucleus effect was found following exposure to phase modulated field. These results would suggest a genotoxic power of the phase modulation per se.

D'Andrea JA, DeWitt JR, Portuguez LM, Gandhi OP. Reduced exposure to microwave radiation by rats: frequency specific effects. Prog Clin Biol Res. 257:289-308, 1988.

Previous research has shown that SAR "hotspots" are induced within the laboratory rat and that the resulting thermal hotspots are not entirely dissipated by bloodflow. Two experiments were conducted to determine if hotspot formation in the body and tail of the rat, which is radiation frequency specific, would have behavioral consequences. In the

first experiment rats were placed in a plexiglas cage one side of which, when occupied by the rat, commenced microwave radiation exposure; occupancy of the other side terminated exposure. Groups of rats were tested during a baseline period to determine the naturally preferred side of the cage. Subsequent exposure to 360-MHz, 700-MHz or 2450-MHz microwave radiation was made contingent on preferred-side occupancy. A significant reduction in occupancy of the preferred side of the cage, and hence, microwaves subsequently occurred. Reduced exposure to 360-MHz and 2450-MHz microwaves at 1, 2, 6 and 10 W/kg were significantly different from 700-MHz microwaves. In the second experiment semichronic exposures revealed the threshold for reduced exposure of 2450-MHz microwaves to be located between whole-body SAR's of 2.1 and 2.8 W/kg.

D'Andrea JA, Thomas A, Hatcher DJ, Rhesus monkey behavior during exposure to high-peak-power 5.62-GHz microwave pulses. Bioelectromagnetics 15(2):163-176, 1994.

Limits on the exposure to high-peak-power, short-duration microwave pulses have only recently been adopted. Additional data, however, are needed to understand the effects that may be produced by exposure to high-peak-power pulsed microwaves. Four male rhesus monkeys (Macaca mulatta) were trained on an operant task for food pellet reward to investigate the behavioral effects of very high-peak-power 5.62 GHz microwaves. The operant task required monkeys to pull one plastic lever on a variable interval schedule (VI-25 s) and then respond to color signals and pull a second lever to obtain food. The monkeys were conditioned to perform a color discrimination task using one of three colors displayed by a fiber-optic cable. A red signal was the discriminative stimulus for responding on the first lever. A response on the second lever when a green signal was presented (1 s duration) delivered a food pellet. If a response on the second lever was made in the presence of a white signal, a 30-s timeout occurred. While performing the behavioral task, the monkeys were exposed to microwave pulses produced by either a military radar (FPS-26A) operating at 5.62 GHz or the same radar coupled to a Stanford linear energy doubler (SLED) pulse-forming device (ITT-2972) that enhanced peak power by a factor of nine by adding a high power pulse to the radar pulse. The effects of both types of pulses were compared to sham exposure. Peak field power densities tested were 518, 1270, and 2520 W/cm2 for SLED pulses and 56, 128, and 277 W/cm2 for the radar pulses. The microwave pulses (radar or SLED) were delivered at 100 pps (2.8 microseconds radar pulse duration; approximately 50 ns SLED pulse duration) for 20 min and produced averaged whole-body SARs of 2, 4, or 6 W/kg. Compared to sham exposures, significant alterations of lever responding, reaction time, and earned food pellets occurred during microwave exposure at 4 and 6 W/kg but not at 2 W/kg. There were no differences between radar or SLED pulses in producing behavioral effects.

Danese E, Lippi G, Buonocore R, Benati M, Bovo C, Bonaguri C, Salvagno GL, Brocco G, Roggenbuck D, Montagnana M. Mobile phone **radiofrequency exposure has no effect on DNA double strand breaks (DSB) in human lymphocytes. Ann Transl Med. 5(13):272, 2017.**

BACKGROUND: The use of **mobile phones** has been associated with an increased risk of developing certain type of cancer, especially in long term users. Therefore, this study

was aimed to investigate the potential genotoxic effect of **mobile phone** radiofrequency exposure on human peripheral blood mononuclear cells in vitro.METHODS: The study population consisted in 14 healthy volunteers. After collection of two whole blood samples, the former was placed in a plastic rack, 1 cm from the chassis of a commercial **mobile phone** (900 MHz carrier frequency), which was activated by a 30-min call. The second blood sample was instead maintained far from **mobile phones** or other RF sources. The influence of **mobile phone** RF on DNA integrity was assessed by analyzing γ-H2AX foci in lymphocytes using immunofluorescence staining kit on AKLIDES. RESULTS: No measure of γ-H2AX foci was significantly influenced by **mobile phone** RF exposure, nor **mobile phone** exposure was associated with significant risk of genetic damages in vitro (odds ratio comprised between 0.27 and 1.00). CONCLUSIONS: The results of this experimental study demonstrate that exposure of human lymphocytes to a conventional 900 MHz RF emitted by a commercial **mobile phone** for 30 min does not significantly impact DNA integrity.

Daniels WM, Pitout IL, Afullo TJ, Mabandla MV. The effect of electromagnetic radiation in the mobile phone range on the behaviour of the rat. Metab Brain Dis. 24(4):629-641, 2009

Electromagnetic radiation (EMR) is emitted from electromagnetic fields that surround power lines, household appliances and mobile phones. Research has shown that there are connections between EMR exposure and cancer and also that exposure to EMR may result in structural damage to neurons. In a study by Salford et al. (Environ Health Perspect 111:881-883, 2003) the authors demonstrated the presence of strongly stained areas in the brains of rats that were exposed to mobile phone EMR. These darker neurons were particularly prevalent in the hippocampal area of the brain. The aim of our study was to further investigate the effects of EMR. Since the hippocampus is involved in learning and memory and emotional states, we hypothesised that EMR will have a negative impact on the subject's mood and ability to learn. We subsequently performed behavioural, histological and biochemical tests on exposed and unexposed male and female rats to determine the effects of EMR on learning and memory, emotional states and corticosterone levels. We found no significant differences in the spatial memory test, and morphological assessment of the brain also yielded non-significant differences between the groups. However, in some exposed animals there were decreased locomotor activity, increased grooming and a tendency of increased basal corticosterone levels. These findings suggested that EMR exposure may lead to abnormal brain functioning.

Daniells, C, Duce, I, Thomas, D, Sewell, P, Tattersall, J, de Pomerai, D, Transgenic nematodes as biomonitors of microwave-induced stress. Mutat Res 399:55-64, 1998.

Transgenic nematodes (Caenorhabditis elegans strain PC72), carrying a stress-inducible reporter gene (Escherichia coli beta-galactosidase) under the control of a C. elegans hsp16 heat-shock promoter, have been used to monitor toxicant responses both in water and soil. Because these transgenic nematodes respond both to heat and toxic chemicals by synthesising an easily detectable reporter product, they afford a useful preliminary

screen for stress responses (whether thermal or non-thermal) induced by microwave radiation or other electromagnetic fields. We have used a transverse electromagnetic (TEM) cell fed from one end by a source and terminated at the other end by a matched load. Most studies were conducted using a frequency of 750 MHz, at a nominal power setting of 27 dBm. The TEM cell was held in an incubator at 25 degrees C inside a shielded room; corresponding controls were shielded and placed in the same 25 degrees C incubator; additional baseline controls were held at 15 degrees C (worm growth temperature). Stress responses were measured in terms of beta-galactosidase (reporter) induction above control levels. The time-course of response to continuous microwave radiation showed significant differences from 25 degrees C controls both at 2 and 16 h, but not at 4 or 8 h. Using a 5 x 5 multiwell plate array exposed for 2 h, the 25 microwaved samples showed highly significant responses compared with a similar control array. The wells most strongly affected were those in the rows closest to the source, whereas the most distant row did not rise above control levels, suggesting a shadow effect. These differential responses are difficult to reconcile with general heating effects, although localised power absorption affords a possible explanation. Experiments in which the frequency and/or power settings were varied suggested a greater response at 21 than at 27 dBm, both at 750 and 300 MHz, although extremely variable responses were observed at 24 dBm and 750 MHz. Thus, lower power levels tended, if anything, to induce larger responses (with the above-mentioned exception), which is opposite to the trend anticipated for any simple heating effect. These results are reproducible and data acquisition is both rapid and simple. The evidence accrued to date suggests that microwave radiation causes measurable stress to transgenic nematodes, presumably reflecting increased levels of protein damage within cells (the common signal thought to trigger hsp gene induction). The response levels observed are comparable to those observed with moderate concentrations (ppm) of metal ions such as Zn2+ and Cu2+. We conclude that this approach deserves further and more detailed investigation, but that it has already demonstrated clear biological effects of microwave radiation in terms of the activation of cellular stress responses (hsp gene induction).

Danker-Hopfe H, Dorn H, Bahr A, Anderer P, Sauter C. Effects of electromagnetic fields emitted by mobile phones (GSM 900 and WCDMA/UMTS) on the macrostructure of sleep. J Sleep Res.20(1 Pt 1):73-81, 2010.

Summary In the present double-blind, randomized, sham-controlled cross-over study, possible effects of electromagnetic fields emitted by Global System for Mobile Communications (GSM) 900 and Wideband Code-Division Multiple Access (WCDMA)/Universal Mobile Telecommunications System (UMTS) cell-phones on the macrostructure of sleep were investigated in a laboratory environment. An adaptation night, which served as screening night for sleep disorders and as an adjustment night to the laboratory environment, was followed by 9 study nights (separated by a 2-week interval) in which subjects were exposed to three exposure conditions (sham, GSM 900 and WCDMA/UMTS). The sample comprised 30 healthy male subjects within the age range 18-30 years (mean +/- standard deviation: 25.3 +/- 2.6 years). A cell-phone usage at maximum radio frequency (RF) output power was simulated and the transmitted power was adjusted in order to approach, but not to exceed, the specific absorption rate (SAR) limits of the International Commission on Non-Ionizing

Radiation Protection (ICNIRP) guidelines for general public exposure (SAR(10g) = 2.0 W kg(-1)). In this study, possible effects of long-term (8 h) continuous RF exposure on the central nervous system were analysed during sleep, because sleep is a state in which many confounding intrinsic and extrinsic factors (e.g. motivation, personality, attitude) are eliminated or controlled. Thirteen of 177 variables characterizing the initiation and maintenance of sleep in the GSM 900 and three in the WCDMA exposure condition differed from the sham condition. The few significant results are not indicative of a negative impact on sleep architecture. From the present results there is no evidence for a sleep-disturbing effect of GSM 900 and WCDMA exposure.

Danker-Hopfe H, Dorn H, Bornkessel C, Sauter C. Do mobile phone base stations affect sleep of residents? Results from an experimental double-blind sham-controlled field study. Am J Hum Biol. 22(5):613-618, 2010.

OBJECTIVES: The aim of the present double-blind, sham-controlled, balanced randomized cross-over study was to disentangle effects of electromagnetic fields (EMF) and non-EMF effects of mobile phone base stations on objective and subjective sleep quality. METHODS: In total 397 residents aged 18-81 years (50.9% female) from 10 German sites, where no mobile phone service was available, were exposed to sham and GSM (Global System for Mobile Communications, 900 MHz and 1,800 MHz) base station signals by an experimental base station while their sleep was monitored at their homes during 12 nights. Participants were randomly exposed to real (GSM) or sham exposure for five nights each. Individual measurement of EMF exposure, questionnaires on sleep disorders, overall sleep quality, attitude towards mobile communication, and on subjective sleep quality (morning and evening protocols) as well as objective sleep data (frontal EEG and EOG recordings) were gathered. RESULTS: Analysis of the subjective and objective sleep data did not reveal any significant differences between the real and sham condition. During sham exposure nights, objective and subjective sleep efficiency, wake after sleep onset, and subjective sleep latency were significantly worse in participants with concerns about possible health risks resulting from base stations than in participants who were not concerned. CONCLUSIONS: The study did not provide any evidence for short-term physiological effects of EMF emitted by mobile phone base stations on objective and subjective sleep quality. However, the results indicate that mobile phone base stations as such (not the electromagnetic fields) may have a significant negative impact on sleep quality.

Danker-Hopfe H, Dorn H, Bahr A, Anderer P, Sauter C. Effects of electromagnetic fields emitted by mobile phones (GSM 900 and WCDMA/UMTS) on the macrostructure of sleep.J Sleep Res. 20(1 Pt 1):73-81, 2011.

In the present double-blind, randomized, sham-controlled cross-over study, possible effects of electromagnetic fields emitted by Global System for Mobile Communications (GSM) 900 and Wideband Code-Division Multiple Access (WCDMA)/Universal Mobile Telecommunications System (UMTS) cell-phones on the macrostructure of sleep were investigated in a laboratory environment. An adaptation night, which served as screening night for sleep disorders and as an adjustment night

to the laboratory environment, was followed by 9 study nights (separated by a 2-week interval) in which subjects were exposed to three exposure conditions (sham, GSM 900 and WCDMA/UMTS). The sample comprised 30 healthy male subjects within the age range 18-30 years (mean ± standard deviation: 25.3 ± 2.6 years). A cell-phone usage at maximum radio frequency (RF) output power was simulated and the transmitted power was adjusted in order to approach, but not to exceed, the specific absorption rate (SAR) limits of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines for general public exposure (SAR(10g) = 2.0 W kg(-1)). In this study, possible effects of long-term (8 h) continuous RF exposure on the central nervous system were analysed during sleep, because sleep is a state in which many confounding intrinsic and extrinsic factors (e.g. motivation, personality, attitude) are eliminated or controlled. Thirteen of 177 variables characterizing the initiation and maintenance of sleep in the GSM 900 and three in the WCDMA exposure condition differed from the sham condition. The few significant results are not indicative of a negative impact on sleep architecture. From the present results there is no evidence for a sleep-disturbing effect of GSM 900 and WCDMA exposure.

Danker-Hopfe H, Dorn H, Bolz T, Peter A, Hansen ML, Eggert T, Sauter C. Effects of mobile phone exposure (GSM 900 and WCDMA/UMTS) on polysomnography based sleep quality: An intra- and inter-individual perspective. Environ Res. 145:50-60, 2015.

BACKGROUND: Studies on effects of radio frequency-electromagnetic fields (RF-EMF) on the macrostructure of sleep so far yielded inconsistent results. This study investigated whether possible effects of RF-EMF exposure differ between individuals. OBJECTIVE: In a double-blind, randomized, sham-controlled cross-over study possible effects of electromagnetic fields emitted by pulsed Global System for Mobile Communications (GSM) 900 and Wideband Code-Division Multiple Access (WCDMA)/Universal Mobile Telecommunications System (WCDMA/UMTS) devices on sleep were analysed. METHODS: Thirty healthy young men (range 18-30 years) were exposed three times per exposure condition while their sleep was recorded. Sleep was evaluated according to the American Academy of Sleep Medicine standard and eight basic sleep variables were considered. RESULTS: Data analyses at the individual level indicate that RF-EMF effects are observed in 90% of the individuals and that all sleep variables are affected in at least four subjects. While sleep of participants was affected in various numbers, combinations of sleep variables and in different directions, showing improvements but also deteriorations, the only consistent finding was an increase of stage R sleep under GSM 900MHz exposure (9 of 30 subjects) as well as under WCDMA/UMTS exposure (10 of 30 subjects). CONCLUSIONS: The results underline that sleep of individuals can be affected differently. The observations found here may indicate an underlying thermal mechanism of RF-EMF on human REM sleep. Nevertheless, the effect of an increase in stage R sleep in one third of the individuals does not necessarily indicate a disturbance of sleep.

Das S, Chakraborty S, Mahanta B. A study on the effect of prolonged mobile phone **use on pure tone audiometry thresholds of medical students of Sikkim. J Postgrad Med. 63(4):221-225, 2017.**

INTRODUCTION: **Mobile phones** have become indispensable for daily activities, and people are exposed to them from an early age. There is, however, concern about the harmful effect of the electromagnetic radiation emitted from the **mobile phones**.OBJECTIVE: The objective of the study was to study the effect of **mobile phone** on average pure tone audiometry (PTA) threshold of the person and to study the changes in the pure tone threshold at high frequencies such as 2 kHz, 4 kHz, and 8 kHz among the students with prolonged exposure to **mobile phones**.METHODOLOGY: A cross-sectional study was conducted among the medical students who have been using **mobile phones** for the past 5 years. The effect of **mobile phones** on the PTA threshold in the exposed ear and the nonexposed ear was assessed.RESULTS: The study shows that there is a significant difference in average air conduction (AC) and bone conduction (BC) hearing threshold among the exposed and the nonexposed ears ($P < 0.05$). A significant rise of both AC and BC threshold at individual frequencies between the exposed and the nonexposed ear is also noted in this study.CONCLUSION: The study conducted shows changes in the hearing threshold of the exposed ear when compared with the nonexposed ear. There are however lot of unanswered questions which provide an interesting avenue for further research. Till concrete evidence is available the only feasible way to control its exposure is to limit the duration of usage of **mobile phones**.

Dasdag, S, Ketani, MA, Akdag, Z, Ersay, AR, Sar,i I, Demirtas ,OC, Celik, MS, Whole-body microwave exposure emitted by cellular phones and testicular function of rats. Urol Res 27(3):219-223, 1999.

This study investigated whether there are adverse effects due to microwave exposure emitted by cellular phones in male rats. Eighteen Wistar Albino rats were separated into three groups, a sham group and two experimental groups. The rats were confined in Plexiglas cages and cellular phones were placed 0.5 cm under the cages. In the first experimental group, cellular phones were in standby position for 2 h. In the second experimental group, phones were turned to the speech position three times each for 1 min duration over 2 h. Rats in the first and second experimental groups were exposed to microwaves emitted by phones for 2 h/day for a duration of 1 month. After the last exposure the rats were killed. Brain, eyes, ears, liver, heart, lungs, stomach, kidneys, testes, small and large intestines and skin of the rats were observed histologically. The decrease of epididymal sperm counts in the speech groups were not found to be significant ($P > 0.05$). Differences in terms of normal and abnormal sperm forms were not observed ($P > 0.05$). Histological changes were especially observed in the testes of rats of the speech groups. Seminiferous tubular diameter of rat testes in the standby and speech groups was found to be lower than the sham group ($P < 0.05$). Rectal temperatures of rats in the speech group were found to be higher than the sham and standby groups ($P < 0.05$). The rectal temperatures of rats before and after exposure were also found to be significantly higher in the speech group ($P < 0.05$). Specific absorption rate (SAR) was determined as 0.141 W/kg.

Dasdag S, Zulkuf Akdag M, Aksen F, Yilmaz F, Bashan M, Mutlu Dasdag M, Salih Celik M. Whole body exposure of rats to microwaves emitted from a cell phone does not affect the testes. Bioelectromagnetics 24(3):182-188, 2003.

The objective of this study was to investigate the effects of radiofrequency radiation emitted from cellular phones on the lipid composition, malondialdehyde concentration, p53 immune reactivity, sperm count, morphology, histological structure of testes, and on rectal temperature of rats exposed to microwave radiation emitted from cellular phones. Sixteen Spraque-Dawley rats were separated into two groups of eight, sham exposed (control) and experimental. The rats were confined in plexiglas cages specially designed for this study, and cellular phones were placed 0.5 cm under the cages. For the experimental group, cellular phones were activated 20 min per day (7 days a week) for 1 month. For the control group, the cellular phones were placed beneath the cages for 20 min a day, but the phones were turned off. Rectal temperatures were measured weekly. For 250 mW radiated power, the whole body average SAR (rms) is 0.52 W/kg and 1 g averaged peak SAR (rms) is 3.13 W/kg. The Mann-Whitney U-test was used for statistical comparisons of groups. No statistically significant alteration in any of the endpoints was noted. This study found no evidence suggesting an adverse effect of cell phone exposure on measures of testicular function or structure.

Dasdag S; Akdag MZ; Ayy□ld□z O, Demirtas OC, Yayla M, Sert C. Do cellular phones alter blood parameters and birth weight of rats? Electromag Biol Med. 19:107-113, 2000.

The present study aimed to investigate the effects of microwaves (MW) emitted by cellular phones (CPs) on peripheral blood parameters and birth weights of rats. Thirty-six albino rats were divided into four groups, male (n = 6) and female sham-exposed groups (n = 12) and male (n = 6) and female experimental groups (n = 12). No blood parameters differed following exposure ($p > 0.05$). The birth weight of offspring in the experimental group was significantly lower than in the sham-exposed group ($p < 0.001$). No significant differences were observed between rectal temperatures of rats in the sham and experimental groups ($p > 0.05$). The specific absorption rate (SAR) was found to be 0.155 W/kg for the experimental groups. All parameters investigated were normal in the next generation of rats ($p > 0.05$).

Dasdag S, Akdag MZ, Ulukaya E, Uzunlar AK, Yegin D. Mobile phone exposure does not induce apoptosis on spermatogenesis in rats.Arch Med Res. 39(1):40-44, 2008.

BACKGROUND: Some studies have reported that microwave radiation can have adverse effects on reproduction. Therefore, the purpose of this study was to investigate the apoptosis-inducing effect of mobile phone exposure on spermatogonia in seminiferous tubules. METHODS: The study was carried out on 31 Wistar albino adult male rats. The rats were separated into three groups in this study (cage control: 10, sham group: 7, and exposed group: 14). For the study group, rats were exposed to radiation 2 h/day (7 days/week) for 10 months. For the sham group, rats were placed into the carousel and the same procedure was applied except that the generator was turned off. For the cage control, nothing was applied to the rats in this group and they completed their life cycle in the cage during the study period. In this

study, rats were sacrificed after 10 months of exposure and their testes were taken. Testes tissue was immunohistochemically stained for the active (cleaved) caspase-3. Positively stained cells were counted in up to ten different areas, and the frequency of positive cells was determined in percentage. Scoring was done by taking into account both the intensity of staining and the distribution of positively stained cells. Therefore, protein expression was evaluated by a semiquantitative scoring system. RESULTS: The final score for apoptosis of testes in the exposed group was not statistically significant according to the sham and the cage control groups ($p > 0.05$). CONCLUSIONS: The results of this study showed that 2 h/day (7 days/week) exposure of 900 MHz radiation over a period of 10 months does not affect the active (cleaved) caspase-3 levels in testes, a well-known feature of typical apoptosis.

Dasdag S, Akdag MZ, Ulukaya E, Uzunlar AK, Ocak AR. Effect of mobile phone exposure on apoptotic glial cells and status of oxidative stress in rat brain. Electromagn Biol Med. 28(4):342-354, 2009.

The aim of this study was to investigate the effects of mobile phone exposure on glial cells in brain. The study carried out on 31 Wistar Albino adult male rats. The rat heads in a carousel exposed to 900 MHz microwave. For the study group (n:14), rats exposed to the radiation 2 h per day (7 days in a week) for 10 months. For the sham group (n:7), rats were placed into the carousel and the same procedure was applied except that the generator was turned off. For the cage control (n:10), nothing applied to rats in this group. In this study, rats were euthanized after 10 months of exposure periods and brains were removed. Brain tissues were immunohistochemically stained for the active (cleaved) caspase-3, which is a well-known apoptosis marker, and p53. The expression of the proteins was evaluated by a semi-quantitative scoring system. However, total antioxidative capacity (TAC), catalase, total oxidant status (TOS), and oxidative stress index were measured in rat brain. Final score for apoptosis in the exposed group was significantly lower than the sham ($p < 0.001$) and the cage control groups ($p < 0.01$). p53 was not significantly changed by the exposure ($p > 0.05$). The total antioxidant capacity and catalase in the experimental group was found higher than that in the sham group ($p < 0.001$, $p < 0.05$). In terms of the TOS and oxidative stress index, there was no statistically significant difference between exposure and sham groups ($p > 0.05$). In conclusion, the final score for apoptosis, total antioxidant capacity and catalase in rat brain might be altered by 900 MHz radiation produced by a generator to represent exposure of global systems for mobile communication (GSM) cellular phones.

Dasdag S, Akdag MZ, Kizil G, Kizil M, Cakir DU, Yokus B. Effect of 900 MHz radio frequency radiation on beta amyloid protein, protein carbonyl, and malondialdehyde in the brain. Electromagn Biol Med. 31(1):67-74, 2012.

Recently, many studies have been carried out in relation to 900 MHz radiofrequency radiation (RF) emitted from a mobile phone on the brain. However, there is little data concerning possible mechanisms between long-term exposure of RF radiation and biomolecules in brain. Therefore, we aimed to investigate long-term effects of 900 MHz radiofrequency radiation on beta amyloid protein, protein carbonyl, and malondialdehyde in the rat brain. The study was carried out on 17 Wistar Albino adult

male rats. The rat heads in a carousel were exposed to 900 MHz radiofrequency radiation emitted from a generator, simulating mobile phones. For the study group (n: 10), rats were exposed to the radiation 2 h per day (7 days a week) for 10 months. For the sham group (n: 7), rats were placed into the carousel and the same procedure was applied except that the generator was turned off. In this study, rats were euthanized after 10 months of exposure and their brains were removed. Beta amyloid protein, protein carbonyl, and malondialdehyde levels were found to be higher in the brain of rats exposed to 900 MHz radiofrequency radiation. However, only the increase of protein carbonyl in the brain of rats exposed to 900 MHz radiofrequency radiation was found to be statistically significant ($p<0.001$). In conclusion, 900 MHz radiation emitted from mobile/cellular phones can be an agent to alter some biomolecules such as protein. However, further studies are necessary.

Dasdag S, Taş M, Akdag MZ, Yegin K. Effect of long-term exposure of 2.4 GHz radiofrequency radiation emitted from Wi-Fi equipment on testes functions. Electromagn Biol Med. 2014 Jan 24. [Epub ahead of print]

The aim of this study was to investigate long-term effects of radiofrequency radiation (RFR) emitted from a Wireless Fidelity (Wi-Fi) system on testes. The study was carried out on 16 Wistar Albino adult male rats by dividing them into two groups such as sham (n: 8) and exposure (n: 8). Rats in the exposure group were exposed to 2.4 GHz RFR radiation for 24 h/d during 12 months (1 year). The same procedure was applied to the rats in the sham control group except the Wi-Fi system was turned off. Immediately after the last exposure, rats were sacrificed and reproductive organs were removed. Motility (%), concentration ($\times 10^6$/mL), tail defects (%), head defects (%) and total morphologic defects (%) of sperms and weight of testes (g), left epididymis (g), prostate (g), seminal vesicles (g) were determined. Seminiferous tubules diameter (μm) and tunica albuginea thickness (μm) were also measured. However, the results were evaluated by using Johnsen's score. Head defects increased in the exposure group ($p < 0.05$) while weight of the epididymis and seminal vesicles, seminiferous tubules diameter and tunica albuginea thickness were decreased in the exposure group ($p < 0.01$, $p < 0.001$, $p < 0.0001$). However, other alterations of other parameters were not found significant ($p > 0.05$). In conclusion, we observed that long-term exposure of 2.4 GHz RF emitted from Wi-Fi (2420 μW/kg, 1 g average) affects some of the reproductive parameters of male rats. We suggest Wi-Fi users to avoid long-term exposure of RF emissions from Wi-Fi equipment.

Dasdag S, Yavuz I1, Bakkal M, Kargul B. Effect of long term 900 MHz radiofrequency radiation on enamel microhardness of rat's teeth. Oral Health Dent Manag. 13(3):749-752, 2014.

PURPOSE: Oral tissues are important parts of body that absorbs radiation emitted from mobile phones which is the most popular technological equipment in the world. Because of the limited studies in this field, we aimed to investigate the effect of Radio Frequency (RF) radiation emitted from 900 MHz mobile phones on the enamel micro hardness of rat teeth. MATERIALS AND METHODS: The study was carried out on twenty one Wistar

Albino adult male rats which were divided into two groups such as control and experiment groups. For the study group (n: 14), rats exposed to the radiation 2 h per day (7 days in a week) for 10 months. For the control group (n: 7), rats were placed into the carousel and the same procedure was applied except that the generator was turned off. At the end of the study, enamel micro hardness of rat's teeth was measured. RESULTS: The results of this study showed that 900 MHz RF radiation did not alter the enamel micro hardness of rats' teeth (p>0.05). CONCLUSIONS: Exposure of 900 MHz RF radiation for 2 hours per day during ten months does not alter enamel micro hardness of rats' teeth. However, further studies are necessary to clarify this topic.

Dasdag S, Akdag MZ, Erdal ME, Erdal N, Ay OI, Ay ME, Yilmaz SG, Tasdelen B, Yegin K. Long term and excessive use of 900 MHz radiofrequency radiation alter microrna expression in brain. Int J Radiat Biol. 2014 Dec 20:1-22. [Epub ahead of print].

Purpose: We still do not have any information on the interaction between radiofrequency radiation (RF) and miRNAs, which play paramount role in growth, differentiation, proliferation and cell death by suppressing one or more target genes. The purpose of this study is to bridge this gap by investigating effects of long term 900 MHz mobile phone exposure on some of the miRNAs in brain tissue.
Materials and Methods: The study was carried out on fourteen Wistar Albino adult male rats by dividing them into two groups: sham (n: 7) and exposure (n: 7). Rats in the exposure group were exposed to 900 MHz RF radiation for 3 h per day (7 d a week) for twelve months (one year). The same procedure was applied to the rats in the sham group except the generator was turned off. Immediately after the last exposure, rats were sacrificed and their brains were removed. rno-miR-9-5p, rno-miR-29a-3p, rno-miR-106b-5p, rno-miR-107 and rno-miR-125a-3p in brain were investigated in detail. Results: Results revealed that long term exposure of 900 MHz RF radiation only decreased rno-miR107 (adjP*= 0,045) value where the whole body (rms) SAR value was 0.0369 W/kg. However, our results indicated that other micro RNAs evaluated in this study was not altered by 900 MHz RF radiation. Conclusion: 900 MHz RF radiation can alter some of the miRNAs, which, in turn, may lead to adverse effects. Therefore, further studies should be performed.

Dasdag S, Akdag MZ, Erdal ME, Erdal N, Ay OI, Ay ME, Yilmaz SG, Tasdelen B, Yegin K. Long term and excessive use of 900 MHz radiofrequency radiation alter microRNA expression in brain. Int J Radiat Biol. 2015 Jan 27:1-6. [Epub ahead of print]

Purpose: We still do not have any information on the interaction between radiofrequency radiation (RF) and miRNA, which play paramount role in growth, differentiation, proliferation and cell death by suppressing one or more target genes. The purpose of this study was to bridge this gap by investigating effects of long-term 900 MHz mobile phone exposure on some of the miRNA in brain tissue. Materials and methods: The study was carried out on 14 Wistar Albino adult male rats by dividing them into two groups: Sham (n = 7) and exposure (n = 7). Rats in the exposure group were exposed to 900 MHz RF radiation for 3 h per day (7 days a week) for 12 months (one year). The same procedure

was applied to the rats in the sham group except the generator was turned off. Immediately after the last exposure, rats were sacrificed and their brains were removed. rno-miR-9-5p, rno-miR-29a-3p, rno-miR-106b-5p, rno-miR-107 and rno-miR-125a-3p in brain were investigated in detail. Results: Results revealed that long-term exposure of 900 MHz RF radiation only decreased rno-miR107 (adjP* = 0.045) value where the whole body (rms) SAR value was 0.0369 W/kg. However, our results indicated that other microRNA evaluated in this study was not altered by 900 MHz RF radiation. Conclusion: 900 MHz RF radiation can alter some of the miRNA, which, in turn, may lead to adverse effects. Therefore, further studies should be performed.

Davis RL, Mostofi FK, Cluster of testicular cancer in police officers exposed to hand-held radar. Am J Ind Med 24(2):231-233, 1993.

Within a cohort of 340 police officers, six incident cases of testicular cancer occurred between 1979 and 1991 (O/E 6.9; p < 0.001, Poisson distribution). Occupational use of hand-held radar was the only shared risk factor among all six officers, and all routinely held the radar gun directly in close proximity to their testicles. Health effects of occupational radar use have not been widely studied, and further research into a possible association with testicular cancer is warranted.

Davidson HC, Lutman ME. Survey of mobile phone use and their chronic effects on the hearing of a student population. Int J Audiol. 46(3):113-118, 2007. [Article in English, French]

Mobile phone ownership and usage is now widespread and public concern has developed over possible harmful physiological effects of their use. This study aimed to investigate the prevalence of student mobile phone ownership and any possible chronic effects of usage on hearing, tinnitus and balance. Questionnaires for electronic self-completion were distributed to University of Southampton postgraduates, and 117 out of 160 returned met the criteria for analysis. A total of 94% were current mobile phone users, and only 2% had never used a mobile phone. Duration of ownership and daily usage ranged from 0-7 years and 0-45 minutes respectively. Text-messaging was more popular than talking. High or long-term users reported no worse hearing, tinnitus, or balance than low or short-term users. The results of this study confirm that the prevalence of mobile phone ownership amongst students is extremely high. However there appear to be no harmful effects of mobile phone usage on their audiovestibular systems within the range of exposure of the study, insofar as can be detected by the self-report method employed.

Dawe AS, Smith B, Thomas DW, Greedy S, Vasic N, Gregory A, Loader B, de Pomerai DI. A small temperature rise may contribute towards the apparent induction by microwaves of heat-shock gene expression in the nematode Caenorhabditis Elegans. Bioelectromagnetics.27(2):88-97, 2006.

We have previously reported that low intensity microwave exposure (0.75-1.0 GHz CW at 0.5 W; SAR 4-40 mW/kg) can induce an apparently non-thermal heat-shock response in Caenorhabditis elegans worms carrying hsp16-1::reporter genes. Using matched copper TEM cells for both sham and exposed groups, we can detect only modest reporter

induction in the latter exposed group (15-20% after 2.5 h at 26 degrees C, rising to approximately 50% after 20 h). Traceable calibration of our copper TEM cell by the National Physical Laboratory (NPL) reveals significant power loss within the cell (8.5% at 1.0 GHz), accompanied by slight heating of exposed samples (approximately 0.3 degrees C at 1.0 W). Thus, exposed samples are in fact slightly warmer (by </=0.2 degrees C at 0.5 W) than sham controls. Following NPL recommendations, our TEM cell design was modified with the aim of reducing both power loss and consequent heating. In the modified silver-plated cell, power loss is only 1.5% at 1.0 GHz, and sample warming is reduced to approximately 0.15 degrees C at 1.0 W (i.e., </=0.1 degrees C at 0.5 W). Under sham:sham conditions, there is no difference in reporter expression between the modified silver-plated TEM cell and an unmodified copper cell. However, worms exposed to microwaves (1.0 GHz and 0.5 W) in the silver-plated cell also show no detectable induction of reporter expression relative to sham controls in the copper cell. Thus, the 20% "microwave induction" observed using two copper cells may be caused by a small temperature difference between sham and exposed conditions. In worms incubated for 2.5 h at 26.0, 26.2, and 27.0 degrees C with no microwave field, there is a consistent and significant increase in reporter expression between 26.0 and 26.2 degrees C (by approximately 20% in each of the six independent runs), but paradoxically expression levels at 27.0 degrees C are similar to those seen at 26.0 degrees C. This surprising result is in line with other evidence pointing towards complex regulation of hsp16-1 gene expression across the sub-heat-shock range of 25-27.5 degrees C in C. elegans. We conclude that our original interpretation of a non-thermal effect of microwaves cannot be sustained; at least part of the explanation appears to be thermal.

Dawe AS, Nylund R, Leszczynski D, Kuster N, Reader T, De Pomerai DI. Continuous wave and simulated GSM exposure at 1.8 W/kg and 1.8 GHz do not induce hsp16-1 heat-shock gene expression in Caenorhabditis elegans. Bioelectromagnetics. 29(2):92-99, 2008.

Recent data suggest that there might be a subtle thermal explanation for the apparent induction by radiofrequency (RF) radiation of transgene expression from a small heat-shock protein (hsp16-1) promoter in the nematode, Caenorhabditis elegans. The RF fields used in the C. elegans study were much weaker (SAR 5-40 mW kg(-1)) than those routinely tested in many other published studies (SAR approximately 2 W kg(-1)). To resolve this disparity, we have exposed the same transgenic hsp16-1::lacZ strain of C. elegans (PC72) to higher intensity RF fields (1.8 GHz; SAR approximately 1.8 W kg(-1)). For both continuous wave (CW) and Talk-pulsed RF exposures (2.5 h at 25 degrees C), there was no indication that RF exposure could induce reporter expression above sham control levels. Thus, at much higher induced RF field strength (close to the maximum permitted exposure from a mobile telephone handset), this particular nematode heat-shock gene is not up-regulated. However, under conditions where background reporter expression was moderately elevated in the sham controls (perhaps as a result of some unknown co-stressor), we found some evidence that reporter expression may be reduced by approximately 15% following exposure to either Talk-pulsed or CW RF fields.

D'Costa H, Trueman G, Tang L, Abdel-rahman U, Abdel-rahman W, Ong K, Cosic I. Human brain wave activity during exposure to radiofrequency field emissions from mobile phones. Australas Phys Eng Sci Med. 26(4):162-167, 2003.

The aim of this study was to determine whether there is an effect of mobile phone electromagnetic field emissions on the human electroencephalograph (EEG). EEG recordings from ten awake subjects were taken during exposure to radiofrequency (RF) emissions from a mobile phone positioned behind the head. Two experimental trials were conducted. In the first trial, RF exposures were generated by a GSM mobile phone with the speaker disabled and configured to transmit at full-radiated power. During the second trial, exposures were generated by a non-modified GSM mobile phone in active standby mode. For each trial, subjects were exposed in five minute intervals to a randomized, interrupted sequence of five active and five sham exposures. The experiment was conducted under single-blind conditions. The average EEG band power in active exposure recordings was compared to corresponding sham recordings. Statistical tests indicated significant difference in the full-power mode trial within the EEG alpha (8-13 Hz) and beta (13-32 Hz) bands. A subsequent statistical analysis of median spectral power in discrete EEG rhythms revealed significant differences in 7 of the 32 distinct frequencies overall. In conclusion, the results of this study lend support to EEG effects from mobile phones activated in talk-mode.

de Gannes FP, Taxile M, Duleu S, Hurtier A, Haro E, Geffard M, Ruffié G, Billaudel B, Lévêque P, Dufour P, Lagroye I, Veyret B. A confirmation study of Russian and Ukrainian data on effects of 2450 MHz microwave exposure on immunological processes and teratology in rats. Radiat Res. 172(5):617-624, 2009.

In a series of Russian and Ukrainian papers published from 1974-1986, it was reported that 30-day whole-body exposures to continuous-wave (CW) radiofrequency (RF) radiation at 2375 MHz and 5 W/m(2) disrupted the antigenic structure of rat brain tissue. The authors suggested that this action caused an autoimmune response in exposed animals. Moreover, these studies reported that blood serum from exposed rats injected into intact nonexposed female rats on the 10th day of pregnancy led to increased postimplantation embryo mortality and decreased fetus size and body weight. Because the results of these studies served in part as the basis for setting exposure limits in the former USSR, it was deemed necessary to perform confirmation studies, using modern dosimetric and biological methods. In our study, a new system was constructed to expose free-moving rats under far-field conditions. Whole-body and brain-averaged specific absorption rates (SARs) were calculated. All results, using ELISA and classic teratology end points, were negative in our laboratory. On the basis of this investigation, we conclude that, under these exposure conditions (2450 MHz, CW, 7 h/day, 30 days, 0.16 W/kg whole-body SAR), RF-radiation exposure had no influence on several immune and degenerative parameters or on prenatal development.

de Gannes FP, Billaudel B, Taxile M, Haro E, Ruffié G, Lévêque P, Veyret B, Lagroye I. Effects of head-only exposure of rats to GSM-900 on blood-brain barrier permeability and neuronal degeneration. Radiat Res. 172(3):359-367, 2009.

Salford et al. reported in 2003 that a single 2-h exposure to GSM-900 mobile telephony signals induced brain damage (increased permeability of the blood-brain barrier and presence of dark neurons) 50 days after exposure. In our study, 16 Fischer 344 rats (14

weeks old) were exposed head-only to the GSM-900 signal for 2 h at various brain-averaged SARs (0, 0.14 and 2.0 W/kg) or were used as cage or positive controls. Albumin leakage and neuron degeneration were evaluated 14 and 50 days after exposure. No apoptotic neurons were found 14 days after the last exposure using the TUNEL method. No statistically significant albumin leakage was observed. Neuronal degeneration, assessed using cresyl violet or the more specific marker Fluoro-Jade B, was not significantly different among the tested groups. No apoptotic neurons were detected. The findings of our study did not confirm the previous results of Salford et al.

De Iuliis GN, **Newey RJ**, **King BV**, **Aitken RJ**. **Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro. PLoS One. 4(7):e6446, 2009.**

BACKGROUND: In recent times there has been some controversy over the impact of electromagnetic radiation on human health. The significance of mobile phone radiation on male reproduction is a key element of this debate since several studies have suggested a relationship between mobile phone use and semen quality. The potential mechanisms involved have not been established, however, human spermatozoa are known to be particularly vulnerable to oxidative stress by virtue of the abundant availability of substrates for free radical attack and the lack of cytoplasmic space to accommodate antioxidant enzymes. Moreover, the induction of oxidative stress in these cells not only perturbs their capacity for fertilization but also contributes to sperm DNA damage. The latter has, in turn, been linked with poor fertility, an increased incidence of miscarriage and morbidity in the offspring, including childhood cancer. In light of these associations, we have analyzed the influence of RF-EMR on the cell biology of human spermatozoa in vitro. PRINCIPAL FINDINGS: Purified human spermatozoa were exposed to radio-frequency electromagnetic radiation (RF-EMR) tuned to 1.8 GHz and covering a range of specific absorption rates (SAR) from 0.4 W/kg to 27.5 W/kg. In step with increasing SAR, motility and vitality were significantly reduced after RF-EMR exposure, while the mitochondrial generation of reactive oxygen species and DNA fragmentation were significantly elevated ($P<0.001$). Furthermore, we also observed highly significant relationships between SAR, the oxidative DNA damage bio-marker, 8-OH-dG, and DNA fragmentation after RF-EMR exposure. CONCLUSIONS: RF-EMR in both the power density and frequency range of mobile phones enhances mitochondrial reactive oxygen species generation by human spermatozoa, decreasing the motility and vitality of these cells while stimulating DNA base adduct formation and, ultimately DNA fragmentation. These findings have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and wellbeing of their offspring.

De Luca C, Chung Sheun Thai J, Raskovic D, Cesareo E, Caccamo D, Trukhanov A, Korkina L. Metabolic and genetic screening of electromagnetic hypersensitive subjects as a feasible tool for diagnostics and intervention. Mediators Inflamm. 2014;2014:924184. doi: 10.1155/2014/924184. Epub 2014 Apr 9.

Growing numbers of "electromagnetic hypersensitive" (EHS) people worldwide self-report severely disabling, multiorgan, non-specific symptoms when exposed to low-dose

electromagnetic radiations, often associated with symptoms of multiple chemical sensitivity (MCS) and/or other environmental "sensitivity-related illnesses" (SRI). This cluster of chronic inflammatory disorders still lacks validated pathogenetic mechanism, diagnostic biomarkers, and management guidelines. We hypothesized that SRI, not being merely psychogenic, may share organic determinants of impaired detoxification of common physic-chemical stressors. Based on our previous MCS studies, we tested a panel of 12 metabolic blood redox-related parameters and of selected drug-metabolizing-enzyme gene polymorphisms, on 153 EHS, 147 MCS, and 132 control Italians, confirming MCS altered ($P < 0.05$-0.0001) glutathione-(GSH), GSH-peroxidase/S-transferase, and catalase erythrocyte activities. We first described comparable-though milder-metabolic pro-oxidant/proinflammatory alterations in EHS with distinctively increased plasma coenzyme-Q10 oxidation ratio. Severe depletion of erythrocyte membrane polyunsaturated fatty acids with increased ω 6/ ω 3 ratio was confirmed in MCS, but not in EHS. We also identified significantly ($P = 0.003$) altered distribution-versus-control of the CYP2C19∗1/∗2 SNP variants in EHS, and a 9.7-fold increased risk (OR: 95% C.I. = 1.3-74.5) of developing EHS for the haplotype (null)GSTT1 + (null)GSTM1 variants. Altogether, results on MCS and EHS strengthen our proposal to adopt this blood metabolic/genetic biomarkers' panel as suitable diagnostic tool for SRI.

de Pomerai D, Daniells C, David H, Allan J, Duce I, Mutwakil M, Thomas D, Sewell P, Tattersall J, Jones D, Candido P, Non-thermal heat-shock response to microwaves, Nature 405:417-418, 2000.

Nematode worms (C. elegans) exposed overnight to 750-MHz microwaves at a SAR of 0.001 W/kg showed an increased in heat shock proteins (HSPs). (Heat shock proteins are induced in most organisms by adverse conditions (such as heat or toxins) that cause damage to cellular proteins, acting as molecular chaperones to rescue damaged proteins). The authors give several arguments that the microwave-induced effect on HSPs is non-thermal and suggest that 'current exposure limits for microwave equipment may need to be reconsidered.'

de Pomerai DI, Dawe A, DjerbibL, Allan, Brunt G, Daniells C. Growth and maturation of the nematode Caenorhabditis elegans following exposure to weak microwave fields. Enzyme Microbial Tech 30:73-79, 2002.

Prolonged exposure to weak microwave fields (750–1000 MHz, 0.5 W) at 25°C induces a heat-shock response in transgenic C. elegans strains carrying hsp16 reporter genes [1]. A comparable response to heat alone requires a substantially higher temperature of 28°C, suggesting that microwave heating of worms or of the system as a whole might provide a sufficient explanation, although this can be ruled out by indirect arguments [1]. Here we investigate two further biological consequences of prolonged microwave exposure at 25°C in synchronised cultures of wild-type worm larvae, namely alterations in (i) growth rate (GR) and (ii) the proportion of worms later maturing into egg-bearing adults (MP). Both of these parameters are significantly increased following microwave exposure (GR by 8–11%, and MP by 28–40%), whereas both are significantly decreased (GR by 10% and MP almost abolished) after mild heat treatment at 28°C for the same period. It follows that the biological consequences of microwave exposure are opposite to, and therefore

incompatible with, those attributable to mild heating. This evidence does not in itself necessitate a non-thermal mechanism, but does eliminate explanations that invoke the bulk heating of tissues by microwaves. This latter, however, remains the sole basis for current regulations governing microwave exposure.

de Pomerai DI, Smith B, Dawe A, North K, Smith T, Archer DB, Duce IR, Jones D, Candido EP. Microwave radiation can alter protein conformation without bulk heating. FEBS Lett 543(1-3):93-97, 2003.

Exposure to microwave radiation enhances the aggregation of bovine serum albumin in vitro in a time- and temperature-dependent manner. Microwave radiation also promotes amyloid fibril formation by bovine insulin at 60 degrees C. These alterations in protein conformation are not accompanied by measurable temperature changes, consistent with estimates from field modelling of the specific absorbed radiation (15-20 mW kg(-1)). Limited denaturation of cellular proteins could explain our previous observation that modest heat-shock responses are induced by microwave exposure in Caenorhabditis elegans. We also show that heat-shock responses both to heat and microwaves are suppressed after RNA interference ablating heat-shock factor function.

De Roos AJ, Teschke K, Savitz DA, Poole C, Grufferman S, Pollock BH, Olshan AF. Parental occupational exposures to electromagnetic fields and radiation and the incidence of neuroblastoma in offspring. Epidemiology 12(5):508-517, 2001.

We examined parental occupational exposures to electromagnetic fields and radiation and the incidence of neuroblastoma in offspring. Cases were 538 children diagnosed with neuroblastoma between 1992 and 1994 in the United States or Canada. Age-matched controls were selected by random-digit dialing. Occupational exposures to electrical equipment and radiation sources were classified by an industrial hygienist, and average exposures to extremely low frequency magnetic fields were estimated using a job exposure matrix. Maternal exposure to a broad grouping of sources that produce radiofrequency radiation was associated with an increased incidence of neuroblastoma (odds ratio = 2.8; 95% confidence interval = 0.9-8.7). Paternal exposure to battery-powered forklifts was positively associated with neuroblastoma (odds ratio = 1.6; 95% confidence interval = 0.8-3.2), as were some types of equipment that emit radiofrequency radiation (odds ratios congruent with2.0); however, the broad groupings of sources that produce ELF fields, radiofrequency radiation, or ionizing radiation were not associated with neuroblastoma. Paternal average extremely low frequency magnetic field exposure >0.4 microTesla was weakly associated with neuroblastoma (odds ratio = 1.6; 95% confidence interval = 0.9-2.8), whereas maternal exposure was not. Overall, there was scant supportive evidence of strong associations between parental exposures in electromagnetic spectrum and neuroblastoma in offspring.

de Salles AA, Bulla G, Rodriguez CE. Electromagnetic absorption in the head of adults and children due to mobile phone operation close to the head. Electromagn Biol Med. 2006;25(4):349-360, 2006.

The Specific Absorption Rate (SAR) produced by mobile phones in the head of adults and children is simulated using an algorithm based on the Finite Difference Time Domain (FDTD) method. Realistic models of the child and adult head are used. The

electromagnetic parameters are fitted to these models. Comparison also are made with the SAR calculated in the children model when using adult human electromagnetic parameters values. Microstrip (or patch) antennas and quarter wavelength monopole antennas are used in the simulations. The frequencies used to feed the antennas are 1850 MHz and 850 MHz. The SAR results are compared with the available international recommendations. It is shown that under similar conditions, the 1g-SAR calculated for children is higher than that for the adults. When using the 10-year old child model, SAR values higher than 60% than those for adults are obtained.

de Seze R, Ayoub J, Peray P, Miro L, Touitou Y, Evaluation in humans of the effects of radiocellular telephones on the circadian patterns of melatonin secretion, a chronobiological rhythm marker. J Pineal Res 27(4):237-242, 1999.

A decrease in melatonin secretion has been observed in small mammals under exposure to extremely low frequency electromagnetic fields. As there is some concern about possible health effects of the increasing use of radiocellular telephones emitting radiofrequency electromagnetic fields, we examined whether such fields would alter melatonin levels in the human. Volunteers were two groups totalling 38 men, 20-32 yr old. Exposures were to commercially available cellular telephones of the GSM 900 type (Global System for Mobile communication at 900 MHz) or DCS 1800 type (Digital Communication System at 1800 MHz), for 2 hr/day, 5 days/wk, for 4 wk, at their maximum power. Attention of the volunteers was sustained by TV projection of movies. Blood samples were collected hourly during the night and every 3 hr in the daytime. Four sampling sessions were performed at 15-day intervals: before the beginning of the exposure period, at the middle and the end of the exposure period, and 15 days later to evaluate the persistence or late appearance of potential effects. Evaluated parameters were the maximum serum concentration, the time of this maximum, and the area under the curve of the hormone profile. Melatonin circadian profile was not disrupted in 37 young male volunteers submitted to a typical pattern of exposure to the electromagnetic fields generated by two common types of cell phones.

de Seze R, Fabbro-Peray P, Miro L, GSM radiocellular telephones do not disturb the secretion of antepituitary hormones in humans. Bioelectromagnetics 19(5):271-278, 1998.

It is known that the endocrine system of experimental animals is susceptible to perturbation by radiofrequency (RF) radiation. Because of the recent interest in health and safety issues of cellular telephones, an experiment was designed to evaluate the effect of a 900 MHz RF radiation emitted by a Global System for Mobile radiotelephone (217 Hz impulses, one-eighth duty cycle, 2 W peak power) on human endocrine functions. Twenty healthy male volunteers aged from 19 to 40 were inducted in the present experiment. Each subject was exposed to RF radiation through the use of a cellular phone 2 h/day, 5 days/wk, for 1 month. Subjects were their own control. End points were serum adrenocorticotropin, thyrotropin, growth hormone, prolactin, luteinizing hormone, and follicle stimulating hormone concentrations. These end points were determined in nine weekly blood samples obtained starting 3 weeks before the

commencement of the exposure and ending 2 weeks after exposures. All but one blood sample was drawn 48 h after each weekly session. The seventh drawing was performed the morning after the last weekly exposure. Within each individual, the preexposure hormone concentration was used as a control. Results indicated that all hormone concentrations remained within normal physiologic ranges. A difference was not noted among the nine weekly samples in five of six hormones studied. There was a significant change only in thyrotropin concentration, showing a 21% decrease on the seventh sampling. Because this change recovered fully during the postexposure period, it is concluded that 1 month of intermittent exposures to RF radiation from a cellular telephone does not induce a long-lasting or cumulative effect on the hormone secretion rate of the anterior pituitary gland in humans.

de Souza FT, Silva JF, Ferreira EF, Siqueira EC, Duarte AP, Gomez MV, Gomez RS, Gomes CC. Cell phone use and parotid salivary gland alterations: no molecular evidence. Cancer Epidemiol Biomarkers Prev. 2014 Apr 21. [Epub ahead of print]

Background The association between cell phone use and the development of parotid tumors is controversial. Because there is unequivocal evidence that the microenvironment is important for tumor formation, we investigated in the parotid glands whether cell phone use alters the expression of gene products related to cellular stress. Methods We used the saliva produced by the parotid glands of 62 individuals to assess molecular alterations compatible with cellular stress, comparing the saliva from the gland exposed to cell phone radiation (ipsilateral) to the saliva from the opposite, unexposed parotid gland (contralateral) of each individual. We compared salivary flow, total protein concentration, p53, p21, reactive oxygen species (ROS), and salivary levels of glutathione (GSH), heat shock proteins 27 and 70 and IgA between the ipsilateral and contralateral parotids. Results No difference was found for any of these parameters, even when grouping individuals by period of cell phone use in years or by monthly average calls in minutes. Conclusions and Impact We provide molecular evidence that the exposure of parotid glands to cell phone use does not alter parotid salivary flow, protein concentration or levels of proteins of genes that are directly or indirectly affected by heat-induced cellular stress.

de Tommaso M, Rossi P, Falsaperla R, Francesco VD, Santoro R, Federici A. Mobile Phones exposure induces changes of Contingent Negative Variation in humans. Neurosci Lett.464(2):79-83, 2009.

Event related potentials have been largely employed to test effects of GSM emissions on human brain. The aim of the present study, was the evaluation of initial Contingent Negative Variation (iCNV) changes, induced by 900MHz GSM exposure, in a double blind design in healthy volunteers, subjected to a threefold experimental condition, EXPOSED (A), a real GSM phone emitting electromagnetic power, SHAM (B), a real phone where the electromagnetic power was dissipated on an internal load and OFF (C), a phone completely switched off. Ten healthy right-handed volunteers were evaluated. The CNV was recorded during a 10minutes time interval in each of the three experimental conditions A, B, and C, in order to assess the iCNV amplitude and habituation. The iCNV amplitude decreased and habituation increased during both A and B conditions,

compared with condition C. This effect was diffuse over the scalp, and there was no significant prevalence of iCNV amplitude reduction on the left side, were the phones were located. Mobile Phones exposures A and B seemed to act on brain electrical activity, reducing the arousal and expectation of warning stimulus. This evidence, limited by the low number of subjects investigated, could be explained in terms of an effect induced by both the GSM signal and the Extremely Low Frequency magnetic field produced by battery and internal circuits.

de Vocht F, Hannam K, Buchan I. Environmental risk factors for cancers of the brain and nervous system: the use of ecological data to generate hypotheses. Occup Environ Med. 2013 Jan 23. [Epub ahead of print]

BACKGROUND: There is a public health need to balance timely generation of hypotheses with cautious causal inference. For rare cancers this is particularly challenging because standard epidemiological study designs may not be able to elucidate causal factors in an early period of newly emerging risks. Alternative methodologies need to be considered for generating and shaping hypotheses prior to definitive investigation. OBJECTIVES: To evaluate whether open-access databases can be used to explore links between potential risk factors and cancers at an ecological level, using the case study of brain and nervous system cancers as an example. METHODS: National age-adjusted cancer incidence rates were obtained from the GLOBOCAN 2008 resource and combined with data from the United Nations Development Report and the World Bank list of development indicators. Data were analysed using multivariate regression models. RESULTS: Cancer rates, potential confounders and environmental risk factors were available for 165 of 208 countries. 2008 national incidences of brain and nervous system cancers were associated with continent, gross national income in 2008 and Human Development Index Score. The only exogenous risk factor consistently associated with higher incidence was the penetration rate of mobile/cellular telecommunications subscriptions, although other factors were highlighted. According to these ecological results the latency period is at least 11-12 years, but probably more than 20 years. Missing data on cancer incidence and for other potential risk factors prohibit more detailed investigation of exposure-response associations and/or explore other hypotheses. CONCLUSIONS: Readily available ecological data may be underused, particularly for the study of risk factors for rare diseases and those with long latencies. The results of ecological analyses in general should not be overinterpreted in causal inference, but equally they should not be ignored where alternative signals of aetiology are lacking.

Degrave E, Autier P, Grivegnee AR, Zizi M. All-cause mortality among belgian military radar operators: a 40-year controlled longitudinal study. Eur J Epidemiol. 20(8):677-681, 2005.

Background: It has been suggested that exposure to radiofrequency/microwaves radiations could be associated with greater health hazards and higher mortality. Methods: The all-cause mortality of 27,671 Belgian militaries who served from 1963 until 1994 in battalions equipped with radars for anti-aircraft defence was studied over the period 1968-2003. End of the seventies, technical modifications brought to the shielding of the micro-

wave generators resulted in a reduction in irradiations. A control group was formed by 16,128 militaries who served during the same period in the same military area but who were never exposed to radars. Administrative procedures for identifying militaries and their vital status were equivalent in the radar and the control groups. Results: The age-standardized mortality ratio (SMR) in the radar battalions was 1.05 (95% CI: 0.95-1.16) in professional militaries, and 0.80 (95% CI: 0.75-0.85) in conscripts. In professional militaries no difference in mortality was found according to duration (less than, or five years or more) or to period of service (before 1978 or after 1977). Conclusions: During a 40-year period of observation, we found no increase in all-cause mortality in Belgian militaries who were in close contact with radar equipments of anti-aircraft defence battalions.

Del Signore A, Boscolo P, Kouri S, Di Martino G, Giuliano G, Combined effects of traffic and electromagnetic fields on the immune system of fertile atopic women. Ind Health 38(3):294-300, 2000.

Object of this preliminary study was the immune response to high or low frequency electromagnetic fields (ELMF) of non-atopic and atopic fertile women with uniform exposure to toxic compounds produced by traffic. Women were divided in group A (non-atopic, non-exposed to ELMF); B (atopic, non-exposed to ELMF); C (non-atopic, exposed to ELMF); D (atopic, exposed to ELMF). "In vitro" cell proliferation of peripheral blood mononuclear cells (PBMC) of atopic women (groups B and D) stimulated by phytohaemoglutinin (PHA) was reduced. The ELMF exposed women (groups C and D) showed lower levels of blood NK CD16(+)-CD56+ lymphocyte subpopulations and of "in vitro" production of interferon-gamma (both spontaneously and in presence of PHA) by PBMC, suggesting that ELMF reduces blood cytotoxic activity. Serum IgE of the atopic women exposed to ELMF (group D) was higher than that of the other groups. Linear discriminant analysis including serum zinc and copper (essential enzymes for immune functions), blood lead and urinary transtrans muconic acid, a metabolite of benzene (markers of exposure to traffic) and key parameters of immune functions (CD16(+)-CD56+ lymphocyte subset, serum IgE, interferon-gamma produced by PBMC in presence of PHA, stimulation index of blastogenesis) showed absence of significant difference between groups A and C and a marked separation of groups B and D. This datum suggests that ELMF have a greater influence on atopic women exposed to traffic than on non-atopic ones.

Del Vecchio G, Giuliani A, Fernandez M, Mesirca P, Bersani F, Pinto R, Ardoino L, Lovisolo GA, Giardino L, Calzaà L. Effect of radiofrequency electromagnetic field exposure on in vitro models of neurodegenerative disease. Bioelectromagnetics.30(7):564-72, 2009.

In this work we tested viability, proliferation, and vulnerability of neural cells, after continuous radiofrequency (RF) electromagnetic fields exposure (global system for mobile telecommunications (GSM) modulated 900 MHz signal at a specific absorption rate (SAR) of 1 W/kg and maximum duration 144 h) generated by transverse electromagnetic cells. We used two cellular systems, SN56 cholinergic for example, SN56 cholinergic cell line and rat primary cortical neurons, and well-known neurotoxic

challenges, such as glutamate, 25-35AA beta-amyloid, and hydrogen peroxide. Exposure to RF did not change viability/proliferation rate of the SN56 cholinergic cells or viability of cortical neurons. Co-exposure to RF exacerbated neurotoxic effect of hydrogen peroxide in SN56, but not in primary cortical neurons, whereas no cooperative effects of RF with glutamate and 25-35AA beta-amyloid were found. These data suggest that only under particular circumstances exposure to GSM modulated, 900 MHz signal act as a co-stressor for oxidative damage of neural cells.

Del Vecchio G, Giuliani A, Fernandez M, Mesirca P, Bersani F, Pinto R, Ardoino L, Lovisolo GA, Giardino L, Calzà L. Continuous exposure to 900MHz GSM-modulated EMF alters morphological maturation of neural cells. Neurosci Lett. 455(3):173-177, 2009.

The effects of radiofrequency electromagnetic field (RF-EMF) exposure on neuronal phenotype maturation have been studied in two different in vitro models: murine SN56 cholinergic cell line and rat primary cortical neurons. The samples were exposed at a dose of 1W/kg at 900 MHz GSM modulated. The phenotype analysis was carried out at 48 and 72 h (24 and 48 h of SN56 cell line differentiation) or at 24, 72, 120 h (2, 4 and 6 days in vitro for cortical neurons) of exposure, on live and immunolabeled neurons, and included the morphological study of neurite emission, outgrowth and branching. Moreover, cortical neurons were studied to detect alterations in the expression pattern of cytoskeleton regulating factors, e.g. beta-thymosin, and of early genes, e.g. c-Fos and c-Jun through real-time PCR on mRNA extracted after 24h exposure to EMF. We found that RF-EMF exposure reduced the number of neurites generated by both cell systems, and this alteration correlates to increased expression of beta-thymosin mRNA.

Deltour I, Auvinen A, Feychting M, Johansen C, Klaeboe L, Sankila R, Schüz J. Mobile phone use and incidence of glioma in the Nordic countries 1979-2008: consistency check.Epidemiology. 23(2):301-307, 2012.

BACKGROUND: Some case-control studies have reported increased risks of glioma associated with mobile phone use. If true, this would ultimately affect the time trends for incidence rates (IRs). Correspondingly, lack of change in IRs would exclude certain magnitudes of risk. We investigated glioma IR trends in the Nordic countries, and compared the observed with expected incidence rates under various risk scenarios.**METHODS:** We analyzed annual age-standardized incidence rates in men and women aged 20 to 79 years during 1979-2008 using joinpoint regression (35,250 glioma cases). Probabilities of detecting various levels of relative risk were computed using simulations.**RESULTS:** For the period 1979 through 2008, the annual percent change in incidence rates was 0.4% (95% confidence interval = 0.1% to 0.6%) among men and 0.3% (0.1% to 0.5%) among women. Incidence rates have decreased in young men (20-39 years) since 1987, remained stable in middle-aged men (40-59 years) throughout the 30-year study period, and increased slightly in older men (60-79 years). In simulations, assumed relative risks for all users of 2.0 for an induction time of up to 15 years, 1.5 for up to 10 years, and 1.2 for up to 5 years were incompatible with observed incidence time trends. For heavy users of mobile phones, risks of 2.0 for up to 5 years' induction were also incompatible.**CONCLUSION:** No clear trend change in glioma incidence rates was

observed. Several of the risk increases seen in case-control studies appear to be incompatible with the observed lack of incidence rate increase in middle-aged men. This suggests longer induction periods than currently investigated, lower risks than reported from some case-control studies, or the absence of any association.

Deltour I, Wiart J, Taki M, Wake K, Varsier N, Mann S, Schüz J, Cardis E. Analysis of three-dimensional SAR distributions emitted by mobile phones in an epidemiological perspective.Bioelectromagnetics. 32(8):634-643, 2011.

The three-dimensional distribution of the specific absorption rate of energy (SAR) in phantom models was analysed to detect clusters of mobile phones producing similar spatial deposition of energy in the head. The clusters' characteristics were described from the phones external features, frequency band and communication protocol. Compliance measurements with phones in cheek and tilt positions, and on the left and right side of a physical phantom were used. Phones used the Personal Digital Cellular (PDC), Code division multiple access One (CdmaOne), Global System for Mobile Communications (GSM) and Nordic Mobile Telephony (NMT) communication systems, in the 800, 900, 1500 and 1800 MHz bands. Each phone's measurements were summarised by the half-ellipsoid in which the SAR values were above half the maximum value. Cluster analysis used the Partitioning Around Medoids algorithm. The dissimilarity measure was based on the overlap of the ellipsoids, and the Manhattan distance was used for robustness analysis. Within the 800 MHz frequency band, and in part within the 900 MHz and the 1800 MHz frequency bands, weak clustering was obtained for the handset shape (bar phone, flip with top and flip with central antennas), but only in specific positions (tilt or cheek). On measurements of 120 phones, the three-dimensional distribution of SAR in phantom models did not appear to be related to particular external phone characteristics or measurement characteristics, which could be used for refining the assessment of exposure to radiofrequency energy within the brain in epidemiological studies such as the Interphone.

Demirel S, Doganay S, Turkoz Y, Dogan Z, Turan B, Firat PG. Effects of third generation mobile phone-emitted electromagnetic radiation on oxidative stress parameters in eye tissue and blood of rats. Cutan Ocul Toxicol.31(2):89-94, 2012.

Purpose: To investigate the effects of electromagnetic radiation (EMR) emitted by a third generation (3G) mobile phone on the antioxidant and oxidative stress parameters in eye tissue and blood of rats. Methods: Eighteen Wistar albino rats were randomly assigned into two groups: Group I (n = 9) received a standardized a daily dose of 3G mobile phone EMR for 20 days, and Group II served as the control group (n = 9), receiving no exposure to EMR. Glutathione peroxidase (GSH-Px) and catalase (CAT) levels were measured in eye tissues; in addition, malondialdehyde (MDA) and reduced GSH levels were measured in blood. Results: There was no significant difference between groups in GSH-Px (p = 0.99) and CAT (p = 0.18) activity in eye tissue. There was no significant difference between groups in MDA (p = 0.69) and GSH levels (p = 0.83) in blood. Conclusions: The results of this study suggest that under a short period of exposure, 3G mobile phone radiation does not

lead to harmful effects on eye tissue and blood in rats.

Demsia G, Vlastos D, Matthopoulos DP. Effect of 910-MHz electromagnetic field on rat bone marrow. ScientificWorldJournal. 4 Suppl 2:48-54, 2004.

Aiming to investigate the possibility of electromagnetic fields (EMF) developed by nonionizing radiation to be a noxious agent capable of inducing genotoxicity to humans, in the current study we have investigated the effect of 910-MHz EMF in rat bone marrow. Rats were exposed daily for 2 h over a period of 30 consecutive days. Studying bone marrow smears from EMF-exposed and sham-exposed animals, we observed an almost threefold increase of micronuclei (MN) in polychromatic erythrocytes (PCEs) after EMF exposure. An induction of MN was also observed in polymorphonuclear cells. The induction of MN in female rats was less than that in male rats. The results indicate that 910-MHz EMF could be considered as a noxious agent capable of producing genotoxic effects.

Denny-Bas V, Zmirou-Navier D, De Tychey C, Briançon S. The role of anxiety in the perception of technological hazards - A cross-sectional study on cell phones and masts. Rev Epidemiol Sante Publique. 2014 Mar 16. pii: S0398-7620(14)00160-6. doi: 10.1016/j.respe.2013.11.076. [Epub ahead of print]

BACKGROUND: Risk perception is determined by parameters related to the nature of the risk, as well as inherent to the individual perceiving this risk. This study was designed to provide a better understanding of the role of personality, especially anxiety traits, on risk perception. It compared representations of two different risks, smoking (with known and generally accepted adverse health effects) and cell phones (whose hazardous potency is still controversial), each presented in two different forms of exposure, active (smokers and cell phone users) and passive (passive smoking and exposure to cell phone masts). METHODS: A self-administered questionnaire sent to volunteer subjects collected sociodemographic and exposure data. It measured the perceived risk as well as 11 psychometric properties of risk using visual analogue scales (values ranging from 0 to 10). An anxiety trait was evaluated by the Spielberger questionnaire. RESULTS: In all, 72% of the questionnaires sent were returned. Mean declared risk scores attributed to passive and active smoking were higher (8.75 and 8.31 respectively) than those attributed to cell phones and masts (4.44 and 4.73 respectively). However, scores for the 11 psychometric properties of the risk attributed to cell phones were higher than those associated with smoking, especially for dissatisfaction with information (6.71 and 7.36 respectively for cell phones and masts versus 1.75 and 2.18 for passive and active smoking) and the capacity of authorities to master the risk (6.45 and 6.65 for cell phones and masts versus 4.72 and 4.40 for passive and active smoking). Anxiety did not directly influence the risk scores attributed to these 4 forms of exposure but was predictive of the way in which subjects perceived the risk in terms of two essential properties: uncertainty concerning the effects on health and the potential to trigger health catastrophes. Indeed anxious subjects are more certain about the hazards of cell phones and masts than non-anxious subjects (P=0.008 et P≤0.001) and attributed a higher catastrophic potential (P=0.02 and P=0.004). CONCLUSION: This study suggests that subjects with an anxious

profile are affected by the destabilizing nature of uncertain knowledge concerning the hazardous potency of new technologies and of the controversies concerning this hazard.

de Oliveira FM, Carmona AM[2] Ladeira C. Is mobile phone radiation genotoxic? An analysis of micronucleus frequency in exfoliated buccal cells. Mutat Res. 2017 Oct;822:41-46. doi: 10.1016/j.mrgentox.2017.08.001. Epub 2017 Aug 5.

Electromagnetic fields (EMF) are classified as "possibly carcinogenic" by the International Agency for Research on Cancer (IARC). Some publications have reported associations between EMF exposure and DNA damage, but many other studies contradict such findings. Cytomorphological changes, such as micronuclei (MN), indicative of genomic damage, are biomarkers of genotoxicity. To test whether mobile phone-associated EMF exposure affects the MN frequency in exfoliated buccal cells, we obtained cells smears from the left and right inner cheeks of healthy mobile phone users, aged 18-30 (n=86), who also completed a characterization survey. MN frequencies were tested for potential confounding factors and for duration of phone use and preferential side of mobile phone use. No relationship was observed between MN frequency and duration of mobile phone use in daily calls. Cells ipsilateral to mobile phone use did not present a statistically significantly higher MN frequency, compared to cells contralateral to exposure. A highly statistically significant ($p<0.0001$) increase in MN frequency was found in subjects reporting regular exposure to genotoxic agents. Therefore, our results suggest that mobile phone-associated EMF do not to induce MN formation in buccal cells at the observed exposure levels.

Deshmukh PS, Banerjee BD, Abegaonkar MP, Megha K, Ahmed RS, Tripathi AK, Mediratta PK. Effect of low level microwave radiation exposure on cognitive function and oxidative stress in rats. Indian J Biochem Biophys. 50(2):114-119, 2013.

Use of wireless communicating devices is increasing at an exponential rate in present time and is raising serious concerns about possible adverse effects of microwave (MW) radiation emitted from these devices on human health. The present study aimed to evaluate the effects of 900 MHz MW radiation exposure on cognitive function and oxidative stress in blood of Fischer rats. Animals were divided into two groups (6 animals/group): Group I (MW-exposed) and Group II (Sham-exposed). Animals were subjected to MW exposure (Frequency 900 MHz; specific absorption rate 8.4738 x 10(-5) W/kg) in Gigahertz transverse electromagnetic cell (GTEM) for 30 days (2 h/day, 5 days/week). Subsequently, cognitive function and oxidative stress parameters were examined for each group. Results showed significant impairment in cognitive function and increase in oxidative stress, as evidenced by the increase in levels of MDA (a marker of lipid peroxidation) and protein carbonyl (a marker of protein oxidation) and unaltered GSH content in blood. Thus, the study demonstrated that low level MW radiation had significant effect on cognitive function and was also capable of leading to oxidative stress.

Deshmukh PS, Megha K, Banerjee BD, Ahmed RS, Chandna S, Abegaonkar MP, Tripathi AK. Detection of Low Level Microwave Radiation Induced Deoxyribonucleic Acid Damage Vis-à-vis Genotoxicity in Brain of Fischer Rats. Toxicol Int. 20(1):19-24, 2013.

BACKGROUND: Non-ionizing radiofrequency radiation has been increasingly used in industry, commerce, medicine and especially in mobile phone technology and has become a matter of serious concern in present time. OBJECTIVE: The present study was designed to investigate the possible deoxyribonucleic acid (DNA) damaging effects of low-level microwave radiation in brain of Fischer rats. MATERIALS AND METHODS: Experiments were performed on male Fischer rats exposed to microwave radiation for 30 days at three different frequencies: 900, 1800 and 2450 MHz. Animals were divided into 4 groups: Group I (Sham exposed): Animals not exposed to microwave radiation but kept under same conditions as that of other groups, Group II: Animals exposed to microwave radiation at frequency 900 MHz at specific absorption rate (SAR) 5.953 × 10(-4) W/kg, Group III: Animals exposed to 1800 MHz at SAR 5.835 × 10(-4) W/kg and Group IV: Animals exposed to 2450 MHz at SAR 6.672 × 10(-4) W/kg. At the end of the exposure period animals were sacrificed immediately and DNA damage in brain tissue was assessed using alkaline comet assay. RESULTS: In the present study, we demonstrated DNA damaging effects of low level microwave radiation in brain. CONCLUSION: We concluded that low SAR microwave radiation exposure at these frequencies may induce DNA strand breaks in brain tissue.

Deshmukh PS, Nasare N, Megha K, Banerjee BD, Ahmed RS, Singh D, Abegaonkar MP, Tripathi AK, Mediratta PK. Cognitive Impairment and Neurogenotoxic Effects in Rats Exposed to Low-Intensity Microwave Radiation. Int J Toxicol. 2015 Mar 5. pii: 1091581815574348. [Epub ahead of print]

The health hazard of microwave radiation (MWR) has become a recent subject of interest as a result of the enormous increase in mobile phone usage. The present study aimed to investigate the effects of chronic low-intensity microwave exposure on cognitive function, heat shock protein 70 (HSP70), and DNA damage in rat brain. Experiments were performed on male Fischer rats exposed to MWR for 180 days at 3 different frequencies, namely, 900, 1800 MHz, and 2450 MHz. Animals were divided into 4 groups: group I: sham exposed; group II: exposed to MWR at 900 MHz, specific absorption rate (SAR) 5.953×10^{-4} W/kg; group III: exposed to 1800 MHz, SAR 5.835×10^{-4} W/kg; and group IV: exposed to 2450 MHz, SAR 6.672×10^{-4} W/kg. All the rats were tested for cognitive function at the end of the exposure period and were subsequently sacrificed to collect brain. Level of HSP70 was estimated by enzyme-linked immunotarget assay and DNA damage was assessed using alkaline comet assay in all the groups. The results showed declined cognitive function, elevated HSP70 level, and DNA damage in the brain of microwave-exposed animals. The results indicated that, chronic low-intensity microwave exposure in the frequency range of 900 to 2450 MHz may cause hazardous effects on the brain.

Deshmukh PS, Megha K, Nasare N, Banerjee BD, Ahmed RS, Abegaonkar MP, Tripathi AK, Mediratta PK. Effect of Low Level Subchronic Microwave Radiation on Rat Brain. Biomed Environ Sci. 29(12):858-867, 2016

OBJECTIVE: The present study was designed to investigate the effects of subchronic low level microwave radiation (MWR) on cognitive function, heat shock protein 70 (HSP70) level and DNA damage in brain of Fischer rats. METHODS: Experiments were performed on male Fischer rats exposed to microwave radiation for 90 days at three different frequencies: 900, 1800, and 2450 MHz. Animals were divided into 4 groups: Group I: Sham exposed, Group II: animals exposed to microwave radiation at 900 MHz and specific absorption rate (SAR) 5.953 × 10-4 W/kg, Group III: animals exposed to 1800 MHz at SAR 5.835 × 10-4 W/kg and Group IV: animals exposed to 2450 MHz at SAR 6.672 × 10-4 W/kg. All the animals were tested for cognitive function using elevated plus maze and Morris water maze at the end of the exposure period and subsequently sacrificed to collect brain tissues. HSP70 levels were estimated by ELISA and DNA damage was assessed using alkaline comet assay. RESULTS: Microwave exposure at 900-2450 MHz with SAR values as mentioned above lead to decline in cognitive function, increase in HSP70 level and DNA damage in brain. CONCLUSION: The results of the present study suggest that low level microwave exposure at frequencies 900, 1800, and 2450 MHz may lead to hazardous effects on brain.

Desta AB, Owen RD, Cress LW. Non-thermal exposure to radiofrequency energy from digital wireless phones does not affect ornithine decarboxylase activity in L929 Cells. Radiat Res 160:488–491, 2003.

L929 murine fibroblast cells were exposed to radiofrequency (RF) radiation from a time division multiple access wireless phone operating at 835 MHz frequency to determine the effect of RF-radiation energy emitted by wireless phones on ornithine decarboxylase (ODC) activity in cultured cells. Exposure was for 8 h to an average specific absorption rate (SAR) from <1 W/kg up to 15 W/kg. After exposure, cells were harvested and ODC activity was measured. No statistically significant difference in ODC activity was found between RF-radiation-exposed and sham-exposed cells at non-thermal specific absorption rates. At SARs which resulted in measurable heating of the medium, a dose-dependent decrease in enzymatic activity was observed and was shown to be consistent with a comparable decrease caused by non-RF-radiation heating. Thus we observed only the well-known enzyme inhibition due to heating, rather than the previously reported enhancement attributed to RF-radiation exposure.

Detlavs I, Dombrovska L, Turauska A, Shkirmante B, Slutskii L. Experimental study of the effects of radiofrequency electromagnetic fields on animals with soft tissue wounds. Sci Total Environ 180(1):35-42, 1996.

The effect of radio frequency electromagnetic fields (RF EMF) was studied on Wistar rats with excised full-thickness dermal wounds in the interscapular region. The wounded regions of experimental animals were subjected to EMF for 30 min daily during the first 5 days after wound infliction. Control animals received no treatment. We used RF EMF with (1) frequency 53.53 GHz without modulation; (2) frequency 42.19 GHz without

modulation; (3) frequency 42.19 GHz, but with a frequency modulation band 200-MHz wide. On the 7th day the animals were terminated and the granulation-fibrous tissue (GFT) developed in the wounds was subjected to complex quantitative biochemical analysis. RF EMF without frequency modulation decreased the amounts of glycoprotein macromolecules, diminishing the inflammatory exudation. In striking contrast, under the influence of RF EMF with frequency modulation, hexoses and especially sialic acid concentrations were significantly elevated ($P < 0.001$). This indicated intensification of exudative phenomena. As a consequence of inflammation inhibition in the treatment without frequency modulation, the total collagen accumulation was lowered. However, when frequency was modulated, the inflammatory phenomena were intensified, and pronounced accumulation of collagenous proteins was noted. Thus, our experiments confirm the effects of non-thermal EMF on the reparative-proliferative processes of animals with soft tissue wounds

Devrim E, Ergüder IB, Kılıçoğlu B, Yaykaşlı E, Cetin R, Durak I. Effects of electromagnetic radiation use on oxidant/antioxidant status and dna turn-over enzyme activities in erythrocytes and heart, kidney, liver, and ovary tissues from rats: possible protective role of Vitamin C. Toxicol Mech Methods.18(9):679-683, 2008.

ABSTRACT In this study, the aim was to investigate possible effects of Electromagnetic Radiation (EMR) use on oxidant and antioxidant status in erythrocytes and kidney, heart, liver, and ovary tissues from rats, and possible protective role of vitamin C. For this aim, 40 Wistar albino female rats were used throughout the study. The treatment group was exposed to EMR in a frequency of 900 MHz, the EMR plus vitamin C group was exposed to the same EMR frequency and given vitamin C (250 mg/kg/day) orally for 4 weeks. There were 10 animals in each group including control and vitamin C groups. At the end of the study period, blood samples were obtained from the animals to get erythrocyte sediments. Then the animals were sacrificed and heart, kidney, liver, and ovary tissues were removed. Malondialdehyde (MDA) levels and superoxide dismutase (SOD), catalase (CAT), glutathione peroxidase (GSH-Px), xanthine oxidase (XO), and adenosine deaminase (ADA) enzyme activities were measured in the tissues and erythrocytes. It was observed that MDA level, XO, and GSH-Px activities significantly increased in the EMR group as compared with those of the control group in the erythrocytes. In the kidney tissues, it was found that MDA level and CAT activity significantly increased, whereas XO and ADA activities decreased in the cellular phone group as compared with those of the control group. However, in the heart tissues it was observed that MDA level, ADA, and XO activities significantly decreased in the cellular phone group as compared with those of the control group. The results suggest that EMR at the frequency generated by a cell phone causes oxidative stress and peroxidation in the erythrocytes and kidney tissues from rats. In the erythrocytes, vitamin C seems to make partial protection against the oxidant stress.

Devyatkov ND, Pletnyov SD, Betskii OV, Faikin VV, Effect of low-energy and high-peak-power nanosecond pulses of microwave radiation on malignant tumors. Crit Rev Biomed Eng 29(1):98-110, 2001.

This article presents the results of experimental investigations of the inhibitory effect of low-energy and high-peak-power nanosecond microwave pulses on the growth of malignant tumors. From the results obtained, it was concluded that these microwave pulses can serve as a promising means for treating malignant diseases.

Dhami AK. Study of electromagnetic radiation pollution in an Indian city. Environ Monit Assess.184(11):6507-6512, 2012.

Abstract. Electromagnetic radiation emitted by cell phone towers is a form of environmental pollution and is a new health hazard, especially to children and patients. The present studies were taken to estimate the microwave/RF pollution by measuring radiation power densities near schools and hospitals of Chandigarh city in India. The cell phone radiations were measured using a handheld portable power density meter TES 593 and specific absorption rates were estimated from the measured values. These values of electromagnetic radiation in the environment were compared with the levels at which biological system of humans and animals starts getting affected. The values were also compared with the international exposure limits set by the International Commission on Non-Ionizing Radiation Protection (ICNIRP). The highest measured power density was 11.48 mW/m(2) which is 1,148% of the biological limit. The results indicated that the exposure levels in the city were below the ICNIRP limit, but much above the biological limit.

Di Carlo A, White N, Guo F, Garrett P, Litovitz T. Chronic electromagnetic field exposure decreases HSP70 levels and lowers cytoprotection. J. Cell. Biochem. 84: 447-454, 2002.

Electromagnetic field (EMF) exposures have been shown to induce heat shock proteins (HSPs), which help to maintain the conformation of cellular proteins during periods of stress. We have previously reported that short-term exposure of chick embryos to either 60 Hz (extremely low frequency: ELF), or radio-frequency (RF: 915 MHz) EMFs induce protection against hypoxia. Experiments presented in the current report are based on a study in which long-term (4 days), continuous exposure to ELF-EMFs decreased protection against ultraviolet radiation. Based on this result, it was hypothesized that de-protection against hypoxia should also occur following long-term, continuous, or daily, repeated exposures to EMFs. To test this hypothesis, chick embryos were exposed to ELF-EMFs (8 μT) continuously for 4 days, or to ELF or RF (3.5 mW incident power)-EMFs repeated daily (20, 30, or 60 min once or twice daily for 4 days). Several of the exposure protocols yielded embryos that had statistically significant decreases in protection against hypoxic stress (continuous and 30 or 60 min ELF twice daily; or 30 or 60 min once daily RF). This is consistent with our finding that following 4 days of ELF-EMF exposure, HSP70 levels decline by 27% as compared to controls. In addition, the superposition of ELF-EM noise, previously shown to minimize ELF-EMF induced hypoxia protection, inhibited hypoxia de-protection caused by long term, continuous ELF or daily, repeated RF exposures. This EMF-induced decrease in HSP70 levels and resulting decline in cytoprotection suggests a mechanism by which daily exposure (such as might be experienced by mobile phone users) could enhance the probability of cancer and other diseases.

Diem E, Schwarz C, Adlkofer F, Jahn O, Rudiger H. Non-thermal DNA breakage by

mobile-phone radiation (1800MHz) in human fibroblasts and in transformed GFSH-R17 rat granulosa cells in vitro. Mutat Res. 583:178-183, 2005.

Cultured human diploid fibroblasts and cultured rat granulosa cells were exposed to intermittent and continuous radiofrequency electromagnetic fields (RF-EMF) used in mobile phones, with different specific absorption rates (SAR) and different mobile-phone modulations. DNA strand breaks were determined by means of the alkaline and neutral comet assay. RF-EMF exposure (1800MHz; SAR 1.2 or 2W/kg; different modulations; during 4, 16 and 24h; intermittent 5min on/10min off or continuous wave) induced DNA single- and double-strand breaks. Effects occurred after 16h exposure in both cell types and after different mobile-phone modulations. The intermittent exposure showed a stronger effect in the comet assay than continuous exposure. Therefore we conclude that the induced DNA damage cannot be based on thermal effects.

Dimbylow PJ. FDTD calculations of the SAR for a dipole closely coupled to the head at 900 MHz and 1.9 GHz. Phys Med Biol 38(3):361-368, 1993.

This paper presents finite-different time-domain (FDTD) calculations of the specific absorption rate (SAR) averaged over the mass of the eye, and over 1 g and 100 g of tissue in a realistic model of the head from a closely coupled half-wavelength dipole source. The SAR is predicted as a function of the separation between the vertical dipole and the surface of the eye. The feed point of the dipole is on the axis defined by the centre of the eye. Phantoms representing an adult and a one-year-old child have been considered for irradiation at 900 MHz and 1.9 GHz.

Dimbylow PJ, Mann SM. SAR calculations in an anatomically realistic model of the head for mobile communication transceivers at 900 MHz and 1.8 GHz. Phys. Med. Biol. 39:1537-1553, 1994.

Abstract. A new mathematical model of the head has been constructed from a set of serial MRI slices from one subject. Finite-difference time-domain (FDTD) calculations of the specific energy absorption rate (SAR) have been performed on this model with a 2 mm resolution for a generic mobile communication transceiver represented by a quarter-wavelength monopole on a metal box. The antenna was mounted either at the centre or corner of the top face of the box. The frequencies considered were 900 MHz and 1.8 GHz. Three irradiation geometries were considered, a vertical handset in front of the eye and vertical and horizontal orientations at the side of the ear. The effect of a hand grasping the handset was considered. The head model was scaled to represent the head of an infant and a subset of calculations was performed to verify that the SAR deposited in the infant head did not exceed that in the adult. Results are also presented for a half-wavelength dipole. The maximum SAR values produced by the generic transceiver for the horizontal orientation at the side of the head which is the most typical position, averaged over 10 g of tissue at 900 MHz and 1.8 GHz, are 2.1 and 3.0 W kg^{-1} per W of radiated power. The corresponding values over 1 g of tissue are 2.3 and 4.8 W kg^{-1} per W at 900 MHz and 1.8 GHz. However, if one were to consider all possible operational conditions, the placement of the transceiver in front of the eye will give 3.1 and 4.6 W kg^{-1} per W averaged over 10 g of tissue and 4.7 and 7.7 W kg^{-1} per W over 1 g of tissue at 900 MHz and 1.8 GHz, respectively.

Dimbylow P, Khalid M, Mann S. Assessment of specific energy absorption rate (SAR) in the head from a TETRA handset. Phys Med Biol. 48(23):3911-26, 2003.

Finite-difference time-domain (FDTD) calculations of the specific energy absorption rate (SAR) from a representative TETRA handset have been performed in an anatomically realistic model of the head. TETRA (Terrestrial Trunked Radio) is a modern digital private mobile radio system designed to meet the requirements of professional users, such as the police and fire brigade. The current frequency allocations in the UK are 380-385 MHz and 390-395 MHz for the public sector network. A comprehensive set of calculations of SAR in the head was performed for positions of the handset in front of the face and at both sides of the head. The representative TETRA handset considered. operating at 1 W in normal use, will show compliance with both the ICNIRP occupational and public exposure restrictions. The handset with a monopole antenna operating at 3 W in normal use will show compliance with both the ICNIRP occupational and public exposure restrictions. The handset with a helical antenna operating at 3 W in normal use will show compliance with the ICNIRP occupational exposure restriction but will be over the public exposure restriction by up to approximately 50% if kept in the position of maximum SAR for 6 min continuously.

Dimbylow P. SAR in the mother and foetus for RF plane wave irradiation. Phys Med Biol. 52(13):3791-3802, 2007.

This paper describes the finite-difference time-domain calculation of SAR from 20 MHz to 3 GHz in hybrid voxel-mathematical models of the pregnant female. Mathematical models of the developing foetus at 8-, 13-, 26- and 38-week gestation were converted into voxels and combined with the reference adult female model, NAOMI at a resolution of 2 mm. Whole-body averaged SAR in the mother is presented as well as the average over the foetus, over the foetal brain and in 10 g of the foetus. The electric field values required to produce the ICNIRP public exposure restriction of 2 W kg(-1) when averaged over 10 g of the foetus were calculated. Comparison suggests that the ICNIRP public reference level is a conservative predictor of local SAR in the foetus.

Dimbylow PJ, Hirata A, Nagaoka T. Intercomparison of whole-body averaged SAR in European and Japanese voxel phantoms.Phys Med Biol. 53(20):5883-5897, 2008.

This paper provides an intercomparison of the HPA male and female models, NORMAN and NAOMI with the National Institute of Information and Communications Technology (NICT) male and female models, TARO and HANAKO. The calculations of the whole-body SAR in these four phantoms were performed at the HPA, at NICT and at the Nagoya Institute of Technology (NIT). These were for a plane wave with a vertically aligned electric field incident upon the front of the body from 30 MHz to 3 GHz for isolated conditions. As well as investigating the general differences through this frequency range, particular emphasis was placed on the assumptions of how dielectric properties are assigned to tissues (particularly skin and fat) and the consequence of using different algorithms for calculating SAR at the higher frequencies.

Dimbylow PJ, Nagaoka T, Xu XG. A comparison of foetal SAR in three sets of pregnant female models. Phys Med Biol. 54(9):2755-2767, 2009.

This paper compares the foetal SAR in the HPA hybrid mathematical phantoms with the 26-week foetal model developed at the National Institute of Information and Communications Technology, Tokyo, and the set of 13-, 26- and 38-week boundary representation models produced at Rensselaer Polytechnic Institute. FDTD calculations are performed at a resolution of 2 mm for a plane wave with a vertically aligned electric field incident upon the body from the front, back and two sides from 20 MHz to 3 GHz under isolated conditions. The external electric field values required to produce the ICNIRP public exposure localized restriction of 2 W kg(-1) when averaged over 10 g of the foetus are compared with the ICNIRP reference levels.

Ding G, Xie X, Zhang L et al. Changes of nitric oxide synthase in hippocampus and cerebellum of the rat following exposure to electromagnetic pulse. Chin J Phys Med 20:81-83, 1998.

Objective: In order to explore the role of nitric oxide in the obstruction of learning and memory of the rat caused by exposing to electromagnetic pulses (EMP), the distribution of nitric oxide synthase (NOS) expression was studied in hippocampus and cerebellum of the rat following exposure to EMP. Methods: SP immunohistochemical staining was employed to detect the distribution of NOS expression. Results: The number of NOS positive neurons and the intensity of positive staining in hippocampus were decreased at 1.5 and 24 h after exposure to EMP. At 48 h, the number of NOS positive neurons reversed to control level but the intensity of positive staining was still low. the expression of NOS in cerebellum had no obvious changes. Conclusion: Decrease of NOS expression in hippocampus relates to the obstruction of learning and memory of the rat after exposure to EMP.

Ding S, Peng H, Fang HS, Zhou JL, Wang Z. Pulsed electromagnetic fields stimulation prevents steroid-induced osteonecrosis in rats.BMC Musculoskelet Disord. 12:215, 2011.

BACKGROUND: Pulsed electromagnetic fields (PEMF) stimulation has been used successfully to treat nonunion fractures and femoral head osteonecrosis, but relatively little is known about its effects on preventing steroid-induced osteonecrosis. The purpose of the study was to investigate the effects of PEMF stimulation on the prevention of steroid-induced osteonecrosis in rats and explore the underlying mechanisms. **METHODS:** Seventy-two male adult Wistar rats were divided into three groups and treated as follows. (1) PEMF stimulation group (PEMF group, n = 24): intravenously injected with lipopolysaccharide (LPS, 10 μg/kg) on day 0 and intramuscularly injected with methylprednisolone acetate (MPSL, 20 mg/kg) on days 1, 2 and 3, then subjected to PEMF stimulation 4 h per day for 1 to 8 weeks. (2) Methylprednisolone-treated group (MPSL group, n = 24): injected the same dose of LPS and MPSL as the PEMF group but without exposure to PEMF. (3) Control group (PS group, n = 24): injected 0.9% saline in the same mode at the same time points. The incidence of osteonecrosis, serum lipid levels and the mRNA and protein expression of transforming growth factor β1 (TGF-β1) in the proximal femur were measured 1, 2, 4 and 8 weeks after the last MPSL (or saline) injection. **RESULTS:** The incidence of osteonecrosis in the PEMF group (29%) was significantly lower than that observed in the MPSL group (75%), while no osteonecrosis

was observed in the PS group. The serum lipid levels were significantly lower in the PEMF and PS groups than in the MPSL group. Compared with the MPSL and PS groups, the mRNA expression of TGF-β1 increased, reaching a peak 1 week after PEMF treatment, and remained high for 4 weeks, then declined at 8 weeks, whereas the protein expression of TGF-β1 increased, reaching a peak at 2 weeks after PEMF treatment, and remained high for 8 weeks. **CONCLUSIONS:** PEMF stimulation can prevent steroid-induced osteonecrosis in rats, and the underlying mechanisms involve decreased serum lipid levels and increased expression of TGF-β1.

D'Silva MH, Swer RT, Anbalagan J, Rajesh B. Effect of Radiofrequency Radiation Emitted from 2G and 3G Cell Phone **on Developing Liver of Chick Embryo - A Comparative Study. J Clin Diagn Res. 11(7):AC05-AC09,2017.**

INTRODUCTION: The increasing scientific evidence of various health hazards on exposure of Radiofrequency Radiation (RFR) emitted from both the **cell phones** and base stations have caused significant media attention and public discussion in recent years. The mechanism of interaction of RF fields with developing tissues of children and fetuses may be different from that of adults due to their smaller physical size and variation in tissue electromagnetic properties. The present study may provide an insight into the basic mechanisms by which RF fields interact with developing tissues in an embryo. AIM: To evaluate the possible tissue and DNA damage in developing liver of chick embryo following chronic exposure to Ultra-High Frequency/Radiofrequency Radiation (UHF/RFR) emitted from 2G and 3G **cell phone**.MATERIALS AND METHODS: Fertilized chick embryos were incubated in four groups. Group A-experimental group exposed to 2G radiation (60 eggs), Group B- experimental group exposed to 3G radiation (60 eggs), Group C- sham exposed control group (60 eggs) and Group D- control group (48 eggs). On completion of scheduled duration, the embryos were collected and processed for routine histological studies to check structural changes in liver. The nuclear diameter and karyorrhexis changes of hepatocytes were analysed using oculometer and square reticule respectively. The liver procured from one batch of eggs from all the four groups was subjected to alkaline comet assay technique to assess DNA damage. The results were compared using one-way ANOVA test. RESULTS: In our study, the exposure of developing chick embryos to 2G and 3G **cell phone** radiations caused structural changes in liver in the form of dilated sinusoidal spaces with haemorrhage, increased vacuolations in cytoplasm, increased nuclear diameter and karyorrhexis and significantly increased DNA damage. CONCLUSION: The chronic exposure of chick embryo liver to RFR emitted from 2G and 3G **cell phone** resulted in various structural changes and DNA damage. The changes were more pronounced in 3G experimental group. Based on these findings it is necessary to create awareness among public about the possible ill effects of RFR exposure from **cell phone**

Divan HA, Kheifets L, Obel C, Olsen J. Prenatal and postnatal exposure to cell phone use and behavioral problems in children. Epidemiology.19(4):523-529, 2008.

BACKGROUND: The World Health Organization has emphasized the need for research into the possible effects of radiofrequency fields in children. We examined the association

between prenatal and postnatal exposure to cell phones and behavioral problems in young children. METHODS:: Mothers were recruited to the Danish National Birth Cohort early in pregnancy. When the children of those pregnancies reached 7 years of age in 2005 and 2006, mothers were asked to complete a questionnaire regarding the current health and behavioral status of children, as well as past exposure to cell phone use. Mothers evaluated the child's behavior problems using the Strength and Difficulties Questionnaire. RESULTS:: Mothers of 13,159 children completed the follow-up questionnaire reporting their use of cell phones during pregnancy as well as current cell phone use by the child. Greater odds ratios for behavioral problems were observed for children who had possible prenatal or postnatal exposure to cell phone use. After adjustment for potential confounders, the odds ratio for a higher overall behavioral problems score was 1.80 (95% confidence interval = 1.45-2.23) in children with both prenatal and postnatal exposure to cell phones. CONCLUSIONS: Exposure to cell phones prenatally-and, to a lesser degree, postnatally-was associated with behavioral difficulties such as emotional and hyperactivity problems around the age of school entry. These associations may be noncausal and may be due to unmeasured confounding. If real, they would be of public health concern given the widespread use of this technology.

Divan HA, Kheifets L, Olsen J.Prenatal cell phone use and developmental milestone delays among infants.Scand J Work Environ Health.37(4):341-348, 2011.

OBJECTIVE: The aim of this study was to examine if prenatal use of cell phones by pregnant mothers is associated with developmental milestones delays among offspring up to 18 months of age.**METHODS:** Our work is based upon the Danish National Birth Cohort (DNBC), which recruited pregnant mothers from 1996-2002, and was initiated to collect a variety of detailed information regarding in utero exposures and various health outcomes. At the end of 2008, over 41,000 singleton, live births had been followed with the Age-7 questionnaire, which collected cell phone use exposure for mothers during pregnancy. Outcomes for developmental milestones were obtained from telephone interviews completed by mothers at age 6 and 18 months postpartum.**RESULTS:** A logistic regression model estimated the odds ratios (OR) for developmental milestone delays, adjusted for potential confounders. Less than 5% of children at age 6 and 18 months had cognitive/language or motor developmental delays. At 6 months, the adjusted OR was 0.8 [95% confidence interval (95% CI) 0.7-1.0] for cognitive/language delay and 0.9 (95% CI 0.8-1.1) for motor development delay. At 18 months, the adjusted OR were 1.1 (95% CI 0.9-1.3) and 0.9 (95% CI 0.8-1.0) for cognitive/language and motor development delay, respectively.**CONCLUSIONS:** No evidence of an association between prenatal cell phone use and motor or cognitive/language developmental delays among infants at 6 and 18 months of age was observed. Even when considering dose-response associations for cell phone, associations were null.

Divan HA, Kheifets L, Obel C, Olsen J. Cell phone use and behavioural problems in young children. J Epidemiol Community Health.66(6):524-529, 2012.

Background: Potential health effects of cell phone use in children have not been adequately examined. As children are using cell phones at earlier ages, research among

this group has been identified as the highest priority by both national and international organisations. The authors previously reported results from the Danish National Birth Cohort (DNBC), which looked at prenatal and postnatal exposure to cell phone use and behavioural problems at age 7years. Exposure to cell phones prenatally, and to a lesser degree postnatally, was associated with more behavioural difficulties. The original analysis included nearly 13 000 children who reached age 7 years by November 2006. Methods: To see if a larger, separate group of DNBC children would produce similar results after considering additional confounders, children of mothers who might better represent current users of cell phones were analysed. This 'new' dataset consisted of 28 745 children with completed Age-7 Questionnaires to December 2008. Results: The highest OR for behavioural problems were for children who had both prenatal and postnatal exposure to cell phones compared with children not exposed during either time period. The adjusted effect estimate was 1.5 (95% CI 1.4 to 1.7). Conclusions: The findings of the previous publication were replicated in this separate group of participants demonstrating that cell phone use was associated with behavioural problems at age 7years in children, and this association was not limited to early users of the technology. Although weaker in the new dataset, even with further control for an extended set of potential confounders, the associations remained.

Djeridane Y, Touitou Y, de Seze R. Influence of Electromagnetic Fields Emitted by GSM-900 Cellular Telephones on the Circadian Patterns of Gonadal, Adrenal and Pituitary Hormones in Men. Radiat Res. 169(3):337-343, 2008.

.The potential health risks of radiofrequency electromagnetic fields (RF EMFs) emitted by mobile phones are currently of considerable public interest. The present study investigated the effect of exposure to 900 MHz GSM radiofrequency radiation on steroid (cortisol and testosterone) and pituitary (thyroid-stimulating hormone, growth hormone, prolactin and adrenocorticotropin) hormone levels in 20 healthy male volunteers. Each subject was exposed to RF EMFs through the use of a cellular phone for 2 h/day, 5 days/ week, for 4 weeks. Blood samples were collected hourly during the night and every 3 h during the day. Four sampling sessions were performed at 15-day intervals: before the beginning of the exposure period, at the middle and the end of the exposure period, and 15 days later. Parameters evaluated included the maximum serum concentration, the time of this maximum, and the area under the curve for hormone circadian patterns. Each individual's pre-exposure hormone concentration was used as his control. All hormone concentrations remained within normal physiological ranges. The circadian profiles of prolactin, thyroid-stimulating hormone, adrenocorticotropin and testosterone were not disrupted by RF EMFs emitted by mobile phones. For growth hormone and cortisol, there were significant decreases of about 28% and 12%, respectively, in the maximum levels when comparing the 2-week (for growth hormone and cortisol) and 4-week (for growth hormone) exposure periods to the pre-exposure period, but no difference persisted in the postexposure period. Our data show that the 900 MHz EMF exposure, at least under our experimental conditions, does not appear to affect endocrine functions in men.

Djordjevic B, Sokolovic D, Kocic G, Veljkovic A, Despotovic M, Basic J, Jevtovic-Stoimenov T, Sokolovic DM. The effect of melatonin on the liver of rats exposed to microwave radiation. Bratisl Lek Listy. 116(2):96-100, 2015.

OBJECTIVES: We aimed to clarify if melatonin treatment (2 mg/kg i.p.) may favorably impact the liver tissue in rats exposed to microwave radiation. The experiment was performed on 84 six-weeks-old Wistar male rats exposed for 4h a day, for 20, 40 and 60 days, respectively, to microwaves (900 MHz, 100-300 microT, 54-160 V/m). Rats were divided in to four groups: I (control) - rats treated with saline, II (Mel) - rats treated with melatonin, III (MWs) - microwave exposed rats, IV (MWs + Mel) - MWs exposed rats treated with melatonin. We evaluated oxidative stress parameters (malondialdehyde and carbonyl group content), catalase, xanthine oxidase, deoxyribonuclease I and II activity. BACKGROUND: Oxidative stress is the key mechanism of the microwave induced tissue injury. Melatonin, a lipophilic indoleamine primarily synthesized and released from the pineal gland is a powerful antioxidant. RESULTS: Exposure to microwaves caused an increase in malondialdehyde after 40 ($p < 0.01$), protein carbonyl content after 20 ($p < 0.05$), catalase ($p < 0.05$) and xantine oxidase activity ($p < 0.05$) after 40 days. Increase in deoxyribonuclease I activity was observed after 60 days ($p < 0.05$), while deoxyribonuclease II activity was unaffected. Melatonin treatment led to malondialdehyde decrease after 40 days ($p< 0.05$), but surprisingly had no effect on other analyzed parameters. CONCLUSION: Melatonin exerts certain antioxidant effects in the liver of rats exposed to microwaves, by diminishing the intensity of lipid peroxidation(Fig. 6, Ref. 32).

Dmoch A, Moszczynski P, [Levels of immunoglobulin and subpopulations of T lymphocytes and NK cells in men occupationally exposed to microwave radiation in frequencies of 6-12 GHz]. Med Pr 49(1):45-49, 1998. [Article in Polish]

Immunoglobulin concentrations and T-lymphocyte subsets in workers of TV re-transmission and satellite communication centres were assessed. An increase in IgG and IgA concentrations, an increased count of lymphocytes and T8 lymphocytes, an decreased count of NK cells and a lower value of T-helper/T-suppressor ratio were found. Neither disorders in immunoglobulin concentrations nor in the count of T8 and NK cells had any clinical implications.

Dode AC, Leão MM, Tejo Fde A, Gomes AC, Dode DC, Dode MC, Moreira CW, Condessa VA, Albinatti C, Caiaffa WT. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais state, Brazil.Sci Total Environ. 409(19):3649-3665, 2011.

Pollution caused by the electromagnetic fields (EMFs) of radio frequencies (RF) generated by the telecommunication system is one of the greatest environmental problems of the twentieth century. The purpose of this research was to verify the existence of a spatial correlation between base station (BS) clusters and cases of deaths by neoplasia in the Belo Horizonte municipality, Minas Gerais state, Brazil, from 1996 to 2006 and to measure the human exposure levels to EMF where there is a major concentration of cellular telephone transmitter antennas. A descriptive spatial analysis of the BSs and the cases of death by neoplasia identified in the municipality was performed

through an ecological-epidemiological approach, using georeferencing. The database employed in the survey was composed of three data banks: 1. death by neoplasia documented by the Health Municipal Department; 2. BSs documented in ANATEL (''Agência Nacional de Telecomunicações'': 'Telecommunications National Agency'); and 3. census and demographic city population data obtained from official archives provided by IBGE (''Instituto Brasileiro de Geografia e Estatística'': 'Brazilian Institute of Geography and Statistics'). The results show that approximately 856 BSs were installed through December 2006. Most (39.60%) of the BSs were located in the ''Centro-Sul'' ('Central-Southern') region of the municipality. Between 1996 and 2006, 7191 deaths by neoplasia occurred and within an area of 500 m from the BS, the mortality rate was 34.76 per 10,000 inhabitants. Outside of this area, a decrease in the number of deaths by neoplasia occurred. The greatest accumulated incidence was 5.83 per 1000 in the Central-Southern region and the lowest incidence was 2.05 per 1000 in the Barreiro region. During the environmental monitoring, the largest accumulated electric field measured was 12.4 V/m and the smallest was 0.4 V/m. The largest density power was 40.78 μW/cm(2), and the smallest was 0.04 μW/cm(2).

Dogan M, Turtay MG, Oguzturk H, Samdanci E, Turkoz Y, Tasdemir S, Alkan A, Bakir S. Effects of electromagnetic radiation produced by 3G mobile phones on rat brains: magnetic resonance spectroscopy, biochemical, and histopathological evaluation.Hum Exp Toxicol. 31(6):557-564, 2012.

Objective: The effects of electromagnetic radiation (EMR) produced by a third-generation (3G) mobile phone (MP) on rat brain tissues were investigated in terms of magnetic resonance spectroscopy (MRS), biochemistry, and histopathological evaluations. Methods: The rats were randomly assigned to two groups: Group 1 is composed of 3G-EMR-exposed rats (n = 9) and Group 2 is the control group (n = 9). The first group was subjected to EMR for 20 days. The control group was not exposed to EMR. Choline (Cho), creatinin (Cr), and N-acetylaspartate (NAA) levels were evaluated by MRS. Catalase (CAT) and glutathione peroxidase (GSH-Px) enzyme activities were measured by spectrophotometric method. Histopathological analyses were carried out to evaluate apoptosis in the brain tissues of both groups. Results: In MRS, NAA/Cr, Cho/Cr, and NAA/Cho ratios were not significantly different between Groups 1 and 2. Neither the oxidative stress parameters, CAT and GSH-Px, nor the number of apoptotic cells were significantly different between Groups 1 and 2. Conclusions:Usage of short-term 3G MP does not seem to have a harmful effect on rat brain tissue.

Dolk H, Shaddick G, Walls P, Grundy C, Thakrar B, Kleinschmidt I, Elliott P, Cancer incidence near radio and television transmitters in Great Britain. I. Sutton Coldfield transmitter. Am J Epidemiol 145(1):1-9, 1997.

A small area study of cancer incidence in 1974-1986 was carried out to investigate an unconfirmed report of a "cluster" of leukemias and lymphomas near the Sutton Coldfield television (TV) and frequency modulation (FM) radio transmitter in the West Midlands, England. The study used a national database of postcoded cancer registrations, and population and socioeconomic data from the 1981 census. Selected cancers were hematopoietic and lymphatic, brain, skin, eye, male breast, female breast, lung,

colorectal, stomach, prostate, and bladder. Expected numbers of cancers in small areas were calculated by indirect standardization, with stratification for a small area socioeconomic index. The study area was defined as a 10 km radius circle around the transmitter, within which 10 bands of increasing distance from the transmitter were defined as a basis for testing for a decline in risk with distance, and an inner area was arbitrarily defined for descriptive purposes as a 2 km radius circle. The risk of adult leukemia within 2 km was 1.83 (95% confidence interval 1.22-2.74), and there was a significant decline in risk with distance from the transmitter (p = 0.001). These findings appeared to be consistent over the periods 1974-1980, 1981-1986, and were probably largely independent of the initially reported cluster, which appeared to concern mainly a later period. In the context of variability of leukemia risk across census wards in the West Midlands as a whole, the Sutton Coldfield findings were unusual. A significant decline in risk with distance was also found for skin cancer, possibly related to residual socioeconomic confounding, and for bladder cancer. Study of other radio and TV transmitters in Great Britain is required to put the present results in wider context. No causal implications can be made from a single cluster investigation of this kind.

Dolk H, Elliott P, Shaddick G, Walls P, Thakrar B, Cancer incidence near radio and television transmitters in Great Britain. II. All high power transmitters. Am J Epidemiol 145(1):10-17, 1997.

A small area study of cancer incidence, 1974-1986, near 20 high power television (TV) and frequency modulation (FM) radio transmitters in Great Britain was carried out to place in context the findings of an earlier study around the Sutton Coldfield transmitter. The national database of postcoded cancer registrations was used with population and socioeconomic data from the 1981 census. Cancers examined were adult leukemias, skin melanoma, and bladder cancer, following the findings in the earlier study of significant declines in risk of these cancers with distance from the Sutton Coldfield transmitter. Childhood leukemia and brain cancer were also examined. Statistical analysis was performed for all transmitters combined, four overlapping groups of transmitters defined by their transmission characteristics, and for all transmitters separately. There were 3,305 adult leukemia cases from 0-10 km (observed/expected (O/E) ratio = 1.03, 95% confidence interval (CI) 1.00-1.07). A decline in risk of adult leukemia was found for all transmitters combined (p = 0.05), two of the transmitter groups, and three of the single transmitters; for all transmitters combined, observed excess risk was no more than 15% at any distance up to 10 km, and there was no observed excess within 2 km of transmitters (O/E ratio = 0.97, 95% CI 0.78-1.21). For childhood leukemia and brain cancer, and adult skin melanoma and bladder cancer, results were not indicative of a decline in risk with distance from transmitters. The magnitude and pattern of risk found in the Sutton Coldfield study did not appear to be replicated. The authors conclude that the results at most give no more than very weak support to the Sutton Coldfield findings.

Donnellan M, McKenzie DR, French PW, Effects of exposure to electromagnetic radiation at 835 MHz on growth, morphology and secretory characteristics of a mast cell analogue, RBL-2H3.Cell Biol Int 21:427-439, 1997.

A mast cell line, RBL-2H3, was exposed to 835 MHz for 20 minutes, three times per day for 7 days at a power density of 8.1 +/- 3 mW/cm2. From day 4 onwards, it was observed

that the rate of DNA synthesis and cell replication increased, that actin distribution and cell morphology became altered, and the amount of beta-hexosaminidase (a marker of granule secretion) released in response to a calcium ionophore was significantly enhanced, in comparison to unexposed cultures. There were no effects seen on levels of cytoskeletal protein synthesis or of beta-actin mRNA. Morphological changes persisted following subculture for at least 7 days in the absence of further exposure. It is hypothesized that effects of exposure to an electromagnetic field at 835 MHz may be mediated via a signal transduction pathway.

Dovrat A, Berenson R, Bormusov E, Lahav A, Lustman T, Sharon N, Schachter L. Localized effects of microwave radiation on the intact eye lens in culture conditions. Bioelectromagnetics. 26(5):398-405, 2005.

A novel experimental system was used to investigate the localized effects of microwave radiation on bovine eye lenses in culture for over 2 weeks. Using this setup, we found clear evidence that this radiation has a significant impact on the eye lens. At the macroscopic level, it is demonstrated that exposure to a few mW at 1 GHz for over 36 h affects the optical function of the lens. Most importantly, self-recovery occurs if the exposure is interrupted. At the microscopic level, close examination of the lens indicates that the interaction mechanism is completely different from the mechanism-causing cataract via temperature increase. Contrary to the latter's effect, that is particularly pronounced in the vicinity of the sutures and it is assumed to be a result of local friction between the edges of the fibers consisting the lens. Even if macroscopically the lens has recovered from the irradiation, microscopically the indicators of radiation impact remain.

Dragicevic N, Bradshaw PC, Mamcarz M, Lin X, Wang L, Cao C, Arendash GW. Long-term electromagnetic field treatment enhances brain mitochondrial function of both Alzheimer's transgenic mice and normal mice: a mechanism for electromagnetic field-induced cognitive benefit? Neuroscience. 185:135-149, 2011.

We have recently reported that long-term exposure to high frequency electromagnetic field (EMF) treatment not only prevents or reverses cognitive impairment in Alzheimer's transgenic (Tg) mice, but also improves memory in normal mice. To elucidate the possible mechanism(s) for these EMF-induced cognitive benefits, brain mitochondrial function was evaluated in aged Tg mice and non-transgenic (NT) littermates following 1 month of daily EMF exposure. In Tg mice, EMF treatment enhanced brain mitochondrial function by 50-150% across six established measures, being greatest in cognitively-important brain areas (e.g. cerebral cortex and hippocampus). EMF treatment also increased brain mitochondrial function in normal aged mice, although the enhancement was not as robust and less widespread compared to that of Tg mice. The EMF-induced enhancement of brain mitochondrial function in Tg mice was accompanied by 5-10 fold increases in soluble Aβ1-40 within the same mitochondrial preparations. These increases in mitochondrial soluble amyloid-β peptide (Aβ) were apparently due to the ability of EMF treatment to disaggregate Aβ oligomers, which are believed to be the form of Aβ causative to mitochondrial dysfunction in Alzheimer's disease (AD). Finally, the EMF-induced mitochondrial enhancement in both Tg and normal mice occurred through non-thermal effects because brain temperatures were either stable or decreased

during/after EMF treatment. These results collectively suggest that brain mitochondrial enhancement may be a primary mechanism through which EMF treatment provides cognitive benefit to both Tg and NT mice. Especially in the context that mitochondrial dysfunction is an early and prominent characteristic of Alzheimer's pathogenesis, EMF treatment could have profound value in the disease's prevention and treatment through intervention at the mitochondrial level.

Dreyer NA, Loughlin JE, Rothman KJ, Cause-specific mortality in cellular telephone users. JAMA 282(19):1814-1816, 1999.

A survey of standandized mortality rates (from cancer, circulatory diseases, and motor vehicle collisions) of 285,561 analog telephone users with known age, sex, and telephone type, showed that the only catelogy of cause of death for which there was an indication of increasing risk with increasing minutes of phone use was motor vehicle collisions. Similar results were found for number of telephone calls per day. 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.

Duan L, Shan Y, Yu X, [Observations of changes in neurobehavioral functions in workers exposed to high-frequency radiation]. Chung Hua Yu Fang I Hsueh Tsa Chih 32(2):109-111, 1998. [Article in Chinese]

OBJECTIVE: To study the effects of exposure to high-frequency radiation on neurobehavioral function of the exposed workers and its measurement in evaluating occupational hazards caused by it. METHODS: Four neurobehavioral functions were tested for the workers exposed to high-frequency radiation with Neurobehavioral Core Tests Battery recommended by WHO. RESULTS: Scores for various indicators in exposed workers were significantly lower than those in controls, and correlated to the detection of neurasthenia in the exposed workers, to certain extent. CONCLUSION: Changes in neurobehavioral function in workers exposed to high-frequency radiation can reflect its important adverse effects.

Dubreuil D, Jay T, Edeline JM. Does head-only exposure to GSM-900 electromagnetic fields affect the performance of rats in spatial learning tasks? Behav Brain Res 129(1-2):203-210, 2002.

The rapid expansion of mobile communication has generated intense interest, but has also fuelled ongoing concerns. In both humans and animals, radiofrequency radiations are suspected to affect cognitive functions. More specifically, several studies performed in rodents have suggested that spatial learning can be impaired by electromagnetic field exposure. However, none of these previous studies have simulated the common

conditions of GSM mobile phones use. This study is the first using a head-only exposure system emitting a 900-MHz GSM electromagnetic field (pulsed at 217 Hz). The two behavioural tasks that were evaluated here have been used previously to demonstrate performance deficits in spatial learning after electromagnetic field exposure: a classical radial maze elimination task and a spatial navigation task in an open-field arena (dry-land version of the Morris water maze). The performances of rats exposed for 45 min to a 900-MHz electromagnetic field (1 and 3.5 W/kg) were compared to those of sham-exposed and cage-control rats. There were no differences among exposed, sham, and cage-control rats in the two spatial learning tasks. The discussion focuses on the potential reasons that led previous studies to conclude that learning deficits do occur after electromagnetic field exposure.

Dubreuil D, Jay T, Edeline JM.Head-only exposure to GSM 900-MHz electromagnetic fields does not alter rat's memory in spatial and non-spatial tasks. Behav Brain Res. 145(1-2):51-61, 2003.

Over the last decade, exposure to high frequency (2450 MHz) electromagnetic fields (EMFs) has been found to induce performance deficit in rodents in spatial memory tasks. As concern was expressed about potential biological effects of mobile communication microwaves, studies testing the effects of signals such as GSM were required. In a previous study, using head-only exposure to 900 MHz GSM EMF, we could not demonstrate any behavioural deficit in two simple learning tasks. The present study aimed at extending these results with more complex spatial learning tasks and a non-spatial task. In a first experiment, rats were trained in a radial-arm maze with a 10-s confinement between each visited arm. In a second experiment, a 15-min intra-trial delay was introduced after four visited arms. In a third experiment, non-spatial memory was tested in an object recognition task. In all experiments, performance of the head-only exposed rats (1 and 3.5 W/kg) was compared with that of sham and control rats. In the first experiment, a slightly improved performance was found after 3.5 W/kg exposure, a result that was not observed in the delay-task. In the third experiment, although some effects on exploratory activity were found, recognition memory was unaffected in exposed rats. Altogether, this set of experiments provides no evidence indicating that spatial and non-spatial memory can be affected by a 45-min head-only exposure to 900 MHz GSM EMF.

Durusoy R, Hassoy H, Özkurt A, Karababa AO. Mobile phone **use, school electromagnetic field levels and related symptoms: a cross-sectional survey among 2150 high school students in Izmir. Environ Health. 16(1):51, 2017.**

BACKGROUND: Health outcomes of electromagnetic fields (EMF) from **mobile phones** and their base stations are of concern. Conducting multidisciplinary research, targeting children and exploring dose-response are recommended. Our objectives were to describe the **mobile phone** usage characteristics of high school students and to explore the association between **mobile phone** usage characteristics, high school EMF levels and self-reported symptoms.METHODS: This cross-sectional study's data were collected by a survey questionnaire and by measuring school EMF levels between November 2009 and April 2011. A sample size of 2530 was calculated from a total of 20,493 students in 26 high schools and 2150 (85.0%) were included in the analysis. The frequencies of 23

symptoms were questioned and analysed according to 16 different aspects of **mobile phone** use and school EMF levels, exploring also dose-response. School EMF levels were measured with Aaronia Spectran HF-4060 device. Chi square and trend tests were used for univariate and logistic regression was used for multivariate analyses.RESULTS: Among participants, 2021 (94.0%) were using **mobile phones** and 129 (6.0%) were not. Among users, 49.4% were speaking <10 min and 52.2% were sending/receiving 75 or more messages per day. Headache, fatigue and sleep disturbances were observed respectively 1.90 (95% CI 1.30-2.77), 1.78 (1.21-2.63) and 1.53 (1.05-2.21) times more among **mobile phone** users. Dose-response relationships were observed especially for the number of calls per day, total duration of calls per day, total number of text messages per day, position and status of **mobile phone** at night and making calls while charging as exposures and headache, concentration difficulties, fatigue and sleep disturbances as general symptoms and warming of the ear and flushing as local symptoms. CONCLUSIONS: We found an association between **mobile phone** use and especially headache, concentration difficulties, fatigue, sleep disturbances and warming of the ear showing also dose-response. We have found limited associations between vicinity to base stations and some general symptoms; however, we did not find any association with school EMF levels. Decreasing the numbers of calls and messages, decreasing the duration of calls, using earphones, keeping the **phone** away from the head and body and similar precautions might decrease the frequencies or prevalence of the symptoms.

Dutta SK, Das K, Ghosh B, Blackman CF, Dose dependence of acetylcholinesterase activity in neuroblastoma cells exposed to modulated radio-frequency electromagnetic radiation. Bioelectromagnetics 13(4):317-322, 1992.

Radio-frequency electromagnetic radiation (RFR) at 915 and 147 MHz, when sinusoidally amplitude modulated (AM) at 16 Hz, has been shown to enhance release of calcium ions from neuroblastoma cells in culture. The dose-response relation is unusual, consisting of two power-density "windows" in which enhanced efflux occurs, separated by power-density regions in which no effect is observed. To explore the physiological importance of these findings, we have examined the impact of RFR exposure on a membrane-bound enzyme, acetylcholinesterase (AChE), which is intimately involved with the acetylcholine (ACh) neurotransmitter system. Neuroblastoma cells (NG108), exposed for 30 min to 147-MHz radiation, AM at 16 Hz, demonstrated enhanced AChE activity, as assayed by a procedure using 14C-labeled ACh. Enhanced activity was observed within a time window between 7.0 and 7.5 h after the cells were plated and only when the exposure occurred at power densities identified in a previous report as being effective for altering the release of calcium ions. Thus RFR affects both calcium-ion release and AChE activity in nervous system-derived cells in culture in a common dose-dependent manner.

Dutta SK, Verma M, Blackman CF, Frequency-dependent alterations in enolase activity in Escherichia coli caused by exposure to electric and magnetic fields. Bioelectromagnetics 15(5):377-383, 1994.

Some neurochemical effects of low-intensity electric and magnetic fields have been

shown to be nonlinear functions of exposure parameters. These effects occurred within narrow ranges of frequency and intensity. Previous studies on membrane-associated endpoints in cell culture preparations demonstrated changes in calcium efflux and in acetylcholinesterase activity following exposure to radiofrequency radiation, amplitude modulated (AM) at 16 and at 60 Hz, at a specific absorption rate of 0.05 W/kg. In this study, these modulation frequencies were tested for their influence on the activity of a cytoplasmic enzyme, enolase, which is being tested clinically for detection of neoplasia. Escherichia coli cultures containing a plasmid with a mammalian gene for enolase were exposed for 30 min, and cell extracts were assayed for enolase activity by measuring absorbance at 240 nm. The enolase activity in exposed cultures was compared to the activity in paired control cultures. Exposure to 147 MHz carrier waves at 0.05 W/kg, AM at 16 Hz showed enolase activity enhanced by 62%, and AM at 60 Hz showed enolase activity reduced by 28%. Similarly, exposure to 16 Hz fields alone, at 21.2 V/mrms (electric) and 97 nTrms (magnetic), showed enhancement in enolase activity by 59%, whereas exposure to 60 Hz fields alone, at 14.1 V/mrms (electric) and 65 nTrms (magnetic), showed reduction in activity by 24%. Sham exposures as well as exposure to continuous-wave 147 MHz radiation at 0.05 W/kg showed no change in enolase activity.

Eberhardt JL, Persson BR, Brun AE, Salford LG, Malmgren LO. Blood-brain barrier permeability and nerve cell damage in rat brain 14 and 28 days after exposure to microwaves from GSM mobile phones. Electromagn Biol Med. 27(3):215-229, 2008.

We investigated the effects of global system for mobile communication (GSM) microwave exposure on the permeability of the blood-brain barrier and signs of neuronal damage in rats using a real GSM programmable mobile phone in the 900 MHz band. Ninety-six non-anaesthetized rats were either exposed to microwaves or sham exposed in TEM-cells for 2 h at specific absorption rates of average whole-body Specific Absorption Rates (SAR) of 0.12, 1.2, 12, or 120 mW/kg. The rats were sacrificed after a recovery time of either 14 or 28 d, following exposure and the extravazation of albumin, its uptake into neurons, and occurrence of damaged neurons was assessed. Albumin extravazation and also its uptake into neurons was seen to be enhanced after 14 d (Kruskal Wallis test: $p = 0.02$ and 0.002, respectively), but not after a 28 d recovery period. The occurrence of dark neurons in the rat brains, on the other hand, was enhanced later, after 28 d ($p = 0.02$). Furthermore, in the 28-d brain samples, neuronal albumin uptake was significantly correlated to occurrence of damaged neurons (Spearman $r = 0.41$; $p < 0.01$).

Ebert S, Eom SJ, Schuderer J, Apostel U, Tillmann T, Dasenbrock C, Kuster N. Response, thermal regulatory threshold and thermal breakdown threshold of restrained RF-exposed mice at 905 MHz. Phys Med Biol. 50(21):5203-5215, 2005.

The objective of this study was the determination of the thermal regulatory and the thermal breakdown thresholds for in-tube restrained B6C3F1 and NMRI mice exposed to radiofrequency electromagnetic fields at 905 MHz. Different levels of the whole-body averaged specific absorption rate (SAR = 0, 2, 5, 7.2, 10, 12.6 and 20 W kg(-1)) have been applied to the mice inside the 'Ferris Wheel' exposure setup at 22 +/- 2 degrees C and 30-70% humidity. The thermal responses were assessed by measurement of the rectal temperature prior, during and after the 2 h exposure session. For B6C3F1 mice, the

thermal response was examined for three different weight groups (20 g, 24 g, 29 g), both genders and for pregnant mice. Additionally, NMRI mice with a weight of 36 g were investigated for an interstrain comparison. The thermal regulatory threshold of in-tube restrained mice was found at SAR levels between 2 W kg(-1) and 5 W kg(-1), whereas the breakdown of regulation was determined at 10.1 +/- 4.0 W kg(-1)(K = 2) for B6C3F1 mice and 7.7 +/- 1.6 W kg(-1)(K = 2) for NMRI mice. Based on a simplified power balance equation, the thresholds show a clear dependence upon the metabolic rate and weight. NMRI mice were more sensitive to thermal stress and respond at lower SAR values with regulation and breakdown. The presented data suggest that the thermal breakdown for in-tube restrained mice, whole-body exposed to radiofrequency fields, may occur at SAR levels of 6 W kg(-1)(K = 2) at laboratory conditions.

Edelstyn N, Oldershaw A. The acute effects of exposure to the electromagnetic field emitted by mobile phones on human attention. Neuroreport 13(1):119-121, 2002.

The aim of our study was to investigate the effects of acute mobile phone exposure on a range of tasks which tapped capacity and processing speed within the attentional system. Thirty-eight healthy volunteers were randomly assigned to either an experimental group which was exposed to a connected mobile phone or a control group in which the mobile phone was switched off. Subjects remained blind to mobile phone status throughout duration of study. The experimental group were exposed to an electromagnetic field emitted by a 900 MHz mobile phone for 30 min. Cognitive performance was assessed at three points (prior to mobile phone exposure, at 15 and 30 min post-exposure) using six cognitive neuropsychological tests (digit span and spatial span forwards and backwards, serial subtraction and verbal fluency). Significant differences between the two groups were evident after 5 min on two tests of attentional capacity (digit span forwards and spatial span backwards) and one of processing speed (serial subtraction). In all three instances, performance was facilitated following mobile phone exposure. No deficits were evident. These findings are discussed in terms of possible functional and neuroanatomical bases.

Eghlidospour M, Ghanbari A, Mortazavi SMJ, Azari H. Effects of radiofrequency exposure emitted from a GSM mobile phone on proliferation, differentiation, and apoptosis of neural stem cells. Anat Cell Biol. 50(2):115-123, 2017.

Due to the importance of neural stem cells (NSCs) in plasticity of the nervous system and treating neurodegenerative diseases, the main goal of this study was to evaluate the effects of radiofrequency radiation emitted from a GSM 900-MHz mobile phone with different exposure duration on proliferation, differentiation and apoptosis of adult murine NSCs *in vitro*. We used neurosphere assay to evaluate NSCs proliferation, and immunofluorescence assay of neural cell markers to examine NSCs differentiation. We also employed alamarBlue and caspase 3 apoptosis assays to assess harmful effects of mobile phone on NSCs. Our results showed that the number and size of resulting neurospheres and also the percentage of cells differentiated into neurons decreased significantly with increasing exposure duration to GSM 900-MHz radiofrequency (RF)-electromagnetic field (EMF). In contrast, exposure to GSM 900-MHz RF-EMF at different durations did not influence cell viability and apoptosis of NSCs and also their astrocytic

differentiation. It is concluded that accumulating dose of GSM 900-MHz RF-EMF might have devastating effects on NSCs proliferation and neurogenesis requiring more causations in terms of using mobile devices.

Ekici B, Tanındı A, Ekici G, Diker E. The effects of the duration of mobile phone use on heart rate variability parameters in healthy subjects. Anatol J Cardiol. 2016 Apr 7. doi: 10.14744/AnatolJCardiol.2016.6717. [Epub ahead of print]

OBJECTIVE: This study aimed to estimate the influence of the duration of mobile phone use on heart rate variability (HRV) in healthy individuals. METHODS: One hundred forty-eight individuals without any established systemic disease and who had undergone 24-h ambulatory ECG monitoring were included in the case-control study. All the individuals had been using mobile phones for more than 10 years. Three-channel 24-h Holter monitoring was performed to derive the mean heart rate, standard deviation of normal NN intervals (SDNN), standard deviation of 5-min (m) mean NN intervals (SDANN), the proportion of NN50 divided by the total number of NNs (pNN50), the root mean square differences of successive NN intervals (RMSSD), high (HF)-, low (LF)-, very low (VLF)-frequency power, total power components, and the LF/HF ratio. Individuals were divided into four groups according to their duration of mobile phone use [no mobile phone use (Control group), <30 min/day (Group 1), 30-60 min/day (Group 2), and >60 min/day (Group 3)]. RESULTS: All the groups had similar features with regard to demographic and clinical characteristics. No significant arrhythmias were observed in any of the groups. The LF/HF ratio was higher, whereas the SDNN, SDANN, RMSSD, and pNN50 values were lower in the study groups than in the control group ($p<0.05$). No significant differences were identified among groups with respect to heart rate, VLF, and total power values ($p>0.05$). CONCLUSION: In this study, it was shown that the duration of mobile phone use may affect the autonomic balance in healthy subjects. The electromagnetic field created by mobile phone use may induce HRV changes in the long term.

El-Bediwi AB, Saad M, El-Kott AF, Eid E. Influence of Electromagnetic Radiation Produced by Mobile Phone on Some Biophysical Blood Properties in Rats.Cell Biochem Biophys. 2012 Oct 10. [Epub ahead of print]

Effects of electromagnetic radiation produced by mobile phone on blood viscosity, plasma viscosity, hemolysis, Osmotic fragility, and blood components of rats have been investigated. Experimental results show that there are significant change on blood components and its viscosity which affects on a blood circulation due to many body problems. Red blood cells, White blood cells, and Platelets are broken after exposure to electromagnetic radiation produced by mobile phone. Also blood viscosity and plasma viscosity values are increased but Osmotic fragility value decreased after exposure to electromagnetic radiation produced by mobile phone.

El Kholy SE, El Husseiny EM. Effect of 60 minutes exposure to electromagnetic field on fecundity, learning and memory, speed of movement and whole body protein of the fruit fly Drosophila melanogaster. J Egypt Soc Parasitol. 42(3):639-648, 2012.

This study investigated the effect of four different electrical devices as source of electromagnetic field on fecundity, learning and memory function, speed of movement, in addition to the whole body proteins of the fruit fly Drosophila melanogaster. The results showed that exposure to EMF has no significant effect on adult fecundity (ANOVA and Duncan's test) but alters learning and memory function in Drosophila larvae, especially those exposed to mobile phone. Highly significant differences occurred in the larval speed of movement after exposure to EMF, with maximal effect occurred for larvae exposed to mobile phone (their speed of movement increased 2.5 times of wild type). Some protein bands serve as characters for exposure to certain electrical devices which suggest that exposure to EMF may affect the whole body proteins.

Elekes, E, Thuroczy, G, Szabo, LD, Effect on the immune system of mice exposed chronically to 50 Hz amplitude-modulated 2.45 GHz microwaves. Bioelectromagnetics 17(3):246-248, 1996.

The effect of continuous (CW; 2.45 GHz carrier frequency) or amplitude-modulated (AM; 50 Hz square wave) microwave radiation on the immune response was tested. CW exposures (6 days, 3 h/day) induced elevations of the number of antibody-producing cells in the spleen of male Balb/c mice (+37%). AM microwave exposure induced elevation of the spleen index (+15%) and antibody-producing cell number (+55%) in the spleen of male mice. No changes were observed in female mice. It is concluded that both types of exposure conditions induced moderate elevation of antibody production only in male mice.

El-Gohary OA, Said MA. Effect of electromagnetic waves from mobile phone on immune status of male rats: possible protective role of vitamin D. Can J Physiol Pharmacol. 2016 Sep 5:1-6. [Epub ahead of print]

There are considerable public concerns about the relationship between mobile phone radiation and human health. The present study assesses the effect of electromagnetic field (EMF) emitted from a mobile phone on the immune system in rats and the possible protective role of vitamin D. Rats were randomly divided into six groups: Group I: control group; Group II: received vitamin D (1000 IU/kg/day) orally; Group III: exposed to EMF 1 h/day; Group IV: exposed to EMF 2 h/day; Group V: exposed to EMF 1 h/day and received vitamin D (1000 IU/kg/day); Group VI: exposed to EMF 2 h/day and received vitamin D (1000 IU/kg/day). After 30 days of exposure time, 1 h/day EMF exposure resulted in significant decrease in immunoglobulin levels (IgA, IgE, IgM, and IgG); total leukocyte, lymphocyte, eosinophil and basophil counts; and a significant increase in neutrophil and monocyte counts. These changes were more increased in the group exposed to 2 h/day EMF. Vitamin D supplementation in EMF-exposed rats reversed these results when compared with EMF-exposed groups. In contrast, 7, 14, and 21 days of EMF exposure produced nonsignificant differences in these parameters among all experimental groups. We concluded that exposure to mobile phone radiation compromises the immune system of rats, and vitamin D appears to have a protective effect.

Elhag MA, Nabil GM, Attia AM. Effects of electromagnetic field produced by mobile phones on the oxidant and antioxidant status of rats. Pak J Biol Sci. 10(23):4271-4274, 2007.

This study was designed to investigate the effect of EMR produced by GSM Mobile Phones (MP) on the oxidant and antioxidant status in rats. Rats were divided into three groups: (1) controls, (2) rats exposed to a fractionated dose of EMR (15 min day(-1) for four days) (EMR-F) and (3) rats exposed to an acute dose of EMR (EMR-A). A net drop in the plasma concentration of vitamin C (-47 and -59.8%) was observed in EMR-F and EMR-A groups, respectively, when compared to controls. While, a significant decrease in the levels of lypophilic antioxidant vitamins: vitamin E (-33 and -65.8%), vitamin A (-44.4 and -46.8%) was observed in EMR-F and EMR-A groups, respectively, when compared to controls. A net drop in plasma level of reduced glutathione (GSH) (-19.8 and -35.3%) was observed in EMR-F and EMR-A groups, respectively. EMR exposure of rats produced a significant decrease in catalase (CAT) and superoxide dismutase (SOD) activities, with the values of these activities for EMR-A group is significantly lower than those of EMR-F. These results indicate that the effects of acute doses of EMR produced by mobile phones on the rat's antioxidant status is significantly higher than those of fractionated doses of the same type of radiation. On the basis of present results, it can be concluded that exposure to acute doses of EMR produced by mobile phones is more hazardous than that produced by fractionated doses of the same type of radiation.

Eliyahu I, Luria R, Hareuveny R, Margaliot M, Meiran N, Shani G. Effects of radiofrequency radiation emitted by cellular telephones on the cognitive functions of humans. Bioelectromagnetics.27(2):119-126, 2006.

The present study examined the effects of exposure to Electromagnetic Radiation emitted by a standard GSM phone at 890 MHz on human cognitive functions. This study attempted to establish a connection between the exposure of a specific area of the brain and the cognitive functions associated with that area. A total of 36 healthy right-handed male subjects performed four distinct cognitive tasks: spatial item recognition, verbal item recognition, and two spatial compatibility tasks. Tasks were chosen according to the brain side they are assumed to activate. All subjects performed the tasks under three exposure conditions: right side, left side, and sham exposure. The phones were controlled by a base station simulator and operated at their full power. We have recorded the reaction times (RTs) and accuracy of the responses. The experiments consisted of two sections, of 1 h each, with a 5 min break in between. The tasks and the exposure regimes were counterbalanced. The results indicated that the exposure of the left side of the brain slows down the left-hand response time, in the second-later-part of the experiment. This effect was apparent in three of the four tasks, and was highly significant in only one of the tests. The exposure intensity and its duration exceeded the common exposure of cellular phone users.

Ellingsrud S, Johnsson A, Perturbations of plant leaflet rhythms caused by electromagnetic radio-frequency radiation. Bioelectromagnetics 14(3):257-271, 1993.

The minute-range up and down rhythms of the lateral leaflets of Desmodium gyrans

has been studied when exposed to electromagnetic radiation in the radio-frequency (RF) range. The RF radiation was applied as homogeneous 27.12 MHz fields in specially-designed exposure cells (and in some cases as non-homogeneous radiation of 27 MHz, amplitude modulated by 50 Hz, in front of commercial diathermy equipment). All fields were applied as pulses. We report effects in the leaflet rhythms such as temporary changes in the amplitude, period, and phase. The radiation could also cause temporary or complete cessations of the rhythms. The lowest dose (8 W/cm2) used was still effective.

Elliott P, Toledano MB, Bennett J, Beale L, de Hoogh K, Best N, Briggs DJ. Mobile phone base stations and early childhood cancers: case-control study.BMJ. 340:c3077, 2010.

OBJECTIVE: To investigate the risk of early childhood cancers associated with the mother's exposure to radiofrequency from and proximity to macrocell mobile phone base stations(masts) during pregnancy. **DESIGN:** Case-control study. **SETTING:** Cancer registry and national birth register data in Great Britain. **PARTICIPANTS:** 1397 cases of cancer in children aged 0-4 from national cancer registry 1999-2001 and 5588 birth controls from national birth register, individually matched by sex and date of birth (four controls per case). **MAIN OUTCOME MEASURES:** Incidence of cancers of the brain and central nervous system, leukaemia, and non-Hodgkin's lymphomas, and all cancers combined, adjusted for small area measures of education level, socioeconomic deprivation, population density, and population mixing. **RESULTS:** Mean distance of registered address at birth from a macrocell base station, based on a national database of 76,890 base station antennas in 1996-2001, was similar for cases and controls (1107 (SD 1131) m v 1073 (SD 1130) m, P=0.31), as was total power output of base stations within 700 m of the address (2.89 (SD 5.9) kW v 3.00 (SD 6.0) kW, P=0.54) and modelled power density (-30.3 (SD 21.7) dBm v -29.7 (SD 21.5) dBm, P=0.41). For modelled power density at the address at birth, compared with the lowest exposure category the adjusted odds ratios were 1.01 (95% confidence interval 0.87 to 1.18) in the intermediate and 1.02 (0.88 to 1.20) in the highest exposure category for all cancers (P=0.79 for trend), 0.97 (0.69 to 1.37) and 0.76 (0.51 to 1.12), respectively, for brain and central nervous system cancers (P=0.33 for trend), and 1.16 (0.90 to 1.48) and 1.03 (0.79 to 1.34) for leukaemia and non-Hodgkin's lymphoma (P=0.51 for trend). **CONCLUSIONS:** There is no association between risk of early childhood cancers and estimates of the mother's exposure to mobile phone base stations during pregnancy.

Eltiti S, Wallace D, Ridgewell A, Zougkou K, Russo R, Sepulveda F, Mirshekar-Syahkal D, Rasor P, Deeble R, Fox E. Does short-term exposure to mobile phone base station signals increase symptoms in individuals who report sensitivity to electromagnetic fields? A double-blind randomized provocation study. Environ Health Perspect. 115(11):1603-1608, 2007.

BACKGROUND: Individuals with idiopathic environmental illness with attribution to electromagnetic fields (IEI-EMF) believe they suffer negative health effects when exposed to electromagnetic fields from everyday objects such as mobile phone base stations. OBJECTIVES: This study used both open provocation and double-blind tests to

determine if sensitive and control individuals experience more negative health effects when exposed to base station-like signals compared with sham. METHODS: Fifty-six self-reported sensitive and 120 control participants were tested in an open provocation test. Of these, 12 sensitive and 6 controls withdrew after the first session. The remainder completed a series of double-blind tests. Subjective measures of well-being and symptoms as well as physiological measures of blood volume pulse, heart rate, and skin conductance were obtained. RESULTS: During the open provocation, sensitive individuals reported lower levels of well-being in both the global system for mobile communication (GSM) and universal mobile telecommunications system (UMTS) compared with sham exposure, whereas controls reported more symptoms during the UMTS exposure. During double-blind tests the GSM signal did not have any effect on either group. Sensitive participants did report elevated levels of arousal during the UMTS condition, whereas the number or severity of symptoms experienced did not increase. Physiological measures did not differ across the three exposure conditions for either group. CONCLUSIONS: Short-term exposure to a typical GSM base station-like signal did not affect well-being or physiological functions in sensitive or control individuals. Sensitive individuals reported elevated levels of arousal when exposed to a UMTS signal. Further analysis, however, indicated that this difference was likely to be due to the effect of order of exposure rather than the exposure itself.

Eltiti S, Wallace D, Ridgewell A, Zougkou K, Russo R, Sepulveda F, Fox E. Short-term exposure to mobile phone base station signals does not affect cognitive functioning or physiological measures in individuals who report sensitivity to electromagnetic fields and controls. Bioelectromagnetics.30(7):556-563, 2009.

Individuals who report sensitivity to electromagnetic fields often report cognitive impairments that they believe are due to exposure to mobile phone technology. Previous research in this area has revealed mixed results, however, with the majority of research only testing control individuals. Two studies using control and self-reported sensitive participants found inconsistent effects of mobile phone base stations on cognitive functioning. The aim of the present study was to clarify whether short-term (50 min) exposure at 10 mW/m(2) to typical Global System for Mobile Communication (GSM) and Universal Mobile Telecommunications System (UMTS) base station signals affects attention, memory, and physiological endpoints in sensitive and control participants. Data from 44 sensitive and 44 matched-control participants who performed the digit symbol substitution task (DSST), digit span task (DS), and a mental arithmetic task (MA), while being exposed to GSM, UMTS, and sham signals under double-blind conditions were analyzed. Overall, cognitive functioning was not affected by short-term exposure to either GSM or UMTS signals in the current study. Nor did exposure affect the physiological measurements of blood volume pulse (BVP), heart rate (HR), and skin conductance (SC) that were taken while participants performed the cognitive tasks.

Elwood JM. Microwaves in the cold war: the Moscow embassy study and its interpretation. Review of a retrospective cohort study.Environ Health. 11(1):85, 2012.

BACKGROUND: From 1953 to 1976, beams of microwaves of 2.5 to 4.0 GHz were

aimed at the US embassy building in Moscow. An extensive study investigated the health of embassy staff and their families, comparing Moscow embassy staff with staff in other Eastern European US embassies. The resulting large report has never been published in peer reviewed literature.**METHODS:** The original report and other published comments or extracts from the report were reviewed.**RESULTS:** The extensive study reports on mortality and morbidity, recorded on medical records and by regular examinations, and on self-reported symptoms. Exposure levels were low, but similar or greater than present-day exposures to radiofrequencies sources such as cell phone base stations. The conclusions were that no adverse health effects of the radiation were shown. The study validity depends on the assumption that staff at the other embassies were not exposed to similar radiofrequencies. This has been questioned, and other interpretations of the data have been presented.**CONCLUSIONS:** The conclusions of the original report are supported. Contrary conclusions given in some other reports are due to misinterpretation of the results.

Engelmann JC, Deeken R, Müller T, Nimtz G, Roelfsema MR, Hedrich R. Is gene activity in plant cells affected by UMTS-irradiation? A whole genome approach.Adv Appl Bioinform Chem. 1:71-83, 2008.

Mobile phone technology makes use of radio frequency (RF) electromagnetic fields transmitted through a dense network of base stations in Europe. Possible harmful effects of RF fields on humans and animals are discussed, but their effect on plants has received little attention. In search for physiological processes of plant cells sensitive to RF fields, cell suspension cultures of Arabidopsis thaliana were exposed for 24 h to a RF field protocol representing typical microwave exposition in an urban environment. mRNA of exposed cultures and controls was used to hybridize Affymetrix-ATH1 whole genome microarrays. Differential expression analysis revealed significant changes in transcription of 10 genes, but they did not exceed a fold change of 2.5. Besides that 3 of them are dark-inducible, their functions do not point to any known responses of plants to environmental stimuli. The changes in transcription of these genes were compared with published microarray datasets and revealed a weak similarity of the microwave to light treatment experiments. Considering the large changes described in published experiments, it is questionable if the small alterations caused by a 24 h continuous microwave exposure would have any impact on the growth and reproduction of whole plants.

English NJ, Mooney DA. Denaturation of hen egg white lysozyme in electromagnetic fields: A molecular dynamics study. J Chem Phys. 126(9):091105, 2007.

Nonequilibrium molecular dynamics simulations of hen egg white lysozyme have been performed in the canonical ensemble at 298 K in the presence of external electromagnetic fields of varying intensity in the microwave to far-infrared frequency range. Significant nonthermal field effects were noted, such as marked changes in the protein's secondary structure which led to accelerated incipient local denaturation relative to zero-field conditions. This occurred primarily as a consequence of alignment of the protein's total dipole moment with the external field, although the

enhanced molecular mobility and dipolar alignment of water molecules is influential on sidechain motion in solvent-exposed regions. The applied field intensity was found to be highly influential on the extent of denaturation in the frequency range studied, and 0.25-0.5 V A(rms) (-1) fields were found to induce initial denaturation to a comparable extent to thermal denaturation in the 400 to 500 K range. In subsequent zero-field simulations following exposure to the e/m field, the extent of perturbation from the native fold and the degree of residual dipolar alignment were found to be influential on incipient folding.

Enin LD, Akoev GN, Potekhina IL, Oleiner VD, [Effect of extremely high-frequency electromagnetic radiation on the function of skin sensory endings]. Patol Fiziol Eksp Ter Sep-Dec;(5-6):23-25, 1992. [Article in Russian]

The specific features of skin receptor function on the sole of the hind limb of an albino rat were studied in an acute experiment. Impulse activity recorded from the solitary fibres of the tibial nerve showed that receptor units (RU) responded to mechanical stimulation of the skin. Irradiation of the skin surface by low-intensity millimeter band electromagnetic field (frequencies of 55.61 and 73 GHz) in the zone of the RU led to diminution of RU sensitivity to the mechanical stimulus. One half of the RU ceased to respond to the mechanical stimulation 25 minutes after irradiation. The other half continued responding to stimulation even after 35 minutes of irradiation, but the character of the RU response was significantly changed. A strict frequency-resonance dependence of the biological effects was revealed. It is concluded that electromagnetic radiation has a modulatory-inhibiting effect on the skin RU. The authors suggest a possible mechanism of realization of the effect of electromagnetic radiation of extremely high-frequencies and low power on the skin receptor function.

Erdem Koç G, Kaplan S, Altun G, Gümüş H, Gülsüm Deniz Ö, Aydin I, Emin Onger M, Altunkaynak Z. Neuroprotective effects of melatonin and omega-3 on hippocampal cells prenatally exposed to 900 MHz electromagnetic fields. Int J Radiat Biol. 92(10):590-595, 2016.

PURPOSE: Adverse effects on human health caused by electromagnetic fields (EMF) associated with the use of mobile phones, particularly among young people, are increasing all the time. The potential deleterious effects of EMF exposure resulting from mobile phones being used in close proximity to the brain require particular evaluation. However, only a limited number of studies have investigated the effects of prenatal exposure to EMF in the development of the pyramidal cells using melatonin (MEL) and omega-3 (ω-3). MATERIALS AND METHODS: We established seven groups of pregnant rats consisting of three animals each; control (CONT), SHAM, EMF, EMF + MEL, MEL, EMF + ω-3 and ω-3 alone. The rats in the EMF, EMF + MEL, EMF + ω-3 groups were exposed to 900 MHz EMF for 60 min/day in an exposure tube during the gestation period. The CONT, MEL and ω-3 group rats were not placed inside the exposure tube or exposed to EMF during the study period. After delivery, only spontaneously delivered male rat pups were selected for the establishment of further groups. Each group of offspring consisted of six animals. The optical fractionator technique was used to determine total pyramidal neuron numbers in the rat hippocampal region. RESULTS: The total number of pyramidal cells in the cornu ammonis (CA) in the

EMF group was significantly lower than in the CONT, SHAM, EMF + MEL, and EMF + ω-3 groups. No significant difference was observed between the EMF, MEL and ω-3 groups. No difference was also observed between any groups in terms of rats' body or brain weights. CONCLUSION: MEL and ω-3 can protect the cell against neuronal damage in the hippocampus induced by 900 MHz EMF. However, further studies are now needed to evaluate the chronic effects of 900 MHz EMF on the brain in the prenatal period.

Erdreich LS, Van Kerkhove MD, Scrafford CG, Barraj L, McNeely M, Shum M, Sheppard AR, Kelsh M. Factors that influence the radiofrequency power output of GSM mobile phones. Radiat Res. 168(2):253-261, 2007.

Epidemiological studies of mobile phone use and risk of brain cancer have relied on self-reported use, years as a subscriber, and billing records as exposure surrogates without addressing the level of radiofrequency (RF) power output. The objective of this study was to measure environmental, behavioral and engineering factors affecting the RF power output of GSM mobile phones during operation. We estimated the RF-field exposure of volunteer subjects who made mobile phone calls using software-modified phones (SMPs) that recorded output power settings. Subjects recruited from three geographic areas in the U.S. were instructed to log information (place, time, etc.) for each call made and received during a 5-day period. The largest factor affecting energy output was study area, followed by user movement and location (inside or outside), use of a hands-free device, and urbanicity, although the two latter factors accounted for trivial parts of overall variance. Although some highly statistically significant differences were identified, the effects on average energy output rate were usually less than 50% and were generally comparable to the standard deviation. These results provide information applicable to improving the precision of exposure metrics for epidemiological studies of GSM mobile phones and may have broader application for other mobile phone systems and geographic locations.

Eris AH, Kiziltan HS, Meral I, Genc H, Trabzon M, Seyithanoglu H, Yagci B, Uysal O. Effect of Short-term 900 MHz low level electromagnetic radiation exposure on blood serotonin and glutamate levels. Bratisl Lek Listy. 116(2):101-103, 2015.

BACKGROUND: Long term exposure to low level electromagnetic radiation (LLER) by using cellular phones causes serious health problems. METHODS: Ten male Wistar Albino rats were anesthetized 30 min before the LLER exposure, 0.5 ml blood was taken from the tail vein of rats in order to determine control values. Rats were grouped by three and placed on a plexi-glass flat. A fixed equivalent frequency emitter device was used. A sign to be an electromagnetic field 15.14 V/m (608 mW/m2) in strength in the head region with 100 kHz FM modulation at 900 MHz was applied to the animals. After calculating the ideal position for the device, electromagnetic LLER energy was applied for 45 minutes from a distance to be equal with energy transmitted by a mobile phone from a 0.5-1 cm distance to their head regions. After 1.5 hours and before the rats awoke, 0.5 ml of blood was taken from the tail veins in order to determine the treatment values. RESULTS: Plasma 5-HT and glutamate levels were measured by enzyme immunoassay (EIA) using commercial kits. It was found that a single 45 min of LLER exposure increased the blood

5-HT level significantly, but did not change the glutamate level of rats. CONCLUSION: It was concluded that even a single 45 min of LLER exposure may produce an increase in 5-HT level without changing the blood glutamate level. Increased 5-HT level may lead to a retarded learning and a deficit in spatial memory (Tab. 2, Fig. 2, Ref. 24).

Erkut A, Tumkaya L, Balik MS, Kalkan Y, Guvercin Y, Yilmaz A, Yuce S, Cure E, Sehitoglu I. The effect of prenatal exposure to 1800 MHz electromagnetic field on calcineurin and bone development in rats. Acta Cir Bras. 2016 Feb;31(2):74-83.

PURPOSE: To investigate the effects of exposure to an 1800 MHz electromagnetic field (EMF) on bone development during the prenatal period in rats. METHODS: Pregnant rats in the experimental group were exposed to radiation for six, 12, and 24 hours daily for 20 days. No radiation was given to the pregnant rats in the control group. We distributed the newborn rats into four groups according to prenatal EMF exposure as follows: Group 1 was not exposed to EMF; groups 2, 3, and 4 were exposed to EMF for six, 12, and 24 hours a day, respectively. The rats were evaluated at the end of the 60th day following birth. RESULTS: Increasing the duration of EMF exposure during the prenatal period resulted in a significant reduction of resting cartilage levels and a significant increase in the number of apoptotic chondrocytes and myocytes. There was also a reduction in calcineurin activities in both bone and muscle tissues. We observed that the development of the femur, tibia, and ulna were negatively affected, especially with a daily EMF exposure of 24 hours. CONCLUSION: Bone and muscle tissue development was negatively affected due to prenatal exposure to 1800 MHz radiofrequency electromagnetic field.

Erogul O, Oztas E, Yildirim I, Kir T, Aydur E, Komesli G, Irkilata HC, Irmak MK, Peker AF. Effects of electromagnetic radiation from a cellular phone on human sperm motility: an in vitro study. Arch Med Res. 37(7):840-843, 2006.

BACKGROUND: There has been growing public concern on the effects of electromagnetic radiation (EMR) emitted by cellular phones on human health. Many studies have recently been published on this topic. However, possible consequences of the cellular phone usage on human sperm parameters have not been investigated adequately. METHODS: A total number of 27 males were enrolled in the study. The semen sample obtained from each participant was divided equally into two parts. One of the specimens was exposed to EMR emitted by an activated 900 MHz cellular phone, whereas the other was not. The concentration and motility of the specimens were compared to analyze the effects of EMR. Assessment of sperm movement in all specimens was performed using four criteria: (A) rapid progressive, (B) slow progressive, (C) nonprogressive, (D) no motility. RESULTS: Statistically significant changes were observed in the rapid progressive, slow progressive and no-motility categories of sperm movement. EMR exposure caused a subtle decrease in the rapid progressive and slow progressive sperm movement. It also caused an increase in the no-motility category of sperm movement. There was no statistically significant difference in the sperm concentration between two groups. CONCLUSIONS: These

data suggest that EMR emitted by cellular phone influences human sperm motility. In addition to these acute adverse effects of EMR on sperm motility, long-term EMR exposure may lead to behavioral or structural changes of the male germ cell. These effects may be observed later in life, and they are to be investigated more seriously.

Ersan Odacı, Ayşe İkinci, Mehmet Yıldırım, Haydar Kaya, Metehan Akça, Hatice Hancı, Osman Fikret Sönmez, Ali Aslan, Mukadder Okuyan, Orhan Baş The Effects of 900 Megahertz Electromagnetic Field Applied in the Prenatal Period on Spinal Cord Morphology and Motor Behavior in Female Rat Pups. NeuroQuantology 11:573-581, 2013.

This study investigated the effect of a 900 megahertz (MHz) electromagnetic field (EMF) applied in the prenatal period on the spinal cord and motor behavior of female rat pups. Beginning of the study, female Sprague Dawley rats (180–250 g) were left to mate with male rats. Rats identified as pregnant were then divided into control (n=3) and EMF groups (n=3). The EMF group was exposed to 1-h 900 MHz EMF daily between days 13 and 21 of pregnancy. At 21 days old, rat pups were removed from their mothers and divided into two newborn rat groups, control (n=13) and EMF (n=10). The rotarod test was applied to the rat pups to assess motor functions and the open field test to evaluate locomotor activity. On day 32 of the study, the rat pups were decapitated, and the spinal cord in the upper thoracic region was removed. Following routine histological tests, they were stained with Cresyl fast violet. Rotarod test results revealed a significant increase in EMF group rat pups' motor functions ($p=0.037$). However, no difference was observed in the open field test results ($p>0.05$). In the EMF group' rat pups, we observed pathological changes in the spinal cord. On the basis of our results, 900 MHz EMF applied in the prenatal period affected spinal cord development. This effect was observed in the form of pathological changes in the spinal cord of rat pups, and it may be that these pathological changes led to an increase in rat pups' motor activities.

Esen F, Esen HEffect of electromagnetic fields emitted by cellular phones on the latency of evoked electrodermal activity. Int J Neurosci. 116(3):321-329, 2006.

The widespread use of cellular phones raises the question of their possible adverse biological effects, especially on the central nervous system (CNS). Therefore, the authors examined the effect of electromagnetic fields emitted by cellular phones (CPEMFs) on the evoked neuronal activity of CNS relating to generation and representation of electrodermal activity (EDA), an index of sympathetic nervous system activity. EDA (skin resistance response; SRR) latency was lengthened approximately 200 ms with CPEMFs exposure irrespective of the head site next to mobile phone used. Hemispheric asymmetry of EDA-2 pathway, which is represented by shorter SRR latency in the right hand of the right hand responders, was also distorted with CPEMFs. Because the CNS regions including EDA-2 are also involved in tasks of motor timing and time estimation, delayed response in this neuronal network due to CPEMFs exposure may increase the response time of mobile phone users. Therefore, the findings point to the potential risks of mobile phones on the function of CNS and consequently, possible increase in the risk of phone-related driving hazards.

Eser O, Songur A, Aktas C, Karavelioglu E, Caglar V, Aylak F, Ozguner F, Kanter M. The effect of electromagnetic radiation on the rat brain: an experimental study. Turk Neurosurg. 23(6):707-715, 2013.

AIM: The aim of this study is to determine the structural changes of electromagnetic waves in the frontal cortex, brain stem and cerebellum. MATERIAL and METHODS: 24 Wistar Albino adult male rats were randomly divided into four groups: group I consisted of control rats, and groups II-IV comprised electromagnetically irradiated (EMR) with 900, 1800 and 2450 MHz. The heads of the rats were exposed to 900, 1800 and 2450 MHz microwaves irradiation for 1h per day for 2 months. RESULTS: While the histopathological changes in the frontal cortex and brain stem were normal in the control group, there were severe degenerative changes, shrunken cytoplasm and extensively dark pyknotic nuclei in the EMR groups. Biochemical analysis demonstrated that the Total Antioxidative Capacity level was significantly decreased in the EMR groups and also Total Oxidative Capacity and Oxidative Stress Index levels were significantly increased in the frontal cortex, brain stem and cerebellum. IL-1β level was significantly increased in the EMR groups in the brain stem. CONCLUSION: EMR causes to structural changes in the frontal cortex, brain stem and cerebellum and impair the oxidative stress and inflammatory cytokine system. This deterioration can cause to disease including loss of these areas function and cancer development.

Eskander EF, Estefan SF, Abd-Rabou AA. How does long term exposure to base stations and mobile phones affect human hormone profiles? Clin Biochem. 45(1-2):157-161, 2012

OBJECTIVES: This study is concerned with assessing the role of exposure to radio frequency radiation (RFR) emitted either from mobiles or base stations and its relations with human's hormone profiles. **DESIGN AND METHODS:** All volunteers' samples were collected for hormonal analysis. **RESULTS:** This study showed significant decrease in volunteers' ACTH, cortisol, thyroid hormones, prolactin for young females, and testosterone levels. **CONCLUSION:** The present study revealed that high RFR effects on pituitary-adrenal axis.

Eşmekaya MA, Seyhan N, Omeroğlu S. Pulse modulated 900 MHz radiation induces hypothyroidism and apoptosis in thyroid cells: A light, electron microscopy and immunohistochemical study. Int J Radiat Biol. 86(12):1106-1116, 2010.

Purpose: In the present study we investigated the possible histopathological effects of pulse modulated Radiofrequency (RF) fields on the thyroid gland using light microscopy, electron microscopy and immunohistochemical methods. Materials and methods: Two months old male Wistar rats were exposed to a 900 MHz pulse-modulated RF radiation at a specific absorption rate (SAR) of 1.35 Watt/kg for 20 min/day for three weeks. The RF signals were pulse modulated by rectangular pulses with a repetition frequency of 217 Hz and a duty cycle of 1:8 (pulse width 0.576 ms). To assess thyroid endocrine disruption and estimate the degree of the pathology of

the gland, we analysed structural alterations in follicular and colloidal diameters and areas, colloid content of the follicles, and height of the follicular epithelium. Apoptosis was confirmed by Transmission Electron Microscopy and assessing the activites of an initiator (caspase-9) and an effector (caspase-3) caspases that are important markers of cells undergoing apoptosis. Results: Morphological analyses revealed hypothyrophy of the gland in the 900 MHz RF exposure group. The results indicated that thyroid hormone secretion was inhibited by the RF radiation. In addition, we also observed formation of apoptotic bodies and increased caspase-3 and caspase-9 activities in thyroid cells of the rats that were exposed to modulated RF fields. Conclusion: The overall findings indicated that whole body exposure to pulse-modulated RF radiation that is similar to that emitted by global system for mobile communications (GSM) mobile phones can cause pathological changes in the thyroid gland by altering the gland structure and enhancing caspase-dependent pathways of apoptosis.

Esmekaya MA, Aytekin E, Ozgur E, Güler G, Ergun MA, Omeroğlu S, Seyhan N. Mutagenic and morphologic impacts of 1.8GHz radiofrequency radiation on human peripheral blood lymphocytes (hPBLs) and possible protective role of pre-treatment with Ginkgo biloba (EGb 761). Sci Total Environ. 410-411:59-64, 2011.

The mutagenic and morphologic effects of 1.8GHz Global System for Mobile Communications (GSM) modulated RF (radiofrequency) radiation alone and in combination with Ginkgo biloba (EGb 761) pre-treatment in human peripheral blood lymphocytes (hPBLs) were investigated in this study using Sister Chromatid Exchange (SCE) and electron microscopy. Cell viability was assessed with 3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide (MTT) reduction assay. The lymphocyte cultures were exposed to GSM modulated RF radiation at 1.8GHz for 6, 8, 24 and 48h with and without EGb 761. We observed morphological changes in pulse-modulated RF radiated lymphocytes. Longer exposure periods led to destruction of organelle and nucleus structures. Chromatin change and the loss of mitochondrial crista occurred in cells exposed to RF for 8h and 24h and were more pronounced in cells exposed for 48h. Cytoplasmic lysis and destruction of membrane integrity of cells and nuclei were also seen in 48h RF exposed cells. There was a significant increase ($p<0.05$) in SCE frequency in RF exposed lymphocytes compared to sham controls. EGb 761 pre-treatment significantly decreased SCE from RF radiation. RF radiation also inhibited cell viability in a time dependent manner. The inhibitory effects of RF radiation on the growth of lymphoctes were marked in longer exposure periods. EGb 761 pre-treatment significantly increased cell viability in RF+EGb 761 treated groups at 8 and 24h when compared to RF exposed groups alone. The results of our study showed that RF radiation affects cell morphology, increases SCE and inhibits cell proliferation. However, EGb 761 has a protective role against RF induced mutagenity. We concluded that RF radiation induces chromosomal damage in hPBLs but this damage may be reduced by EGb 761 pre-treatment.

Esmekaya MA, Ozer C, Seyhan N. 900 MHz pulse-modulated radiofrequency radiation induces oxidative stress on heart, lung, testis and liver tissues. Gen Physiol Biophys. 30(1):84-89, 2011.

Oxidative stress may affect many cellular and physiological processes including gene expression, cell growth, and cell death. In the recent study, we aimed to investigate whether 900 MHz pulse-modulated radiofrequency (RF) fields induce oxidative damage on lung, heart and liver tissues. We assessed oxidative damage by investigating lipid peroxidation (malondialdehyde, MDA), nitric oxide (NOx) and glutathione (GSH) levels which are the indicators of tissue toxicity. A total of 30 male Wistar albino rats were used in this study. Rats were divided randomly into three groups; control group (n = 10), sham group (device off, n = 10) and 900 MHz pulsed-modulated RF radiation group (n = 10). The RF rats were exposed to 900 MHz pulsed modulated RF radiation at a specific absorption rate (SAR) level of 1.20 W/kg 20 min/day for three weeks. MDA and NOx levels were increased significantly in liver, lung, testis and heart tissues of the exposed group compared to sham and control groups ($p < 0.05$). Conversely GSH levels were significantly lower in exposed rat tissues ($p < 0.05$). No significantly difference was observed between sham and control groups. Results of our study showed that pulse-modulated RF radiation causes oxidative injury in liver, lung, testis and heart tissues mediated by lipid peroxidation, increased level of NOx and suppression of antioxidant defense mechanism.

Espinosa JM, Liberti M, Lagroye I, Veyret B. Exposure to AC and DC magnetic fields induces changes in 5-HT1B receptor binding parameters in rat brain membranes. Bioelectromagnetics. 27(5):414-422, 2006.

The binding properties of the G-protein coupled receptor (GPCR) serotonin 5-HT1B receptor were studied under exposure to AC (50 and 400 Hz) and DC magnetic fields (MF) in rat brain membranes. This was an attempt at replicating the positive findings of Massot et al. In saturation experiments using [3H]5-HT, 1-h exposures at 1.1 mT(rms) 50 Hz caused statistically significant increases in both the K(D) and B(max) binding parameters, from 1.74 +/- 0.3 to 4.51 +/- 0.86 nM and from 1428 +/- 205 to 2137 +/- 399 CPM, respectively, in good agreement with previous results. Exposure of the membranes at 400 Hz 0.675 mT(rms) did not elicit a larger increase in K(D) in spite of a much larger induced current density. DC fields (1.1 and 11 mT) had a lesser effect compared to AC fields at low values of K(Dsham), but decreased the affinity at higher values of K(Dsham). Modeling of the receptor-ligand-G protein interactions using the extended ternary complex model yielded good fits for all our data and that of Massot et al., showing that the AC field may act by decreasing the ability of the G-protein to alter the ligand-receptor affinity. The hypothesis is that the bipolar nature of the AC field explains the different nature of the effects observed with AC and DC exposures. These findings constitute one of the few documented pieces of evidence for cell-free effects of DC and extremely low frequency (ELF) AC MFs in the mT range.

Estenberg J, Augustsson T. Extensive frequency selective measurements of radiofrequency fields in outdoor environments performed with a novel mobile monitoring system. Bioelectromagnetics. 2013 Dec 27. doi: 10.1002/bem.21830. [Epub ahead of print]

A novel, car based, measuring system for estimation of general public outdoor exposure to radiofrequency fields (RF) has been developed. The system enables fast, large area, isotropic spectral measurements with a bandwidth covering the frequency range of 30 MHz to 3 GHz. Measurements have shown that complete mapping of a town with 15000 inhabitants and a path length of 115 km is possible to perform within 1 day. The measured areas were chosen to represent typical rural, urban and city areas of Sweden. The data sets consist of more than 70000 measurements. All measurements were performed during the daytime. The median power density was 16 μW/m^2 in rural areas, 270 μW/m^2 in urban areas, and 2400 μW/m^2 in city areas. In urban and city areas, base stations for mobile phones were clearly the dominating sources of exposure.

Eulitz, C, Ullsperger, P, Freude, G, Elbert ,T, Mobile phones modulate response patterns of human brain activity. Neuroreport 9(14):3229-3232, 1998.

Mobile phones emit a pulsed high-frequency electromagnetic field (PEMF) which may penetrate the scalp and the skull. Increasingly, there is an interest in the interaction of this pulsed microwave radiation with the human brain. Our investigations show that these electromagnetic fields alter distinct aspects of the brain's electrical response to acoustic stimuli. More precisely, our results demonstrate that aspects of the induced but not the evoked brain activity during PEMF exposure can be different from those not influenced by PEMF radiation. This effect appears in higher frequency bands when subjects process task-relevant target stimuli but was not present for irrelevant standard stimuli. As the induced brain activity in higher frequency bands has been proposed to be a correlate of coherent high-frequency neuronal activity, PEMF exposure may provide means to systematically alter the pattern fluctuations in neural mass activity.

Exelmans L, Van den Bulck J. Bedtime mobile phone use and sleep in adults. Soc Sci Med. 148:93-101, 2015.

BACKGROUND: The few studies that have investigated the relationship between mobile phone use and sleep have mainly been conducted among children and adolescents. In adults, very little is known about mobile phone usage in bed our after lights out. This cross-sectional study set out to examine the association between bedtime mobile phone use and sleep among adults. METHODS: A sample of 844 Flemish adults (18-94 years old) participated in a survey about electronic media use and sleep habits. Self-reported sleep quality, daytime fatigue and insomnia were measured using the Pittsburgh Sleep Quality Index (PSQI), the Fatigue Assessment Scale (FAS) and the Bergen Insomnia Scale (BIS), respectively. Data were analyzed using hierarchical and multinomial regression analyses. RESULTS: Half of the respondents owned a smartphone, and six out of ten took their mobile phone with them to the bedroom. Sending/receiving text messages and/or phone calls after lights out significantly predicted respondents' scores

on the PSQI, particularly longer sleep latency, worse sleep efficiency, more sleep disturbance and more daytime dysfunction. Bedtime mobile phone use predicted respondents' later self-reported rise time, higher insomnia score and increased fatigue. Age significantly moderated the relationship between bedtime mobile phone use and fatigue, rise time, and sleep duration. An increase in bedtime mobile phone use was associated with more fatigue and later rise times among younger respondents (≤ 41.5 years old and ≤ 40.8 years old respectively); but it was related to an earlier rise time and shorter sleep duration among older respondents (≥ 60.15 years old and ≥ 66.4 years old respectively). CONCLUSION: Findings suggest that bedtime mobile phone use is negatively related to sleep outcomes in adults, too. It warrants continued scholarly attention as the functionalities of mobile phones evolve rapidly and exponentially.

Fabbro-Peray P, Daures JP, Rossi JF. Environmental risk factors for non-Hodgkin's lymphoma: a population-based case-control study in Languedoc-Roussillon, France. Cancer Causes Control 12(3):201-212, 2001.

OBJECTIVE: To investigate the occupational and environmental risk factors related to non-Hodgkin's lymphoma (NHL). METHODS: A case-control study was performed during the 1992-1996 period in Languedoc-Roussillon, southern France. Four hundred and forty-five cases of histologically diagnosed NHL were declared. One thousand and twenty-five randomly selected population controls were interviewed about their medical histories; occupational exposures, such as chemicals, pesticides, and electromagnetic radiation; and toxic habits. RESULTS: The following factors were independently and significantly related to NHL as a result of the multivariate analysis: a previous hematopoietic malignancy (ORa = 11.5, 95% CI 2.4-55.4), a history of hives (ORa = 1.7, 95% CI 1.2-2.2), benzene exposure > 810 days (ORa = 4.6, 95% CI 1.1-19.2), daily welding (ORa = 2.5, 95% CI 1.2-5.0), and activity of radio operator (ORa = 3.1, 95% CI 1.4-6.6). To be an agricultural professional seemed slightly related to NHL in reference to non-professionals (ORa = 1.5, 95% CI 1.0-2.1). All of these results have also been adjusted for age, gender, education level, and urban setting. CONCLUSIONS: As some of the reported associations were based on a very small proportion of exposed subjects, further investigations are necessary to confirm our results. However, the findings suggest that factors related to altered immune functions such as a history of hematopoietic malignancy, history of hives, occupational exposure to benzene, or being an agricultural professional might increase the risk of NHL. Currently, underlying mechanisms for these associations are still unclear, and further investigations focused on interactions between immunity alterations and different chemicals would be of great interest.

Falzone N, Huyser C, Fourie F, Toivo T, Leszczynski D, Franken D. In vitro effect of pulsed 900 MHz GSM radiation on mitochondrial membrane potential and motility of human spermatozoa. Bioelectromagnetics.29(4):268-276, 2008.

Ejaculated, density purified, human spermatozoa were exposed to pulsed 900 MHz GSM mobile phone radiation at two specific absorption rate levels (SAR 2.0 and 5.7 W/kg) and compared with controls over time. Change in sperm mitochondrial membrane potential was analysed using flow cytometry. Sperm motility was determined by computer assisted sperm analysis (CASA). There was no effect of

pulsed 900 MHz GSM radiation on mitochondrial membrane potential. This was also the case for all kinematic parameters assessed at a SAR of 2.0 W/kg. However, over time, the two kinematic parameters straight line velocity (VSL) and beat-cross frequency (BCF) were significantly impaired ($P < 0.05$) after the exposure at SAR 5.7 W/kg and no exposure by time interaction was present. This result should not be ascribed to thermal effects, due to the cooling methods employed in the RF chamber and temperature control within the incubator.

Falzone N, Huyser C, Becker P, Leszczynski D, Franken DR. The effect of pulsed 900-MHz GSM mobile phone radiation on the acrosome reaction, head morphometry and zona binding of human spermatozoa. Int J Androl. 34(1):20-26, 2011.

Summary Several recent studies have indicated that radiofrequency electromagnetic fields (RF-EMF) have an adverse effect on human sperm quality, which could translate into an effect on fertilization potential. This study evaluated the effect of RF-EMF on sperm-specific characteristics to assess the fertilizing competence of sperm. Highly motile human spermatozoa were exposed for 1 h to 900-MHz mobile phone radiation at a specific absorption rate of 2.0 W/kg and examined at various times after exposure. The acrosome reaction was evaluated using flow cytometry. The radiation did not affect sperm propensity for the acrosome reaction. Morphometric parameters were assessed using computer-assisted sperm analysis. Significant reduction in sperm head area (9.2 +/- 0.7 mum(2) vs. 18.8 +/- 1.4 mum(2)) and acrosome percentage of the head area (21.5 +/- 4% vs. 35.5 +/- 11.4%) was reported among exposed sperm compared with unexposed controls. Sperm-zona binding was assessed directly after exposure using the hemizona assay. The mean number of zona-bound sperm of the test hemizona and controls was 22.8 +/- 12.4 and 31.8 +/- 12.8 ($p < 0.05$), respectively. This study concludes that although RF-EMF exposure did not adversely affect the acrosome reaction, it had a significant effect on sperm morphometry. In addition, a significant decrease in sperm binding to the hemizona was observed. These results could indicate a significant effect of RF-EMF on sperm fertilization potential.

Falzone N, Huyser C, Franken DR, Leszczynski D. Mobile phone radiation does not induce pro-apoptosis effects in human spermatozoa. Radiat Res. 174(2):169-176, 2010.

Abstract Recent reports suggest that mobile phone radiation may diminish male fertility. However, the effects of this radiation on human spermatozoa are largely unknown. The present study examined effects of the radiation on induction of apoptosis-related properties in human spermatozoa. Ejaculated, density-purified, highly motile human spermatozoa were exposed to mobile phone radiation at specific absorption rates (SARs) of 2.0 and 5.7 W/kg. At various times after exposure, flow cytometry was used to examine caspase 3 activity, externalization of phosphatidylserine (PS), induction of DNA strand breaks, and generation of reactive oxygen species. Mobile phone radiation had no statistically significant effect on any of the parameters studied. This suggests that the impairment of fertility reported in some studies was not caused by the induction of apoptosis in spermatozoa.

Faraone, A., Luengas, W., Chebrolu, S., Ballen, M., Bit-Babik, G., Gessner, A. V., Kanda, M. Y., Babij, T., Swicord, M. L. and Chou, C-K. Radiofrequency dosimetry for the ferris-wheel mouse exposure system. Radiat. Res. 165, 105-112, 2006.

Numerical and experimental methods were employed to assess the individual and collective dosimetry of mice used in a bioassay on the exposure to pulsed radiofrequency energy at 900 MHz in the Ferris-wheel exposure system (Utteridge et al., Radiat. Res. 158, 357-364, 2002). Twin-well calorimetry was employed to measure the whole-body specific absorption rate (SAR) of mice for three body masses (23 g, 32 g and 36 g) to determine the lifetime exposure history of the mice used in the bioassay. Calorimetric measurements showed about 95% exposure efficiency and lifetime average whole-body SARs of 0.21, 0.86, 1.7 and 3.4 W kg(-1) for the four exposure groups. A larger statistical variation in SAR was observed in the smallest mice because they had the largest variation in posture inside the plastic restrainers. Infrared thermography provided SAR distributions over the sagittal plane of mouse cadavers. Thermograms typically showed SAR peaks in the abdomen, neck and head. The peak local SAR at these locations, determined by thermometric measurements, showed peak-to-average SAR ratios below 6:1, with typical values around 3:1. Results indicate that the Ferris wheel fulfills the requirement of providing a robust exposure setup, allowing uniform collective lifetime exposure of mice.

Fasseas MK, Fragopoulou AF, Manta AK, Skouroliakou A, Vekrellis K, Margaritis LH, Syntichaki P. Response of Caenorhabditis elegans to wireless devices radiation exposure. Int J Radiat Biol. 91(3):286-293, 2015.

Purpose: The aim of this study was to examine the impact of electromagnetic radiation, produced by GSM (Global System for Mobile communications) mobile phones, Wi-Fi (Wireless-Fidelity) routers and wireless DECT (Digital Enhanced Cordless Telecommunications) phones, on the nematode C. elegans. Materials and methods: We exposed synchronized populations, of different developmental stages, to these wireless devices at E-field levels below ICNIRP's (International Commission on Non-Ionizing Radiation Protection) guidelines for various lengths of time. WT (wild-type) and aging- or stress-sensitive mutant worms were examined for changes in growth, fertility, lifespan, chemotaxis, short-term memory, increased ROS (Reactive Oxygen Species) production and apoptosis by using fluorescent marker genes or qRT-PCR (quantitative Reverse Transcription-Polymerase Chain Reaction). Results: No statistically significant differences were found between the exposed and the sham/control animals in any of the experiments concerning lifespan, fertility, growth, memory, ROS, apoptosis or gene expression. Conclusions: The worm appears to be robust to this form of (pulsed) radiation, at least under the exposure conditions used.

Fatma M. Ghoneim, Eetmad A. Arafat. Histological and histochemical study of the protective role of rosemary extract against harmful effect of cell phone electromagnetic radiation on the parotid glands. Acta Histochemica, Available online 4 May 2016.

Electromagnetic fields (EMFs) are a class of non-ionizing radiation (NIR) that is emitted

from mobile phone. It may have hazardous effects on parotid glands. So, we aimed to investigate the histological and histochemical changes of the parotid glands of rats exposed to mobile phone and study the possible protective role of rosemary against its harmful effect. Forty adult male albino rats were used in this study. They were classified into 4 equal groups. Group I (control), group II (control receiving rosemary), group III (mobile phone exposed group) and group IV (mobile exposed, rosemary treated group). Parotid glands were dissected out for histological and histochemical study. Moreover, measurement of oxidative stress markers; malondialdehyde (MDA) and total antioxidant capacity (TAC) was done. The results of this study revealed that rosemary has protective effect through improving the histological and histochemical picture of the parotid gland in addition of its antioxidant effect. It could be concluded from the current study, that exposure of parotid gland of rat models to electromagnetic radiation of mobile phone resulted in structural changes at the level of light and electron microscopic examination which could be explained by oxidative stress effect of mobile phone. Rosemary could play a protective role against this harmful effect through its antioxidant activity.

Fattahi-Asl J, Baradaran-Ghahfarokhi M, Karbalae M, Baradaran-Ghahfarokhi M, Baradaran-Ghahfarokhi HR. Effects of radiofrequency radiation on human ferritin: an in vitro enzymun assay. J Med Signals Sens. 2(4):235-340, 2012.

Ferritin is a macromolecule and is responsible for the long term iron storage function in human serum and plasma. Recent studies have highlighted the role of cell phone exposure on central nervous system, immune function and reproduction. The aim of this study was to investigate whether the human serum ferritin level could be interfered by the exposure to the 900 MHz GSM cell phones. Fifty human serum wells from 25 normal healthy donors were labeled with ruthenium to form a sandwich complex based on an immunoassay technique. All of them were placed into two batches, and the well heads in the first batch were exposed to 900 MHz exposure emitted from a speech mode cell phone (Nokia, Model 1202, India) for 30 min. Unexposed batch was served as the control sample under identical conditions and was compared with the exposed one in quantitative determination of ferritin using the Wilcoxon test with criterion level of P = 0.050. Human serum wells in the exposed batch showed a significant decrease in serum ferritin relative to the control batch (P = 0.029). The average ± SD ferritin level in the exposed batch was 84.94 ± 1.04 µg/L while it was 87.25 ± 0.83 µg/L for the unexposed batch. Radiofrequency electromagnetic waves emitted from cell phones may lead to oxidative stress and rapid diffusion of the human ferritin level in an in vitro enzymun assay. Also, the enzyme activity can be affected. Effects of exposure from mobile phones must be considered further.

Faucon G, Le Bouquin Jeannes R, Maby E. Short-term effects of GSM mobiles phones on spectral components of the human electroencephalogram. Conf Proc IEEE Eng Med Biol Soc. 1(1):3751-3754, 2006.

The aim of the study was to investigate whether the GSM (global system for mobile) signals affect the electrical activity of the human brain. Nine healthy subjects and six temporal epileptic patients were exposed to radiofrequencies emitted by a GSM

mobile phone signals. Electroencephalographic (EEG) signals were recorded using surface electrodes with and without radiofrequency. In order to obtain a reference, a control session was also carried out. The spectral attributes of the EEG signals recorded by surface electrodes were analyzed. The significant decrease of spectral correlation coefficients under radiofrequency influence showed that the GSM signal altered the spectral arrangement of the EEG activity for healthy subjects as well as epileptic patients. For the healthy subjects, the EEG spectral energy decreased on the studied frequency band [0-40 Hz] and more precisely on occipital electrodes for the alpha-band. For the epileptic patients, these modifications were demonstrated by an increase of the power spectral density of the EEG signal. Nevertheless, these biological effects on the EEG are not sufficient to put forward some electrophysiological hypothesis.

Favre D. Mobile phone-induced honeybee worker piping Apidologie 42:270–279, 2011.

The worldwide maintenance of the honeybee has major ecological, economic, and political implications. In the present study, electromagnetic waves originating from mobile phones were tested for potential effects on honeybee behavior. Mobile phone handsets were placed in the close vicinity of honeybees. The sound made by the bees was recorded and analyzed. The audiograms and spectrograms revealed that active mobile phone handsets have a dramatic impact on the behavior of the bees, namely by inducing the worker piping signal. In natural conditions, worker piping either announces the swarming process of the bee colony or is a signal of a disturbed bee colony.

Fayos-Fernandez J, Arranz-Faz C, Martinez-Gonzalez AM, Sanchez-Hernandez D. Effect of pierced metallic objects on sar distributions at 900 MHz. Bioelectromagnetics. 27(5):337-353, 2006.

. A study of the interaction between mobile phone antennas and a human head in the presence of different types of metallic objects, attached and pierced to the compressed ear, is presented in this article. Computed and measured results have been performed by considering a quasi-half-wavelength dipole as the radiating source and measurements with the DASY4 dosimetric assessment system. Two different human head models have been implemented: a homogeneously shaped sphere and a three-level head model with four different kinds of tissue. Antenna input impedance, reflection coefficient, radiation patterns, SAR distribution, absorbed power, and peak SAR values have been computed and measured for diverse scenarios, electromagnetic simulators, and organs. Despite the measuring accuracy limitations of the study, both simulated and measured results suggest that special attention has to be paid to peak SAR averaged values when wearing metallic objects close to the radiation source, since some increment of peak SAR averaged values is expected.

Fejes I, Za Vaczki Z, Szollosi J, Kolosza R S, Daru J, Kova Cs L, Pa L Als there a relationship between cell phone use and semen quality? Arch Androl. 51(5):385-393, 2005.

This study was conducted to determine a possible relationship between regular cell

phone use and different human semen attributes. The history-taking of men in our university clinic was supplemented with questions concerning cell phone use habits, including possession, daily standby position and daily transmission times. Semen analyses were performed by conventional methods. Statistics were calculated with SPSS statistical software. A total of 371 were included in the study. The duration of possession and the daily transmission time correlated negatively with the proportion of rapid progressive motile sperm (r = - 0.12 and r = - 0.19, respectively), and positively with the proportion of slow progressive motile sperm (r = 0.12 and r = 0.28, respectively). The low and high transmitter groups also differed in the proportion of rapid progressive motile sperm (48.7% vs. 40.6%). The prolonged use of cell phones may have negative effects on the sperm motility characteristics.

Ferreira AR, Knakievicz T, de Bittencourt Pasquali MA, Gelain DP, Dal-Pizzol F, Fernandez CE, de Almeida de Salles AA, Ferreira HB, Moreira JC. Ultra high frequency-electromagnetic field irradiation during pregnancy leads to an increase in erythrocytes micronuclei incidence in rat offspring. Life Sci. 80(1)43-50, 2006.

Mobile telephones and their base stations are an important ultra high frequency-electromagnetic field (UHF-EMF) source and their utilization is increasing all over the world. Epidemiological studies suggested that low energy UHF-EMF emitted from a cellular telephone may cause biological effects, such as DNA damage and changes on oxidative metabolism. An in vivo mammalian cytogenetic test, the micronucleus (MN) assay, was used to investigate the occurrence of chromosomal damage in erythrocytes from rat offspring exposed to a non-thermal UHF-EMF from a cellular phone during their embryogenesis; the irradiated group showed a significant increase in MN occurrence. In order to investigate if UHF-EMF could also alter oxidative parameters in the peripheral blood and in the liver - an important hematopoietic tissue in rat embryos and newborns - we also measured the activity of antioxidant enzymes, quantified total sulfhydryl content, protein carbonyl groups, thiobarbituric acid-reactive species and total non-enzymatic antioxidant defense. No significant differences were found in any oxidative parameter of offspring blood and liver. The average number of pups in each litter has also not been significantly altered. Our results suggest that, under our experimental conditions, UHF-EMF is able to induce a genotoxic response in hematopoietic tissue during the embryogenesis through an unknown mechanism.

Ferreri F, Curcio G, Pasqualetti P, De Gennaro L, Fini R, Rossini PM. Mobile phone emissions and human brain excitability. Ann Neurol.60(2):188-196, 2006.

OBJECTIVE: To test-via Transcranial Magnetic Stimulation (TMS)-the excitability of each brain hemisphere after 'real' or 'sham' exposure to the electromagnetic field (EMF) generated by a mobile phone operating in the Global System for Mobile Communication (GSM). METHODS: Fifteen male volunteers attended two experimental sessions, one week apart, in a cross-over, double-blind paradigm. In one session the signal was turned ON (EMF-on, real exposure), in the other it was turned OFF (EMF-off, sham exposure), for 45 minutes. Motor Evoked Potentials (MEPs) were recorded using a paired-pulse paradigm (testing intracortical excitability with 1 to 17 ms interstimulus intervals), both before and at different times after exposure to the EMF. Short Intracortical Inhibition (SICI) and Facilitation (ICF) curves were evaluated both on the exposed and non-

exposed hemispheres. Tympanic temperature was collected during each session. RESULTS: The intracortical excitability curve becomes significantly modified during real exposure, with SICI being reduced and ICF enhanced in the acutely exposed brain hemisphere as compared to the contralateral, non-exposed hemisphere or to sham exposure. Tympanic temperature showed no significant main effect or interactions. INTERPRETATION: These results demonstrate that GSM-EMFs modify brain excitability. Possible implications and applications are discussed.

Fesenko EE, Geletyuk VI, Kazachenko VN, Chemeris NK Preliminary microwave irradiation of water solutions changes their channel-modifying activity. FEBS Lett 366(1):49-52, 1995.

Earlier we have shown that millimetre microwaves (42.25 GHz) of non-thermal power, upon direct admittance into an experiment bath, greatly influence activation characteristics of single Ca(2+)-dependent K+ channels (in particular, the channel open state probability, Po). Here we present new data showing that similar changes in Po arise due to the substitution of a control bath solution for a preliminary microwave irradiated one of the same composition (100 mmol/l KCl with Ca2+ added), with irradiation time being 20-30 min. Therefore, due to the exposure to the field the solution acquires some new properties that are important for the channel activity. The irradiation terminated, the solution retains a new state for at least 10-20 min (solution memory). The data suggest that the effects of the field on the channels are mediated, at least partially, by changes in the solution properties.

Fesenko EE, Novoselova EG, Semiletova NV, Agafonova TA, Sadovnikov VB, [Stimulation of murine natural killer cells by weak electromagnetic waves in the centimeter range]. Biofizika 44(4):737-741, 1999. [Article in Russian]

Irradiation with electromagnetic waves (8.15-18 GHz, 1 Hz within, 1 microW/cm2) in vivo increases the cytotoxic activity of natural killer cells of rat spleen. In mice exposed for 24-72 h, the activity of natural killer cells increased by 130-150%, the increased level of activity persisting within 24 h after the cessation of treatment. Microwave irradiation of animals in vivo for 3.5 and 5 h, and a short exposure of splenic cells in vitro did not affect the activity of natural killer cells.

Fesenko, EE, Makar, VR, Novoselova, EG, Sadovnikov, VB, Microwaves and cellular immunity. I. Effect of whole body microwave irradiation on tumor necrosis factor production in mouse cells. Bioelectrochem Bioenerg 49(1):29-35, 1999.

Whole body microwave sinusoidal irradiation of male NMRI mice with 8.15-18 GHz (1 Hz within) at a power density of 1 microW/cm2 caused a significant enhancement of TNF production in peritoneal macrophages and splenic T lymphocytes. Microwave radiation affected T cells, facilitating their capacity to proliferate in response to mitogenic stimulation. The exposure duration necessary for the stimulation of cellular immunity ranged from 5 h to 3 days. Chronic irradiation of mice for 7 days produced the decreasing of TNF production in peritoneal macrophages. The exposure of mice for 24 h increased the TNF production and immune proliferative response, and these stimulatory effects persisted over 3 days after the termination of exposure. Microwave treatment increased the endogenously produced TNF more effectively than did lipopolysaccharide, one of the

most potential stimuli of synthesis of this cytokine. The role of microwaves as a factor interfering with the process of cell immunity is discussed.

Fetter JG, Ivans V, Benditt DG, Collins J, Digital cellular telephone interaction with implantable cardioverter-defibrillators. J Am Coll Cardiol 31(3):623-628, 1998.

OBJECTIVES: This study sought to determine, in vivo, whether electromagnetic interference (EMI), generated by North American Digital Communications (NADC)/Time Division Multiple Access-50-Hz (TDMA-50) mobile cellular digital telephone model AT&T 6650, disturbs normal implantable cardioverter-defibrillator (ICD) operation and to verify these observations in vitro by testing a selection of telephones representing worldwide systems. METHODS: The effects of cellular phone interference on the operation of various models of market-released ICDs from a single manufacturer, Medtronic, Inc., were tested. The in vivo clinical test was undertaken in 41 patients using the AT&T 6650 digital telephone with the NADC/TDMA-50 technology. The in vitro component of the study was examined twofold: 1) antenna generated far field; and 2) analog/digital cellular telephone near field. RESULTS: None of the ICDs tested in 41 patients were affected by oversensing of the EMI field of the cellular telephones during the in vivo study. Therefore, the binomial upper 95% confidence limit for the failure rate of 0% is 7%. The in vitro antenna-generated field testing showed that telephone modulation frequencies used in the international Global System Mobile and TDMA-50 cellular telephone technologies did not result in ICD sensing interference at the predicted electric field intensity. The in vitro near field tests were performed using both analog and digital cellular telephones in service, or in the test mode, and indicated no interaction with normal operation. However, the static magnetic field generated by the cellular telephone placed over the ICD at a distance < or = 0.5 cm will activate the internal reed switch, resulting in temporary suspension of ventricular tachycardia and fibrillation detection. CONCLUSIONS: We conclude that TDMA-50 cellular telephones did not interfere with these types of ICDs. However, we recommend that the patient not carry or place the digital cellular telephone within 15 cm (6 in.) of the ICD.

Field AS, Ginsburg K, Lin JC The effect of pulsed microwaves on passive electrical properties and interspike intervals of snail neurons. Bioelectromagnetics 14(6):503-520, 1993.

The effects of pulsed microwaves (2.45 GHz, 10 microseconds, 100 pps, SAR: 81.5 kW/kg peak, 81.5 W/kg average) on membrane input resistance and action potential (AP) interval statistics were studied in spontaneously active ganglion neurons of land snails (Helix aspersa), at strictly constant temperature (20.8 +/- .07 degrees C worst case). Statistical comparison with sham-irradiated neurons revealed a significant increase in the mean input resistance of neurons exposed to pulsed microwaves (P < or = .05). Pulsed microwaves had no visible effect on mean AP firing rate; this observation was confirmed by analysis of interspike intervals (ISIs). Using an integrator model for spontaneously active neurons, we found the net input current to be more variable in neurons exposed to pulsed microwaves. The mean input current was not affected. The standard deviation of ISIs and the autocorrelation of the input current were marginally affected, but these changes were not consistent across neurons. Although the observed effects were less obvious than those reported in other studies, they represent evidence of a direct interaction between neurons and pulsed microwaves, in the absence of macroscopic temperature changes. The data do not suggest a single, specific mechanism for such interaction.

Findlay RP, Dimbylow PJ. SAR in a child voxel phantom from exposure to wireless computer networks (Wi-Fi). Phys Med Biol. 55(15):N405-411, 2010.

Specific energy absorption rate (SAR) values have been calculated in a 10 year old sitting voxel model from exposure to electromagnetic fields at 2.4 and 5 GHz,

frequencies commonly used by Wi-Fi devices. Both plane-wave exposure of the model and irradiation from antennas in the near field were investigated for a variety of exposure conditions. In all situations studied, the SAR values calculated were considerably below basic restrictions. For a typical Wi-Fi exposure scenario using an inverted F antenna operating at 100 mW, a duty factor of 0.1 and an antenna-body separation of 34 cm, the maximum peak localized SAR was found to be 3.99 mW kg(-1) in the torso region. At 2.4 GHz, using a power of 100 mW and a duty factor of 1, the highest localized SAR value in the head was calculated as 5.7 mW kg(-1). This represents less than 1% of the SAR previously calculated in the head for a typical mobile phone exposure condition.

Fink JM, Wagner JP, Congleton JJ, Rock JC, Microwave emission from police radar. Am Ind Hyg Assoc J 60(6):770-76, 1999.

This study evaluated police officers' exposures to microwaves emitted by traffic radar units. Exposure measurements were taken at approximated ocular and testicular levels of officers seated in patrol vehicles. Comparisons were made of the radar manufacturers' published maximum power density specifications and actual measured power densities taken at the antenna faces of those units. Four speed-enforcement agencies and one transportation research institute provided 54 radar units for evaluation; 17 different models, encompassing 4 frequency bands and 3 antenna configurations, were included. Four of the 986 measurements taken exceeded the 5 mW/cm2 limit accepted by the International Radiation Protection Association and the National Council on Radiation Protection and Measurement, though none exceeded the American Conference of Governmental Industrial Hygienists, American National Standards Institute, Institute of Electrical and Electronic Engineers, or Occupational Safety and Health Administration standard of 10 mW/cm2. The four high measurements were maximum power density readings taken directly in front of the radar. Of the 812 measurements taken at the officers' seated ocular and testicular positions, none exceeded 0.04 mW/cm2; the highest of these (0.034 mW/cm2) was less than 1% of the most conservative current safety standards. High exposures in the limited region directly in front of the radar aperture are easily avoided with proper training. Results of this study indicate that police officer exposure to microwave radiation is apparently minimal. However, because of uncertainty in the medical and scientific communities concerning nonionizing radiation, it is recommended that law enforcement agencies implement a policy of prudent avoidance, including purchasing units with the lowest published maximum power densities, purchasing dash/rear deck-mounted units with antennae mounted outside the patrol vehicle, and training police officers to use the "stand-by" mode when not actually using radar.

Finnie JW, Blumbergs PC, Manavis J, Utteridge TD, Gebski V, Swift JG, Vernon-Roberts B, Kuchel TR. Effect of global system for mobile communication (gsm)-like radiofrequency fields on vascular permeability in mouse brain. Pathology 33(3):338-340, 2001.

The effect of global system for mobile communication (GSM) radiofrequency fields on vascular permeability in the brain was studied using a purpose-designed exposure system at 898.4 MHz. Mice (n= 30) were given a single far field, whole body exposure for

60 minutes at a specific absorption rate of 4 W/kg. Control mice were also sham-exposed (n = 10) or permitted free movement in a cage (n = 10) to exclude any stress-related effects. Vascular permeability changes were detected using albumin immunohistochemistry and the efficacy of this vascular tracer was confirmed with a positive control group exposed to a clostridial toxin known to increase vascular permeability in the brain. No significant difference in albumin extravasation was detected between any of the groups at the light microscope level using the albumin marker.

Finnie JW, Blumbergs PC, Manavis J, Utteridge TD, Gebski V, Davies RA, Vernon-Roberts B, Kuchel TR. Effect of long-term mobile communication microwave exposure on vascular permeability in mouse brain. Pathology 34(4):344-347, 2002.

AIMS: To study the effect of long-term exposure to global system for mobile communication (GSM) radiofrequency fields on vascular permeability in murine brains. METHODS: Using a purpose-designed exposure system at 900 MHz, mice were given a 60-minute far-field, whole body exposure on each of 5 days perweekfor 104 weeks at specific absorption rates (SAR) of 0.25, 1.0,2.0 and 4.0 W/kg. Control mice were sham-exposed or permitted free movement in a cage to evaluate any stress-related effects. Albumin immunohistochemistry was used to detect increased vascular permeability and the efficacy of the vascular tracer was confirmed with a positive control group exposed to a clostridial toxin known to increase vascular permeability in the brain. RESULTS: In all exposed and control groups, albumin extravasation was minimal, often leptomeningeal, and was deemed insignificant as a maximum of three capillaries or venules in a given brain showed leakage from the very many blood vessels present in the three coronal brain sections. CONCLUSIONS: These results suggest that prolonged exposure to mobile telephone-type radiation produces negligible disruption to blood-brain barrier integrity at the light microscope level using endogenous albumin as a vascular tracer.

Finnie JW. Expression of the immediate early gene, c-fos, in mouse brain after acute global system for mobile communication microwave exposure. Pathology. 37(3):231-233, 2005.

AIMS: To study the effect of acute exposure to global system for mobile communication radiofrequency fields on immediate early gene, c-fos, expression in the brain. METHODS: Using a purpose-designed exposure system at 900 MHz, mice were given a single, far-field, whole body exposure for 60 minutes at a specific absorption rate of 4 W/kg. Control mice were sham-exposed or freely mobile in a cage without further restraint. c-fos protein expression was detected immunohistochemically in perfusion-fixed brains. RESULTS: Activation of c-fos in exposed and sham-exposed brains was comparable, but was greatly increased compared with freely moving controls. CONCLUSION: These results suggest that the majority of the acute genomic response detected by c-fos expression was due to immobilisation rather than irradiation.

Finnie JW, Blumbergs PC, Cai Z, Manavis J, Kuchel TR. Effect of mobile telephony on blood-brain barrier permeability in the fetal mouse brain. Pathology. 38(1):63-65, 2006.

AIMS: To study the effect of mobile telephone exposure on blood-brain barrier (BBB) permeability in the immature brain. METHODS: Using a purpose-designed exposure

system at 900 MHz, pregnant mice were given a single, far-field, whole body exposure at a specific absorption rate of 4 W/kg for 60 min/day from day 1 to day 19 of gestation. Pregnant control mice were sham-exposed or freely mobile in a cage without further restraint and a positive control group with cadmium-induced BBB damage was also included. Immediately prior to parturition on gestational day 19, fetal heads were collected, fixed in Bouin's fixative and paraffin embedded. Disruption of BBB integrity was detected immunohistochemically using endogenous albumin as a vascular tracer in cerebral cortex, thalamus, basal ganglia, hippocampus, cerebellum, midbrain and medulla. RESULTS: No albumin extravasation was found in exposed or control brains. CONCLUSION: In this animal model, whole of gestation exposure to global system for mobile communication-like radiofrequency fields did not produce any increase in vascular permeability in the fetal brain regions studied using endogenous albumin as a light microscopic immunohistochemical marker.

Finnie JW, Cai Z, Blumbergs PC, Manavis J, Kuchel TR. Expression of the immediate early gene, c-fos, in fetal brain after whole of gestation exposure of pregnant mice to global system for mobile communication microwaves. Pathology. 38(4):333-335, 2006.

Aims: To study immediate early gene, c-fos, expression as a marker of neural stress after whole of gestation exposure of the fetal mouse brain to mobile telephone-type radiofrequency fields.Methods: Using a purpose-designed exposure system at 900 MHz, pregnant mice were given a single, far-field, whole body exposure at a specific absorption rate of 4 W/kg for 60 min/day from day 1 to day 19 of gestation. Pregnant control mice were sham-exposed or freely mobile in a cage without further restraint. Immediately prior to parturition on gestational day 19, fetal heads were collected, fixed in 4% paraformaldehyde and paraffin embedded. Any stress response in the brain was detected by c-fos immunohistochemistry in the cerebral cortex, basal ganglia, thalamus, hippocampus, midbrain, cerebellum and medulla.Results: c-fos expression was of limited, but consistent, neuroanatomical distribution and there was no difference in immunoreactivity between exposed and control brains. Conclusion: In this animal model, no stress response was detected in the fetal brain using c-fos immunohistochemistry after whole of gestation exposure to mobile telephony.

Finnie JW, Chidlow G, Blumbergs PC, Manavis J, Cai Z.. Heat shock protein induction in fetal mouse brain as a measure of stress after whole of gestation exposure to mobile telephony radiofrequency fields.Pathology. 41(3):276-279, 2009.

Aim: To determine whether whole of gestation exposure of fetal mouse brain to mobile telephone radiofrequency fields produces a stress response detectable by induction of heat shock proteins (HSPs). Methods: Using a purpose-designed exposure system at 900 MHz, pregnant mice were given a single, far-field, whole body exposure at a specific absorption rate of 4 W/kg for 60 min/day from day 1 to day 19 of gestation. Control mice were sham-exposed or freely mobile in a cage to control for any stress caused by restraint in the exposure module. Immediately prior to parturition on day 19, fetal brains were collected, fixed in 4% paraformaldehyde and paraffin-embedded. Three coronal sections encompassing a wide range of anatomical regions were cut from each brain and

any stress response detected by immunostaining for HSP25, 32 and 70. Results: There was no induction of HSP32 or 70 in any brains, while HSP25 expression was limited to two brainstem nuclei and occurred consistently in exposed and non-exposed brains. Conclusion: Whole of gestation exposure of fetal mouse brains to mobile phone radiofrequency fields did not produce any stress response using HSPs as an immunohistochemical marker.

Finnie JW, Blumbergs PC, Cai Z, Manavis J. Expression of the water channel protein, aquaporin-4, in mouse brains exposed to mobile telephone radiofrequency fields. Pathology. 41(5):473-475, 2009.

Aim: To determine whether exposure to mobile telephone radiofrequency (RF) fields, either acutely or long-term, produces up-regulation of the water channel protein, aquaporin-4 (AQP-4). Methods: Using a purpose-designed exposure system at 900 MHz, mice were given a single, far-field whole body exposure at a specific absorption rate of 4 W/kg for 60 minutes or a similar exposure on 5 successive days/week for 104 weeks. Control mice were sham-exposed or freely mobile in a cage to control for any stress caused by restraint in the exposure module. A positive control group was given a clostridial toxin known to cause microvascular endothelial injury, severe vasogenic oedema and upregulation of AQP-4. Brains were perfusion fixed with 4% paraformaldehyde, coronal sections cut from six levels, and immunostained for the principal water channel protein in brain, AQP-4. Results: There was no increase in AQP-4 expression in brains exposed to mobile phone microwaves compared to control (sham exposed and freely moving caged mice) brains after short or protracted exposure, while AQP-4 was substantially upregulated in the brains of mice given the clostridial toxin. Conclusion: Brains exposed to mobile telephone RF fields for a short (60 minutes) or long (2 years) duration did not show any immunohistochemically detectable up-regulation of the water channel protein, AQP-4, suggesting that there was no significant increase in blood-brain barrier permeability.

Finnie JW, Blumbergs PC, Cai Z, Manavis J. Expression of the water channel protein, aquaporin-4, in mouse brains exposed to mobile telephone radiofrequency fields. Pathology. 41(5):473-475, 2009

AIM: To determine whether exposure to mobile telephone radiofrequency (RF) fields, either acutely or long-term, produces up-regulation of the water channel protein, aquaporin-4 (AQP-4). METHODS: Using a purpose-designed exposure system at 900 MHz, mice were given a single, far-field whole body exposure at a specific absorption rate of 4 W/kg for 60 minutes or a similar exposure on 5 successive days/week for 104 weeks. Control mice were sham-exposed or freely mobile in a cage to control for any stress caused by restraint in the exposure module. A positive control group was given a clostridial toxin known to cause microvascular endothelial injury, severe vasogenic oedema and upregulation of AQP-4. Brains were perfusion fixed with 4% paraformaldehyde, coronal sections cut from six levels, and immunostained for the principal water channel protein in brain, AQP-4. RESULTS: There was no increase in AQP-4 expression in brains exposed to mobile phone microwaves compared to control (sham exposed and freely moving caged mice) brains after short or protracted exposure, while AQP-4 was substantially upregulated

in the brains of mice given the clostridial toxin. CONCLUSION: Brains exposed to mobile telephone RF fields for a short (60 minutes) or long (2 years) duration did not show any immunohistochemically detectable up-regulation of the water channel protein, AQP-4, suggesting that there was no significant increase in blood-brain barrier permeability

Finnie JW, Cai Z, Manavis J, Helps S, Blumbergs PC. Microglial activation as a measure of stress in mouse brains exposed acutely (60 minutes) and long-term (2 years) to mobile telephone radiofrequency fields. Pathology. 42(2):151-154, 2010.

AIM: To determine whether acute or long-term exposure of the brain to mobile telephone radiofrequency (RF) fields produces activation of microglia, which normally respond rapidly to any change in their microenvironment. METHODS: Using a purpose designed exposure system at 900 MHz, mice were given a single, far-field whole body exposure at a specific absorption rate (SAR) of 4 W/kg for 60 min (acute) or on five successive days per week for 104 weeks (long-term). Control mice were sham-exposed or freely mobile in a cage to control for any stress caused by immobilisation in the exposure module. Positive control brains subjected to a stab wound were also included to confirm the ability of microglia to react to any neural stress. Brains were perfusion-fixed with 4% paraformaldehyde and representative regions of the cerebral cortex and hippocampus immunostained for ionised calcium binding adaptor molecule (Iba1), a specific microglial marker. RESULTS: There was no increase in microglial Iba1 expression in brains short or long-term exposed to mobile telephony microwaves compared to control (sham-exposed or freely moving caged mice) brains, while substantial microglial activation occurred in damaged positive control neural tissue. CONCLUSION: Acute (60 minutes) or longer duration (2 years) exposure of murine brains to mobile telephone RF fields did not produce any microglial activation detectable by Iba1 immunostaining.

Fisun OI, 2D plasmon excitation and nonthermal effects of microwaves on biological membranes. Bioelectromagnetics 14(1):57-66, 1993.

There are several experimental reports that have demonstrated a remarkable increase in conduction of ions along the interface between water and a polar-lipid monolayer as contrasted with that in a bulk-water phase. A simple model was developed for the collective ionic modes of a charged spherical membrane that takes the increase into account. Starting from the hydrodynamic equations for surface ions inside and outside a cell, the dispersion relation for intrinsic cellular electrical oscillations was obtained. Properties were calculated for surface-plasmon modes as well as for a resonant response of a charged membrane bilayer to microwave pumping.

Forgacs Z, Somosy Z, Kubinyi G, Bakos J, Hudak A, Surjan A, Thuroczy G. Effect of whole-body 1800MHz GSM-like microwave exposure on testicular steroidogenesis and histology in mice. Reprod Toxicol.22(1):111-117, 2006.

The aim of our study was to evaluate the possible effects of whole-body 1800MHz GSM-like microwave exposure on male reproduction. After repeated exposure of mice to microwaves at 0.018-0.023W/kg whole-body specific energy absorption rate (SAR) an

elevated serum testosterone level was measured, but no microwave exposure related histopathological alteration could be detected in the reproductive organs. The in vitro steroidogenic response of 48h Leydig cell cultures obtained from exposed animals did not differ from the controls, suggesting that Leydig cells were not the primary targets of the applied microwave exposure or direct action of microwaves on Leydig cells was temporary only. In exposed animals the red blood cell count and volume of packed red cells were also increased. Further investigations are required to clarify the mechanism of action of the applied microwave exposure on male mice, as well as to establish the biological significance of the observed phenomena.

Fornes-Leal A, Garcia-Pardo C, Frasson M, Pons Beltrán V, Cardona N. Dielectric characterization of healthy and malignant colon tissues in the 0.5-18 GHz frequency band. Phys Med Biol.61(20):7334-7346, 2016.

Several reports over the last few decades have shown that the dielectric properties of healthy and malignant tissues of the same body organ usually show different values. However, no intensive dielectric studies of human colon tissue have been performed, despite colon cancer's being one of the most common types of cancer in the world. In order to provide information regarding this matter, a dielectric characterization of healthy and malignant colon tissues is presented. Measurements are performed on ex vivo surgery samples obtained from 20 patients, using an open-ended coaxial probe in the 0.5-18 GHz frequency band. Results show that the dielectric constant of colon cancerous tissue is 8.8% higher than that of healthy tissues ($p = 0.002$). Besides, conductivity is about 10.6% higher, but in this case measurements do not have statistical significance ($p = 0.038$). Performing an analysis per patient, the differences in dielectric constant between healthy and malignant tissues appear systematically. Particularized results for specific frequencies (500 MHz, 900 MHz, 2.45 GHz, 5 GHz, 8.5 GHz and 15 GHz) are also reported. The findings have potential application in early-stage cancer detection and diagnosis, and can be useful in developing new tools for hyperthermia treatments as well as creating electromagnetic models of healthy and cancerous tissues.

Fragopoulou AF, **Koussoulakos SL**, **Margaritis LH**. **Cranial and postcranial skeletal variations induced in mouse embryos by mobile phone radiation. Pathophysiology. 17(3):169-177, 2010.**

This study focuses on foetal development following mild daily exposure of pregnant mice to near field electromagnetic radiation emitted by a mobile phone. The investigation was motivated by the fact that the potentially hazardous electromagnetic radiation emitted by mobile phones is currently of tremendous public interest. Physically comparable pregnant mice were exposed to radiofrequency radiation GSM 900MHz emitted by a mobile phone. Within 5h after birth most cubs were fixed followed by double staining in toto, and conventional paraffin histology. Other cubs remained with their mothers until teeth eruption. Structural development was assessed by examining newborns for the presence of anomalies and/or variations in soft tissues and skeletal anatomy. Electromagnetic radiofrequency exposed newborns, externally examined, displayed a normal phenotype. Histochemical and histological studies, however, revealed variations in the exposed foetuses with respect to control ones concerning the ossification of cranial bones and

thoracic cage ribs, as well as displacement of Meckelian cartilage. Littermates examined after teeth eruption displayed normal phenotypes. It is concluded that mild exposure to mobile phone radiation may affect, although transiently, mouse foetal development at the ossification level. The developmental variations observed could be explained by considering the different embryonic origin and mode of ossification of the affected skeletal elements.

Fragopoulou AF, Miltiadous P, Stamatakis A, Stylianopoulou F, Koussoulakos SL, Margaritis LH. Whole body exposure with GSM 900MHz affects spatial memory in mice. Pathophysiology. 17(3):179-187,2010.

Extended work has been performed worldwide on the effects of mobile phone radiation upon rats' cognitive functions, however there is great controversy to the existence or not of deficits. The present work has been designed in order to test the effects of mobile phone radiation on spatial learning and memory in mice Mus musculus Balb/c using the Morris water maze (a hippocampal-dependent spatial memory task), since there is just one other study on mice with very low SAR level (0.05W/kg) showing no effects. We have applied a 2h daily dose of pulsed GSM 900MHz radiation from commercially available mobile phone for 4 days at SAR values ranging from 0.41 to 0.98W/kg. Statistical analysis revealed that during learning, exposed animals showed a deficit in transferring the acquired spatial information across training days (increased escape latency and distance swam, compared to the sham-exposed animals, on the first trial of training days 2-4). Moreover, during the memory probe-trial sham-exposed animals showed the expected preference for the target quadrant, while the exposed animals showed no preference, indicating that the exposed mice had deficits in consolidation and/or retrieval of the learned spatial information. Our results provide a basis for more thorough investigations considering reports on non-thermal effects of electromagnetic fields (EMFs).

Fragopoulou AF, Samara A, Antonelou MH, Xanthopoulou A, Papadopoulou A, Vougas K, Koutsogiannopoulou E, Anastasiadou E, Stravopodis DJ, Tsangaris GT, Margaritis LH. Brain proteome response following whole body exposure of mice to mobile phone or wireless DECT base radiation. Electromagn Biol Med.31(4):250-274, 2012.

The objective of this study was to investigate the effects of two sources of electromagnetic fields (EMFs) on the proteome of cerebellum, hippocampus, and frontal lobe in Balb/c mice following long-term whole body irradiation. Three equally divided groups of animals (6 animals/group) were used; the first group was exposed to a typical mobile phone, at a SAR level range of 0.17-0.37 W/kg for 3 h daily for 8 months, the second group was exposed to a wireless DECT base (Digital Enhanced Cordless Telecommunications/Telephone) at a SAR level range of 0.012-0.028 W/kg for 8 h/day also for 8 months and the third group comprised the sham-exposed animals. Comparative proteomics analysis revealed that long-term irradiation from both EMF sources altered significantly ($p < 0.05$) the expression of 143 proteins in total (as low as 0.003 fold downregulation up to 114 fold overexpression). Several neural function related proteins (i.e., Glial Fibrillary Acidic Protein (GFAP), Alpha-

synuclein, Glia Maturation Factor beta (GMF), and apolipoprotein E (apoE)), heat shock proteins, and cytoskeletal proteins (i.e., Neurofilaments and tropomodulin) are included in this list as well as proteins of the brain metabolism (i.e., Aspartate aminotransferase, Glutamate dehydrogenase) to nearly all brain regions studied. Western blot analysis on selected proteins confirmed the proteomics data. The observed protein expression changes may be related to brain plasticity alterations, indicative of oxidative stress in the nervous system or involved in apoptosis and might potentially explain human health hazards reported so far, such as headaches, sleep disturbance, fatigue, memory deficits, and brain tumor long-term induction under similar exposure conditions.

Franke H, Streckert J, Bitz A, Goeke J, Hansen V, Ringelstein EB, Nattkamper H, Galla HJ, Stogbauer FEffects of universal mobile telecommunications system (UMTS) electromagnetic fields on the blood-brain barrier In Vitro. Radiat Res. 164(3):258-269, 2005.

The extensive use of mobile phone communication has raised public concerns about adverse health effects of radiofrequency (RF) electromagnetic fields (EMFs) in recent years. A central issue in this discussion is the question whether EMFs enhance the permeability of the blood-brain barrier (BBB). Here we report an investigation on the influence of a generic UMTS (Universal Mobile Telecommunications System) signal on barrier tightness, transport processes and the morphology of porcine brain microvascular endothelial cell cultures (PBEC) serving as an in vitro model of the BBB. An exposure device with integrated online monitoring system was developed for simultaneous exposure and measuring of transendothelial electrical resistance (TEER) to determine the tightness of the BBB. PBEC were exposed continuously for up to 84 h at an average electric-field strength of 3.4-34 V/m (maximum 1.8 W/kg) ensuring athermal conditions. We did not find any evidence of RF-field-induced disturbance of the function of the BBB. After and during exposure, the tightness of the BBB quantified by (14)C-sucrose and serum albumin permeation as well as by TEER remained unchanged compared to sham-exposed cultures. Permeation of transporter substrates at the BBB as well as the localization and integrity of the tight-junction proteins occludin and ZO1 were not affected either.

Franzellitti S, Valbonesi P, Contin A, Biondi C, Fabbri E. HSP70 expression in human trophoblast cells exposed to different 1.8 Ghz mobile phone signals. Radiat Res. 170(4):488-497, 2008.

The heat-shock proteins (HSPs) are important cellular stress markers and have been proposed as candidates to infer biological effects of high-frequency electromagnetic fields (EMFs). In the current study, HSP70 gene and protein expression were evaluated in cells of the human trophoblast cell line HTR-8/SVneo after prolonged exposure (4 to 24 h) to 1.8 GHz continuous-wave (CW) and different GSM signals (GSM-217Hz and GSM-Talk) to assess the possible effects of time and modulation schemes on cell responses. Inducible HSP70 protein expression was not modified by high-frequency EMFs under any condition tested. The inducible HSP70A, HSP70B and the constitutive HSC70 transcripts did not change in cells exposed to high-frequency EMFs with the different modulation schemes. Instead, levels of the

inducible HSP70C transcript were significantly enhanced after 24 h exposure to GSM-217Hz signals and reduced after 4 and 16 h exposure to GSM-Talk signals. As in other cell systems, in HTR-8/SVneo cells the response to high-frequency EMFs was detected at the mRNA level after exposure to amplitude-modulated GSM signals. The present results suggest that the expression analysis for multiple transcripts, though encoding the same or similar protein products, can be highly informative and may account for subtle changes not detected at the protein level.

Franzellitti S, Valbonesi P, Ciancaglini N, Biondi C, Contin A, Bersani F, Fabbri E. Transient DNA damage induced by high-frequency electromagnetic fields (GSM 1.8 GHz) in the human trophoblast HTR-8/SVneo cell line evaluated with the alkaline comet assay. Mutat Res. 683(1-2):35-42, 2010.

One of the most controversial issue regarding high-frequency electromagnetic fields (HF-EMF) is their putative capacity to affect DNA integrity. This is of particular concern due to the increasing use of HF-EMF in communication technologies, including mobile phones. Although epidemiological studies report no detrimental effects on human health, the possible disturbance generated by HF-EMF on cell physiology remains controversial. In addition, the question remains as to whether cells are able to compensate their potential effects. We have previously reported that a 1-h exposure to amplitude-modulated 1.8 GHz sinusoidal waves (GSM-217 Hz, SAR=2 W/kg) largely used in mobile telephony did not cause increased levels of primary DNA damage in human trophoblast HTR-8/SVneo cells. Nevertheless, further investigations on trophoblast cell responses after exposure to GSM signals of different types and durations were considered of interest. In the present work, HTR-8/SVneo cells were exposed for 4, 16 or 24h to 1.8 GHz continuous wave (CW) and different GSM signals, namely GSM-217 Hz and GSM-Talk (intermittent exposure: 5 min field on, 10 min field off). The alkaline comet assay was used to evaluate primary DNA damages and/or strand breaks due to uncompleted repair processes in HF-EMF exposed samples. The amplitude-modulated signals GSM-217 Hz and GSM-Talk induced a significant increase in comet parameters in trophoblast cells after 16 and 24h of exposure, while the un-modulated CW was ineffective. However, alterations were rapidly recovered and the DNA integrity of HF-EMF exposed cells was similar to that of sham-exposed cells within 2h of recovery in the absence irradiation. Our data suggest that HF-EMF with a carrier frequency and modulation scheme typical of the GSM signal may affect the DNA integrity.

Frei, MR, Jauchem, JR, Dusch, SJ, Merritt ,JH, Berger, RE, Stedham, MA, Chronic, low-level (1.0 W/kg) exposure of mice prone to mammary cancer to 2450 MHz microwaves. Radiat Res 150(5):568-576, 1998.

In a previous study (Frei et al., Bioelectromagnetics 19, 20-31, 1998), we showed that low-level (0.3 W/kg), long-term exposure of mice prone to mammary tumors to 2450 MHz radiofrequency (RF) radiation did not affect the incidence of mammary tumors, latency to tumor onset, tumor growth rate or animal survival when compared to sham-irradiated animals. In the current study, the specific absorption rate (SAR) was increased from 0.3 W/kg to 1.0 W/kg. The same biological end points were used. One hundred C3H/HeJ mice were exposed in circularly polarized waveguides for 78 weeks (20 h/day, 7

days/week) to continuous-wave, 2450 MHz RF radiation; 100 mice were sham-exposed. There was no significant difference between exposed and sham-exposed groups with respect to the incidence of palpated mammary tumors (sham-exposed = 30%; irradiated = 38%), latency to tumor onset (sham-exposed = 62.0 +/- 2.3 weeks; irradiated = 62.5 +/- 2.2 weeks) and rate of tumor growth. Histopathological evaluations revealed no significant difference in numbers of malignant, metastatic or benign neoplasms between the two groups. Thus long-term exposures of mice prone to mammary tumors to 2450 MHz RF radiation at SARs of 0.3 and 1.0 W/kg had no significant effects when compared to sham-irradiated animals.

Frei P, Mohler E, Neubauer G, Theis G, Bürgi A, Fröhlich J, Braun-Fahrländer C, Bolte J, Egger M, Röösli M. Temporal and spatial variability of personal exposure to radio frequency electromagnetic fields.Environ Res. 109:779-785, 2009.

BACKGROUND: Little is known about the population's exposure to radio frequency electromagnetic fields (RF-EMF) in industrialized countries. OBJECTIVES: To examine levels of exposure and the importance of different RF-EMF sources and settings in a sample of volunteers living in a Swiss city. METHODS: RF-EMF exposure of 166 volunteers from Basel, Switzerland, was measured with personal exposure meters (exposimeters). Participants carried an exposimeter for 1 week (two separate weeks in 32 participants) and completed an activity diary. Mean values were calculated using the robust regression on order statistics (ROS) method. RESULTS: Mean weekly exposure to all RF-EMF sources was 0.13mW/m(2) (0.22V/m) (range of individual means 0.014-0.881mW/m(2)). Exposure was mainly due to mobile phone base stations (32.0%), mobile phone handsets (29.1%) and digital enhanced cordless telecommunications (DECT) phones (22.7%). Persons owning a DECT phone (total mean 0.15mW/m(2)) or mobile phone (0.14mW/m(2)) were exposed more than those not owning a DECT or mobile phone (0.10mW/m(2)). Mean values were highest in trains (1.16mW/m(2)), airports (0.74mW/m(2)) and tramways or buses (0.36mW/m(2)), and higher during daytime (0.16mW/m(2)) than nighttime (0.08mW/m(2)). The Spearman correlation coefficient between mean exposure in the first and second week was 0.61. CONCLUSIONS: Exposure to RF-EMF varied considerably between persons and locations but was fairly consistent within persons. Mobile phone handsets, mobile phone base stations and cordless phones were important sources of exposure in urban Switzerland.

Frei P, Mohler E, Bürgi A, Fröhlich J, Neubauer G, Braun-Fahrländer C, Röösli M; The QUALIFEX Team. Classification of personal exposure to radio frequency electromagnetic fields (RF-EMF) for epidemiological research: Evaluation of different exposure assessment methods. Environ Int.36(7):714-20, 2010.

The use of personal exposure meters (exposimeters) has been recommended for measuring personal exposure to radio frequency electromagnetic fields (RF-EMF) from environmental far-field sources in everyday life. However, it is unclear to what extent exposimeter readings are affected by measurements taken when personal mobile and cordless phones are used. In addition, the use of exposimeters in large epidemiological studies is limited due to high costs and large effort for study

participants. In the current analysis we aimed to investigate the impact of personal phone use on exposimeter readings and to evaluate different exposure assessment methods potentially useful in epidemiological studies. We collected personal exposimeter measurements during one week and diary data from 166 study participants. Moreover, we collected spot measurements in the participants' bedrooms and data on self-estimated exposure, assessed residential exposure to fixed site transmitters by calculating the geo-coded distance and mean RF-EMF from a geospatial propagation model, and developed an exposure prediction model based on the propagation model and exposure relevant behavior. The mean personal exposure was 0.13mW/m(2), when measurements during personal phone calls were excluded and 0.15mW/m(2), when such measurements were included. The Spearman correlation with personal exposure (without personal phone calls) was 0.42 (95%-CI: 0.29 to 0.55) for the spot measurements, -0.03 (95%-CI: -0.18 to 0.12) for the geo-coded distance, 0.28 (95%-CI: 0.14 to 0.42) for the geospatial propagation model, 0.50 (95%-CI: 0.37 to 0.61) for the full exposure prediction model and 0.06 (95%-CI: -0.10 to 0.21) for self-estimated exposure. In conclusion, personal exposure measured with exposimeters correlated best with the full exposure prediction model and spot measurements. Self-estimated exposure and geo-coded distance turned out to be poor surrogates for personal exposure.

Frei P, Poulsen AH, Johansen C, Olsen JH, Steding-Jessen M, Schüz J. Use of mobile phones and risk of brain tumours: update of Danish cohort study. BMJ. 2011 Oct 19;343:d6387. doi: 10.1136/bmj.d6387.

OBJECTIVE: To investigate the risk of tumours in the central nervous system among Danish mobile phone subscribers.DESIGN: Nationwide cohort study.SETTING: Denmark.PARTICIPANTS: All Danes aged ≥ 30 and born in Denmark after 1925, subdivided into subscribers and non-subscribers of mobile phones before 1995.MAIN OUTCOME MEASURES: Risk of tumours of the central nervous system, identified from the complete Danish Cancer Register. Sex specific incidence rate ratios estimated with log linear Poisson regression models adjusted for age, calendar period, education, and disposable income.RESULTS: 358,403 subscription holders accrued 3.8 million person years. In the follow-up period 1990-2007, there were 10,729 cases of tumours of the central nervous system. The risk of such tumours was close to unity for both men and women. When restricted to individuals with the longest mobile phone use--that is, ≥ 13 years of subscription--the incidence rate ratio was 1.03 (95% confidence interval 0.83 to 1.27) in men and 0.91 (0.41 to 2.04) in women. Among those with subscriptions of ≥ 10 years, ratios were 1.04 (0.85 to 1.26) in men and 1.04 (0.56 to 1.95) in women for glioma and 0.90 (0.57 to 1.42) in men and 0.93 (0.46 to 1.87) in women for meningioma. There was no indication of dose-response relation either by years since first subscription for a mobile phone or by anatomical location of the tumour--that is, in regions of the brain closest to where the handset is usually held to the head.CONCLUSIONS: In this update of a large nationwide cohort study of mobile phone use, there were no increased risks of tumours of the central nervous system, providing little evidence for a causal association.

Frei P, Mohler E, Braun-Fahrländer C, Fröhlich J, Neubauer G, Röösli M; QUALIFEX-team. Cohort study on the effects of everyday life radio frequency

electromagnetic field exposure on non-specific symptoms and tinnitus.Environ Int. 38(1):29-36, 2012.

BACKGROUND: There is public concern regarding potential health effects of radio frequency electromagnetic fields (RF-EMF) exposure, as produced by mobile phones or broadcast transmitters. The objective of this study was to investigate the association between RF-EMF exposure and non-specific symptoms and tinnitus in a prospective cohort study.**METHODS:** In 2008, 1375 randomly selected participants from Basel, Switzerland, were enrolled in a questionnaire survey with follow-up after one year (participation rate 82%). A score for somatic complaints (von Zerssen list) and headache (HIT-6) was assessed. Far-field environmental RF-EMF exposure was predicted using a validated prediction model. Regarding near-field exposure, self-reported mobile and cordless phone use as well as mobile phone operator data were collected. In multivariate regression models, we investigated whether exposure at baseline (cohort analysis) or changes in exposure between baseline and follow-up (change analysis) were related to changes in health scores.**RESULTS:** For participants in the top decile of environmental far-field RF-EMF exposure at baseline, in comparison to participants exposed below the median value, the change in the von Zerssen- and HIT-6-scores between baseline and follow-up was -0.12 (95%-CI: -1.79 to 1.56) and -0.37 (95%-CI: -1.80 to 1.07) units, respectively. Exposure to near-field sources and a change in exposure between baseline and follow-up were not related to non-specific symptoms. Similarly, no association between RF-EMF exposure and tinnitus was observed.**CONCLUSIONS:** In this first cohort study using objective and well-validated RF-EMF exposure measures, we did not observe an association between RF-EMF exposure and non-specific symptoms or tinnitus.

French PW, Donnellan M, McKenzie DR, Electromagnetic radiation at 835 MHz changes the morphology and inhibits proliferation of a human astrocytoma cell line. Bioelectrochem Bioenerg 43:13-18, 1997.

A human astrocytoma cell line, U-87 MG, was exposed to 835 MHz electromagnetic radiation for 20 min, 3 times per day for 7 days, at a power density of either 40+15 $mWcm^{-2}$ or 8.1 + 3 $mWcm^{-2}$. At the low power density, it was observed that the rate of DNA synthesis decreased, and that the cells flattened and spread out in comparison to unexposed culture. At 40 $mWcm^{-2}$, there were no effects seen on cell proliferation, but alteration in cell morphology included increased cell spreading and also the appearance of actin-containing blebs at localized sites on the membrane. It is hypothesised that 835 MHz radiation at low power density may be affecting a signal transduction pathway involved in cell proliferation.

Freude, G, Ullsperger, P, Eggert ,S, Ruppe, I, Effects of microwaves emitted by cellular phones on human slow brain potentials. Bioelectromagnetics 19(6):384-387, 1998.

The influence of electromagnetic fields (EMF) emitted by cellular phones on preparatory slow brain potentials (SP) was studied in two different experimental tasks: In the first, healthy male human subjects had to perform simple self-paced finger movements to elicit a Bereitschaftspotential; in the second, they performed a complex and cognitive

demanding visual monitoring task (VMT). Both tasks were performed with and without EMF exposure in counterbalanced order. Whereas subjects' performance did not differ between the EMF exposure conditions, SP parameters were influenced by EMF in the VMT: EMF exposure effected a significant decrease of SPs at central and temporo-parieto-occipital brain regions, but not at the frontal one. In the simple finger movement task, EMF did not affect the Bereitschaftspotential.

Freude, G, Ullsperger, P, Eggert, S, Ruppe, I, Microwaves emitted by cellular telephones affect human slow brain potentials. Eur J Appl Physiol 81(1-2):18-27, 2000.

The influence of electromagnetic fields (EMF) emitted by cellular telephones on preparatory slow brain potentials (SP) was studied in two experiments, about 6 months apart. In the first experiment, a significant decrease of SP was found during exposure to EMF in a complex visual monitoring task (VMT). This effect was replicated in the second experiment. In addition to the VMT, EMF effects on SP were analysed in two further, less demanding tasks: in a simple finger movement task to elicit a Bereitschaftspotential (BP) and in a two-stimulus task to elicit a contingent negative variation (CNV). In comparison to the VMT, no significant main EMF effects were found in BP and CNV tasks. The results accounted for a selective EMF effect on particular aspects of human information processing, but did not indicate any influence on human performance, well-being and health.

Frey AH, Headaches from cellular telephones: are they real and what are the implications? Environ Health Perspect 106(3):101-103, 1998.

There have been numerous recent reports of headaches occurring in association with the use of hand-held cellular telephones. Are these reported headaches real? Are they due to emissions from telephones? There is reason to believe that the answer is "yes" to both questions. There are several lines of evidence to support this conclusion. First, headaches as a consequence of exposure to low intensity icrowaves were reported in the literature 30 years ago. These were observed during the course of microwave hearing research before there were cellular telephones. Second, the blood-brain barrier appears to be involved in headaches, and low intensity microwave energy exposure affects the barrier. Third, the dopamine-opiate systems of the brain appear to be involved in headaches, and low intensity electromagnetic energy exposure affects those systems. In all three lines of research, the microwave energy used was approximately the same--in frequencies, modulations, and incident energies—as those emitted by present day cellular telephones. Could the current reports of headaches be the canary in the coal mine, warning of biologically significant effects?

Frick U, Rehm J, Eichhammer P. Risk perception, somatization, and self report of complaints related to electromagnetic fields--a randomized survey study.Int J Hyg Environ Health. 205(5):353-360, 2002.

Exposure to electromagnetic fields (EMF) as well as EMF-related complaints has increased over the past decades. However, it is unclear whether these complaints are related to the electromagnetic or other physical properties of these fields per se, to salience of EMF in media, or to both. What is the prevalence of EMF-related

complaints in the general population? What are the influencing factors on this prevalence? Does reporting of EMF-related symptoms depend on cognitive factors? To answer these questions, a survey with random variation of three cognitive factors was performed. As expected, EMF-related complaints were reported more by females and people with higher somatization tendency. Age had no significant linear effect on EMF-related complaints. The cognitive condition of threat produced a significant contrast effect among people with high somatization tendency on EMF-related complaints. Cognition can influence reporting of EMF-related effects. Thus, in future research of such effects, psychologically influencing factors should be included. Also risk communication should incorporate knowledge about social cognition.

Friedman J, Kraus S, Hauptman Y, Schiff Y, Seger R. Mechanism of a short-term ERK activation by electromagnetic fields at mobile phone frequency. Biochem J. 405:559-568, 2007.

The exposure to non-thermal microwave electromagnetic field generated by mobile phones affects the expression of many proteins. This effect on transcription and protein stability can be mediated by the mitogen-activated protein kinase (MAPK) cascades, which serve as central signaling pathways, and govern essentially all stimulated cellular processes. Indeed, a long-term exposure of cells to mobile phone irradiation results in the activation of p38MAPKs as well as the ERK/MAPKs. Here we studied the immediate effect of irradiation on the MAPK cascades, and found that ERKs, but not stress related MAPKs are rapidly activated in response to various frequencies and intensities. Using signaling inhibitors we delineated the mechanism that is involved in this activation. We found that the first step is mediated in the plasma membrane by NADH oxidase, which rapidly generates reactive oxygen species (ROS). These ROS then directly stimulate matrix metalloproteinases and allow them to cleave and release heparin binding-EGF. This secreted factor, activates EGF receptor, which in turn further activates the ERK cascade. Thus, this study demonstrates for the first time a detailed molecular mechanism by which electromagnetic irradiation by mobile phones induces the activation of the ERK cascade and thereby induces transcription and other cellular processes.

Fritze K, Wiessner C, Kuster N, Sommer C, Gass P, Hermann DM, Kiessling M,Hossmann KA, Effect of global system for mobile communication microwave exposure on the genomic response of the rat brain. Neuroscience 81(3):627-639, 1997.

The acute effect of global system for mobile communication (GSM) microwave exposure on the genomic response of the central nervous system was studied in rats by measuring changes in the messenger RNAs of hsp70, the transcription factor genes c-fos and c-jun and the glial structural gene GFAP using in situ hybridization histochemistry. Protein products of transcription factors, stress proteins and marker proteins of astroglial and microglial activation were assessed by immunocytochemistry. Cell proliferation was evaluated by bromodeoxyuridine incorporation. A special GSM radiofrequency test set, connected to a commercial cellular phone operating in the discontinuous transmission mode, was used to simulate GSM exposure. The study was conducted at time averaged

and brain averaged specific absorption rates of 0.3 W/kg (GSM exposure), 1.5 W/kg (GSM exposure) and 7.5 W/kg (continuous wave exposure), respectively. Immediately after exposure, in situ hybridization revealed slight induction of hsp70 messenger RNA in the cerebellum and hippocampus after 7.5 W/kg exposure, but not at lower intensities. A slightly increased expression of c-fos messenger RNA was observed in the cerebellum, neocortex and piriform cortex of all groups subjected to immobilization, but no differences were found amongst different exposure conditions. C-jun and GFAP messenger RNAs did not increase in any of the experimental groups. 24 h after exposure, immunocytochemical analysis of FOS and JUN proteins (c-FOS, FOS B, c-JUN JUN B, JUN D), of HSP70 or of KROX-20 and -24 did not reveal any alterations. Seven days after exposure, neither increased cell proliferation nor altered expression of astroglial and microglial marker proteins were observed. In conclusion, acute high intensity microwave exposure of immobilized rats may induce some minor stress response but does not result in lasting adaptive or reactive changes of the brain.

Fritze K, Sommer C, Schmitz B, Mies G, Hossmann KA, Kiessling M, Wiessner C, Effect of global system for mobile communication (GSM) microwave exposure on blood-brain barrier permeability in rat. Acta Neuropathol (Berl) 94(5):465-470, 1997.

We investigated the effects of global system for mobile communication (GSM) microwave exposure on the permeability of the blood-brain barrier using a calibrated microwave exposure system in the 900 MHz band. Rats were restrained in a carousel of circularly arranged plastic tubes and sham-exposed or microwave irradiated for a duration of 4 h at specific brain absorption rates (SAR) ranging from 0.3 to 7.5 W/kg. The extravasation of proteins was assessed either at the end of exposure or 7 days later in three to five coronal brain slices by immunohistochemical staining of serum albumin. As a positive control two rats were subjected to cold injury. In the brains of freely moving control rats (n = 20) only one spot of extravasated serum albumin could be detected in one animal. In the sham-exposed control group (n = 20) three animals exhibited a total of 4 extravasations. In animals irradiated for 4 h at SAR of 0.3, 1.5 and 7.5 W/kg (n = 20 in each group) five out of the ten animals of each group killed at the end of the exposure showed 7, 6 and 14 extravasations, respectively. In the ten animals of each group killed 7 days after exposure, the total number of extravasations was 2, 0 and 1, respectively. The increase in serum albumin extravasations after microwave exposure reached significance only in the group exposed to the highest SAR of 7.5 W/kg but not at the lower intensities. Histological injury was not observed in any of the examined brains. Compared to other pathological conditions with increased blood-brain barrier permeability such as cold injury, the here observed serum albumin extravasations are very modest and, moreover, reversible. Microwave exposure in the frequency and intensity range of mobile telephony is unlikely to produce pathologically significant changes of the blood-brain barrier permeability.

Fritzer G, Göder R, Friege L, Wachter J, Hansen V, Hinze-Selch D, Aldenhoff JB. Effects of short- and long-term pulsed radiofrequency electromagnetic fields on night sleep and cognitive functions in healthy subjects.Bioelectromagnetics. 28(4):316-325, 2007.

There has been wide public discussion on whether the electromagnetic fields of mobiletelephones and their base stations affect human sleep or cognitive functioning. As there is evidence for learning and memory-consolidating effects of sleep and particularly of REM sleep, disturbance of sleep by radiofrequency electromagnetic fields might also impair cognitive functions. Previously realized sleep studies yielded inconsistent results regarding short-term exposure. Moreover, data are lacking on the effect that short- and long-term exposure might have on sleep as well as on cognitive functions. Therefore, 10 healthy young male subjects were included and nocturnal sleep was recorded during eight consecutive nights. In the second, third, and last night, we investigated polysomnographic night sleep and cognitive functions. After the adaptation and baseline nights, the participants were exposed to a defined radiofrequency electromagnetic field during the following six nights. We analyzed polysomnographic night sleep according to Rechtschaffen and Kales [1968, Manual of Standardized Terminology, Techniques and Scoring System for Sleep of Human Subjects] as well as by power spectra and correlation dimension. Cognitive functions were investigated by an array of neuropsychological tests. Data analysis was done by comparing the baseline night with the first and last exposure night and the first two sleep cycles of the respective nights. We did not find significant effects, either on conventional sleep parameters or on power spectra and correlation dimension, nor were there any significant effects on cognitive functions. With our results, we are unable to reveal either short-term or cumulative long-term effects of radiofrequency electromagnetic fields on night sleep and cognitive functions in healthy young male subjects.

Fry TL, Schlegel RE, Grant H, Impact of CDMA wireless phone power output and puncture rate on hearing aid interference levels. Biomed Instrum Technol 34(1):29-38, 2000.

Interference between digital wireless phones and hearing aids occurs when the radiofrequency bursts from the phone transmission are demodulated by the hearing aid amplifier. The amplified interference signal is heard as a "buzz" or "static" by the hearing aid wearer. Most research and standards development activity has focused on worst-case scenarios with the phone operating at its maximum power. Since this power level is often not typical in urban and suburban settings, it is of value to determine the impact of lower power levels on the overall level of audible interference. Using a frequency analyzer, and several hearings aids and code division multiple access (CDMA) phones, the audio frequency spectrum of interference was recorded for each phone-aid combination and for a range of power levels producing from no interference to maximum interference. As phone power is increased, the interference signal becomes distinguishable from the ambient noise level and a linear response region is observed in which a specified increase in power output results in a proportional increase in the overall input referenced interference level (OIRIL). As power is increased beyond the linear region, the hearing aid enters a saturation region where an additional power increase results in a reduction or no increase in the OIRIL. The numeric differences in interference documented in this study were used in conjunction with the results of a previous study by the authors to determine the impact of reduced power on speech intelligibility and annoyance. The amount of improvement for a given power reduction depends on the

radiofrequency immunity of the hearing aid and is substantial for hearing aids with poor immunity. For high-immunity aids, the level of audible interference remains low even at high phone power levels.

Fucic A, Garaj-Vrhovac V, Skara M, Dimitrovic B, X-rays, microwaves and vinyl chloride monomer: their clastogenic and aneugenic activity, using the micronucleus assay on human lymphocytes. Mutat Res 282(4):265-271, 1992.

Chromosome aberration assays, sister-chromatid exchange techniques and micronucleus assays are commonly used methods for biomonitoring genetic material damaged by chemical or physical agents. On the other hand, their aneugenic activity, which can lead to hypoploidy and may also be associated with carcinogenesis, has not been thoroughly investigated. In our study we chose the micronucleus assay with a new mathematical approach to separate clastogenic from aneugenic activity of three well-known mutagens (vinyl chloride monomer, X-rays and microwaves) on the genome of human somatic cells. The comparison of frequencies of size distribution of micronuclei in the lymphocytes of humans exposed to each of these three mutagens showed that X-rays and microwaves were preferentially clastogens while vinyl chloride monomer showed aneugenic activity as well. Microwaves possess some mutagenic characteristics typical of chemical mutagens.

Fukui Y, Hoshino K, Inouye M, Kameyama Y, Effects of hyperthermia induced by microwave irradiation on brain development in mice. J Radiat Res (Tokyo) 33(1):1-10, 1992.

Pregnant mice were exposed to 2.45 GHz of microwave radiation for 15 or 20 min on day 13 of gestation. The highest maternal core temperature during the exposure did not exceed 42.5 degrees C. Pregnant females also were immersed in hot water at 42 degrees C for 15 min to compare thermal effects on brain development. Animals were killed 9 hours after treatment, and the pyknotic cells in the ventricular zone of telencephalon were counted. The respective incidences of these cells in the groups exposed to microwaves for 15 and 20 min were 1.83% and 3.06%. Microwave radiation for 20 min had an effect that was comparable to that of immersion in 42 degrees C hot water for 15 min. In addition, some animals were examined on day 18 of gestation, and some of their offspring were examined at 6 weeks of age in an examination of long-term effects. Brain weight for the group exposed to microwaves for 20 min was significantly lower than for the control group, and the numerical density of the neurons in the cerebrum was higher. We concluded that microwave radiation at the dose tested mainly has a thermal effect.

Funch DP, Rothman KJ, Loughlin JE, Dreyer NA, Utility of telephone company records for epidemiologic studies of cellular telephones. Epidemiology 7(3):299-302, 1996.

We conducted a survey of over 5,000 telephone users who were customers of one large cellular telephone company covering four major geographical areas. Our primary goal was to assess the utility of ascertaining information on telephone use and type from telephone company records. We compared information from 3,949 respondents with corresponding data from company billing records. We found that 48% of the account

holders were sole users, and 69% were the primary user, meaning that they accounted for at least 75% of the use. Respondent reports of amount of telephone use were highly correlated with data on the billing record (r = 0.74). Respondent reports of telephone type were similarly correlated with data from the manufacturer (r = 0.92). We also inquired about telephone holding patterns, since these have implications for exposure. Most users reported favoring one side of the head when using the telephone, but the side of the head used was not strongly associated with handedness.

Furtado-Filho OV, Borba JB, Dallegrave A, Pizzolato TM, Henriques JA, Moreira JC, Saffi J. Effect of 950 MHz UHF electromagnetic radiation on biomarkers of oxidative damage, metabolism of UFA and antioxidants in the livers of young rats of different ages. Int J Radiat Biol. 2013 Jul 25. [Epub ahead of print]

Purpose: To assess the effect of 950 MHz ultra-high-frequency electromagnetic radiation (UHF EMR) on biomarkers of oxidative damage, as well as to verify the concentration of unsaturated fatty acids (UFA) and the expression of the catalase in the livers of rats of different ages. Materials and methods: Twelve rats were equally divided into two groups as controls (CR) and exposed (ER), for each age (0, 6, 15 and 30 days). Radiation exposure lasted half an hour per day for up to 51 days (21 days of gestation and 6, 15 or 30 days of life outside the womb). The specific absorption rate (SAR) ranged from 1.3-1.0 W/kg. The damage to lipids, proteins and DNA was verified by thiobarbituric acid reactive substances (TBARS), protein carbonyls and comets, respectively. UFA were determined by gas chromatography with a flame ionization detector. The expression of catalase was by Western blotting. Results: The neonates had low levels of TBARS and concentrations of UFA after exposure. There was no age difference in the accumulation of protein carbonyls for any age. The DNA damage of ER 15 or 30 days was different. The exposed neonates exhibited lower expression of catalase. Conclusions: 950 MHz UHF EMR does not cause oxidative stress (OS), and it is not genotoxic to the livers of neonates or those of 6 and 15 day old rats, but it changes the concentrations of polyunsaturated fatty acid (PUFA) in neonates. For rats of 30 days, no OS, but it is genotoxic to the livers of ER to total body irradiation.

Furtado-Filho OV, Borba JB, Maraschin T, Souza LM, Jose JA, Moreira CF, Saffi J. Effects of chronic exposure to 950 MHz ultra-high-frequency electromagnetic radiation on reactive oxygen species metabolism in the right and left cerebral cortex of young rats of different ages. Int J Radiat Biol. 2015 Aug 14:1-17. [Epub ahead of print]

PURPOSE: To assess the effect of 950 MHz ultra-high-frequency electromagnetic radiation (UHF-EMR) on biomarkers of oxidative damage to DNA, proteins and lipids in the left cerebral cortex (LCC) and right cerebral cortex (RCC) of neonate and 6-day-old rats. MATERIALS AND METHODS: Twelve rats were equally divided into two groups as controls (CR) and exposed (ER), for each age (0 and 6 days). The LCC and RCC were examined in ER and CR after exposure. Radiation exposure lasted half an hour per day for up to 27 days (throughout pregnancy and 6 days postnatal). The specific absorption rate ranged from 1.32 - 1.14 W/kg. The damage to lipids,

proteins and DNA was verified by thiobarbituric acid reactive substances, carbonylated proteins (CP) and comets, respectively. The concentration of glucose in the peripheral blood of the rats was measured by the Accu-Chek Active Kit due to increased CP in RCC. RESULTS: In neonates, no modification of the biomarkers tested was detected. On the other hand, there was an increase in the levels of CP in the RCC of the 6-day-old ER. Interestingly, the concentration of blood glucose was decreased in this group. CONCLUSIONS: Our results indicate that there is no genotoxicity and oxidative stress in neonates and 6 days rats. However, the RCC had the highest concentration of CP that do not seem to be a consequence of oxidative stress. This study is the first to demonstrate the use of UHF-EMR causes different damage responses to proteins in the LCC and RCC.

Furubayashi T, Ushiyama A, Terao Y, Mizuno Y, Shirasawa K, Pongpaibool P, Simba AY, Wake K, Nishikawa M, Miyawaki K, Yasuda A, Uchiyama M, Yamashita HK, Masuda H, Hirota S, Takahashi M, Okano T, Inomata-Terada S, Sokejima S, Maruyama E, Watanabe S, Taki M, Ohkubo C, Ugawa Y. Effects of short-term W-CDMA mobile phone base station exposure on women with or without mobile phone related symptoms. Bioelectromagnetics. 30(2):100-113, 2009.

To investigate possible health effects of mobile phone use, we conducted a double-blind, cross-over provocation study to confirm whether subjects with mobile phone related symptoms (MPRS) are more susceptible than control subjects to the effect of electromagnetic fields (EMF) emitted from base stations. We sent questionnaires to 5,000 women and obtained 2,472 valid responses from possible candidates; from these, we recruited 11 subjects with MPRS and 43 controls. There were four EMF exposure conditions, each of which lasted 30 min: continuous, intermittent, and sham exposure with and without noise. Subjects were exposed to EMF of 2.14 GHz, 10 V/m (W-CDMA), in a shielded room to simulate whole-body exposure to EMF from base stations, although the exposure strength we used was higher than that commonly received from base stations. We measured several psychological and cognitive parameters pre- and post-exposure, and monitored autonomic functions. Subjects were asked to report on their perception of EMF and level of discomfort during the experiment. The MPRS group did not differ from the controls in their ability to detect exposure to EMF; nevertheless they consistently experienced more discomfort, regardless of whether or not they were actually exposed to EMF, and despite the lack of significant changes in their autonomic functions. Thus, the two groups did not differ in their responses to real or sham EMF exposure according to any psychological, cognitive or autonomic assessment. In conclusion, we found no evidence of any causal link between hypersensitivity symptoms and exposure to EMF from base stations.

Gadhia PK, Shah T, Mistry A, Pithawala M, Tamakuwala D. A preliminary study to assess possible chromosomal damage among users of digital mobile phones. Electromag Biol Med 22:149-159, 2003.

In a preliminary study to examine possible lymphocyte chromosomal damage, we have tested two cytogenetic endpoints, namely, chromosomal aberrations (CA) and sister chromatid exchange frequencies (SCE), in 24 mobile phone users (12 nonsmoker–nonalcoholic subjects and 12 smoker–alcoholics), who used digital

mobile phones for at least 2 years, employing Gaussian Minimum Shift Keying modulations with uplink frequencies at 935–960 MHz. and downlinks at 890–915 MHz. For comparison, the control study group included another 24 individuals, matched according to their age, sex, drinking and smoking habits, as well as similar health status, working habits, and professional careers; but did not use mobile phones. Blood samples of 12 mobile users (6 smoker–alcoholic and 6 nonsmoker–nonalcoholic) and 12 controls (identical to mobile users in every respect) were further treated with a known mutagen Mitomycin-C (MMC) to find out comutagenic/synergistic effect. A complete blood picture for each individual was assessed with an automatic particle cell counter. There was a significant increase ($P < 0.05$) in dicentric chromosomes among mobile users who were smoker–alcoholic as compared to nonsmoker–nonalcoholic; the same held true for controls of both types. After MMC treatment, there was a significant increase in dicentrics ($P < 0.05$) and ring chromosomes ($P < 0.001$) in both smoker–alcoholic and nonsmoker–nonalcoholic mobile users when compared with the controls. Although SCEs showed a significant increase among mobile users, no change in cell cycle progression was noted. The hematological picture showed only minor variations between mobile users and controls.

Gadzicka E, Bortkiewicz A, Zmyslony M, Palczynski C, [Evaluation of selected functional circulation parameters of workers from various occupational groups exposed to electromagnetic fields of high frequency. III. 24-h monitoring of arterial blood pressure]. Med Pr 48(1):15-24, 1997. [Article in Polish]

The problem of blood pressure regulation in persons occupationally exposed to electromagnetic fields (EMF) has not as yet been elucidated, and most data come from studies carried out long time ago (1960-70) in the former Soviet Union. Our study was aimed at verifying the Soviet data by means of modern methods. Together with traditional methods, a 24-h monitoring of arterial blood pressure (ABP) using a Medilog ABP kit (Oxford) were employed. Measurements were taken automatically every 0.5 h during daily activities and every 1 h during the night rest (about 41 measurements/day). The mean systolic and diastolic blood pressure and heart rate were calculated over day (BPSDOver, BPDOver, HROver), during daily activities (HPDD, BPSD, HRD) and during the night rest (BPSN, BPDN, HRN). The subjective and objective examinations were carried out as well as resting ECG and a 24-h Holter were performed (the results have been published earlier). The study covered male workers of middlewave broadcast stations (71), radioservice (40) and radio line stations (42). The subjects were aged 21-60 years and the duration of their work with devices generating high frequency EMF ranged between 1 and 42 years. The first group of workers was exposed to EFM at the frequency of 1 Mhz, the second at about 150 Mhz and the third group, not exposed, served as the control group. The study revealed that the mean arterial blood pressure and the day/night blood pressure variability indicator showed no significant differences between the groups, whereas the daily heart rate was significantly lower in the workers of middlewave broadcast stations in comparison with the controls despite similar type of work as far as physical effort and psychic burden are concerned, and similar non-occupational activities. The day/night heart rate variability indicator was significantly lower in the groups exposed. The decreased value of this indicator may suggest the occurrence of disorders in the

neurovegetative regulation. In persons employed at radioservice stations a higher incidence of the increased arterial blood pressure, in comparison with the control group, was observed.

Gajski G, Garaj-Vrhovac V. Radioprotective effects of honeybee venom (Apis mellifera) against 915-MHz microwave radiation-induced DNA damage in wistar rat lymphocytes: in vitro study. Int J Toxicol. 28(2):88-98, 2009.

The aim of this study is to investigate the radioprotective effect of bee venom against DNA damage induced by 915-MHz microwave radiation (specific absorption rate of 0.6 W/kg) in Wistar rats. Whole blood lymphocytes of Wistar rats are treated with 1 microg/mL bee venom 4 hours prior to and immediately before irradiation. Standard and formamidopyrimidine-DNA glycosylase (Fpg)-modified comet assays are used to assess basal and oxidative DNA damage produced by reactive oxygen species. Bee venom shows a decrease in DNA damage compared with irradiated samples. Parameters of Fpg-modified comet assay are statistically different from controls, making this assay more sensitive and suggesting that oxidative stress is a possible mechanism of DNA damage induction. Bee venom is demonstrated to have a radioprotective effect against basal and oxidative DNA damage. Furthermore, bee venom is not genotoxic and does not produce oxidative damage in the low concentrations used in this study.

Galat VV, Mezhevikina LM, Zubin MN, Lepikhov KA, Khramov RN, Chailakhian LM, [Effect of millimeter waves on the early development of the mouse and sea urchin embryo]. Biofizika 44(1):137-140, 1999. [Article in Russian]

The action of nonthermal electromagnetic radiation (EMR) of the millimeter range on the early development of murine and sea urchin embryos was investigated. An MRTA-01E-03 generator with a frequency of 54-78 GHz and radiation intensity of 0.06 mWt/cm2 was used. The embryos were irradiated during 30 min at the stage of two blastomeres. The number of murine embryos that reached the blastocyst stage increased (up to 97.3% in comparison with 87.5% in control). The total time of cultivation up to the blastocyst stage was also shorter (72 h) than in control (96 h). The irradiation had effect on the development of sea urchin embryos only if embryos with a weakened viability were tested. The results indicate that millimeter electromagnetic radiation has a stimulating effect on the early development of embryos, increasing the resistance of embryos to unfavorable environmental conditions.

Galloni P, Lovisolo GA, Mancini S, Parazzini M, Pinto R, Piscitelli M, Ravazzani P, Marino C. Effects of 900 MHz electromagnetic fields exposure on cochlear cells' functionality in rats: Evaluation of distortion product otoacoustic emissions. Bioelectromagnetics. 26(7):536-547, 2005.

In recent years, the widespread use of mobile phones has been accompanied by public debate about possible adverse consequences on human health. The auditory system is a major target of exposure to electromagnetic fields (EMF) emitted by cellular telephones; the aim of this study was the evaluation of possible effects of cellular phone-like emissions on the functionality of rat's cochlea. Distortion Products OtoAcoustic Emission (DPOAE) amplitude was selected as cochlea's outer hair cells (OHC) status indicator. A

number of protocols, including different frequencies (the lower ones in rat's cochlea sensitivity spectrum), intensities and periods of exposure, were used; tests were carried out before, during and after the period of treatment. No significant variation due to exposure to microwaves has been evidenced.

Galloni P, Parazzini M, Piscitelli M, Pinto R, Lovisolo GA, Tognola G, Marino C, Ravazzani P. Electromagnetic Fields from mobile phones do not affect the inner auditory system of Sprague-Dawley Rats. Radiat Res. 164(6):798-804, 2005.

The auditory system is the first biological structure facing the electromagnetic fields emitted by mobile phones. The aim of this study was to evaluate the cochlear functionality of Sprague-Dawley rats exposed to electromagnetic fields at the typical frequencies of GSM mobile phones (900 and 1800 MHz) by distortion product otoacoustic emissions, which are a well-known indicator of the status of the cochlea's outer hair cells. A population of 48 rats was divided into exposed and sham-exposed groups. Three sets of four loop antennas, one for sham-exposed animals and two for exposed animals, were used for the local exposures. Rats were exposed 2 h/day, 5 days/week for 4 weeks at a local SAR of 2 W/kg in the ear. Distortion product otoacoustic emissions tests were carried out before, during and after the exposure. The analysis of the data shows no statistically significant differences between the audiological signals recorded for the different groups

Gandhi G, Anita Genetic damage in mobile phone users: some preliminary findings. Ind J Hum Genet 11(2): 99-104, 2005.

BACKGROUND: The impact of microwave (MW)/radio frequency radiation (RFR) on important biological parameters is probably more than a simply thermal one. Exposure to radio frequency (RF) signals generated by the use of cellular telephones have increased dramatically and reported to affect physiological, neurological, cognitive and behavioural changes and to induce, initiate and promote carcinogenesis. Genotoxicity of RFR has also been reported in various test systems after in vitro and/or in vivo exposure but none in mobile phone users. **AIMS:** In the present study, DNA and chromosomal damage investigations were carried out on the peripheral blood lymphocytes of individuals using mobile phones, being exposed to MW frequency ranging from 800 to 2000 MHz. **METHODS:** DNA damage was assessed using the single cell gel electrophoresis assay and aneugenic and clastogenic damage by the in vivo capillary blood micronucleus test (MNT) in a total of 24 mobile phone users. **RESULTS:** Mean comet tail length (26.76 ± 0.054 mm; 39.75% of cells damaged) in mobile phone users was highly significant from that in the control group. The in vivo capillary blood MNT also revealed highly significant (0.25) frequency of micronucleated (MNd) cells. **CONCLUSIONS:** These results highlight a correlation between mobile phone use (exposure to RFR) and genetic damage and require interim public health actions in the wake of widespread use of mobile telephony.

Gandhi G, Singh P. Cytogenetic damage in mobile phone users: preliminary data. Int J Hum Genet 5(4):259-265, 2005.

Mobile telephones, sometimes called cellular (cell) phones or handies, are now an integral part of modern life. The mobile phone handsets are low-powered radiofrequency transmitters, emitting maximum powers in the range of 0.2 to 0.6 watts. Scientific

concenrns have increased sufficiently over the possible hazard to health from using cell phones. The reported adverse health effects include physiological, behavioural and cognitive changes as well as tumour formation and genetic damage. However findings are controversial and no consensus exists. Genotoxicity has been observed either in lower organisms or in vitro studies. The aim of the present study hence was to detect any cytogenertic damage in mobile phone users by analysing short term peripheral lymphocyte cultures for chromosomal aberrations and the buccal mucosal cells for micronuclei (aneugenicity and clastogenicity). The results revealed increased number of micronucleated buccal cells and cytological abnormalities in cultured lymphocytes indicating the genotoxic response from mobile phone use.

Gandhi G, Kaur G, Nisar U. A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station. Electromagn Biol Med. 34(4):344-354, 2015.

Mobile phone base stations facilitate good communication, but the continuously emitting radiations from these stations have raised health concerns. Hence in this study, genetic damage using the single cell gel electrophoresis (comet) assay was assessed in peripheral blood leukocytes of individuals residing in the vicinity of a mobile phone base station and comparing it to that in healthy controls. The power density in the area within 300 m from the base station exceeded the permissive limits and was significantly ($p = 0.000$) higher compared to the area from where control samples were collected. The study participants comprised 63 persons with residences near a mobile phone tower, and 28 healthy controls matched for gender, age, alcohol drinking and occupational sub-groups. Genetic damage parameters of DNA migration length, damage frequency (DF) and damage index were significantly ($p = 0.000$) elevated in the sample group compared to respective values in healthy controls. The female residents ($n = 25$) of the sample group had significantly ($p = 0.004$) elevated DF than the male residents ($n = 38$). The linear regression analysis further revealed daily mobile phone usage, location of residence and power density as significant predictors of genetic damage. The genetic damage evident in the participants of this study needs to be addressed against future disease-risk, which in addition to neurodegenerative disorders, may lead to cancer.

Gandhi OP. ELECTROMAGNETIC FIELDS: Human Safety Issues. Annu Rev Biomed Eng 4:211-234, 2002.

Most of the recently revised safety standards worldwide are set in terms of internal rates of electromagnetic energy deposition (specific absorption rates or SAR) at radio frequencies (RF) and microwave frequencies, and of induced electric fields or current densities at lower frequencies up to 10 MHz. Numerical methods have been developed that use millimeter resolution anatomically based models of the human body to determine SAR or the induced electric fields and current densities for real-life EM exposure conditions. A popular method for use at RF and microwave frequencies is the finite-difference time-domain method. This method is described and illustrated for SAR distributions due to cellular telephones for head models based on human anatomy. A method often used for calculations of induced electric fields and current densities at low frequencies is the impedance method. Use of this method is illustrated by an example of

an electronic article surveillance (EAS) system for anatomic models of an adult and 10- and 5-year-old children. Experimental phantoms using a fluid to simulate the dielectric properties of the brain may be used for determination of peak 1- or 10-g SAR needed for compliance with the various safety standards.

Gandhi OP, Lazzi G, Tinniswood A, Yu QS, Comparison of numerical and experimental methods for determination of SAR and radiation patterns of handheld wireless telephones. Bioelectromagnetics Suppl 4:93-101, 1999.

Some recent developments in both the numerical and experimental methods for determination of SARs and radiation patterns of handheld wireless telephones are described, with emphasis on comparison of results using the two methods. For numerical calculations, it was possible to use the Pro-Engineer CAD Files of cellular telephones for a realistic description of the device. Also, we used the expanding grid formulation of the finite-difference time-domain (FDTD) method for finer-resolution representation of the coupled region, including the antenna, and an increasingly coarser representation of the more-distant, less-coupled region. Together with the truncation of the model of the head, this procedure led to a saving of computer memory needed for SAR calculations by a factor of over 20. Automated SAR and radiation pattern measurement systems were used to validate both the calculated 1-g SARs and radiation patterns for several telephones, including some research test samples, using a variety of antennas. Even though widely different peak 1-g SARs were obtained, ranging from 0.13 to 5.41 W/kg, agreement between the calculated and the measured data for these telephones, five each at 835 and 1900 MHz, was excellent and generally within +/-20% (+/-1 dB). An important observation was that for a maximum radiated power of 600 mW at 800/900 MHz, which may be used for telephones using AMPS technology, the peak 1-g SARs can be higher than 1.6 W/kg unless antennas are carefully designed and placed further away from the head.

Gao X, Luo R, Ma B, Wang H, Liu T, Zhang J, Lian Z, Cui X. [Interference of vitamin E on the brain tissue damage by electromagnetic radiation of cell phone in pregnant and fetal rats]. Wei Sheng Yan Jiu. 2013 Jul;42(4):642-6.
[Article in Chinese]

OBJECTIVE: To investigate the interlerence ot vitamin E on brain tissue damage by electromagnetic radiation of cell phone in pregnant and fetal rats. METHODS: 40 pregnant rats were randomly divided into five groups (positive control, negative control, low, middle and high dosage of vitamin E groups). The low, middle and high dosage of vitamin E groups were supplemented with 5, 15 and 30 mg/ml vitamin E respectively since the first day of pregnancy. And the negative control group and the positive control group were given peanut oil without vitamin E. All groups except for the negative control group were exposed to 900MHz intensity of cell phone radiation for one hour each time, three times per day for 21 days. After accouchement, the right hippocampus tissue of fetal rats in each group was taken and observed under electron microscope. The vitality of superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px), and the content of malondialdehyde (MDA) in pregnant and fetal rats' brain tissue were tested. RESULTS: Compared with the negative control group, the chondriosomes in neuron and neuroglia of brain tissues was swelling, mild edema was found around the capillary, chromatin was

concentrated and collected, and bubbles were formed in vascular endothelial cells (VEC) in the positive fetal rat control group, whereas the above phenomenon was un-conspicuous in the middle and high dosage of vitamin E groups. We can see uniform chromatin, abundant mitochondrion, rough endoplasmic reticulum and free ribosomes in the high dosage group. The apoptosis has not fond in all groups'sections. In the antioxidase activity analysis, compared with the negative control group, the vitality of SOD and GSH-Px significantly decreased and the content of MDA significantly increased both in the pregnant and fetal rats positive control group ($P < 0.05$). In fetal rats, the vitality of SOD and GSH-Px significantly increased in the brain tissues of all three different vitamin E dosages groups when compared with the positive control group, and the content of MDA was found significantly decreased in both middle and high dosage of vitamin E groups($P < 0.05$). The same results have also been found in high dosage pregnant rat group, but in middle dosage group only SOD activity was found increased with significance ($P < 0.05$). With the dosage increase of vitamin E, the vitality of SOD and GSH-Px was increasing and the content of MDA was decreasing. CONCLUSION: Under the experimental dosage, vitamin E has certain interference on damage of antioxidant capacity and energy metabolization induced by electromagnetic radiation of cell phone in pregnant rats and fetal rats.

Gao XF,Pei LP, Chen CH, Yang XS, Zhang GB, Deng ZH, Yu ZP. [Effects of occupational microwave irradiation on heat shock protein 70 expressions in rat hippocampus.] Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 27(9):553-556, 2009. [Article in Chinese]

OBJECTIVE: To study the change of heat shock protein (HSP)70 expression after exposure to occupational microwave in rats hippocampus, and explore the role of HSP70 in the mechanism of bio-effect of microwave irradiation. METHODS: The animal model was established by whole body exposures in 90, 5 W/cm(2) microwave irradiation field for 20 min in rats. Changes of the mRNA of hsp70 expressions in rat hippocampus at different time were studied by RT-PCR, and the protein change by Western blot. RESULTS: The mRNA and protein expression of hsp70 in rat hippocampus increased after 90 W/cm(2) and 5 W/cm(2) microwave irradiation for 20 min. The anal temperature and the value of SAR increased significantly. These changes were positively correlated with power and irradiation time of microwave. The results indicated that microwave irradiation led to HSP70 syntheses effectively. CONCLUSION: Microwave irradiation can obviously induce the thermal effect and activate HSP70, and initiate the endogens protective mechanism of central nervous system.

Gao XF, Wang SM, Peng RY, Wang LF, Zuo HY, Gao YB, Dong Q, Dong B. [Effect of microwave radiation on primary cultured Sertoli cells.] Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 27(9):530-533, 2009. [Article in Chinese]

OBJECTIVE: To explore whether microwave radiation may cause injury of primary cultured Sertoli cells. METHODS: The model of primary cultured Sertoli cells in vitro was established, which was radiated by microwave with average power density 0, 30 and 100 mW/cm(2) for five minutes. The changes of cell cycle, apoptosis and death, and intracellular Ca2+ concentration in the Sertoli cells were measured at sixth hours

through Annexin V-PI double labeling and Fluo-3-AM labeling, flow cytometry combined with laser scanning confocal microscopy after microwave exposure. RESULTS: The numbers of Sertoli cells were obviously reduced in G0-G1 and G2-M phase (62.57% +/- 3.22% and 8.25% +/- 1.75%) and increased in S phase (29.17% +/- 4.87%) compared with the control groups (79.18% +/- 0.24%, 11.17% +/- 0.50% and 9.64% +/- 0.62%) (P < 0.05 or P < 0.01), but the changes of rate of apoptosis and death and intracellular Ca2+ concentration showed no difference at 6 h after exposure to 30 mW/cm(2) microwave. There was a significant increase in the Sertoli cell counts of G0-G1 phase (87.69% +/- 1.32%), and decrese in the Sertoli cell counts of G2-M and S phase (7.41% +/- 0.60% and 4.87% +/- 0.91%) (P < 0.01). There was also a significant increase in intracellular Ca2+ concentration and rate of apoptosis and death (P < 0.05 or P < 0.01) at 6 h after exposure to 100 mW/cm(2) microwave. CONCLUSION: 100 mW/cm(2) microwave radiation may cause growth inhibition and increase of apoptosis and death in the primary cultured Sertoli cells. The increase of intracellular Ca2+ concentration is one of the injury mechanisms.

Gapeev AB, Lakushina VS, Chemeris NK, Fesenko EE [Modulated extremely high frequency electromagnetic radiation of low intensity activates or inhibits respiratory burst in neutrophils depending on modulation frequency]. Biofizika 42(5):1125-1134, 1997. [Article in Russian]

The influence of low-intensity modulated electromagnetic radiation of extremely high frequencies (EHF EMR) on synergistic reaction of calcium ionophore A23187 and phorbol ester PMA in activation of the respiratory burst of the peritoneal neutrophils of mice line NMRI was investigated. The production of reactive oxygen species by the neutrophils was estimated by luminol-dependent chemiluminescence technique. The cells were irradiated in the far field zone of the channel radiator for 20 min in the presence of A23187 and then were activated by PMA after switching off the irradiation. It was shown, that continuous EHF EMR (50 microW/cm2) inhibited quasi-resonantly the synergistic reaction. The maximum effect was about 25% at carrier frequency of 41.95 GHz. Modulated radiation with carrier frequency of 41.95 GHz and modulation frequency of 1 Hz activated the synergistic reaction, but at modulation frequencies of 0.1, 16 and 50 Hz inhibited one. At fixed modulation frequency of 1 Hz the nonlinear dependence of the effect on the carrier frequency was found. The synergistic reaction was activated in the frequency range of 41.95-42.05 GHz and was inhibited at the frequencies of 41.8-41.9 GHz. The effect was observed only at raised intracellular free calcium concentration and at calcium fluxes through plasma membrane. The obtained results prove the possibility of control over cell functioning by low-intensity modulated EHF EMR, presumably, manipulating by connected systems of enzyme reactions.

Gapeev AB, Safronova VG, Chemeris NK, Fesenko EE [Modification of the activity of murine peritoneal neutrophils upon exposure to millimeter waves at close and far distances from the emitter]. Biofizika 41(1): 205-219, 1996. [Article in Russian]

The comparison of horn, dielectric and channel antennae on their matching with various types of loads, including a biological object, is carried out. The channel antenna in contrast to dielectric and horn ones provides the uniform spatial distribution of specific absorbed rating in the frequency range used and wide-band matching with the object

both in near field and far field zones of the radiator. It is shown, that low-intensity electromagnetic radiation of extremely high frequency in near field zone of the channel radiator modifies the activity of mouse peritoneal neutrophils on a quasi-resonance manner. The interaction of electromagnetic radiation with the biological object has been revealed in the narrow-band frequencies of 41.8-42.05 GHz and consists in inhibition of luminol-dependent chemiluminescence of neutrophils activated by opsonized zymosan. It is not found any frequency dependence of the electromagnetic radiation effects in the far field zone of the radiator. The results obtained suggest, that the quasi-resonance dependence of the biological effect on the frequency of the electromagnetic radiation in the near field zone is conditioned by structure and nature of the electromagnetic radiation in this zone.

Gapeev AB, Chemeris NK, [Modeling of the effect of modulated electromagnetic radiation on animal cells]. Biofizika 45(2):299-312, 2000.

Frequency-dependent modifications of intracellular free calcium concentration ([Ca2+]i) in neutrophils exposures to modulated extremely high frequency electromagnetic radiation were analyzed using a special mathematical model for [Ca2+]i oscillations. The model took into account the activation of Ca2+ influx into the cell by cytosolic Ca2+ and Ca(2+)-induced Ca2+ release from intracellular stores. The calcium channels of plasma membrane were chosen as a target for the influence of harmonic signal and additive noise in the model. The model simulation showed that in response to modulating signal, the rise in [Ca2+]i, has frequency dependence and phase dependence in relation to the moment of chemical stimulation. The phase-frequency dependence of the effect was observed at a certain sequence of delivery of chemical stimulus and modulating signal to the cell. At intensities of modulating signals exceeding the threshold, a rise in [Ca2+]i, reaching a level of more than 50% of the initial level, was observed at a frequency of about 1 Hz and in the phase range of 0.3-2.5 radians. The effect was found only at high intensities of chemical stimulus. The additive noise introduced into the system modified qualitatively and quantitatively the phase-frequency characteristics of the cell response to the modulating signal. An increase in noise intensity resulted in a displacement of the average frequency of the band of rise in [Ca2+]i, and then the emergence of a set of bands with a greater Q-factors. The analysis of dynamics of the nonlinear system in terms of the stability theory showed that, as the intensity of chemical stimulus increases, the system transits by means of a series of bifurcations from regular driving to chaotic, and then to oscillations, induced by a modulating harmonic signal. The boundary of the transition of oscillations from chaotic to induced ones corresponds to a specific "threshold" of the intensity of chemical stimulus for the significant rise in [Ca2+]i in response to the modulating signal. The results of the model analysis are in good correspondence with the experimental data obtained earlier, namely, with the effects of modulated extremely high-frequency electromagnetic radiation on neutrophils, which were observed only in the presence of Ca2+ in extracellular medium and at high concentrations of calcium ionophore A23187. Thus, as the characteristic frequency of the quasi-periodic process of calcium signalling in the cell coincides with the frequency of external field, a narrow-band rise in [Ca2+]i is observed, which can result in a modification of the functional activity of the cell.

Gapeev AB, Lushnikov KV, Shumilina IuV, Sirota NP, Sadovnikov VB, Chemeris

NK. [Effects of low-intensity extremely high frequency electromagnetic radiation on chromatin structure of lymphoid cells in vivo and in vitro] Radiats Biol Radioecol 43(1):87-92, 2003. [Article in Russian]

Using a comet assay technique, it was shown for the first time that low-intensity extremely high-frequency electromagnetic radiation (EHF EMR) in vivo causes oppositely directed effects on spatial organization of chromatin in cells of lymphoid organs. In 3 hrs after single whole-body exposure of NMRI mice for 20 min at 42.0 GHz and 0.15 mW/cm2, an increase by 16% ($p < 0.03$ as compared with control) and a decrease by 16% ($p < 0.001$) in fluorescence intensity of nucleoids stained with ethidium bromide were found in thymocytes and splenocytes, respectively. The fluorescence intensity of stained nucleoids in peripheral blood leukocytes was not changed after the exposure. The exposure of cells of Raji hunan lymphoid line and peripheral blood leukocytes to the EHF EMR in vitro induced a decrease in fluorescence intensity by 23% ($p < 0.001$) and 18% ($p < 0.05$), respectively. These effects can be determined by changes in a number of physiological alkali-labile sites in DNA of exposed cells. We suggested that the effects of low-intensity EHF EMR on the immune system cells are realized with the participation of neuroendocrine and central nervous systems.

Gapeyev AB, Kulagina TP, Aripovsky AV. Exposure of tumor-bearing mice to extremely high-frequency electromagnetic radiation modifies the composition of fatty acids in thymocytes and tumor tissue. Int J Radiat Biol. 89(8):602-610, 2013.

Purpose: To test the participation of fatty acids (FA) in antitumor effects of extremely high-frequency electromagnetic radiation (EHF EMR), the changes in the FA composition in the thymus, liver, blood plasma, muscle tissue, and tumor tissue in mice with Ehrlich solid carcinoma exposed to EHF EMR were studied. Materials and methods: Normal and tumor-bearing mice were exposed to EHF EMR with effective parameters (42.2 GHz, 0.1 mW/cm^2, 20 min daily during five consecutive days beginning the first day after the inoculation of tumor cells). Fatty acid composition of various organs and tissues of mice were determined using a gas chromatography. Results: It was shown that the exposure of normal mice to EHF EMR or tumor growth significantly increased the content of monounsaturated FA (MUFA) and decreased the content of polyunsaturated FA (PUFA) in all tissues examined. Exposure of tumor-bearing mice to EHF EMR led to the recovery of FA composition in thymocytes to the state that is typical for normal animals. In other tissues of tumor-bearing mice, the exposure to EHF EMR did not induce considerable changes that would be significantly distinguished between disturbances caused by EHF EMR exposure or tumor growth separately. In tumor tissue which is characterized by elevated level of MUFA, the exposure to EHF EMR significantly decreased the summary content of MUFA and increased the summary content of PUFA. Conclusions: The recovery of the FA composition in thymocytes and the modification of the FA composition in the tumor under the influence of EHF EMR on tumor-bearing animals may have crucial importance for elucidating the mechanisms of antitumor effects of the electromagnetic radiation.

Gapeyev AB, Aripovsky AV, Kulagina TP. Modifying Effects of Low-Intensity Extremely High-Frequency Electromagnetic Radiation on Content and Composition of Fatty Acids in Thymus of Mice Exposed to X-Rays. Int J Radiat Biol. 2014 Oct 27:1-26. [Epub ahead of print]

Purpose: To test the involvement of fatty acids (FA) in possible protective effects of extremely high-frequency electromagnetic radiation (EHF EMR) against ionizing radiation, the effects of EHF EMR on thymus weight and its FA content and FA composition in X-irradiated mice were studied. Materials and methods: Mice were exposed to low-intensity pulse-modulated EHF EMR (42.2 GHz, 0.1 mW/cm^2, 20 min exposure, 1 Hz modulation) and/or X-rays at a dose of 4 Gy with different sequences of the treatments. In four-five hours, 10, 30, and 40 days after the last exposure, the thymuses were weighed; total FA content and FA composition of the thymuses were determined on days 1, 10, and 30 using a gas chromatography. Results: It was shown that after X-irradiation of mice the total FA content per mg of thymic tissue was significantly increased in 4-5 h and decreased in 10 and 30 days after the treatment. On days 30 and 40 after X-irradiation, the thymus weight remained significantly reduced. First and tenth days after X-rays injury independently of the presence and sequence of EHF EMR exposure were characterized by an increased content of polyunsaturated FA (PUFA) and a decreased content of monounsaturated FA (MUFA) with unchanged content of saturated FA (SFA). Exposure of mice to EHF EMR before or after X-irradiation prevented changes in the total FA content in thymic tissue, returned the summary content of PUFA and MUFA to the control level and decreased the summary content of SFA on the 30th day after the treatments, and promoted the restoration of the thymus weight of X-irradiated mice to 40th day of the observations. Conclusions: Changes in the content and composition of PUFA in the early period after treatments as well as at the restoration of the thymus weight under the combined action of EHF EMR and X-rays indicate to an active participation of FA in the acceleration of post-radiation recovery of the thymus by EHF EMR exposure.

Garaj-Vrhovac V, Horvat D, Koren Z, The effect of microwave radiation on the cell genome. Mutat Res 243(2):87-93, 1990.

Cultured V79 Chinese hamster cells were exposed to continuous radiation, frequency 7.7 GHz, power density 30 mW/cm2 for 15, 30, and 60 min. The parameters investigated were the incorporation of [3H]thymidine and the frequency of chromosome aberrations. Data obtained by 2 methods (the incorporation of [3H]thymidine into DNA and autoradiography) showed that the inhibition of [3H]thymidine incorporation took place by complete prevention of DNA from entering into the S phase. The normal rate of incorporation of [3H]thymidine was recovered within 1 generation cycle of V79 cells. Mutagenic tests performed concurrently showed that even DNA macromolecules were involved in the process. In comparison with the control samples there was a higher frequency of specific chromosome lesions in cells that had been irradiated. Results discussed in this study suggest that microwave radiation causes changes in the synthesis as well as in the structure of DNA molecules.

Garaj-Vrhovac V, Horvat D, Koren Z, The relationship between colony-forming ability, chromosome aberrations and incidence of micronuclei in V79 Chinese

hamster cells exposed to microwave radiation. Mutat Res 263(3):143-149, 1991.

Cultured V79 Chinese hamster fibroblast cells were exposed to continuous radiation, frequency 7.7 GHz, power density 0.5 mW/cm2 for 15, 30 and 60 min. The effect of microwave radiation on cell survival and on the incidence and frequency of micronuclei and structural chromosome aberrations was investigated. The decrease in the number of irradiated V79 cell colonies was related to the power density applied and to the time of exposure. In comparison with the control samples there was a significantly higher frequency of specific chromosome aberrations such as dicentric and ring chromosomes in irradiated cells. The presence of micronuclei in irradiated cells confirmed the changes that had occurred in chromosome structure. These results suggest that microwave radiation can induce damage in the structure of chromosomal DNA.

Garaj-Vrhovac V, Fucic A, Horvat D, The correlation between the frequency of micronuclei and specific chromosome aberrations in human lymphocytes exposed to microwave radiation in vitro. Mutat Res 281(3):181-186, 1992.

Human whole-blood samples were exposed to continuous microwave radiation, frequency 7.7 GHz, power density 0.5, 10 and 30 mW/cm2 for 10, 30 and 60 min. A correlation between specific chromosomal aberrations and the incidence of micronuclei after in vitro exposure was observed. In all experimental conditions, the frequency of all types of chromosomal aberrations was significantly higher than in the control samples. In the irradiated samples the presence of dicentric and ring chromosomes was established. The incidence of micronuclei was also higher in the exposed samples. The results of the structural chromosome aberration test and of the micronucleus test were comparatively analyzed. The values obtained showed a positive correlation between micronuclei and specific chromosomal aberrations (acentric fragments and dicentric chromosomes). The results of the study indicate that microwave radiation causes changes in the genome of somatic human cells and that the applied tests are equally sensitive for the detection of the genotoxicity of microwaves.

Garaj-Vrhovac, V, Micronucleus assay and lymphocyte mitotic activity in risk assessment of occupational exposure to microwave radiation. Chemosphere;39(13):2301-2312, 1999.

The effects of radiofrequency electromagnetic radiation (RFR) on the cell kinetics and genome damages in peripheral blood lymphocytes were determined in lymphocytes of 12 subjects occupationally exposed to microwave radiation. Results showed an increase in frequency of micronuclei (MN) as well as disturbances in the distribution of cells over the first, second and third mitotic division in exposed subjects compared to controls. According to previous reports micronucleus assay can serve as a suitable indicator for the assessment of exposure to genotoxic agents (such as RFR) and the analysis of mitotic activity as an additional parameter for the efficient biomonitoring.

Garaj-Vrhovac V, Gajski G, Pažanin S, Sarolić A, Domijan AM, Flajs D, Peraica M. Assessment of cytogenetic damage and oxidative stress in personnel occupationally exposed to the pulsed microwave radiation of marine radar equipment. Int J Hyg Environ Health. 4(1):59-65, 2011.

Due to increased usage of microwave radiation, there are concerns of its adverse effect in today's society. Keeping this in view, study was aimed at workers occupationally exposed to pulsed microwave radiation, originating from marine radars. Electromagnetic field strength was measured at assigned marine radar frequencies (3 GHz, 5.5 GHz and 9.4 GHz) and corresponding specific absorption rate values were determined. Parameters of the comet assay and micronucleus test were studied both in the exposed workers and in corresponding unexposed subjects. Differences between mean tail intensity (0.67 vs. 1.22) and moment (0.08 vs. 0.16) as comet assay parameters and micronucleus test parameters (micronuclei, nucleoplasmic bridges and nuclear buds) were statistically significant between the two examined groups, suggesting that cytogenetic alterations occurred after microwave exposure. Concentrations of glutathione and malondialdehyde were measured spectrophotometrically and using high performance liquid chromatography. The glutathione concentration in exposed group was significantly lower than in controls (1.24 vs. 0.53) whereas the concentration of malondialdehyde was significantly higher (1.74 vs. 3.17), indicating oxidative stress. Results suggests that pulsed microwaves from working environment can be the cause of genetic and cell alterations and that oxidative stress can be one of the possible mechanisms of DNA and cell damage.

Garcia Callejo FJ, Garcia Callejo F, Pena Santamaria J, Alonso Castaneira I, Sebastian Gil E, Marco Algarra J. [Hearing level and intensive use of mobile phones] Acta Otorrinolaringol Esp. 56(5):187-191, 2005. [Article in Spanish]

INTRODUCTION: Wide studies and substantial controversies build on utilization of actual mobile phones and appearance of systemic disorders or even tumours, but there is no knowledge about an eventual involvement on early hearing loss. PATIENTS AND METHODS: In a group of three hundred and twenty-three healthy and normoacoustic volunteers who were usual costumers of mobile phones an audiometric evaluation was made at the beginnig of its use and three years later, inquiring about the periods of time per day and year employed on direct contacts with phone. A healthy and normoacoustic control group of non users was studied too. RESULTS: Cases carried out 24.3 +/- 8.2 active contacts, reaching 50.4 +/- 27.8 days of mobile phone employment in three years. Audiometric curve was similar in cases and controls at the beginning of the study. After this follow-up, cases showed an increase on hearing threshold between 1 and 5 dB HL more than controls in speech tones ($p<0.001$). Moreover, there was a trend to correlate time of phone use to hearing impairment, but this finding did not result statistically significative. CONCLUSIONS: Frequent management of mobile phones in a middle period of time allows to detect a mild hearing loss, but the cause of this disorder keeps unclear.

Garson OM, McRobert TL, Campbell LJ, Hocking BA, Gordon I. A chromosomal study of workers with long-term exposure to radio-frequency radiation. Med J Aust 155(5):289-292, 1991.

OBJECTIVE: To examine whether an increased level of chromosome damage occurs in the stimulated lymphocytes of radio-linemen after long-term but intermittent exposure to radio-frequency radiation (RFR) during the course of their work. DESIGN AND

PARTICIPANTS: Chromosome studies were performed on blood samples from 38 radio-linemen matched by age with 38 controls, all of whom were employed by Telecom Australia. The radio-linemen had all worked with RFR in the range 400 kHz-20 GHz with exposures at or below the Australian occupational limits, and the controls were members of the clerical staff who had no exposure to RFR. Two hundred metaphases from each subject were studied and chromosome damage was scored by an observer who was blind to the status of the subjects. RESULTS: The ratio of the rate of aberrant cells in the radio-linemen group to that in the control group was 1.0 (95% confidence interval, 0.8-1.3). There were no statistically significant differences in the types of aberrations that were scored. CONCLUSION: Exposure to RFR at or below the described limits did not appear to cause any increase in chromosomal damage in circulating lymphocytes.

Gasmelseed A. Electromagnetic energy absorption patterns in subjects with common visual disorders. Electromagn Biol Med. 30(3):136-145, 2011.

This article describes the analysis of electromagnetic energy absorption properties of models of the human eye with common visual disorders. The investigation addresses two types of visual disorders, namely hyperopia (or farsightedness) and myopia (or nearsightedness). Calculations were carried out using plane multilayered method with common wireless communication frequencies of 900, 1800, and 2450 MHz. The effect of wireless radiation on the eye is studied by calculation of the specific absorption rate (SAR) in three different eye models. The results of the simulations confirmed the anticipated and more complex relationship between absorption and structural variations of the eye at these frequencies.

Gasmelseed A, Yunus J. The effects of metamaterial on electromagnetic fields absorption characteristics of human eye tissues. Prog Biophys Mol Biol. 2013 Nov 13. pii: S0079-6107(13)00113-2. doi: 10.1016/j. pbiomolbio.2013.10.004. [Epub ahead of print]

The interaction of a dipole antenna with a human eye model in the presence of a metamaterial is investigated in this paper. The finite difference time domain (FDTD) method with convolutional perfectly matched layer (CPML) formulation have been used. A three-dimensional anatomical model of the human eye with resolution of 1.25 mm × 1.25 mm × 1.25 mm was used in this study. The dipole antenna was driven by modulated Gaussian pulse and the numerical study is performed with dipole operating at 900 MHz. The analysis has been done by varying the size and value of electric permittivity of the metamaterial. By normalizing the peak SAR (1 g and 10 g) to 1 W for all examined cases, we observed how the SAR values are not affected by the different permittivity values with the size of the metamaterial kept fixed.

Gatta L, Pinto R, Ubaldi V, Pace L, Galloni P, Lovisolo GA, Marino C, Pioli C. Effects of In Vivo Exposure to GSM-Modulated 900 MHz Radiation on Mouse Peripheral Lymphocytes. Radiat Res. 160(5):600-605, 2003.

The aim of this study was to evaluate whether daily whole-body exposure to 900 MHz

GSM-modulated radiation could affect spleen lymphocytes. C57BL/6 mice were exposed 2 h/day for 1, 2 or 4 weeks in a TEM cell to an SAR of 1 or 2 W/kg. Untreated and sham-exposed groups were also examined. At the end of the exposure, mice were killed humanely and spleen cells were collected. The number of spleen cells, the percentages of B and T cells, and the distribution of T-cell subpopulations (CD4 and CD8) were not altered by the exposure. T and B cells were also stimulated ex vivo using specific monoclonal antibodies or LPS to induce cell proliferation, cytokine production and expression of activation markers. The results did not show relevant differences in either T or B lymphocytes from mice exposed to an SAR of 1 or 2 W/kg and sham-exposed mice with few exceptions. After 1 week of exposure to 1 or 2 W/kg, an increase in IFN-gamma (Ifng) production was observed that was not evident when the exposure was prolonged to 2 or 4 weeks. This suggests that the immune system might have adapted to RF radiation as it does with other stressing agents. All together, our in vivo data indicate that the T- and B-cell compartments were not substantially affected by exposure to RF radiation and that a clinically relevant effect of RF radiation on the immune system is unlikely to occur.

Geletyuk VI, Kazachenko VN, Chemeris NK, Fesenko EE, Dual effects of microwaves on single Ca(2+)-activated K+ channels in cultured kidney cells Vero. FEBS Lett 359(1):85-88, 1995.

Using the patch voltage-clamp method, possible effects of millimetre microwaves (42.25 GHz) on single Ca(2+)-activated K+ channels in cultured kidney cells (Vero) were investigated. It was found that exposure to the field of non-thermal power (about 100 microW/cm2) for 20-30 min greatly modifies both the Hill coefficient and an apparent affinity of the channels for Ca2+(i). The data suggest that the field alters both cooperativity and binding characteristics of the channel activation by internal Ca2+. The effects depend on initial sensitivity of the channels to Ca2+ and the Ca2+ concentration applied.

Geller L, Thuroczy G, Merkely B. Orv Hetil 142(36):1963-1970, 2001. [Article in Hungarian]

Electromagnetic compatibility (EMC) of cellular phones and pacemakers (PM) was examined in four different cellular phone system (NMT, GSM, RLL, DCS 1800 MHz) and in fifteen different PM type in-vitro and in-vivo in humans. After more than 1100 in-vitro and 130 in-vivo tests we concluded, that the electromagnetic immunity of the PMs which are implanted in Hungary is suitable with only few exceptions. The highest rate of EMC problems was observed with NMT 450 MHz cellular phones (10.5%-63%). There was no EMC disturbance observed with GSM and DCS 1800 MHz cellular phones. There was only one case when clinically significant symptom was noticed with only one PM type and with NMT system cellular phone when the distance of cellular phone was 3-4 cms, and the power was maximal. There was not any EMC disturbance observed with none of the cellular phone systems during normal talking and when the distance of the PM and cellular phone was more than 20 cms. Our study supports guidelines which suggest that PM patients should contact their physicians when using cellular phones and cellular phones and PMs should not get closer than 20 cms.

George DF, Bilek MM, McKenzie DR.Non-thermal effects in the microwave induced unfolding of proteins observed by chaperone binding. Bioelectromagnetics 29(4):324-330, 2008.

We study the effect of microwaves at 2,450 MHz on protein unfolding using surface plasmon resonance sensing. Our experimental method makes use of the fact that unfolding proteins tend to bind to chaperones on their unfolding pathway and this attachment is readily monitored by surface plasmon resonance. We use the protein citrate synthase (CS) for this study as it shows strong binding to the chaperone alpha crystallin when stressed by exposure to excess temperature. The results of microwave heating are compared with the effect of ambient heating and a combination of ambient and microwave heating to the same final temperature. We study the temperature distributions during the heating process. We show that microwaves cause a significantly higher degree of unfolding than conventional thermal stress for protein solutions heated to the same maximum temperature.

Gerner C, Haudek V, Schandl U, Bayer E, Gundacker N, Hutter HP, Mosgoeller W. Increased protein synthesis by cells exposed to a 1,800-MHz radio-frequency mobile phone electromagnetic field, detected by proteome profiling. Int Arch Occup Environ Health.83(6):691-702, 2010.

PURPOSE: To investigate whether or not low intensity radio frequency electromagnetic field exposure (RF-EME) associated with mobile phone use can affect human cells, we used a sensitive proteome analysis method to study changes in protein synthesis in cultured human cells. METHODS: Four different cell kinds were exposed to 2 W/kg specific absorption rate in medium containing (35)S-methionine/cysteine, and autoradiography of 2D gel spots was used to measure the increased synthesis of individual proteins. RESULTS: While short-term RF-EME did not significantly alter the proteome, an 8-h exposure caused a significant increase in protein synthesis in Jurkat T-cells and human fibroblasts, and to a lesser extent in activated primary human mononuclear cells. Quiescent (metabolically inactive) mononuclear cells, did not detectably respond to RF-EME. Since RF exposure induced a temperature increase of less than 0.15 degrees C, we suggest that the observed cellular response is a so called "athermal" effect of RF-EME. CONCLUSION: Our finding of an association between metabolic activity and the observed cellular reaction to low intensity RF-EME may reconcile conflicting results of previous studies. We further postulate that the observed increased protein synthesis reflects an increased rate of protein turnover stemming from protein folding problems caused by the interference of radio-frequency electromagnetic fields with hydrogen bonds. Our observations do not directly imply a health risk. However, vis-a-vis a synopsis of reports on cells stress and DNA breaks, after short and longer exposure, on active and inactive cells, our findings may contribute to the re-evaluation of previous reports.

Geronikolou S, Zimeras S, Davos CH, Michalopoulos I, Tsitomeneas S. Diverse Radiofrequency Sensitivity and Radiofrequency Effects of Mobile or Cordless Phone near Fields Exposure in Drosophila melanogaster. PLoS One. 2014 Nov 17;9(11):e112139. doi: 10.1371/journal.pone.0112139. eCollection 2014.

INTRODUCTION: The impact of electromagnetic fields on health is of increasing scientific interest. The aim of this study was to examine how the Drosophila melanogaster animal model is affected when exposed to portable or mobile phone fields.

METHODS/RESULTS: Two experiments have been designed and performed in the same laboratory conditions. Insect cultures were exposed to the near field of a 2G mobile phone (the GSM 2G networks support and complement in parallel the 3G wide band or in other words the transmission of information via voice signals is served by the 2G technology in both mobile phones generations) and a 1880 MHz cordless phone both digitally modulated by human voice. Comparison with advanced statistics of the egg laying of the second generation exposed and non-exposed cultures showed limited statistical significance for the cordless phone exposed culture and statistical significance for the 900 MHz exposed insects. We calculated by physics, simulated and illustrated in three dimensional figures the calculated near fields of radiation inside the experimenting vials and their difference. Comparison of the power of the two fields showed that the difference between them becomes null when the experimental cylinder radius and the height of the antenna increase. **CONCLUSIONS/SIGNIFICANCE:** Our results suggest a possible radiofrequency sensitivity difference in insects which may be due to the distance from the antenna or to unexplored intimate factors. Comparing the near fields of the two frequencies bands, we see similar not identical geometry in length and height from the antenna and that lower frequencies tend to drive to increased radiofrequency effects.

Geronikolou SA, Chamakou A, Mantzou A, Chrousos G, KanakaGantenbein C. Frequent cellular phone use modifies hypothalamic-pituitary-adrenal axis response to a cellular phone call after mental stress in healthy children and adolescents: A pilot study. Sci Total Environ. 536:182-188, 2015.

OBJECTIVE: The hypothalamic-pituitary-adrenal (HPA) axis is the main "gate-keeper" of the organism's response to every somatic or mental stress. This prospective study aims to investigate the HPA-axis response to a cellular phone call exposure after mental stress in healthy children and adolescents and to assess the possible predictive role of baseline endocrine markers to this response. SUBJECTS AND METHODS: Two groups of healthy school-age children aged 11-14 (12.5±1.5) years were included in the study, the one comprising those who are occasional users of a cellular phone (Group A; n=16)) while the second those who do regularly use one (Group B; n=12). Blood samples were obtained from all participants at 8.00am after a 12-hour overnight fasting for thyroid hormone, glucose, insulin, and cortisol levels determination. The participants performed the Trier Social Stress Test for Children (TSST-C) (5 min oral task followed by 5min arithmetic task). Salivary cortisol samples were obtained at baseline, 10 and 20 min after the TSST-C and 10 and 20 min after a 5-minute cellular phone call. RESULTS: Significant changes in the salivary cortisol levels were noted between 10 and 20 mins after the cellular phone call with different responses between the two groups. Baseline thyroid hormone levels seem to predict the cortisol response to mental stress mainly in group A, while HOMA (homostasis model assessment) had no impact on salivary cortisol response at any phase of the test, in either group.
CONCLUSIONS: HPA axis response to cellular phone after mental stress in children and adolescents follow a different pattern in frequent users than in occasional users that seems to be influenced by the baseline thyroid hormone levels.

Gevrek F. Histopathological, immunohistochemical, and stereological analysis of the effect of Gingko biloba (Egb761) on the hippocampus of rats exposed to long-term cellphone radiation. Histol Histopathol. 2017 Nov 9:11943.

Cellular phones are major sources of electromagnetic radiation (EMR) that can penetrate the human body and pose serious health hazards. The increasingly widespread use of mobile communication systems has raised concerns about the effects of cellphone radiofrequency (RF) on the hippocampus because of its close proximity to radiation during cellphone use. The effects of cellphone EMR exposure on the hippocampus of rats and the possible counteractive effects of ginkgo biloba (Egb761) were aimed to investigate. Rats were divided into three groups: Control, EMR, and EMR+Egb761. The EMR and EMR+Egb761 groups were exposed to cellphone EMR for one month. Egb761 was also administered to the EMR+Egb761 group. Specifically, we evaluated the effect of RF exposure on rat hippocampi at harmful EMR levels (0.96 W/kg specific absorption rate [SAR]) for one month and also investigated the possible impact of ginkgo biloba (Egb761) using stereological, TUNEL-staining, and immunohistochemical methods. An increase in apoptotic proteins (Bax, Acas-3) and a decrease in anti-apoptotic protein (Bcl-2) immunoreactivity along with a decrease in the total granule and pyramidal cell count were noted in the EMR group. A decrease in Bax and Acas-3 and an increase in Bcl-2 immunoreactivity were observed in rats treated with Egb761 in addition to a decrease in TUNEL-stained apoptotic cells and a higher total viable cell number. In conclusion, chronic cellphone EMR exposure may affect hippocampal cell viability, and Egb761 may be used to mitigate some of the deleterious effects.

Ghanbari M, Mortazavi SB, Khavanin A, Khazaei M. The Effects of Cell Phone Waves (900 MHz-GSM Band) on Sperm Parameters and Total Antioxidant Capacity in Rats. Int J Fertil Steril. 7(1):21-28, 2013.

BACKGROUND: There is tremendous concern regarding the possible adverse effects of cell phone microwaves. Contradictory results, however, have been reported for the effects of these waves on the body. In the present study, the effect of cell phone microwaves on sperm parameters and total antioxidant capacity was investigated with regard to the duration of exposure and the frequency of these waves. MATERIALS AND METHODS: This experimental study was performed on 28 adult male Wistar rats (200-250 g). The animals were randomly assigned to four groups (n=7): i. control; ii. two-week exposure to cell phone-simulated waves; iii. three-week exposure to cell phonesimulated waves; and iv. two-week exposure to cell phone antenna waves. In all groups, sperm analysis was performed based on standard methods and we determined the mean sperm total antioxidant capacity according to the ferric reducing ability of plasma (FRAP) method. Data were analyzed by one-way ANOVA followed by Tukey's test using SPSS version 16 software. RESULTS: The results indicated that sperm viability, motility, and total antioxidant capacity in all exposure groups decreased significantly compared to the control group ($p<0.05$). Increasing the duration of exposure from 2 to 3 weeks caused a statistically significant decrease in sperm viability and motility ($p<0.05$). CONCLUSION: Exposure to cell phone waves can decrease sperm viability and motility in rats. These waves can also decrease sperm total antioxidant capacity in rats and result in oxidative stress.

Ghanmi A, Varsier N, Hadjem A, Conil E, Picon O, Wiart J. Analysis of the influence of handset phone position on RF exposure of brain tissue. Bioelectromagnetics. 34(8):568-579, 2014.

Exposure to mobile phone radio frequency (RF) electromagnetic fields depends on many different parameters. For epidemiological studies investigating the risk of brain cancer linked to RF exposure from mobile phones, it is of great interest to characterize brain tissue exposure and to know which parameters this exposure is sensitive to. One such parameter is the position of the phone during communication. In this article, we analyze the influence of the phone position on the brain exposure by comparing the specific absorption rate (SAR) induced in the head by two different mobile phone models operating in Global System for Mobile Communications (GSM) frequency bands. To achieve this objective, 80 different phone positions were chosen using an experiment based on the Latin hypercube sampling (LHS) to select a representative set of positions. The averaged SAR over 10 g (SAR_{10g}) in the head, the averaged SAR over 1 g (SAR_{1g}) in the brain, and the averaged SAR in different anatomical brain structures were estimated at 900 and 1800 MHz for the 80 positions. The results illustrate that SAR distributions inside the brain area are sensitive to the position of the mobile phone relative to the head. The results also show that for 5-10% of the studied positions the SAR_{10g} in the head and the SAR_{1g} in the brain can be 20% higher than the SAR estimated for the standard cheek position and that the Specific Anthropomorphic Mannequin (SAM) model is conservative for 95% of all the studied positions.

Ghatei N, Nabavi AS, Toosi MHB, Azimian H, Homayoun M, Targhi RG, Haghir H. Evaluation of bax, bcl-2, p21 and p53 genes expression variations on cerebellum of BALB/c mice before and after birth under mobile phone **radiation exposure. Iran J Basic Med Sci. 20(9):1037-1043, 2017.**

OBJECTIVES: The increasing rate of over using **cell phones** has been considerable in youths and pregnant women. We examined the effect of **mobile phones** radiation on genes expression variation on cerebellum of BALB/c mice before and after of the birth. MATERIALS AND METHODS: In this study, a **mobile phone** jammer, which is an instrument to prevent receiving signals between cellular **phones** and base transceiver stations (two frequencies 900 and 1800 MHz) for exposure was used and twelve pregnant mice (BALB/c) divided into two groups (n=6), first group irradiated in pregnancy period (19th day), the second group did not irradiate in pregnancy period. After childbirth, offspring were classified into four groups (n=4): Group1: control, Group 2: B1 (Irradiated after birth), Group 3: B2 (Irradiated in pregnancy period and after birth), Group 4: B3 (Irradiated in pregnancy period). When maturity was completed (8-10 weeks old), mice were dissected and cerebellum was isolated. The expression level of *bax*, bcl-2, p21 and *p53* genes examined by real-time reverse transcription polymerase chain reaction (Real-Time RT- PCR). RESULTS: The data showed that **mobile phone** radio waves were ineffective on the expression level of bcl-2 and p53 genes) $P>0.05$(. Also gene expression level of *bax* decreased and gene expression level of *p21* increased comparing to the control group ($P<0.05$). CONCLUSION: From the obtained data it could be concluded that the **mobile phone**

radiations did not induce apoptosis in cells of the cerebellum and the injured cells can be repaired by **cell** cycle arrest.

Ghazizadeh V, Nazıroğlu M. Electromagnetic radiation (Wi-Fi) and epilepsy induce calcium entry and apoptosis through activation of TRPV1 channel in hippocampus and dorsal root ganglion of rats. Metab Brain Dis. 29(3):787-799, 2014.

Incidence rates of epilepsy and use of Wi-Fi worldwide have been increasing. TRPV1 is a Ca^{2+} permeable and non-selective channel, gated by noxious heat, oxidative stress and capsaicin (CAP). The hyperthermia and oxidant effects of Wi-Fi may induce apoptosis and Ca^{2+} entry through activation of TRPV1 channel in epilepsy. Therefore, we tested the effects of Wi-Fi (2.45 GHz) exposure on Ca^{2+} influx, oxidative stress and apoptosis through TRPV1 channel in the murine dorsal root ganglion (DRG) and hippocampus of pentylentetrazol (PTZ)-induced epileptic rats. Rats in the present study were divided into two groups as controls and PTZ. The PTZ groups were divided into two subgroups namely PTZ + Wi-Fi and PTZ + Wi-Fi + capsazepine (CPZ). The hippocampal and DRG neurons were freshly isolated from the rats. The DRG and hippocampus in PTZ + Wi-Fi and PTZ + Wi-Fi + CPZ groups were exposed to Wi-Fi for 1 hour before CAP stimulation. The cytosolic free Ca^{2+}, reactive oxygen species production, apoptosis, mitochondrial membrane depolarization, caspase-3 and -9 values in hippocampus were higher in the PTZ group than in the control although cell viability values decreased. The Wi-Fi exposure induced additional effects on the cytosolic Ca^{2+} increase. However, pretreatment of the neurons with CPZ, results in a protection against epilepsy-induced Ca^{2+} influx, apoptosis and oxidative damages. In results of whole cell patch-clamp experiments, treatment of DRG with Ca^{2+} channel antagonists [thapsigargin, verapamil + diltiazem, 2-APB, MK-801] indicated that Wi-Fi exposure induced Ca^{2+} influx via the TRPV1 channels. In conclusion, epilepsy and Wi-Fi in our experimental model is involved in Ca^{2+} influx and oxidative stress-induced hippocampal and DRG death through activation of TRPV1 channels, and negative modulation of this channel activity by CPZ pretreatment may account for the neuroprotective activity against oxidative stress.

Ghosn R, Thuróczy G, Loos N, Brenet-Dufour V, Liabeuf S, de Seze R, Selmaoui B. Effects of GSM 900 MHz on Middle Cerebral Artery Blood Flow Assessed by Transcranial Doppler Sonography.Radiat Res. 178(6):543-550, 2012.

Mobile phone use has increased worldwide but its possible effects on the brain remain unclear. The aim of the present study was to investigate the effect of acute exposure to a radio frequency electromagnetic field (RF EMF) generated by a mobile phone operating in the Global System for Mobile Communication (GSM) 900 MHz on cerebral blood flow. Twenty-nine volunteers attended two experimental sessions: a sham exposure session and a real exposure session in a cross-over double-blind study in which a mobile phone was positioned on the left side of the head. In one session, the mobile phone was operated without RF radiation (sham phone) and in the other study it was operated with RF radiation (real phone) for 20 min. Thus, each subject served as its own control. Middle cerebral artery blood flow was monitored noninvasively by transcranial Doppler sonography to measure middle cerebral artery blood flow velocity. Pulsatility index and

resistance index were also evaluated. A voluntary breath holding physiological test was carried out as a positive control for testing cerebral vasoreactivity. Hemodynamic variables were recorded and analyzed before, during and after mobile phone exposure. No significant changes were detected in studied variables in middle cerebral arteries during sham or real exposure. In the exposed side the cerebral blood flow velocity, the pulsatility index and the resistance index during sham and real exposure were respectively: [61.9 ± 1.3, 61.7 ± 1.3 cm/s (P = 0.89)]; [0.93 ± 0.03, 0.90 ± 0.02 (P = 0.84)] and [0.58 ± 0.01, 0.58 ± 0.01 (P = 0.96)] at baseline; and [60.6 ± 1.3, 62 ± 1.6 cm/s (P = 0.40)]; [0.91 ± 0.03, 0.87 ± 0.03 (P = 0.97)]; [0.57 ± 0.01, 0.56 ± 0.01 (P = 0.82)] after 20 min of exposure. Twenty minutes of RF exposure to a mobile phone does not seem to affect the cerebral circulation.

Ghosn R, Yahia-Cherif L, Hugueville L, Ducorps A, Lemarechal JD, Thuroczy G, de Seze R, Selmaoui B. Radiofrequency signal affects alpha band in resting electroencephalogram. J Neurophysiol. 2015 Feb 18:jn.00765.2014. doi: 10.1152/jn.00765.2014. [Epub ahead of print]

Objective: The aim of the present work was to investigate the effects of the radiofrequency (RF) electromagnetic fields (EMFs) on human resting EEG with a control of some parameters that are known to affect alpha band such as electrode impedance, salivary cortisol and caffeine. Methods: Eyes open and eyes-closed resting EEG data were recorded in 26 healthy young subjects under two conditions: sham exposure and real exposure in double-blind, counterbalanced, crossover design. Spectral power of EEG rhythms was calculated for the alpha band (8-12Hz). Saliva samples were collected before and after the study. Salivary cortisol and caffeine were assessed respectively by Enzyme linked immunosorbent assay (ELISA) and high performance liquid chromatography (HPLC). The electrode impedance was recorded at the beginning of each run. Results: Compared with sham session, the exposure session showed a statistically significant ($p < 0.0001$) decrease of the alpha band spectral power during closed eyes condition. This effect persisted in the post-exposure session ($p < 0.0001$). No significant changes were detected in electrode impedance, salivary cortisol and caffeine in the sham session when compared to the exposure one. Conclusions: These results suggest that GSM-EMFs of a mobile phone affect alpha band within spectral power of resting human EEG.

Gkonis F, Boursianis A, Samaras T. Electromagnetic Field Exposure Changes Due to the Digital Television Switchover in Thessaloniki, Greece. Health Phys. 2017 Nov;113(5):382-386.

In the present work, the changes in the exposure to electromagnetic fields due to television signals incurred by the digital switchover in Thessaloniki, Greece, are investigated. It is shown that the measured electric fields comply with ICNIRP guidelines but are higher than those in the reported literature for other countries. However, this may be attributed to the selection of measurement points. Moreover, it is shown that the median value of the power density dropped from 60 μW m during analog broadcasting to

13.3 µW m for digital television. This finding indicates that the digital switchover has resulted in reduced exposure for the population to radiofrequency fields in the UHF range.

Gläser K, Rohland M, Kleine-Ostmann T, Schrader T, Stopper H, Hintzsche H. Effect of Radiofrequency Radiation on Human Hematopoietic Stem Cells. Radiat Res. 186(5):455-465, 2016.

Exposure to electromagnetic fields in the radiofrequency range is ubiquitous, mainly due to the worldwide use of mobile communication devices. With improving technologies and affordability, the number of cell phone subscriptions continues to increase. Therefore, the potential effect on biological systems at low-intensity radiation levels is of great interest. While a number of studies have been performed to investigate this issue, there has been no consensus reached based on the results. The goal of this study was to elucidate the extent to which cells of the hematopoietic system, particularly human hematopoietic stem cells (HSC), were affected by mobile phone radiation. We irradiated HSC and HL-60 cells at frequencies used in the major technologies, GSM (900 MHz), UMTS (1,950 MHz) and LTE (2,535 MHz) for a short period (4 h) and a long period (20 h/66 h), and with five different intensities ranging from 0 to 4 W/kg specific absorption rate (SAR). Studied end points included apoptosis, oxidative stress, cell cycle, DNA damage and DNA repair. In all but one of these end points, we detected no clear effect of mobile phone radiation; the only alteration was found when quantifying DNA damage. Exposure of HSC to the GSM modulation for 4 h caused a small but statistically significant decrease in DNA damage compared to sham exposure. To our knowledge, this is the first published study in which putative effects (e.g., genotoxicity or influence on apoptosis rate) of radiofrequency radiation were investigated in HSC. Radiofrequency electromagnetic fields did not affect cells of the hematopoietic system, in particular HSC, under the given experimental conditions.

Glenister H, How do mobile phones affect electromedical devices? Nurs Times 94(15):44-45, 1998.

Mobile telephones and other electronic communication devices can interfere with medical equipment when used in close proximity. A study of different devices by the Medical Devices Agency showed that emergency services' radio handsets were the most likely to cause interference. It recommends that cell telephones be switched off in theatres and treatment areas and at a patients' bedsides where sensitive medical devices are in use.

Gobba F. [Subjective non-specific symptoms related with electromagnetic fields: description of 2 cases].Epidemiol Prev. 26(4):171-175, 2002. [Article in Italian]

In Italy, as in other countries, an apparently increasing number of subjects is reporting a variety of subjective symptoms that the subjects themselves refer to the exposure to electric, magnetic or electromagnetic fields (EMF) from nearby electric appliances, cellular phones, antennas, etc. Terms like electricity hypersensitivity (EHS), EMF hypersensitivity, or other similar, are frequently adopted to describe such symptoms;

nevertheless, up to now, these terms are not entered the medical terminology. No accepted diagnostic criteria or procedures for the diagnosis of EHS are currently available. Furthermore, apart from the subject's self-attribution of the symptoms to EMFs, no direct cause-effect relationship between EHS symptoms and electromagnetic fields has been proved; additionally, evidence of a possible pathogenetic mechanism is lacking. In this paper, two cases developing symptoms of EHS ascribed to overhead power line in the proximity of their house are discussed. Nervous system (asthenia, depression, paraesthesias etc.), cardiovascular system (cardiac palpitations) and the skin (tingling, itching, etc.), are mostly (but not exclusively) involved. Based on available scientific knowledge, the rationale for an approach to subjects claiming for EHS is discussed. The establishment of a National archive for the collection of cases is needed.

Golden C, Golden CJ, Schneider B. Cell phone use and visual attention. Percept Mot Skills. 97(2):385-389, 2003.

The purpose of the present study was to evaluate how much cell phones and just speaking (similar to speaking to someone in the car vs a hands-free cell phone task) interfere with visual attention skills as might be required in a driving situation. Influence of cell phones on attention has been noted but little research has been completed. Licensed adult drivers were divided into three groups (ns = 15) with all subjects taking the Connors Continuous Performance Test II. Group 1 performed without any distractions: those in Group 2 performed with someone in the same room talking to them: Group 3 engaged in a cell phone conversation during the task. Overall, there were substantial differences among groups on all variables, but primarily between the control group and the two experimental groups. While the cell phone group had lower mean scores than the talking group overall, the differences were not significant. Thus, while cell phones were distracting to visual attention functions on the Connors task, they were not more distracting than a similarly active conversation without a cell phone.

Goldoni J, Hematological changes in peripheral blood of workers occupationally exposed to microwave radiation. Health Physics 58:205-207, 1990.

In a group of 14 men occupationally exposed to microwaves, hematological examinations were performed at an interval of 2 years. The exposed group consisted of male radar technicians working in air traffic control. They were exposed to pulsed microwaves of various frequencies within the whole range used in radar operations for 7-14 years. Controls were 10 male electronic technicians working at the airport, but far from any sources of microwave radiation. The results of hematological examinations at a 2-year interval in the exposed group show a significant decrease in thrombocyte and leukocyte counts. The number of leukocytes and erythrocytes in the peripheral blood was significantly lower in the exposed than in the control group. There was no significant difference in reticulocyte and lymphocyte counts.

Goldoni J, Durek M, Koren Z, Health status of personnel occupationally exposed to radiowaves. Arh Hig Rada Toksikol 44(3):223-228, 1993.

The findings of medical examinations performed in two groups of persons occupationally exposed to microwaves and radiofrequency radiation are presented in comparison with control findings. A group of 49 radar operators from the Zagreb Air Traffic Control was

examined twice within a period of 18 months. The other group comprised 46 workers employed in radio relay stations. The control group were 46 workers from the Zagreb Airport. A follow-up study showed significant changes in haematological and biochemical parameters, in electrical brain activity and in capillaroscopic and ophthalmological findings in the group of radar operators within the followed period. For that group a cross-sectional study of the differences in general health status also showed the highest rate of changes. The results indicate that long-term occupational exposure to microwaves and radiofrequencies may damage sensitive organic systems.

Goldwein O, Aframian DJ. The influence of handheld mobile phones on human parotid gland secretion. Oral Dis.16(2):146-150, 2010.

Abstract. BACKGROUND: Handheld mobile phones (MPHs) have become a 'cultural' accessory device, no less so than a wrist watch. Nevertheless, the use of MPHs has given rise to great concern because of possible adverse health effects from exposure to the radiofrequency radiation (RFR) emitted by the device. Previous studies suggested correlation between MPH and salivary gland tumors. OBJECTIVE: To evaluate whether MPH induces physiologic changes in the adjacent parotid gland, located on the dominant side, in terms of secretion rates and protein levels in the secreted saliva. MATERIALS AND METHOD: Stimulated parotid saliva was collected simultaneously from both glands in 50 healthy volunteers whose MPH use was on a dominant side of the head. RESULTS: A significantly higher saliva secretion rate was noticed in the dominant MPH side compared with that in the non-dominant side. Lower total protein concentration was obtained in the dominant compared with the non-dominant MPH side among the right dominant MPH users. CONCLUSIONS: Parotid glands adjacent to handheld MPH in use respond by elevated salivary rates and decreased protein secretion reflecting the continuous insult to the glands. This phenomenon should be revealed to the worldwide population and further exploration by means of large-scale longitudinal studies is warranted.

Gökçek-Saraç Ç, Er H, Kencebay Manas C, Kantar Gok D, Özen Ş, Derin N. Effects of acute and chronic exposure to both 900 **MHz and 2100 MHz electromagnetic radiation on glutamate receptor signaling pathway. Int J Radiat Biol. 93(9):980-989, 2017.**

PURPOSE: To demonstrate the molecular effects of acute and chronic exposure to both **900** and 2100 MHz radiofrequency electromagnetic radiation (RF-EMR) on the hippocampal level/activity of some of the enzymes - including PKA, CaMKIIα, CREB, and p44/42 MAPK - from N-methyl-D-aspartate receptor (NMDAR)-related signaling pathways.MATERIALS AND METHODS: Rats were divided into the following groups: sham rats, and rats exposed to **900** and 2100 MHz RF-EMR for 2 h/day for acute (1 week) or chronic (10 weeks), respectively. Western blotting and activity measurement assays were used to assess the level/activity of the selected enzymes.RESULTS: The obtained results revealed that the hippocampal level/activity of selected enzymes was significantly higher in the chronic groups as compared to the acute groups at both **900** and 2100 MHz RF-EMR exposure. In addition, hippocampal level/activity of selected enzymes was significantly higher at 2100 MHz RF-EMR than **900** MHz RF-EMR in both

acute and chronic groups.CONCLUSIONS: The present study provides experimental evidence that both exposure duration (1 week versus 10 weeks) and different carrier frequencies (**900** vs. 2100 MHz) had different effects on the protein expression of hippocampus in Wistar rats, which might encourage further research on protection against RF-EMR exposure.

Gómez-Perretta C, Navarro EA, Segura J, Portolés M. Subjective symptoms related to GSM radiation from mobile phone base stations: a cross-sectional study. BMJ Open. 3(12):e003836, 2013. doi: 10.1136/bmjopen-2013-003836.

OBJECTIVES: We performed a re-analysis of the data from Navarro et al (2003) in which health symptoms related to microwave exposure from mobile phone base stations (BSs) were explored, including data obtained in a retrospective inquiry about fear of exposure from BSs. DESIGN: Cross-sectional study. SETTING: La Ñora (Murcia), Spain. PARTICIPANTS: Participants with known illness in 2003 were subsequently disregarded: 88 participants instead of 101 (in 2003) were analysed. Since weather circumstances can influence exposure, we restricted data to measurements made under similar weather conditions. OUTCOMES AND METHODS: A statistical method indifferent to the assumption of normality was employed: namely, binary logistic regression for modelling a binary response (eg, suffering fatigue (1) or not (0)), and so exposure was introduced as a predictor variable. This analysis was carried out on a regular basis and bootstrapping (95% percentile method) was used to provide more accurate CIs. RESULTS: The symptoms most related to exposure were lack of appetite (OR=1.58, 95% CI 1.23 to 2.03); lack of concentration (OR=1.54, 95% CI 1.25 to 1.89); irritability (OR=1.51, 95% CI 1.23 to 1.85); and trouble sleeping (OR=1.49, 95% CI 1.20 to 1.84). Changes in -2 log likelihood showed similar results. Concerns about the BSs were strongly related with trouble sleeping (OR =3.12, 95% CI 1.10 to 8.86). The exposure variable remained statistically significant in the multivariate analysis. The bootstrapped values were similar to asymptotic CIs. CONCLUSIONS: This study confirms our preliminary results. We observed that the incidence of most of the symptoms was related to exposure levels-independently of the demographic variables and some possible risk factors. Concerns about adverse effects from exposure, despite being strongly related with sleep disturbances, do not influence the direct association between exposure and sleep.

Gorlitz BD, Muller M, Ebert S, Hecker H, Kuster N, Dasenbrock C. Effects of 1-week and 6-week exposure to GSM/DCS radiofrequency radiation on micronucleus formation in B6C3F1 Mice. Radiat Res. 164(4):431-439, 2005.

The aim of this study was to examine the possible induction of micronuclei in erythrocytes of the peripheral blood and bone marrow and in keratinocytes and spleen lymphocytes of mice exposed to radiofrequency (RF) radiation for 2 h per day over periods of 1 and 6 weeks, respectively. The applied signal simulated the exposure from GSM900 and DCS1800 handsets, including the low-frequency amplitude-modulation components as they occur during speaking (GSM Basic), listening (DTX) and moving within the environment (handovers, power control). The carrier frequency was set to the center of

the system's uplink band, i.e., 902 MHz for GSM and 1747 MHz for DCS. Uniform whole-body exposure was achieved by restraining the mice in tubes at fixed positions in the exposure setup. Mice were exposed to slot-averaged whole-body SARs of 33.2, 11.0, 3.7 and 0 mW/g during the 1-week study and 24.9, 8.3, 2.8 and 0 mW/g during the 6-week study. Exposure levels for the 1- and 6-week studies were determined in a pretest to confirm that no thermal effect was present that could influence the genotoxic end points. During both experiments and for both frequencies, no clinical abnormalities were detected in the animals. Cells of the bone marrow from the femur (1-week study), erythrocytes of the peripheral blood (6-week study), keratinocytes from the tail root, and lymphocytes from the spleen (both studies) were isolated on slides and stained for micronucleus analysis. Two thousand cells per animal were scored in erythrocyte and keratinocyte samples. In spleen lymphocytes, 1000 binucleated lymphocytes were scored for each animal. The RF-field exposure had no influence on the formation of red blood cells. After 1 week of exposure, the ratio of polychromatic to normochromatic erythrocytes was unchanged in the treated groups compared to the sham-exposed groups. Furthermore, the RF-field exposure of mice did not induce an increase in the number of micronuclei in erythrocytes of the bone marrow or peripheral blood, in keratinocytes, or in spleen lymphocytes compared to the sham-treated control.

Gorpinchenko I, Nikitin O, Banyra O, Shulyak A. The influence of direct mobile phone radiation on sperm quality. Cent European J Urol. 67(1):65-71, 2014.

INTRODUCTION: It is impossible to imagine a modern socially-active man who does not use mobile devices and/or computers with Wi-Fi function. The effect of mobile phone radiation on male fertility is the subject of recent interest and investigations. The aim of this study was to investigate the direct in vitro influence of mobile phone radiation on sperm DNA fragmentation and motility parameters in healthy subjects with normozoospermia. **MATERIAL AND METHODS:** 32 healthy men with normal semen parameters were selected for the study. Each sperm sample was divided into two equal portions (A and B). Portions A of all involved men were placed for 5 hours in a thermostat, and portions B were placed into a second thermostat for the same period of time, where a mobile phone in standby/talk mode was placed. After 5 hours of incubation the sperm samples from both thermostats were re-evaluated regarding basic motility parameters. The presence of DNA fragmentation in both A and B portions of each sample was determined each hour using a standard sperm chromatin dispersion test. **RESULTS:** The number of spermatozoa with progressive movement in the group, influenced by electromagnetic radiation, is statistically lower than the number of spermatozoa with progressive movement in the group under no effect of the mobile phone. The number of non-progressive movement spermatozoa was significantly higher in the group, which was influenced by cell phone radiation. The DNA fragmentation was also significantly higher in this group. **CONCLUSIONS:** A correlation exists between mobile phone radiation exposure, DNA-fragmentation level and decreased sperm motility.

Gos, P, Eicher, B, Kohli, J, Heyer, WD, Extremely high frequency electromagnetic fields at low power density do not affect the division of exponential phase Saccharomyces cerevisiae cells. Bioelectromagnetics 18(2):142-155, 1997.

Exponentially growing cells of the yeast Saccharomyces cerevisiae were exposed to

electromagnetic fields in the frequency range from 41.682 GHz to 41.710 GHz in 2 MHz increments at low power densities (0.5 microW/cm2 and 50 microW/cm2) to observe possible nonthermal effects on the division of this microorganism. The electronic setup was carefully designed and tested to allow precise determination and stability of the electromagnetic field parameters as well as to minimize possible effects of external sources. Two identical test chambers were constructed in one exposure system to perform concurrent control and test experiments at every frequency step under well-controlled exposure conditions. Division of cells was assessed via time-lapse photography. Control experiments showed that the cells were dividing at submaximal rates, ensuring the possibility of observing either an increase or a decrease of the division rate. The data from several independent series of exposure experiments and from control experiments show no consistently significant differences (between) exposed and unexposed cells. This is in contrast to previous studies claiming nonthermal effects of electromagnetic fields in this frequency range on the division of S. cerevisiae cells. Possible reasons for this difference are discussed.

Gos P, Eicher B, Kohli J, Heyer WD, No mutagenic or recombinogenic effects of mobile phone fields at 900 MHz detected in the yeast saccharomyces cerevisiae. Bioelectromagnetics 21(7):515-523, 2000.

Both actively growing and resting cells of the yeast Saccharomyces cerevisiae were exposed to 900-MHz fields that closely matched the Global System for Mobile Communication (GSM) pulsed modulation format signals for mobile phones at specific absorption rates (SAR) of 0.13 and 1.3 W/kg. Two identical anechoic test chambers were constructed to perform concurrent control and test experiments under well-controlled exposure conditions. Using specific test strains, we examined the genotoxic potential of mobile phone fields, alone and in combination, with a known genotoxic compound, the alkylating agent methyl methansulfonate. Mutation rates were monitored by two test systems, a widely used gene-specific forward mutation assay at CAN1 and a wide-range assay measuring the induction of respiration-deficient (petite) clones that have lost their mitochondrial function. In addition, two further assays measured the recombinogenic effect of mobile phone fields to detect possible effects on genomic stability: First, an intrachromosomal, deletion-formation assay previously developed for genotoxic screening; and second, an intragenic recombination assay in the ADE2 gene. Fluctuation tests failed to detect any significant effect of mobile phone fields on forward mutation rates at CAN1, on the frequency of petite formation, on rates of intrachromosomal deletion formation, or on rates of intragenic recombination in the absence or presence of the genotoxic agent methyl methansulfonate.

Goswami PC, Albee LD, Parsian AJ, Baty JD, Moros EG, Pickard WF, Roti Roti JL, Hunt CR, Proto-oncogene mRNA levels and activities of multiple transcription factors in C3H 10T 1/2 murine embryonic fibroblasts exposed to 835.62 and 847.74 MHz cellular phone communication frequency radiation. Radiat Res 151(3):300-309, 1999.

This study was designed to determine whether two differently modulated radiofrequencies of the type generally used in cellular phone communications could elicit a general stress response in a biological system. The two modulations and frequencies

studied were a frequency-modulated continuous wave (FMCW) with a carrier frequency of 835.62 MHz and a code division multiple-access (CDMA) modulation centered on 847.74 MHz. Changes in proto-oncogene expression, determined by measuring Fos, Jun, and Myc mRNA levels as well as by the DNA-binding activity of the AP1, AP2 and NF-kappaB transcription factors, were used as indicators of a general stress response. The effect of radiofrequency exposure on proto-oncogene expression was assessed (1) in exponentially growing C3H 10T 1/2 mouse embryo fibroblasts during their transition to plateau phase and (2) during transition of serum-deprived cells to the proliferation cycle after serum stimulation. Exposure of serum-deprived cells to 835.62 MHz FMCW or 847.74 MHz CDMA microwaves (at an average specific absorption rate, SAR, of 0.6 W/kg) did not significantly change the kinetics of proto-oncogene expression after serum stimulation. Similarly, these exposures did not affect either the Jun and Myc mRNA levels or the DNA-binding activity of AP1, AP2 and NF-kappaB in exponential cells during transit to plateau-phase growth. Therefore, these results suggest that the radiofrequency exposure is unlikely to elicit a general stress response in cells of this cell line under these conditions. However, statistically significant increases (approximately 2-fold, P = 0.001) in Fos mRNA levels were detected in exponential cells in transit to the plateau phase and in plateau-phase cells exposed to 835.62MHz FMCW microwaves. For 847.74 MHz CDMA exposure, the increase was 1.4-fold (P = 0.04). This increase in Fos expression suggests that expression of specificgenes could be affected by radiofrequency exposure.

Grafström G, Nittby H, Brun A, Malmgren L, Persson BR, Salford LG, Eberhardt J. Histopathological examinations of rat brains after long-term exposure to GSM-900 mobile phone radiation. Brain Res Bull.77(5):257-263, 2008.

In order to mimic the real life situation, with often life-long exposure to the electromagnetic fields emitted by mobile phones, we have investigated in a rat model the effects of repeated exposures under a long period to Global System for Mobile Communication-900MHz (GSM-900) radiation. Out of a total of 56 rats, 32 were exposed once weekly in a 2-h period, for totally 55 weeks, at different average whole-body specific absorption rates (SAR) (of in average 0.6 and 60mW/kg at the initiation of the experimental period). The animals were exposed in a transverse electromagnetic transmission line chamber (TEM-cell) to radiation 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 behavioural tests, 5-7 weeks after the last exposure, the brains were evaluated for histopathological alterations such as albumin extravasation, dark neurons, lipofuscin aggregation and signs of cytoskeletal and neuritic neuronal changes of the type seen in human ageing. In this study, no significant alteration of any these histopathological parameters was found, when comparing the GSM exposed animals to the sham exposed controls.

Graham JM Jr, Jones KL, Brent RL, Contribution of clinical teratologists and geneticists to the evaluation of the etiology of congenital malformations alleged to be caused by environmental agents: ionizing radiation, electromagnetic fields, microwaves, radionuclides, and ultrasound. Teratology 59(4):307-313, 1999.

Analysis of these six clinical problems demonstrates the value of a complete clinical

evaluation of a child with congenital malformations by an experienced and well-trained physician who is familiar with the fields of developmental biology, teratology , epidemiology, and genetics. Too often, the entire emphasis is placed on epidemiological data that may be meager or insufficient for a rational conclusion when clinical findings that are readily available can provide definitive answers with regard to the etiology of a child's malformations or the merits of an environmental etiology.

Grajewski B, Cox C, Schrader SM, Murray WE, Edwards RM, Turner TW, Smith JM, Shekar SS, Evenson DP, Simon SD, Conover DL, Semen quality and hormone levels among radiofrequency heater operators. J Occup Environ Med42(10):993-1005, 2000.

Approximately 9,000,000 US workers are occupationally exposed to radiogrequency (RF) radiation; over 250,000 operate RF dielectric heaters. Our purpose was to determine whether male RF heater operators experience increased adverse reproductive effects reflected in reduced semen quality or altered hormone levels. We measured incident RF heater radiation exposures and RF-induced foot currents at four companies. For 12 male heater operators and a comparison group of 34 RF-unexposed men, we measured 33 parameters of semen quality and four serum hormones. Despite wide variation in individual exposure levels, near field strengths and induced foot currents did not exceed current standard levels and guidelines. We observed minor semen quality and hormonal differences between the groups, including a slightly higher mean follicle-stimulating hormone level for exposed operators (7.6 vs 5.8 mIU/mL). Further occupational studies of RF-exposed men may be warranted.

Gramowski-Voß A, Schwertle HJ, Pielka AM, Schultz L, Steder A, Jügelt K, Axmann J, Pries W5. Enhancement of Cortical Network Activity in vitro and Promotion of GABAergic Neurogenesis by Stimulation with an Electromagnetic Field with a 150 MHz Carrier Wave Pulsed with an Alternating 10 and 16 Hz Modulation. Front Neurol. 2015 Jul 14;6:158. doi: 10.3389/fneur.2015.00158. eCollection 2015.

In recent years, various stimuli were identified capable of enhancing neurogenesis, a process which is dysfunctional in the senescent brain and in neurodegenerative and certain neuropsychiatric diseases. Applications of electromagnetic fields to brain tissue have been shown to affect cellular properties and their importance for therapies in medicine is recognized. In this study, differentiating murine cortical networks on multiwell microelectrode arrays were repeatedly exposed to an extremely low-electromagnetic field (ELEMF) with alternating 10 and 16 Hz frequencies piggy backed onto a 150 MHz carrier frequency. The ELEMF exposure stimulated the electrical network activity and intensified the structure of bursts. Further, the exposure to electromagnetic fields within the first 28 days in vitro of the differentiation of the network activity induced also reorganization within the burst structure. This effect was already most pronounced at 14 days in vitro after 10 days of exposure. Overall, the development of cortical activity under these conditions was accelerated. These functional electrophysiological changes were accompanied by morphological ones. The percentage of neurons in the neuron glia co-culture was increased without affecting the total number of cells, indicating an

enhancement of neurogenesis. The ELEMF exposure selectively promoted the proliferation of a particular population of neurons, evidenced by the increased proportion of GABAergic neurons. The results support the initial hypothesis that this kind of ELEMF stimulation could be a treatment option for specific indications with promising potential for CNS applications, especially for degenerative diseases, such as Alzheimer's disease and other dementias.

Grant FH, Schlegel RE, Effects of an increased air gap on the in vitro interaction of wireless phones with cardiac pacemakers. Bioelectromagnetics 21(7):485-490, 2000.

Several clinical and laboratory studies have demonstrated electromagnetic interaction between implantable cardiac pacemakers and hand-held wireless phones operated in close proximity. Current FDA and HIMA labeling guidelines indicate that a minimum separation of 6 in (15 cm) should be maintained between a hand-held wireless phone and an implanted pacemaker. This separation requirement does not distinguish between lateral locations on the chest and a perpendicular air gap. Evidence is provided here for a substantially reduced separation threshold when measured across an air gap rather than near the saline conductive media of a simulated torso. Twenty pacemaker-phone combinations involving 6 pacemakers and 9 phones were evaluated in vitro under worst-case conditions with respect to phone output power and pacemaker sensitivity. The phones represented CDMA, TDMA-11 Hz, TDMA-22 Hz, TDMA-50 Hz, and TDMA-217 Hz digital wireless technologies. Small increases in the perpendicular air gap between the phone and the saline surface resulted in a dramatic reduction in interaction. Approximately half of the 208 test runs exhibiting interaction at an air gap of 1 cm no longer resulted in interaction when the gap was increased to 2 cm. At a gap of 7.4 cm, the percentage of runs with interaction decreased to 1.4%. The overall interaction rate, considering a total of 8296 test runs from an earlier study, was less than 0.07% at a total perpendicular distance of 8.6 cm from the saline surface to the phone antenna axis. The perpendicular distance threshold of 8.6 cm was significantly less than the horizontal plane projection threshold of 19 cm previously reported. This difference is a function of the electromagnetic field coupling to the saline bath rather than field strength changes along the axis of the phone antenna. The results have implications for those making recommendations to pacemaker patients who may be unaware of this distinction.

Grant H, Heirman D, Kuriger G, Ravindran MM. In vitro study of the electromagnetic interaction between wireless phones and an implantable neural stimulator. Bioelectromagnetics. 25(5):356-361, 2004.

Several clinical and laboratory studies have demonstrated electromagnetic interaction between implantable medical devices like pacemakers and cell phones being operated in close proximity. Those devices are largely now immune to phone interaction or procedures have been established to limit their interaction. The use of cell phones near people with implanted neural stimulators has not been studied. This research was initiated to investigate electromagnetic interaction between current cell phone technology and specific models of Cyberonics neural stimulators. Out of 1080 test runs conducted for this study, no interactions were observed, and it was concluded that the phone

technologies examined in this study did not adversely affect the Cyberonics NeuroStar (Model 102) NeuroCybernetic Prosthesis (NCP) System. This article provides details on the experimental procedure that was used, which can also be used to test other neural stimulators and test technologies, and the results obtained.

Grayson JK, Radiation exposure, socioeconomic status, and brain tumor risk in the US Air Force: a nested case-control study. Am J Epidemiol 143(5):480-486, 1996.

A nested case-control study was used to investigate the relation between a range of electromagnetic field exposures and brain tumor risk in the US Air Force. Cumulative extremely low frequency and radiofrequency/microwave electromagnetic field potential exposures were estimated from a job-exposure matrix developed for this study. Ionizing radiation exposures were obtained from personal dosimetry records. Men who were exposed to nonionizing electromagnetic fields had a small excess risk for developing brain tumors, with the extremely low frequency and radiofrequency/microwave age-race-senior military rank-adjusted odds ratios being 1.28 (95% confidence interval (Cl) 0.95-1.74) and 1.39 (95% Cl 1.01-1.90), respectively. By contrast, men who were exposed to ionizing radiation had an age-race-senior military rank-adjusted odds ratio of 0.58 (95% Cl 0.22-1.52). These results support a small association between extremely low frequency and radiofrequency/microwave electromagnetic field exposure and no association between ionizing radiation exposure and brain tumors in the US Air Force population. Military rank was consistently associated with brain tumor risk. Officers were more likely than enlisted men to develop brain tumors (age-race-adjusted odds ratio (OR) = 2.11, 95% Cl 1.48-3.01), and senior officers were at increased risk compared with all other US Air Force members (age-race-adjusted OR = 3.30, 95% Cl 1.99-5.45).

Green AC, Scott IR, Gwyther RJ, Peyman A, Chadwick P, Chen X, Alfadhl Y, Tattersall JE. An investigation of the effects of TETRA RF fields on intracellular calcium in neurones and cardiac myocytes. Int J Radiat Biol. 81(12):869-885, 2005.

Purpose: This study aimed to determine whether Terrestrial Trunked Radio (TETRA) fields can affect intracellular calcium signalling in excitable cells.Materials and methods: Intracellular calcium concentration ([Ca(2 +)](i)) was measured in cultured rat cerebellar granule cells and cardiac myocytes during exposure to TETRA fields (380.8875 MHz pulse modulated at 17.6 Hz, 25% duty cycle). [Ca(2 +)](i) was measured as fura-PE3, fluo-3 or fluo-4 fluorescence by digital image analysis.Results: Granule cells exposed at specific absorption rates (SARs) of 5, 10, 20, 50 or 400 mW . kg(-1) showed no significant changes in resting [Ca(2 +)](i). Increases in [Ca(2 +)](i) in response to potassium-induced depolarization were significantly different from sham controls in TETRA-exposed cells, but the majority of the difference was attributable to initial biological variation between cell cultures. No difference was found between fura-PE3 (UV excitation) and fluo-3 (visible light excitation) measurements in these cells. Exposure to TETRA (50 or 400 mW . kg(-1)) had no significant effect on either the rate or amplitude of spontaneous Ca(2 +) transients in cardiac myocytes. The cells showed normal responses to salbutamol (50 microM) and acetylcholine (10 microM).Conclusions: Overall, these results showed no evidence of any consistent or biologically relevant effect of TETRA fields on [Ca(2 +)](i) in granule cells and cardiac myocytes at any of the SAR tested.

Grell K, Frederiksen K, Schüz J, Cardis E, Armstrong B, Siemiatycki J, Krewski DR, McBride ML, Johansen C, Auvinen A, Hours M, Blettner M, Sadetzki S, Lagorio S, Yamaguchi N, Woodward A, Tynes T, Feychting M, Fleming SJ, Swerdlow AJ, Andersen PK. The Intracranial Distribution of Gliomas in Relation to Exposure From Mobile Phones: Analyses From the INTERPHONE Study. Am J Epidemiol. 184(11):818-828, 2016.

When investigating the association between brain tumors and use of mobile telephones, accurate data on tumor position are essential, due to the highly localized absorption of energy in the human brain from the radio-frequency fields emitted. We used a point process model to investigate this association using information that included tumor localization data from the INTERPHONE Study (Australia, Canada, Denmark, Finland, France, Germany, Israel, Italy, Japan, New Zealand, Norway, Sweden, and the United Kingdom). Our main analysis included 792 regular mobile phone users diagnosed with a glioma between 2000 and 2004. Similar to earlier results, we found a statistically significant association between the intracranial distribution of gliomas and the self-reported location of the phone. When we accounted for the preferred side of the head not being exclusively used for all mobile phone calls, the results were similar. The association was independent of the cumulative call time and cumulative number of calls. However, our model used reported side of mobile phone use, which is potentially influenced by recall bias. The point process method provides an alternative to previously used epidemiologic research designs when one is including localization in the investigation of brain tumors and mobile phone use.

Grémiaux A, Girard S, Guérin V, Lothier J, Baluška F, Davies E, Bonnet P, Vian A. Low-amplitude, high-frequency electromagnetic field exposure causes delayed and reduced growth in Rosa hybrida. J Plant Physiol. 190:44-53, 2015.

It is now accepted that plants perceive high-frequency electromagnetic field (HF-EMF). We wondered if the HF-EMF signal is integrated further in planta as a chain of reactions leading to a modification of plant growth. We exposed whole small ligneous plants (rose bush) whose growth could be studied for several weeks. We performed exposures at two different development stages (rooted cuttings bearing an axillary bud and 5-leaf stage plants), using two high frequency (900MHz) field amplitudes (5 and 200Vm^{-1}). We achieved a tight control on the experimental conditions using a state-of-the-art stimulation device (Mode Stirred Reverberation Chamber) and specialized culture-chambers. After the exposure, we followed the shoot growth for over a one-month period. We observed no growth modification whatsoever exposure was performed on the 5-leaf stage plants. When the exposure was performed on the rooted cuttings, no growth modification was observed on Axis I (produced from the elongation of the axillary bud). Likewise, no significant modification was noted on Axis II produced at the base of Axis I, that came from pre-formed secondary axillary buds. In contrast, Axis II produced at the top of Axis I, that came from post-formed secondary buds consistently displayed a delayed and significant reduced growth (45%). The measurements of plant energy uptake from HF-EMF in this exposure condition (SAR of 7.2 $10^{-4}Wkg^{-1}$) indicated that this biological

response is likely not due to thermal effect. These results suggest that exposure to electromagnetic field only affected development of post-formed organs.

Grigor'ev IuG, Stepanov VS, [Forming of memory (imprinting) in chicks after prior low-level exposure to electromagnetic fields]. Radiats Biol Radioecol 38(2):223-231, 1998. [Article in Russian]

EMF of power density from 0.4 to 10 mW/cm2 can influence forming the memory (imprinting). Showed the possibility to fix EMF modulated in embryonic brain during the natal period and conservation of this information after birth.

Grigor'ev IuG, [Role of modulation in biological effects of electromagnetic radiation]. Radiats Biol Radioecol 36(5):659-670, 1996. [Article in Russian]

Data, describing a role of modulation of electromagnetic fields in development of biological effect, are considered. Outcomes of researches, indicating the dependence of a response of nervous and immune systems on a kind of modulation at low levels of effect, are represented. The necessity of the account of a role of modulation in an evaluation of electromagnetic danger is formulated.

Grigor'ev IuG, Luk'ianova SN, Makarov VP, Rynskov VV, [Total bioelectric activity of various structures of the brain in low-intensity microwave irradiation]. Radiats Biol Radioecol 35(1):57-65, 1995. [Article in Russian]

In experiments with thirty rabbits the influence of thirty-minute microwave irradiation (1.5 GHz, pulse intensity 0.3 mW/cm2; pulsed modes: 0.12 Hz, 16 ms or 1000 Hz, 0.4 ms; pack-pulsed mode: pulse frequency 1000 Hz, pack frequency 0.12 Hz) on the total bioelectrical activity of brain structures was studied. The reliable effect was detected only in hippocampus. The total bioelectrical activity of cortex, caudate nucleus, hypothalamus, amygdala and septum was not changed reliably in animal group studied. The reaction of hippocampus was displayed as amplification of theta-range in spectrum within of normal functioning.

Grigor'ev IuG, Luk'ianova SN, Makarov VP, Rynskov VV, Moiseeva NV, [Motor activity of rabbits in conditions of chronic low-intensity pulse microwave irradiation]. Radiats Biol Radioecol 35(1):29-35, 1995. [Article in Russian]

Motor activity of rabbits under daily thirty-minute irradiation (1.5 GHz, pulse duration 16 ms, pulse recurrence frequency 0.12 Hz, pulse intensity 0.3 mw/cm2) for one month was studied. From 14th day the reliable disadaptation changes such as an anxiety and alarm reaction were found. The importance of prolonged irradiation is noted.

Grigor'ev IuG. [Biological effects of mobile phone electromagnetic field on chick embryo (risk assessment using the mortality rate)] Radiats Biol Radioecol. 43(5):541-543, 2003. [Article in Russian]

Chicken embryos were exposed to EMF from GSM mobile phone during the embryonic development (21 days). As a result the embryo mortality rate in the incubation period increased to 75% (versus 16% in control group).

Grigoriev YG, Grigoriev OA, Ivanov AA, Lyaginskaya AM, Merkulov AV, Shagina

NB, Maltsev VN, Lévêque P, Ulanova AM, Osipov VA, Shafirkin AV. Confirmation studies of Soviet research on immunological effects of microwaves: Russian immunology results. Bioelectromagnetics. 31(8):589-602, 2010.

This paper presents the results of a replication study performed to investigate earlier Soviet studies conducted between 1974 and 1991 that showed immunological and reproductive effects of long-term low-level exposure of rats to radiofrequency (RF) electromagnetic fields. The early studies were used, in part, for developing exposure standards for the USSR population and thus it was necessary to confirm the Russian findings. In the present study, the conditions of RF exposure were made as similar as possible to those in the earlier experiments: Wistar rats were exposed in the far field to 2450 MHz continuous wave RF fields with an incident power density in the cages of 5 W/m² for 7 h/day, 5 days/week for a total of 30 days, resulting in a whole-body SAR of 0.16 W/kg. Effects of the exposure on immunological parameters in the brain and liver of rats were evaluated using the complement fixation test (CFT), as in the original studies, and an additional test, the more modern ELISA test. Our results, using CFT and ELISA, partly confirmed the findings of the early studies and indicated possible effects from non-thermal RF exposure on autoimmune processes. The RF exposure resulted in minor increases in formation of antibodies in brain tissue extract and the exposure did not appear to be pathological. In addition, a study was conducted to replicate a previous Soviet study on effects from the injection of blood serum from RF-exposed rats on pregnancy and foetal and offspring development of rats, using a similar animal model and protocol. Our results showed the same general trends as the earlier study, suggesting possible adverse effects of the blood serum from exposed rats on pregnancy and foetal development of intact rats, however, application of these results in developing exposure standards is limited.

Grisanti G, Parlapiano C, Tamburello CC, Tine G, Zanforlin L. Cellular phone effects on otoacoustic emissions. IEEE MTT-S Digest 2: 771-774, 1998.

A study on bioelectromagnetic effects induced by the use of TACS phones, evidencing a variation of the natural response of the auditory system is presented. This study was performed applying a method based on the registration of the evoked otoacosutic emissions (transient and distortion products). The experimental results show that modulated electromagnetic fields modify the distortion products in about all the examined subjects.

Gryz K, Karpowicz J, Leszko W, Zradziński P. Evaluation of exposure to electromagnetic radiofrequency radiation in the indoor workplace accessible to the public by the use of frequency-selective exposimeters. Int J Occup Med Environ Health. 2014 Dec 18. [Epub ahead of print]

OBJECTIVES: The aim of the study was to identify and assess electromagnetic radiofrequency radiation (EMRR) exposure in a workplace located in a publicly accessible environment, and represented by offices (where exposure is caused by various transmitters of local fixed indoor and outdoor wireless communication systems).

MATERIAL AND METHODS: The investigations were performed in 45 buildings (in urban and rural areas in various regions of Poland), using frequency-selective electric field strength (E-field) exposimeters sensitive to the EMRR with a frequency range of 88-2500 MHz, split into 12 sub-bands corresponding to the operating frequencies of typical EMRR sources. The variability of the E-field was analyzed for each frequency range and the total level of exposure by statistical parameters of recorded exposimetric profiles: minimum, maximum, median values and 25-75th - percentiles. RESULTS: The main sources of exposure to EMRR are mobile phone base transceiver stations (BTS) and radio-television transmitters (RTV). The frequency composition in a particular office depends on the building's location. The E-field recorded in buildings in urban and rural areas from the outdoor BTS did not exceed respectively: medians - 0.19 and 0.05 V/m, 75th percentiles - 0.25 and 0.09 V/m. In buildings equipped with the indoor BTS antennas the E-field did not exceed: medians - 1 V/m, 75th percentiles - 1.8 V/m. Whereas in urban and rural areas, the median and 75th percentile values of the E-field recorded in buildings located near the RTV (within 1 km) did not exceed: 1.5 and 3.8 V/m or 0.4 and 0.8 V/m, for radio FM band or for TV bands, respectively. CONCLUSIONS: Investigations confirmed the practical applicability of the exposimetric measurements technique for evaluating parameters of worker's exposure in both frequency- and time-domain. The presented results show EMRR exposure of workers or general public in locations comparable to offices to be well below international limits.

Guberan E, Campana A, Faval P, Guberan M, Sweetnam PM, Tuyn JW, Usel M, Gender ratio of offspring and exposure to shortwave radiation among female physiotherapists. Scand J Work Environ Health 20(5):345-348, 1994.

OBJECTIVES--The goal of this study was to investigate whether the deficit of male births found among the offspring of Danish physiotherapists exposed to shortwave radiation during the first month of their pregnancy could be confirmed among the offspring of physiotherapists from Switzerland. METHODS--A self-administrated questionnaire was mailed (two mailings) to all of the 2846 female members of the Swiss Federation of Physiotherapists. It included questions on the gender and birth-weight of all children of the physiotherapists, as well as on the use of shortwave or microwave equipment during the first month of each pregnancy. The response rate was 79.5%, and the analysis was based on 1781 pregnancies. RESULTS--The gender ratio (the number of males per number of females x 100) was 107 with a 95% confidence interval (95% CI) of 89-127 for the 508 pregnancies exposed to shortwave radiation and 101 (95% CI 90-113) for the 1273 unexposed pregnancies. There was no trend in the gender ratio with increasing intensity or duration of exposure. The prevalence of low birthweight (< or = 2500 g) was not related to exposure to shortwave radiation for either the boys or the girls. CONCLUSIONS--No atypical gender ratio was found for the children of female physiotherapists from Switzerland who had been exposed to shortwave radiation at the beginning of pregnancy. The findings of the Danish study (Larsen et al., 1991) could not be confirmed.

Gul A, Celebi H, Uğraş S. The effects of microwave emitted by cellular phones on ovarian follicles in rats. Arch Gynecol Obstet. 280(5):729-733, 2009.

OBJECTIVE: The aim of this study was to investigate whether there were any toxic effects of microwaves of cellular phones on ovaries in rats. METHODS: In this study, 82 female pups of rats, aged 21 days (43 in the study group and 39 in the control group) were used. Pregnant rats in the study group were exposed to mobile phones that were placed beneath the polypropylene cages during the whole period of pregnancy. The cage was free from all kinds of materials, which could affect electromagnetic fields. A mobile phone in a standby position for 11 h and 45 min was turned on to speech position for 15 min every 12 h and the battery was charged continuously. On the 21st day after the delivery, the female rat pups were killed and the right ovaries were removed. The volumes of the ovaries were measured and the number of follicles in every tenth section was counted. RESULTS: The analysis revealed that in the study group, the number of follicles was lower than that in the control group. The decreased number of follicles in pups exposed to mobile phone microwaves suggest that intrauterine exposure has toxic effects on ovaries. CONCLUSION: We suggest that the microwaves of mobile phones might decrease the number of follicles in rats by several known and, no doubt, countless unknown mechanisms.

Gulati S, Yadav A, Kumar N, Kanupriya, Aggarwal NK, Kumar R, Gupta R. Effect of GSTM1 and GSTT1 Polymorphisms on Genetic Damage in Humans Populations Exposed to Radiation From Mobile Towers. Arch Environ Contam Toxicol. 70(3):615-625, 2016.

All over the world, people have been debating about associated health risks due to radiation from mobile phones and mobile towers. The carcinogenicity of this nonionizing radiation has been the greatest health concern associated with mobile towers exposure until recently. The objective of our study was to evaluate the genetic damage caused by radiation from mobile towers and to find an association between genetic polymorphism of GSTM1 and GSTT1 genes and DNA damage. In our study, 116 persons exposed to radiation from mobile towers and 106 control subjects were genotyped for polymorphisms in the GSTM1 and GSTT1 genes by multiplex polymerase chain reaction method. DNA damage in peripheral blood lymphocytes was determined using alkaline comet assay in terms of tail moment (TM) value and micronucleus assay in buccal cells (BMN). There was a significant increase in BMN frequency and TM value in exposed subjects (3.65 ± 2.44 and 6.63 ± 2.32) compared with control subjects (1.23 ± 0.97 and 0.26 ± 0.27). However, there was no association of GSTM1 and GSTT1 polymorphisms with the level of DNA damage in both exposed and control groups.

Gulati S, Yadav A, Kumar N, Priya K, Aggarwal NK, Gupta R. Phenotypic and genotypic characterization of antioxidant enzyme system in human population exposed to radiation from mobile towers. Mol Cell Biochem. 2017 Aug 17. doi: 10.1007/s11010-017-3150-6. [Epub ahead of print]

In the present era, cellular phones have changed the life style of human beings completely and have become an essential part of their lives. The number of cell phones and cell towers are increasing in spite of their disadvantages. These cell towers transmit radiation continuously without any interruption, so people living within 100s of meters from

the tower receive 10,000 to 10,000,000 times stronger signal than required for mobile communication. In the present study, we have examined superoxide dismutase (SOD) enzyme activity, catalase (CAT) enzyme activity, lipid peroxidation assay, and effect of functional polymorphism of SOD and CAT antioxidant genes against mobile tower-induced oxidative stress in human population. From our results, we have found a significantly lower mean value of manganese superoxide dismutase (MnSOD) enzyme activity, catalase (CAT) enzyme activity, and a high value of lipid peroxidation assay in exposed as compared to control subjects. Polymorphisms in antioxidant MnSOD and CAT genes significantly contributed to its phenotype. In the current study, a significant association of genetic polymorphism of antioxidant genes with genetic damage has been observed in human population exposed to radiations emitted from mobile towers.

Guler G, Tomruk A, Ozgur E, Seyhan N. The effect of radiofrequency radiation on DNA and lipid damage in non-pregnant and pregnant rabbits and their newborns. Gen Physiol Biophys. 29(1):59-66, 2010.

The concerns of people on possible adverse health effects of radiofrequency radiation (RFR) generated from mobile phones as well as their supporting transmitters (base stations) have increased markedly. RFR effect on oversensitive people, such as pregnant women and their developing fetuses, and older people is another source of concern that should be considered. In this study, oxidative DNA damage and lipid peroxidation levels in the brain tissue of pregnant and non-pregnant New Zealand White rabbits and their newborns exposed to RFR were investigated. Thirteen-month-old rabbits were studied in four groups as non-pregnant-control, non-pregnant-RFR exposed, pregnant-control and pregnant-RFR exposed. They were exposed to RFR (1800 MHz GSM; 14 V/m as reference level) for 15 min/day during 7 days. Malondialdehyde (MDA) and 8-hydroxy-2'-deoxyguanosine (8-OHdG) levels were analyzed. MDA and 8-OHdG levels of non-pregnant and pregnant-RFR exposed animals significantly increased with respect to controls ($p < 0.001$, Mann-Whitney test). No difference was found in the newborns ($p > 0.05$, Mann-Whitney). There exist very few experimental studies on the effects of RFR during pregnancy. It would be beneficial to increase the number of these studies in order to establish international standards for the protection of pregnant women from RFR.

Guler G, Tomruk A, Ozgur E, Seyhan N. The effect of radiofrequency radiation on DNA and lipid damage in non-pregnant and pregnant rabbits and their newborns. Gen Physiol Biophys. 29(1):59-66, 2010.

The concerns of people on possible adverse health effects of radiofrequency radiation (RFR) generated from mobile phones as well as their supporting transmitters (base stations) have increased markedly. RFR effect on oversensitive people, such as pregnant women and their developing fetuses, and older people is another source of concern that should be considered. In this study, oxidative DNA damage and lipid peroxidation levels in the brain tissue of pregnant and non-pregnant New Zealand White rabbits and their newborns exposed to RFR were investigated. Thirteen-month-old rabbits were studied in four groups as non-pregnant-control, non-pregnant-RFR exposed, pregnant-control and pregnant-RFR exposed. They were exposed to RFR (1800 MHz GSM; 14 V/m as

reference level) for 15 min/day during 7 days. Malondialdehyde (MDA) and 8-hydroxy-2'-deoxyguanosine (8-OHdG) levels were analyzed. MDA and 8-OHdG levels of non-pregnant and pregnant-RFR exposed animals significantly increased with respect to controls ($p < 0.001$, Mann-Whitney test). No difference was found in the newborns ($p > 0.05$, Mann-Whitney). There exist very few experimental studies on the effects of RFR during pregnancy. It would be beneficial to increase the number of these studies in order to establish international standards for the protection of pregnant women from RFR.

Güler G, Tomruk A, Ozgur E, Sahin D, Sepici A, Altan N, Seyhan N.
The effect of radiofrequency radiation on DNA and lipid damage in female and male infant rabbits. Int J Radiat Biol. 88(4):367-373, 2012.

PURPOSE: We aimed to design a prolonged radiofrequency (RF) radiation exposure and investigate in an animal model, possible bio-effects of RF radiation on the ongoing developmental stages of children from conception to childhood. **MATERIALS AND METHODS:** A total of 72 New Zealand female and male white rabbits aged one month were used. Females were exposed to RF radiation for 15 min/day during 7 days, whereas males were exposed to the same level of radiation for 15 min/day during 14 days. Thirty-six female and 36 male infant rabbits were randomly divided into four groups: Group I [Intrauterine (IU) exposure (-); Extrauterine (EU) exposure (-)]: Sham exposure which means rabbits were exposed to 1800 MHz Global System for Mobile Telecommunication (GSM)-like RF signals neither in the IU nor in the EU periods. Group II [IU exposure (-); EU exposure (+)]: Infant rabbits were exposed to 1800 MHz GSM-like RF signals when they reached one month of age. Group III [IU exposure (+); EU exposure (-)]: Infant rabbits were exposed to 1800 MHz GSM-like RF signals in the IU period (between 15th and 22nd days of the gestational period). Group IV [IU exposure (+); EU exposure (+)]: Infant rabbits were exposed to 1800 MHz GSM-like RF signals both in the IU period (between 15th and 22nd days of the gestational period) and in the EU period when they reached one month of age. Biochemical analysis for lipid peroxidation and DNA damage were carried out in the livers of all rabbits. **RESULTS:** Lipid peroxidation levels in the liver tissues of female and male infant rabbits increased under RF radiation exposure. Liver 8-hydroxy-2'-deoxyguanosine (8-OHdG) levels of female rabbits exposed to RF radiation were also found to increase when compared with the levels of non-exposed infants. However, there were no changes in liver 8-OHdG levels of male rabbits under RF exposure. **CONCLUSION:** Consequently, it can be concluded that GSM-like RF radiation may induce biochemical changes by increasing free radical attacks to structural biomolecules in the rabbit as an experimental animal model.

Gultekin DH, Moeller L. NMR imaging of cell phone radiation absorption in brain tissue. Proc Natl Acad Sci U S A. 2012 Dec 17. [Epub ahead of print]

A method is described for measuring absorbed electromagnetic energy radiated from cell phone antennae into ex vivo brain tissue. NMR images the 3D thermal dynamics inside ex vivo bovine brain tissue and equivalent gel under exposure to power and irradiation time-varying radio frequency (RF) fields. The absorbed RF energy in brain tissue converts into Joule heat and affects the nuclear magnetic shielding and the Larmor precession.

The resultant temperature increase is measured by the resonance frequency shift of hydrogen protons in brain tissue. This proposed application of NMR thermometry offers sufficient spatial and temporal resolution to characterize the hot spots from absorbed cell phone radiation in aqueous media and biological tissues. Specific absorption rate measurements averaged over 1 mg and 10 s in the brain tissue cover the total absorption volume. Reference measurements with fiber optic temperature sensors confirm the accuracy of the NMR thermometry.

Guney M, Ozguner F, Oral B, Karahan N, Mungan T. 900 MHz radiofrequency-induced histopathologic changes and oxidative stress in rat endometrium: protection by vitamins E and C. Toxicol Ind Health. 23(7):411-420, 2007.

There are numerous reports on the effects of electromagnetic radiation (EMR) in various cellular systems. Mechanisms of adverse effects of EMR indicate that reactive oxygen species (ROS) may play a role in the biological effects of this radiation. The aims of this study were to examine 900 MHz mobile phone-induced oxidative stress that promotes production of ROS and to investigate the role of vitamins E and C, which have antioxidant properties, on endometrial tissue against possible 900 MHz mobile phone-induced endometrial impairment in rats. The animals were randomly grouped (eight each) as follows: 1) Control group (without stress and EMR, Group I), 2) sham-operated rats stayed without exposure to EMR (exposure device off, Group II), 3) rats exposed to 900 MHz EMR (EMR group, Group III) and 4) a 900 MHz EMR exposed + vitamin-treated group (EMR + Vit group, Group IV). A 900 MHz EMR was applied to EMR and EMR + Vit group 30 min/day, for 30 days using an experimental exposure device. Endometrial levels of nitric oxide (NO, an oxidant product) and malondialdehyde (MDA, an index of lipid peroxidation), increased in EMR exposed rats while the combined vitamins E and C caused a significant reduction in the levels of NO and MDA. Likewise, endometrial superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSH-Px) activities decreased in EMR exposed animals while vitamins E and C caused a significant increase in the activities of these antioxidant enzymes. In the EMR group histopathologic changes in endometrium, diffuse and severe apoptosis was present in the endometrial surface epithelial and glandular cells and the stromal cells. Diffuse eosinophilic leucocyte and lymphocyte infiltration were observed in the endometrial stroma whereas the combination of vitamins E and C caused a significant decrease in these effects of EMR. It is concluded that oxidative endometrial damage plays an important role in the 900 MHz mobile phone-induced endometrial impairment and the modulation of oxidative stress with vitamins E and C reduces the 900 MHz mobile phone-induced endometrial damage both at biochemical and histological levels.

Gupta N, Goyal D, Sharma R, Arora KS. Effect of Prolonged Use of Mobile Phone **on Brainstem Auditory Evoked Potentials. J Clin Diagn Res. 2015 May;9(5):CC07-9.**
OBJECTIVES: Mobile phones are being widely used throughout the world. Electromagnetic waves generated from mobile phones have raised concerns as these may have adverse effects on human auditory system owing to the daily use of mobile phones. The purpose of current study was to evaluate the effects of long term mobile phone usage on auditory brainstem evoked responses (ABR). MATERIALS AND

METHODS: A retrospective, cross-sectional, case control study was carried out in a tertiary care hospital. Total 100 healthy subjects aged 18 to 30 years of both the genders were selected, out of which 67 subjects were long-term GSM mobile phone users (using mobile phone for more than 1 year) and 33 were controls who were mobile phone non users. Both the groups were investigated for ABR and changes were studied in both the ears of cases and controls to ascertain the effects of electromagnetic exposure. RESULTS: No significant difference (p>0.05) was found in latencies, interpeak latencies and amplitudes of ABR waves between cases and controls. CONCLUSION: Our study shows that long term usage of mobile phones does not affect propagation of electrical stimuli along the auditory nerve to auditory brainstem centres.

Gurbuz N, Sirav B, Yuvaci HU, Turhan N, Coskun ZK, Seyhan N. Is there any possible genotoxic effect in exfoliated bladder cells of rat under the exposure of 1800 MHz GSM-like modulated radio frequency radiation (RFR)? Electromagn Biol Med. 29(3):98-104, 2010.

People are exposed to many carcinogenic and mutagenic chemicals in their everyday lives. These include antineoplastic drugs, Polycyclic aromatic hydrocarbons (PAH)s, aromatic amines, nitrosamines, metals, and electromagnetic radiation. Based on the state of knowledge acquired during the last 50 years of research on possible biological effects of electromagnetic fields (EMF), the majority of the scientific community is convinced that exposure to EMF below the existing security limits does not cause a risk to the health of the general public. However, this position is questioned by others, who are of the opinion that the available research data are contradictory or inconsistent and, therefore, unreliable. In this study, we aimed to investigate if there is any effect of 1800 MHz GSM modulated radio frequency radiation (RFR) on the number of micronucleus in exfoliated bladder cells of rat which will be informative about the genotoxic damage. Exposure period was 20 min/day, 5 days/week during a month. Six female Wistar rats were used for two groups: Group I (n=6): controls; Group II (n=6): 1.8 GHz exposed animals. 1800 MHz RFR did not showed a significant MN frequencies in rat bladder cells when compared with the control group (p>0.05). 1800 MHz RFR-exposed animals did not produce any genotoxic effect when compared with the control group (p>0.05). Kinetic studies are important for any biomarker, especially those in which tissue differentiation and maturation processes will heavily influence the time between induction of damage and collection of damaged cells for micronucleus analysis.

Gurbuz N, Sirav B, Colbay M, Yetkin I, Seyhan N. No genotoxic effect in exfoliated bladder cells of rat under the exposure of 1800 and 2100-MHz radio frequency radiation. Electromagn Biol Med. 2013 Nov 27. [Epub ahead of print]

Abstract In this study, we aimed to investigate the effects of 1800 and 2100 MHz Radio Frequency (RF) radiation on the number of micronucleus (MN) in exfoliated bladder cells of rat which shows the genotoxic damage. Exposure period was 30 min/day, 6 days/week for a month and two months exposure periods. Thirty male wistar albino rats were used for five groups: Group I (n = 6): 1800 MHz RF exposed animals for one month, Group II (n = 6): 2100 MHz RF exposed animals for one

month, Group III (n = 6): 2100 MHz RF exposed for two months, Group IV (n = 6): control group for one month, Group V (n = 6): control group for two months. Rats of the control groups were housed in their home cages during the entire experimental period without subjecting to any experimental manipulation. 1800 and 2100 MHz RF exposures did not result in any significant MN frequencies in rat bladder cells with respect to the control groups ($p > 0.05$). There was no statistically significant difference between 2100 MHz RF exposed groups, either. Further studies are needed to demonstrate if there is any genotoxic effect, micronucleus formation in other tissues of rats.

Gurbuz N, Sirav B, Kuzay D, Ozer C, Seyhan N. Does radio frequency radiation induce micronuclei frequency in exfoliated bladder cells of diabetic rats? Endocr Regul. 49(3):126-130, 2015.

OBJECTIVE: For many years there has been a discussion among both experts and the general public regarding the effects of radio frequency (RF) radiation on the human organism. The purpose of the present study was to evaluate the relationship of micronucleui (MN) frequency and RF radiation in exfoliated bladder cells of non-diabetic and diabetic rats. METHODS: Three groups were used in the experiment: Group I (n=6): diabetic group without RF exposure; Group II (n=6): diabetic group exposed 2100 MHz RF radiation and Group III (n=6): control animals (non-diabetic group, no RF exposure). RF exposure in the experiment resulted in a whole body average SAR of 0.24 W/kg with an ERMS field of 17.5 V/m in non-thermal levels. RESULT: Results showed that there was no statistically important differences between non-RF exposed diabetes group and control group; Group I and Group III ($p>0.05$). There was no statistically important differences between diabetes group and diabetes+RF exposed group (Group I and Group II) ($p>0.05$). RF exposure did not result in increased MN frequencies in exfoliated bladder cells of diabetic rats with respect to control animals (Group II and Group III), either and this result found no statistically important ($p>0.05$). CONCLUSIONS: This study suggested no possible genotoxic effects of RF radiation among human beings especially with chronic disorders, such as diabetes.

Gürler HS, Bilgici B, Akar AK, Tomak L, Bedir A. Increased DNA oxidation (8-OHdG) and protein oxidation (AOPP) by Low level electromagnetic field (2.45 GHz) in rat brain and protective effect of garlic. Int J Radiat Biol. 2014 May 21:1-15. [Epub ahead of print]

Purpose: To investigate the oxidative damage and protective effect of garlic on rats exposed to low level of electromagnetic fields (EMF) at 2.45 GHz Microwave radiation (MWR). Methods: Thirty six Wistar rats were divided into three groups. Group I was the control group and not exposed to EMF. Group II and III were exposed to low level EMF (3.68±0.36 V/m) at 2.45 GHz MWR for 1 hour/day for 30 consecutive days. Daily 500 mg/kg garlic was given to Group III during the study period. At the end of the study, thiobarbituric acid reactive substances (TBARS), advanced oxidation protein products

(AOPP) and 8-hydroxydeoxyguanosine (8-OHdG) levels were investigated in brain tissue and blood samples. Results: Exposure to low level of EMF increased 8-OHdG level in both plasma and brain tissue whereas it increased AOPP level only in plasma. Garlic prevented the increase of 8-OHdG level in brain tissue and plasma AOPP levels. Conclusions: It may be concluded that low level EMF at 2.45 GHz MWR increases the DNA damage in both brain tissues and plasma of the rats whereas it increases protein oxidation only in plasma. It may also be argued that the use of garlic decreases these effects.

Gutschi T, Mohamad Al-Ali B, Shamloul R, Pummer K, Trummer H. Impact of cell phone use on men's semen parameters.Andrologia. 43(5):312-316, 2011.

The objective of the present retrospective study was to report our experience concerning the effects of cell phone usage on semen parameters. We examined 2110 men attending our infertility clinic from 1993 to October 2007. Semen analysis was performed in all patients. Serum free testosterone (T), follicle stimulating hormone (FSH), luteinising hormone (LH) and prolactin (PRL) were collected from all patients. The information on cell phone use of the patients was recorded and the subjects were divided into two groups according to their cell phone use: group A: cell phone use (n = 991); group B: no use (n = 1119). Significant difference was observed in sperm morphology between the two groups. In the patients of group A, 68.0% of the spermatozoa featured a pathological morphology compared to only 58.1% in the subjects of group B. Patients with cell phone usage showed significantly higher T and lower LH levels than those who did not use cell phone. No significant difference between the two groups was observed regarding FSH and PRL values. Our results showed that cell phone use negatively affects sperm quality in men. Further studies with a careful design are needed to determine the effect of cell phone use on male fertility.

Guxens M, van Eijsden M, Vermeulen R, Loomans E, Vrijkotte TG, Komhout H, van Strien RT, Huss A. Maternal cell phone and cordless phone use during pregnancy and behaviour problems in 5-year-old children. J Epidemiol Community Health. 2013 Feb 5. [Epub ahead of print]

BACKGROUND: A previous study found an association between maternal cell phone use during pregnancy and maternal-reported child behaviour problems at age 7. Together with cell phones, cordless phones represent the main exposure source of radiofrequency-electromagnetic fields to the head. Therefore, we assessed the association between maternal cell phone and cordless phone use during pregnancy and teacher-reported and maternal-reported child behaviour problems at age 5. **METHODS:** The study was embedded in the Amsterdam Born Children and their Development study, a population-based birth cohort study in Amsterdam, the Netherlands (2003-2004). Teachers and mothers reported child behaviour problems using the Strength and Difficulties Questionnaire at age 5. Maternal cell phone and cordless phone use during pregnancy was asked when children were 7 years old. **RESULTS:** A total of 2618 children were included. As compared to non-users, those exposed to prenatal cell phone use showed an increased but non-significant association of having teacher-reported overall behaviour

problems, although without dose-response relationship with the number of calls (OR=2.12 (95% CI 0.95 to 4.74) for <1 call/day, OR=1.58 (95% CI 0.69 to 3.60) for 1-4 calls/day and OR=2.04 (95% CI 0.86 to 4.80) for ≥5 calls/day). ORs for having teacher-reported overall behaviour problems across categories of cordless phone use were below 1 or close to unity. Associations of maternal cell phone and cordless phone use with maternal-reported overall behaviour problems remained non-significant. Non-significant associations were found for the specific behaviour problem subscales. **CONCLUSION:** Our results do not suggest that maternal cell phone or cordless phone use during pregnancy increases the odds of behaviour problems in their children.

Ha M, Lim HJ, Cho SH, Choi HD, Cho KY. Incidence of cancer in the vicinity of Korean AM radio transmitters. Arch Environ Health. 58(12):756-762, 2003.

Results of various studies have indicated a potential association between exposures to electrical and/or magnetic fields and risks of various cancers. The authors used a cross-sectional ecological study design to investigate such a potential association. In areas proximate to 42 amplitude modulated (AM) radio transmitters, 11 high-power study sites (i.e., areas exposed to 100-1500-kW transmission power) and 31 low-power study sites (i.e., areas exposed to 50-kW transmission power) were identified. The incidence of cancer within a 2-km radius of each transmitter was obtained from (a) Korean medical-insurance data for the years 1993 through 1996, (b) population census data for the year 1995, and (c) resident registration data for the year 1995. The authors calculated age-standardized rate ratios for total cancer, leukemia, malignant lymphoma, brain cancer, and breast cancer, and compared the incidence of cancer within 2 km of the high-power transmitters vs. the incidence within 2 km of the low-power transmitters. Four control areas for each high-power transmitter were also selected. The control areas were located in the same, or nearest adjacent, province as the high-power sites, but were at least 2 km from any of the transmitters. Indirect standardized observed/expected ratios for the high-power sites vs. control areas were calculated for each transmitter separately, and for 4 transmitter groupings defined by power level (i.e., 100 kW, 250 kW, 500 kW, and 1500 kW). The authors found no significant increase in age-standardized rate ratios of cancers for high-power vs. low-power sites, with the exceptions of total cancer and of brain cancer in women. Among the 11 high-power sites, there were significantly increased incidences of leukemia in 2 areas and of brain cancer in 1 area. Future studies should incorporate additional detailed exposure assessments and a strong analytical study design to explore the possible association between radiofrequency radiation from AM radio transmitters and cancer.

Ha M, Im H, Lee M, Kim HJ, Kim BC, Gimm YM, Pack JK. Radio-frequency radiation exposure from AM radio transmitters and childhood leukemia and brain cancer. Am J Epidemiol. 166(3):270-279, 2007.

Leukemia and brain cancer patients under age 15 years, along with controls with respiratory illnesses who were matched to cases on age, sex, and year of diagnosis (1993-1999), were selected from 14 South Korean hospitals using the South Korean Medical Insurance Data System. Diagnoses were confirmed through the South Korean National Cancer Registry. Residential addresses were obtained from medical records. A newly developed prediction program incorporating a geographic information system that

was modified by the results of actual measurements was used to estimate radio-frequency radiation (RFR) exposure from 31 amplitude modulation (AM) radio transmitters with a power of 20 kW or more. A total of 1,928 leukemia patients, 956 brain cancer patients, and 3,082 controls were analyzed. Cancer risks were estimated using conditional logistic regression adjusted for residential area, socioeconomic status, and community population density. The odds ratio for all types of leukemia was 2.15 (95% confidence interval (CI): 1.00, 4.67) among children who resided within 2 km of the nearest AM radio transmitter as compared with those resided more than 20 km from it. For total RFR exposure from all transmitters, odds ratios for lymphocytic leukemia were 1.39 (95% CI: 1.04, 1.86) and 1.59 (95% CI: 1.19, 2.11) for children in the second and third quartiles, respectively, versus the lowest quartile. Brain cancer and infantile cancer were not associated with AM RFR.

Haarala C, Bjornberg L, Ek M, Laine M, Revonsuo A, Koivisto M, Hamalainen H. Effect of a 902 MHz electromagnetic field emitted by mobile phones on human cognitive function: A replication study. Bioelectromagnetics 24(4):283-288, 2003.

Our study was a replication and extension with methodological improvements to a previous study on effects of the electromagnetic field (EMF) emitted by a 902 MHz mobile phone on human cognitive functioning. Improvements on the previous study included multicentre testing and a double blind design. A total of 64 subjects (32 men and 32 women) in two independent laboratories performed a battery of 9 cognitive tasks twice: while the EMF was on and while it was off. Reaction times (RTs) and accuracy were recorded. The order of exposure and tasks was counterbalanced across subjects and gender. There were no statistically significant differences in performance between genders or laboratories. Although the RTs and the accuracy of answers were very similar to those of our previous study, our previous results were not replicated. We concluded that EMF had no effect on RTs or on the accuracy of the subjects' answers. Further, our results indicate that our EMF had no immediate effect on human cognitive functioning or that such effects are so small that they are observed on behavior only occasionally.

Haarala C, Aalto S, Hautzel H, Julkunen L, Rinne JO, Laine M, Krause B, Hamalainen H. Effects of a 902 MHz mobile phone on cerebral blood flow in humans: a PET study. Neuroreport. 14(16):2019-2023, 2003.

SUMMARY: Fourteen healthy right-handed subjects were scanned using PET with a [15O]water tracer during exposure to electromagnetic field (EMF) emitted by a mobile phone and a sham-exposure under double-blind conditions. During scanning, the subjects performed a visual working memory task. Exposure to an active mobile phone produced a relative decrease in regional cerebral blood flow (rCBF) bilaterally in the auditory cortex but no rCBF changes were observed in the area of maximum EMF. It is possible that these remote findings were caused by the EMF emitted by the active mobile phone. A more likely interpretation of the present findings were a result of an auditory signal from the active mobile phone. Therefore, it is not reasoned to attribute this finding to the EMF emitted by the phone. Further study on human rCBF during exposure to EMF of a mobile phone is needed.

Haarala C, Ek M, Bjornberg L, Laine M, Revonsuo A, Koivisto M, Hamalainen H. 902 MHz mobile phone does not affect short term memory in humans.

Bioelectromagnetics. 25(6):452-456, 2004.

We studied the effects of an electromagnetic field (EMF) as emitted by a 902 MHz mobile phone on human short term memory. This study was a replication with methodological improvements to our previous study. The improvements included multi-centre testing and a double blind design. A total of 64 subjects (32 men) in two independent laboratories performed a short term memory task (n-back) which poses a varying memory load (0-3 items) on the subjects' memory. They performed the task twice, once each under EMF and sham exposure. Reaction times (RTs) and accuracy of the responses were recorded. The order of exposure and memory load conditions were counterbalanced across subjects and gender. There were no statistically significant differences in performance between the two laboratories. We could not replicate our previous results: the EMF had no effect on RTs or on the accuracy of the subjects' answers. The inability to replicate previous findings could have been caused by lack of actual EMF effects or the magnitude of effects being at the sensitivity threshold of the test used.

Haarala C, Bergman M, Laine M, Revonsuo A, Koivisto M, Hamalainen H. Electromagnetic field emitted by 902 MHz mobile phones shows no effects on children's cognitive function. Bioelectromagnetics. Suppl 7:S144-150,2005.

The present study investigated the potential effects of a standard 902 MHz global system for mobile communication (GSM) mobile phone on 10-14 years old children's cognitive function. A total of 32 children (16 boys, 16 girls) participated with their own and parental consent. The subjects were 10-14 years old (mean 12.1 years, SD 1.1). They performed a battery of cognitive tests twice in a counter-balanced order: once while exposed to an active mobile phone and once during exposure to an inactive phone. The tests were selected from those we used earlier with adults. The statistical analyses showed no significant differences between the mobile phone off and on conditions in reaction times and accuracy over all tests or in any single test. It was concluded that a standard mobile phone has no effect on children's cognitive function as measured by response speed and accuracy. The present results challenge some earlier findings suggesting that the electromagnetic field (EMF) created by an active mobile phone would facilitate cognitive functioning.

Haarala C, Takio F, Rintee T, Laine M, Koivisto M, Revonsuo A, Hamalainen H. Pulsed and continuous wave mobile phone exposure over left versus right hemisphere: Effects on human cognitive function. Bioelectromagnetics.28(4):289-295. 2007.

The possible effects of continuous wave (CW) and pulse modulated (PM) electromagnetic field (EMF) on human cognition was studied in 36 healthy male subjects. They performed cognitive tasks while exposed to CW, PM, and sham EMF. The subjects performed the same tasks twice during each session; once with left-sided and once with right-sided exposure. The EMF conditions were spread across three testing sessions, each session separated by 1 week. The exposed hemisphere, EMF condition, and test order were counterbalanced over all subjects. We employed a double-blind design: both the subject and the experimenter were unaware of the EMF condition. The EMF was created with a signal generator connected via amplifier to a dummy phone antenna, creating a power output distribution similar to the original

commercial mobile phone. The EMF had either a continuous power output of 0.25 W (CW) or pulsed power output with a mean of 0.25 W. An additional control group of 16 healthy male volunteers performed the same tasks without any exposure equipment to see if mere presence of the equipment could have affected the subjects' performance. No effects were found between the different EMF conditions, separate hemisphere exposures, or between the control and experimental group. In conclusion, the current results indicate that normal mobile phones have no discernible effect on human cognitive function as measured by behavioral tests.

Haas AJ, Le Page Y, Zhadobov M, Sauleau R, Dréan YL, Saligaut C. Effect of acute millimeter wave exposure on dopamine metabolism of NGF-treated PC12 cells. J Radiat Res. 2017 Feb 24:1-7. doi: 10.1093/jrr/rrx004.

Several forthcoming wireless telecommunication systems will use electromagnetic frequencies at millimeter waves (MMWs), and technologies developed around the 60-GHz band will soon know a widespread distribution. Free nerve endings within the skin have been suggested to be the targets of MMW therapy which has been used in the former Soviet Union. So far, no studies have assessed the impact of MMW exposure on neuronal metabolism. Here, we investigated the effects of a 24-h MMW exposure at 60.4 GHz, with an incident power density (IPD) of 5 mW/cm², on the dopaminergic turnover of NGF-treated PC12 cells. After MMW exposure, both intracellular and extracellular contents of dopamine (DA) and 3,4-dihydroxyphenylacetic acid (DOPAC) were studied using high performance liquid chromatography. Impact of exposure on the dopamine transporter (DAT) expression was also assessed by immunocytochemistry. We analyzed the dopamine turnover by assessing the ratio of DOPAC to DA, and measuring DOPAC accumulation in the medium. Neither dopamine turnover nor DAT protein expression level were impacted by MMW exposure. However, extracellular accumulation of DOPAC was found to be slightly increased, but not significantly. This result was related to the thermal effect, and overall, no evidence of non-thermal effects of MMW exposure were observed on dopamine metabolism.

Habauzit D, Le Quément C, Zhadobov M, Martin C, Aubry M, Sauleau R, Le Dréan Y. Transcriptome Analysis Reveals the Contribution of Thermal and the Specific Effects in Cellular Response to Millimeter Wave Exposure. PLoS One. 2014 Oct 10;9(10):e109435. doi:10.1371/journal.pone.0109435. eCollection 2014.

Radiofrequency radiations constitute a new form of environmental pollution. Among them, millimeter waves (MMW) will be widely used in the near future for high speed communication systems. This study aimed therefore to evaluate the biocompatibility of MMW at 60 GHz. For this purpose, we used a whole gene expression approach to assess the effect of acute 60 GHz exposure on primary cultures of human keratinocytes. Controls were performed to dissociate the electromagnetic from the thermal effect of MMW. Microarray data were validated by RT-PCR, in order to ensure the reproducibility of the results. MMW exposure at 20 mW/cm2, corresponding to the maximum incident power density authorized for public use (local exposure averaged over 1 cm2), led to an increase of temperature and to a strong modification of keratinocyte gene expression

(665 genes differentially expressed). Nevertheless, when temperature is artificially maintained constant, no modification in gene expression was observed after MMW exposure. However, a heat shock control did not mimic exactly the MMW effect, suggesting a slight but specific electromagnetic effect under hyperthermia conditions (34 genes differentially expressed). By RT-PCR, we analyzed the time course of the transcriptomic response and 7 genes have been validated as differentially expressed: ADAMTS6, NOG, IL7R, FADD, JUNB, SNAI2 and HIST1H1A. Our data evidenced a specific electromagnetic effect of MMW, which is associated to the cellular response to hyperthermia. This study raises the question of co-exposures associating radiofrequencies and other environmental sources of cellular stress.

Haghani M, Shabani M, Moazzami K. Maternal mobile phone exposure adversely affects the electrophysiological properties of Purkinje neurons in rat offspring. Neuroscience. 2013 Jul 29. pii: S0306-4522(13)00643-X. doi: 10.1016/j.neuroscience.2013.07.049. [Epub ahead of print]

Electromagnetic field (EMF) radiations emitted from mobile phones may cause structural damage to neurons. With the increased usage of mobile phones worldwide, concerns about their possible effects on the nervous system are rising. In the present study, we aimed to elucidate the possible effects of prenatal EMF exposure on the cerebellum of offspring Wistar rats. Rats in EMF group were exposed to 900 MHz Pulse-EMF irradiation for six hours per day during all gestation period. Ten offspring's per each group were evaluated for behavioral and electrophysiological evaluations. Cerebellum - related behavioral dysfunctions were analyzed using motor learning and cerebellum-dependent functional tasks (Accelerated Rotarod, Hanging and Open field tests). Whole cell- patch clamp recordings were used for electrophysiological evaluations. The results of the present study failed to show any behavioral abnormalities in rats exposed to chronic EMF radiation. However, whole cell patch clamp recordings revealed decreased neuronal excitability of Purkinje cells in rats exposed to EMF. The most prominent changes included afterhyperpolarization amplitude, spike frequency, half width and first spike latency. In conclusion, the results of the present study show that prenatal EMF exposure results in altered electrophysiological properties of Purkinje neurons. However, these changes may not be severe enough to alter the cerebellum-dependent functional tasks.

Hagiwara S, Iwasaka H, Takeshima N, Noguchi T. Mechanisms of analgesic action of pulsed radiofrequency on adjuvant-induced pain in the rat: roles of descending adrenergic and serotonergic systems. Eur J Pain. 13(3):249-252, 2009.

Pulsed radiofrequency (PRF) has been reported to be effective in the treatment of several types of pain. The mechanism of action, however, is not well known. In a recent study, the antinociceptive effects of acute thermal pain were shown to be mediated via descending pain inhibitory pathways. In this study we observed an analgesic effect of PRF treatment in an adjuvant induced inflammatory pain model in rats. In this model, sciatic nerves were treated with PRF at 37 degrees and 42 degrees , which inhibited hyperalgesia in the inflammatory groups when compared to

RF and sham treatment. This effect was attenuated after intrathecal administration of the alpha2-adrenoceptor antagonist yohimbine, the selective 5-HT3 serotonin receptor antagonist MDL72222, and the non-selective serotonin receptor antagonist methysergide. All three drugs were found to significantly inhibit the analgesic effect of PRF. The results suggest that the analgesic action of PRF involves the enhancement of noradrenergic and serotonergic descending pain inhibitory pathways.

Hagström M, Auranen J, Ekman R. Electromagnetic hypersensitive Finns: Symptoms, perceived sources and treatments, a questionnaire study. Pathophysiology. 2013 Apr 1. pii: S0928-4680(13)00002-3.

The aim was to analyze the subjective experiences of Finns who describe themselves as suffering from electromagnetic hypersensitivity (EHS), their symptoms, self-perceived sources of the health complaints and the effectiveness of medical and complementary alternative therapies. A total of 395 questionnaires were mailed to self-diagnosed EHS persons. Of the participants 345 belonged to a Finnish self-help group and 50 came from outside of the group. The return rate of the study was 52.1% (206) and 80.9% of the respondents were women. Before the onset of EHS the most common health complaints were different types of allergies (35.1%, 68). During the acute phase of EHS the most common symptoms were nervous system related: "stress" (60.3%, 117), "sleeping disorders" (59.3%, 115) and "fatigue" (57.2%, 111). The sources that were most often reported to have triggered EHS were: "personal computers" (50.8%, 94) and "mobile phones" (47.0%, 87). The same devices were also claimed to cause the most symptoms during the acute phase. After the acute phase of EHS had passed, the respondents still claimed to react to these same digital and wireless devices while their reactions to basic electrical appliances were reduced. According to 76% of 157 respondents the reduction or avoidance of electromagnetic fields (EMF) helped in their full or partial recovery. The best treatments for EHS were given as: "dietary change" (69.4%), "nutritional supplements" (67.8%) and "increased physical exercise" (61.6%). The official treatment recommendations of psychotherapy (2.6%) and medication (-4.2%) were not significantly helpful. According to the present results the official treatment protocols should take better account the EHS person's own experiences. The avoidance of electromagnetic radiation and fields effectively removed or lessened the symptoms in EHS persons.

Haider T, Knasmueller S, Kundi M, Haider M, Clastogenic effects of radiofrequency radiations on chromosomes of Tradescantia. Mutat Res 324(1-2):65-68, 1994.

The clastogenicity of electromagnetic fields (EMF) has so far been studied only under laboratory conditions. We used the Tradescantia-micronucleus (Trad-MCN) bioassay in an in situ experiment to find out whether short-wave electromagnetic fields used for broadcasting (10-21 MHz) may show genotoxic effects. Plant cuttings bearing young flower buds were exposed (30 h) on both sides of a slewable curtain antenna (300/500 kW, 40-170 V/m) and 15 m (90 V/m) and 30 m (70 V/m) distant from a vertical cage antenna (100 kW) as well as at the neighbors living near the broadcasting station (200 m, 1-3 V/m). The exposure at both sides of the slewable curtain antenna was performed simultaneously within cages, one of the Faraday type shielding the field and one non-shielding mesh cage. Laboratory controls were maintained for comparison. Higher MCN

frequencies than in laboratory controls were found for all exposure sites in the immediate vicinity of the antennae, where the exposure standards of the electric field strength of the International Radiation Protection Association (IRPA) were exceeded. The results at all exposure sites except one were statistically significant. Since the parallel exposure in a non-shielding and a shielding cage also revealed significant differences in MCN frequencies (the latter showing no significant differences from laboratory controls), the clastogenic effects are clearly attributable to the short-wave radiation from the antennae.

Halgamuge MN. Radio Hazard Safety Assessment for Marine Ship Transmitters: Measurements Using a New Data Collection Method and Comparison with ICNIRP and ARPANSA Limits. Int J Environ Res Public Health. 12(5):5338-5354, 2015.

We investigated the levels of radio frequency electromagnetic fields (RF EMFs) emitted from marine ship transmitters. In this study, we recorded the radio frequency (RF) electric field (EF) levels emitted from transmitters from a marine vessel focusing on the areas normally occupied by crew members and passengers. Previous studies considered radiation hazard safety assessment for marine vessels with a limited number of transmitters, such as very high-frequency (VHF) transceivers, radar and communication transmitters. In our investigation, EF levels from seven radio transmitters were measured, including: VHF, medium frequency/high frequency (MF/HF), satellite communication (Sat-Com C), AISnavigation, radar X-band and radar S-band. Measurements were carried out in a 40 m-long, three-level ship (upper deck, bridge deck and bridge roof) at 12 different locations. We developed a new data-collection protocol and performed it under 11 different scenarios to observe and measure the radiation emissions from all of the transmitters. In total, 528 EF field measurements were collected and averaged over all three levels of the marine ship with RF transmitters: the measured electric fields were the lowest on the upper deck (0.82-0.86 V/m), the highest on the bridge roof (2.15-3.70 V/m) and in between on the bridge deck (0.47-1.15 V/m). The measured EF levels were then assessed for compliance with the occupational and general public reference levels of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines and the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) standards. The ICNIRP and the ARPANSA limits for the general public were exceeded on the bridge roof; nevertheless, the occupational limits were respected everywhere. The measured EF levels, hence, complied with the ICNIRP guidelines and the ARPANSA standards. In this paper, we provide a new data collection model for future surveys, which could be conducted with larger samples to verify our observations. Furthermore, this new method could be useful as a reference for researchers and industry professionals without direct access to the necessary equipment.

Halgamuge MN. Review: Weak radiofrequency radiation exposure from mobile phone radiation on plants. Electromagn Biol Med. 36(2):213-235, 2017.

AIM: The aim of this article was to explore the hypothesis that non-thermal, weak, radiofrequency electromagnetic fields (RF-EMF) have an effect on living plants. SUBJECT AND METHODS: In this study, we performed an analysis of the data extracted from the 45 peer-reviewed scientific publications (1996-2016) describing 169 experimental observations to detect the physiological and morphological changes in

plants due to the non-thermal RF-EMF effects from mobile phone radiation. Twenty-nine different species of plants were considered in this work. RESULTS: Our analysis demonstrates that the data from a substantial amount of the studies on RF-EMFs from mobile phones show physiological and/or morphological effects (89.9%, $p < 0.001$). Additionally, our analysis of the results from these reported studies demonstrates that the maize, roselle, pea, fenugreek, duckweeds, tomato, onions and mungbean plants seem to be very sensitive to RF-EMFs. Our findings also suggest that plants seem to be more responsive to certain frequencies, especially the frequencies between (i) 800 and 1500 MHz ($p < 0.0001$), (ii) 1500 and 2400 MHz ($p < 0.0001$) and (iii) 3500 and 8000 MHz ($p = 0.0161$). CONCLUSION: The available literature on the effect of RF-EMFs on plants to date observed the significant trend of radiofrequency radiation influence on plants. Hence, this study provides new evidence supporting our hypothesis. Nonetheless, this endorses the need for more experiments to observe the effects of RF-EMFs, especially for the longer exposure durations, using the whole organisms. The above observation agrees with our earlier study, in that it supported that it is not a well-grounded method to characterize biological effects without considering the exposure duration. Nevertheless, none of these findings can be directly associated with human; however, on the other hand, this cannot be excluded, as it can impact the human welfare and health, either directly or indirectly, due to their complexity and varied effects (calcium metabolism, stress proteins, etc.). This study should be useful as a reference for researchers conducting epidemiological studies and the long-term experiments, using whole organisms, to observe the effects of RF-EMFs.

Hallberg O, Johansson O. Melanoma incidence and frequency modulation (FM) broadcasting. Arch Environ Health. 57(1):32-40, 2002.

The incidence of melanoma has been increasing steadily in many countries since 1960, but the underlying mechanism causing this increase remains elusive. The incidence of melanoma has been linked to the distance to frequency modulation (FM) broadcasting towers. In the current study, the authors sought to determine if there was also a related link on a larger scale for entire countries. Exposure-time-specific incidence was extracted from exposure and incidence data from 4 different countries, and this was compared with reported age-specific incidence of melanoma. Geographic differences in melanoma incidence were compared with the magnitude of this environmental stress. The exposure-time-specific incidence from all 4 countries became almost identical, and they were approximately equal to the reported age-specific incidence of melanoma. A correlation between melanoma incidence and the number of locally receivable FM transmitters was found. The authors concluded that melanoma is associated with exposure to FM broadcasting.

Hallberg O, Johansson O. Long-term sickness and mobile phone use. J Aust Coll Nutr & Env med 23:11-12, 2004.

The number of people unable to work due to long-term sickness is drastically increasing in Sweden. In this paper we take a close look at the development of mobile phone communication to see how it possibly relates to the health impairment of the Swedish population. Official data was collected regarding mobile phone use and long-term

absence from work. The co-variation between those data sets was used to estimate future development of long-term absence rates under the hypothesis that there is a connection between the two sets of data. It was concluded that future long-term absence rates will continue to increase as long as the annual number of ear-heating minute per year is increasing.

Hallberg O. Adverse health indicators correlating with sparsely populated areas in Sweden. Eur J Cancer Prev. 16(1):71-76, 2007.

Earlier studies on health characteristics in Sweden have pointed at a sudden trend change in general health indicators around 1997. The decline was worse in areas with less estimated coverage by the mobile phone system; that is, areas where the average output power from mobile phone handsets is expected to be higher. In this study, health parameters were related to the population density, which is a well defined, rather than an estimated variable. Statistics were obtained from different authorities in Sweden. Data were correlated to the population densities in the 21 different counties of Sweden as well as to estimates of average mobile phone output power. Several health quality measures showed that people in sparsely populated counties in Sweden (as well as in Denmark and Norway) have suffered more illness, and lengthier recovery than people in more densely populated areas since 1997. This is in strong contrast to the situation 20 years ago, when the countryside was the healthiest place in which to live. The indicators strongly correlated with estimated mobile phone area coverage and estimated power output. The indicator statistics suggest that the decline in health in Sweden is not a primary consequence of low population density by itself, but that other factors related to population density are causative. The two factors having the strongest correlation with decreased health quality were the estimated average power output from mobile phones (positive correlation) and the reported coverage from the global system for mobile communication base stations (negative correlation) in each county.

Hamann W, Abou-Sherif S, Thompson S, Hall S. Pulsed radiofrequency applied to dorsal root ganglia causes a selective increase in ATF3 in small neurons. Eur J Pain. 10(2):171-176, 2006.

BACKGROUND: This is a "proof of concept study" to test the hypothesis that pulsed radiofrequency, PRF, produces cell stress at the primary afferent level without signs of overt thermal damage. We assumed that cell stress would result in impairment of normal function, and used the expression of activating transcription factor 3, ATF3, as an indicator of cellular "stress". METHODS: PRF (20ms of 500-kHz RF pulses, delivered at a rate of 2Hz; maximum temperature 42 degrees C) was delivered either to the sciatic nerve of adult rats in mid thigh, or to the L4 anterior primary ramus just distal to the intervertebral foramen. Controls were sham-operated or L4 axotomised. All tissues were examined 14 days after surgery. The percentage of CGRP- or ATF3-positive DRG neuronal somata was calculated using image analysis software (SigmaScan Pro 4). RESULTS: ATF3 expression was upregulated in L4 DRG neuronal cell bodies, irrespective of their size, after axotomy. It was also upregulated significantly ($p<0.002$) and selectively, in small and medium calibre L4 DRG neurons, when PRF was applied close to the DRG just distal to the intervertebral foramen. PRF did not produce any

obvious cellular changes in the nerve or L4 DRG neurons when applied to the sciatic nerve in mid-thigh. CONCLUSION: PRF has a biological effect, unlikely to be related to overt thermal damage. It appears to be selective in that it targets the group of neurons whose axons are the small diameter C and Adelta nociceptive fibres.

Hamblin DL, Wood AW, Croft RJ, Stough C. Examining the effects of electromagnetic fields emitted by GSM mobile phones on human event-related potentials and performance during an auditory task. Clin Neurophysiol. 115(1):171-178, 2004.

OBJECTIVE: Due to the widespread use of mobile phones (MP), it is important to determine whether they affect human physiology. The aim of this study was to explore the sensitivity of auditory event-related potentials to electromagnetic emissions. METHODS: Twelve participants attended two sessions, 1 week apart. Participants performed an auditory oddball task while they were exposed to an active MP during one session and sham exposure during the other. Each condition lasted 1 h and order was counterbalanced. N100 and P200 latencies and amplitudes were analysed for non-target waveforms, and N200 and P300 latencies and amplitudes were analysed for target waveforms. RESULTS: In real relative to sham exposure N100 amplitude and latency to non-targets were reduced, with the reduction larger over midline and right hemisphere sites. P300 latency to targets was delayed in the real exposure condition, however as this difference was greatest at left frontal and left central sites the interpretation of this result is unclear. Reaction time increased in the real relative to sham condition. No difference in accuracy was found. CONCLUSIONS: The results suggest that MP exposure may affect neural activity, particularly in proximity to the phone, however caution should be applied due to the small sample size.

Hamblin DL, Croft RJ, Wood AW, Stough C, Spong J. The sensitivity of human event-related potentials and reaction time to mobile phone emitted electromagnetic fields. Bioelectromagnetics.27(4):265-273, 2006.

There is some evidence to suggest that exposure to mobile phones (MPs) can affect neural activity, particularly in response to auditory stimuli. The current investigation (n = 120) aimed to test recent findings in this area, namely that N100 amplitude and latency would decrease, and that P300 latency and reaction time (RT) would increase under active relative to sham exposure during an auditory task. Visual measures were also explored. A double blind, counterbalanced, crossover design was employed where subjects attended two sessions 1 week apart. In both sessions participants (1) performed auditory and visual oddball tasks while electroencephalogram (EEG) was recorded with a MP set to sham exposure mounted over the temporal region, and (2) performed the same tasks while the handset was set to active/sham. When active, the MP transmitted for 30 min at 895 MHz (average power 250 mW, pulse modulated at 217 Hz, average SAR 0.11 W/kg). Paired t-tests compared difference scores from the sham/sham session to those from the sham/active condition. The study was designed to detect differences of ${1\over4}$ of a standard deviation with a power of 0.80. There was no significant difference between exposure conditions for any auditory or visual event related potential (ERP) component or RT. As previous positive findings were not replicated, it was concluded that there is currently no evidence that acute MP exposure affects these

indices of brain activity.

Hamzany Y, Feinmesser R, Shpitzer T, Mizrachi A, Hilly O, Hod R, Bahar G, Otradnov I, Gavish M, Nagler RM. Is human saliva an indicator of the adverse health effects of using mobile phones? Antioxid Redox Signal. 18(6):622-627, 2013.

Increasing use of mobile phones creates growing concern regarding harmful effects of radiofrequency non-ionizing electromagnetic radiation (NIER) on human tissues located close to the ear where phones are commonly held for long periods of time. We studied 20 subjects in the 'mobile phone group' who had a mean duration of mobile phone use of 12.5 years (range 8-15) and a mean time use of 29.6 hours per month (range 8-100). Deaf individuals served as controls. We compared salivary outcomes (secretion, oxidative damage indices, flow rate and composition) between mobile phone users and non-users. We report significant increase in all salivary oxidative stress indices studied in mobile phone users. Salivary flow, total protein, albumin and amylase activity were decreased in mobile phone users. These observations lead to the hypothesis that the use of mobile phones may cause oxidative stress and modify salivary function.

Han YY, Kano H, Davis DL, Niranjan A, Lunsford LD. Cell phone use and acoustic neuroma: the need for standardized questionnaires and access to industry data. Surg Neurol. 72(3):216-22; discussion 222, 2009.

BACKGROUND: The capacity of radiofrequency from cell phones to be absorbed into the brain has prompted concerns that regular cell phone use may increase the risk of acoustic neuroma (AN) and other brain tumors. This article critically evaluates current literature on cell phone use and AN risks and proposes additional studies to clarify any possible linkage. METHODS: Through a PubMed search, we identified and reviewed 10 case-control studies and 1 cohort study of AN risks associated with cell phone use and a meta-analysis of long-term mobile phone use and its association with AN and other brain tumors. RESULTS: Most studies did not find association between the development of AN and cell phone use, but some studies that followed cases for 10 years or more did show an association. Among 10 case-control studies, odds ratios for AN associated with regular cell phone use ranged from 0.5 (95% confidence interval [CI], 0.2-1.0) to 4.2 (95% CI, 1.8-10). Cell phone use was not associated with increased risk for AN in the Danish cohort study, which excluded business users from their study. The meta-analysis, which included 3 case-control studies, found that subjects who used cell phones for at least 10 years had a 2.4-fold greater risk of developing ipsilateral AN. In general, retrospective studies are limited in the ability to assess cell phone exposure because of recall bias and misclassification. CONCLUSIONS: The evaluation of AN risk factors is challenging due to its long latency. Some studies of longer term cell phone use have found an increased risk of ipsilateral AN. Adopting a prospective approach to acquire data on cell phone use, obtaining retrospective billing records that provide independent evaluations of exposures, and incorporating information on other key potential risk factors from questionnaires could markedly advance the capacity of studies to evaluate the impact of cell phones on AN.

Han YY, Berkowitz O, Talbott E, Kondziolka D, Donovan M, Lunsford LD. Are frequent dental x-ray examinations associated with increased risk of vestibular schwannoma? J Neurosurg. 117 Suppl:78-83, 2012.

Object The authors evaluated the potential role of environmental risk factors, including exposure to diagnostic or therapeutic radiation and to wireless phones that emit nonionizing radiation, in the etiology of vestibular schwannoma (VS). Methods A total of 343 patients with VSs who underwent Gamma Knife surgery performed between 1997 and 2007 were age and sex matched to 343 control patients from the outpatient degenerative spinal disorders service at the University of Pittsburgh Medical Center. The authors obtained information on previous exposure to medical radiation, use of wireless phone technologies, and other environmental factors thought to be associated with the development of a VS. Conditional multivariate logistic regression was used to estimate adjusted odds ratios (aORs) and 95% confidence intervals (CIs). Results After adjusting for race, education, cigarette smoking, alcohol consumption, occupational exposure to noise, use of cell phones, and family history of cancer, the authors identified only a single factor that was associated with a higher risk of VS: individuals exposed to dental x-rays once a year (aOR = 2.27, 95% CI = 1.01-5.09) or once every 2-5 years (aOR = 2.65, 95% CI = 1.20-5.85), compared with those exposed less than once every 5 years. Of interest, a history of exposure to radiation related to head or head-and-neck computed tomography was associated with a reduced risk of VS (aOR = 0.52, 95% CI = 0.30-0.90). No relationship was found between the use of cell phones or cordless phones and VS. Conclusions Patients with acoustic neuromas reported significantly more exposure to dental x-rays than a matched cohort control group. Reducing the frequency of dental x-ray examinations may decrease the potential risk of VS.

Hanada E, Kodama K, Takano K, Watanabe Y, Nose Y. Possible electromagnetic interference with electronic medical equipment by radio waves coming from outside the hospital. J Med Syst 25(4):257-267, 2001.

Electromagnetic interference (EMI) with electronic medical equipment by radio waves from mobile telephone handsets has been reported and is currently receiving wide attention. The possibility of EMI with electronic medical equipment by radio waves coming into the hospital has also been pointed out. But so far, there are no reports measuring the frequency distribution of electric field intensity induced by incoming radio waves. Therefore, we measured electric field intensity induced by radio waves coming into our 11-floor hospital, which was under construction. The maximum intensity observed was about 200 V/m at 2.79 GHz, from airport surveillance radar waves. The maximum intensity induced by radio waves from cellular phone base stations was 1.78 V/m. These data show that various frequencies of radio waves are common in this urban area, and that they induce strong electricfield intensity. This strong electric field intensity might cause EMI with electronic medical equipment. Measurement of the electromagnetic environment should be done by each hospital in urban areas to prevent EMI with electronic medical equipment.

Hanada E, Takano K, Antoku Y, Matsumura K, Watanabe Y, Nose Y.A practical procedure to prevent electromagnetic interference with electronic medical

equipment. J Med Syst 26(1):61-65, 2002.

Problems involving electromagnetic interference (EMI) with electronic medical equipment are well-documented. However, no systematic investigation of EMI has been done. We have systematically investigated the causes of EMI. The factors involved in EMI were determined as follows: 1) Electric-field intensity induced by invasive radio waves from outside a hospital. 2) Residual magnetic-flux density at welding points in a building. 3) Electric-field intensity induced by conveyance systems with a linear motor. 4) The shielding capacity of hospital walls. 5) The shielding capacity of commercial shields against a wide range frequency radio waves. 6) The immunity of electronic medical equipment. 7) EMI by cellular telephone and personal handy-phone system handsets. From the results of our investigation, we developed a following practical procedure to prevent EMI. 1) Measurement of electric-field intensity induced by invasive radio waves from outside the hospital and industrial systems in the hospital. 2) Measurement of residual magnetic-flux density at electric welding points of hospital buildings with steel frame structures. 3) Control of the electromagnetic environment by utilizing the shielding capacity of walls. 4) Measurement of the immunity of electronic medical equipment. And 5) Installation of electronic gate equipment at the building entrance to screen for handsets.

Hanada E, Hoshino Y, Oyama H, Watanabe Y, Nose Y. Negligible electromagnetic interaction between medical electronic equipment and 2.4 GHz band wireless LAN. J Med Syst 26(4):301-308, 2002.

Wireless LANs using radio waves have recently gained popularity for installation in hospitals. Because electromagnetic waves transmitted from mobile telephones have been shown to cause interference with medical electronic equipment, prudence would seem necessary when introducing radio wave communication devices into hospitals. Therefore, we tested the effect of wireless LAN communication on medical electronic equipment and the effect of electronic equipment on wireless LAN communication. We observed nine pieces of electronic equipment in the operating mode while transmitting radio waves from a wireless LAN. Even when the access point was put very close to the medical electronic equipment surface and data was transmitted, no malfunction of the equipment was observed. The medical electronic equipment caused little change in the effectiveness of the communication device, although radio waves emitted from electric knives and a remote patient monitor reduced the reception rate to about 60%. The communication speed of the wireless LAN was temporarily reduced only when a microwave oven was located close to and facing the access point. Because output in Japan is limited to a maximum of 10 mW wireless LAN following the IEEE802.11b standard should be able to be installed safely in Japanese hospitals. However, wireless LAN access points should not be installed near microwave ovens.

Hancı H, Odacı E, Kaya H, Aliyazıcıoğlu Y, Turan I, Demir S, Colakoğlu S. The effect of prenatal exposure to 900-MHz electromagnetic field on the 21-old-day rat testicle. Reprod Toxicol. 42:203-209, 2013.

The aim of this study was to investigate the effect of exposure to a 900-MHz electromagnetic field (EMF) in the prenatal term on the 21-old-day rat testicle. Pregnant

rats were divided into control (CG) and EMF (EMFG) groups. EMFG was exposed to 900-MHz EMF during days 13-21 of pregnancy. Newborn CG rats were obtained from the CG and newborn EMFG (NEMFG) rats from the EMFG. Testicles were extracted at postnatal day 21. Lipid peroxidation and DNA oxidation levels, apoptotic index and histopathological damage scores were compared. NEMFG rats exhibited irregularities in seminiferous tubule basal membrane and epithelium, immature germ cells in the lumen, and a decreased diameter in seminiferous tubules and thickness of epithelium. Apoptotic index, lipid peroxidation and DNA oxidation were higher in NEMFG rats than in NCG. 21-day-old rat testicles exposed to 900-MHz EMF in the prenatal term may be adversely affected, and this effect persists after birth.

Hancı H, Türedi S, Topal Z, Mercantepe T, Bozkurt I, Kaya H, Ersöz Ş, Ünal B, Odacı E. Can prenatal exposure to a 900 MHz electromagnetic field affect the morphology of the spleen and thymus, and alter biomarkers of oxidative damage in 21-day-old male rats? Biotech Histochem. 2015 May 19:1-9. [Epub ahead of print]

We investigated the effects of a 900 Megahertz (MHz) electromagnetic field (EMF), applied during the prenatal period, on the spleen and thymus of 21-day-old male rat pups. Pregnant Sprague-Dawley rats were divided into control and EMF groups. We applied 900 MHz EMF for 1 h/day to the EMF group of pregnant rats. Newborn male rat pups were removed from their mothers and sacrificed on postnatal day 21. Spleen and thymus tissues were excised and examined. Compared to the control group, thymus tissue malondialdehyde levels were significantly higher in the group exposed to EMF, while glutathione levels were significantly decreased. Increased malondialdehyde and glutathione levels were observed in splenic tissue of rats exposed to EMF, while a significant decrease occurred in superoxide dismutase values compared to controls. Transmission electron microscopy showed pathological changes in cell morphology in the thymic and splenic tissues of newborn rats exposed to EMF. Exposure to 900 MHz EMF during the prenatal period can cause pathological and biochemical changes that may compromise the development of the male rat thymus and spleen.

Hanson Mild, K, Oftedal, G, Sandstrom, M, Wilen, J, Tynes, T, Haugsdal, B, Hauger E, Comparison of symptoms experienced by users of analogue and digital mobile phones: a Swedish-Norwegian epidemiological study. Arbetslivsrapport 1998:23.

Study of mobile phone users showed a statistically significant association between calling time/number of calls per day and the prevalence of warmth behind/around the ear, headaches, and fatigue.

Hansson Mild K, Hardell L, Carlberg M. Pooled analysis of two Swedish case-control studies on the use of mobile and cordless telephones and the risk of brain tumours diagnosed during 1997-2003. Int J Occup Saf Ergon 13(1):63-71, 2007.

Here we present the pooled analysis of 2 case-control studies on the association of brain tumours with mobile phone use. Use of analogue cellular phones increased the risk for acoustic neuroma by 5%, 95% confidence interval (CI) = 2-9% per 100 hrs of use. The risk increased for astrocytoma grade III-IV with latency period with highest estimates using >10-year time period from first use of these phone types. The risk

increased per one year of use of analogue phones by 10%, 95% CI = 6-14%, digital phones by 11%, 95% CI = 6-16%, and cordless phones by 8%, 95% CI = 5-12%. For all studied phone types OR for brain tumours, mainly acoustic neuroma and malignant brain tumours, increased with latency period, especially for astrocytoma grade III-IV.

Hansson B, Thors B, Törnevik C. Analysis of the effect of mobile phone base station antenna loading on localized SAR and its consequences for measurements. Bioelectromagnetics. 32(8):664-672, 2011.

In this work, the effect of antenna element loading on the localized specific absorption rate (SAR) has been analyzed for base station antennas. The analysis was conducted in order to determine whether localized SAR measurements of large multi-element base station antennas can be conducted using standardized procedures and commercially available equipment. More specifically, it was investigated if the antenna shifting measurement procedure, specified in the European base station exposure assessment standard EN 50383, will produce accurate localized SAR results for base station antennas larger than the specified measurement phantom. The obtained results show that SAR accuracy is affected by the presence of lossy material within distances of one wavelength from the tested antennas as a consequence of coupling and redistribution of transmitted power among the antenna elements. It was also found that the existing standardized phantom is not optimal for SAR measurements of large base station antennas. A new methodology is instead proposed based on a larger, box-shaped, whole-body phantom.

Hansteen IL, Lågeide L, Clausen KO, Haugan V, Svendsen M, Eriksen JG, Skiaker R, Hauger E, Vistnes AI, Kure EH. Cytogenetic effects of 18.0 and 16.5 GHz microwave radiation on human lymphocytes in vitro. Anticancer Res. 29(8):2885-2892, 2009.

BACKGROUND: There are few cell studies on the direct genotoxic effects of microwave radiation. In this study, cytogenetic effects of microwave radiation alone or in combination with mitomycin C (MMC) were investigated. MATERIALS AND METHODS: Lymphocytes from two smoking and four non-smoking donors were exposed for 53 hours in vitro to 1.0 W/m(2) continuous-wave radiation at 18.0 GHz or 10 W/m(2) pulsed-wave at 16.5 GHz, alone or in combination with MMC. DNA synthesis and repair were inhibited in vitro in some cultures. RESULTS: No synergistic effect was observed in cells exposed to combinations of microwave radiation and in vitro exposure to MMC, or to cells pre-exposed in vivo to tobacco smoke. For the 16.5 GHz pulsed exposure, a non-significant trend consisting of an increase in aberration frequencies with microwave radiation was shown for the DNA synthesis and repair inhibited cultures both with and without MMC. CONCLUSION: Neither 18.0 GHz continuous-wave nor 16.5 GHz pulsed-wave exposure to human lymphocytes in vitro induced statistically significant increases in chromosomal aberration frequencies. 16.5 GHz pulsed-wave exposure requires further documentation before a true negative conclusion can be drawn.

Hansteen IL, Clausen KO, Haugan V, Svendsen M, Svendsen MV, Eriksen JG,

Skiaker R, Hauger E, Lågeide L, Vistnes AI, Kure EH. Cytogenetic effects of exposure to 2.3 GHz radiofrequency radiation on human lymphocytes in vitro. Anticancer Res. 29(11):4323-4330, 2009.

BACKGROUND: No previous in vitro studies have tested radio frequency radiation for at least one full cell cycle in culture. The aim was to test if exposure used in mobile phones and wireless network technologies would induce DNA damage in cultured human lymphocytes with and without a known clastogen. MATERIALS AND METHODS: Lymphocytes from six donors were exposed to 2.3 GHz, 10 W/m(2) continuous waves, or 2.3 GHz, 10 W/m(2) pulsed waves (200 Hz pulse frequency, 50% duty cycle). Mitomycin C was added to half of the cultures. DNA synthesis and repair were inhibited in one experiment. RESULTS: No statistically significant differences were observed between control and exposed cultures. A weak trend for more chromosomal damage with the interaction of pulsed fields with mitomycin C compared to a constant field was observed. CONCLUSION: Exposure during the whole cell cycle in inhibited cultures did not resulted in significant differences in chromosomal aberrations as compared to controls.

Hao D, Yang L, Chen S, Tong J, Tian Y, Su B, Wu S, Zeng Y. Effects of long-term electromagnetic field exposure on spatial learning and memory in rats. Neurol Sci. 2012 Feb 24. [Epub ahead of print]

With the development of communications industry, mobile phone plays an important role in daily life. Whether or not the electromagnetic radiation emitted by mobile phone causes any adverse effects on brain function has become of a great concern. This paper investigated the effect of electromagnetic field on spatial learning and memory in rats. 32 trained Wistar rats were divided into two groups: exposure group and control group. The exposure group was exposed to 916 MHz, 10w/m2 mobile phone electromagnetic field (EMF) 6 h a day, 5 days a week, 10 weeks. The completion time, number of total errors and the neuron discharge signals were recorded while the rats were searching for food in an eight-arm radial maze at every weekend. The neuron signals of one exposed rat and one control rat in the maze were obtained by the implanted microelectrode arrays in their hippocampal regions. It can be seen that during the weeks 4-5 of the experiment, the average completion time and error rate of the exposure group were longer and larger than that of control group ($p < 0.05$). During the weeks 1-3 and 6-9, they were close to each other. The hippocampal neurons showed irregular firing patterns and more spikes with shorter interspike interval during the whole experiment period. It indicates that the 916 MHz EMF influence learning and memory in rats to some extent in a period during exposure, and the rats can adapt to long-term EMF exposure.

Hao YT, Pei LP, Chen CH, Yang XS, Zhang GB, Deng ZH, Yu ZP. [Effects of occupational microwave irradiation on heat shock protein 70 expressions in rat hippocampus.] Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 27(9):553-556, 2009. [Article in Chinese]

OBJECTIVE: To study the change of heat shock protein (HSP)70 expression after exposure to occupational microwave in rats hippocampus, and explore the role of

HSP70 in the mechanism of bio-effect of microwave irradiation. METHODS: The animal model was established by whole body exposures in 90, 5 W/cm(2) microwave irradiation field for 20 min in rats. Changes of the mRNA of hsp70 expressions in rat hippocampus at different time were studied by RT-PCR, and the protein change by Western blot. RESULTS: The mRNA and protein expression of hsp70 in rat hippocampus increased after 90 W/cm(2) and 5 W/cm(2) microwave irradiation for 20 min. The anal temperature and the value of SAR increased significantly. These changes were positively correlated with power and irradiation time of microwave. The results indicated that microwave irradiation led to HSP70 syntheses effectively. CONCLUSION: Microwave irradiation can obviously induce the thermal effect and activate HSP70, and initiate the endogens protective mechanism of central nervous system.

Hao Y, Yang X, Chen C, Yuan-Wang, Wang X, Li M, Yu Z. STAT3 signalling pathway is involved in the activation of microglia induced by 2.45 GHz electromagnetic fields. Int J Radiat Biol. 86(1):27-36, 2010.

PURPOSE: Microglia activation plays a pivotal role in the initiation and progression of central nervous system (CNS) insult. The aim of the present work was to investigate theactivation of microglia and involvement of signal transducer and activator of transcription 3 (STAT3) in microglia activation after 2.45 GHz electromagnetic fields (EMF) exposure. **MATERIALS AND METHODS:** In this study, murine N9 microglial cells were exposed to 2.45 GHz EMF, the protein expressions of STAT3, Janus Tyrosine kinase 1 and 2(JAK1 and JAK2), phosphor-(Try705)STAT3 and DNA binding activity of STAT3 were examined by Western blot analysis and electrophoresis mobility shift assay (EMSA). Levels of the nitric oxide (NO) derivative nitrite were determined in the culture medium by the Griess reaction. The mRNA expression of tumour necrosis factor alpha (TNF-alpha) and inducible nitric oxide synthase (iNOS) were detected by reverse transcription and polymerase chain reaction (RT-PCR). **RESULTS:** A significant increase of STAT3 DNA-binding ability was noted after exposure. Consistent with this, EMF rapidly induced phosphorylation of STAT3 and activated JAK1 and JAK2. In addition, EMF exposure increased transcription levels of the inflammation-associated genes, iNOS and TNF-alpha, which are reported to contain STAT-binding elements in their promoter region. P6, a JAK inhibitor, reduced induction of iNOS and TNF-alpha, nuclear factor binding activity, and activation of STAT3 in EMF-stimulated microglia. **CONCLUSION:** These results provide evidence that EMF exposure can initiate the activation of microglia cells and STAT3 signalling involves in EMF-induced microglial activation.

Hardell L, Carlberg M. Mobile phones, cordless phones and the risk for brain tumours. Int J Oncol. 35(1):5-17, 2009.

The Hardell-group conducted during 1997-2003 two case control studies on brain tumours including assessment of use of mobile phones and cordless phones. The questionnaire was answered by 905 (90%) cases with malignant brain tumours, 1,254 (88%) cases with benign tumours and 2,162 (89%) population-based controls. Cases were reported from the Swedish Cancer Registries. Anatomical area in the brain for the

tumour was assessed and related to side of the head used for both types of wireless phones. In the current analysis we defined ipsilateral use (same side as the tumour) as >/=50% of the use and contralateral use (opposite side) as <50% of the calling time. We report now further results for use of mobile and cordless phones. Regarding astrocytoma we found highest risk for ipsilateral mobile phone use in the >10 year latency group, OR=3.3, 95% CI=2.0-5.4 and for cordless phone use OR=5.0, 95% CI=2.3-11. In total, the risk was highest for cases with first use <20 years age, for mobile phone OR=5.2, 95% CI=2.2-12 and for cordless phone OR=4.4, 95% CI=1.9-10. For acoustic neuroma, the highest OR was found for ipsilateral use and >10 year latency, for mobile phone OR=3.0, 95% CI=1.4-6.2 and cordless phone OR=2.3, 95% CI=0.6-8.8. Overall highest OR for mobile phone use was found in subjects with first use at age <20 years, OR=5.0, 95% CI 1.5-16 whereas no association was found for cordless phone in that group, but based on only one exposed case. The annual age-adjusted incidence of astrocytoma for the age group >19 years increased significantly by +2.16%, 95% CI +0.25 to +4.10 during 2000-2007 in Sweden in spite of seemingly underreporting of cases to the Swedish Cancer Registry. A decreasing incidence was found for acoustic neuroma during the same period. However, the medical diagnosis and treatment of this tumour type has changed during recent years and underreporting from a single center would have a large impact for such a rare tumour.

Hardell L, Hansson Mild K, Pahlson A, Hallquist A, Ionizing radiation, cellular telephones and the risk of brain tumours. Europ J Cancer Prevent 10:523-529, 2001.

A case-control study on brain tumours included 233 patients aged 20-80 years and alive at the study time. They had histopathologically verified brain tumour and lived in the Upsala-Orebro region (1994-1996) or in Stockholm region (1995-1996). Two matched controls to each case were selected from the Swedish Population Register. Two hundred and nine cases (90%) and 425 controls (91%) answered the questionnaire. Results are presented for the whole study group, as given here, and for malignant and benign tumours separately. For workers in the chemical industry the odds ratio (OR) was 4.10, 95% confidence interval (95% CI) 1.25-13.4 and laboratory workers OR 3.21, 95%CI 1.16-8.85. Radiotherapy of the head and neck region gave OR 3.61, 95% CI 0.65-19.9. Medical diagnostic X-ray of the same area yielded OR 1.64, 95% CI 1.04-2.58. Work as a physician gave OR 6.00, 95% CI 0.62-57.7. All three cases had worked with fluoroscopy. Ipsilateral (same side) use of a cellular telephone increased the risk of tumours in the temporal, temporo-parietal and occipital areas, with OR 2.42, 95% CI 0.97-6.05 (i.e., the anatomical areas with highest exposure to microwaves from a mobile phone).

Hardell, L, Reizenstein, J, Johansson, B, Gertzen, H, Mild, KH, Angiosarcoma of the scalp and use of a cordless (portable) telephone. Epidemiology 10(6):785-786, 1999.

This is a case study of a 57-year old woman who was diagnosed in January 1999 with an angiosarcoma of the scalp on the left side of her head (2 cm above her ear). Angiosarcoma is a rare type of soft tissue sarcoma (STS). Since 1988, the patient had, on a regular basis (1 hr per day), used a cordless (portable) phone, always using her left

ear. Starting in 1994, she also used a GSM (digital) mobile phone on her left ear (a few minutes per week). The exposure to microwaves from a cordless phone in this patient is of interest because she had exposure on a daily basis starting 10 years before the first clinical signs of her angiosarcoma. Moreover, the tumor developed in the anatomical area with the highest exposure to microwaves on the same side of the head that she had used the phone. She also reported no exposure to other know risk factors for STS.

Hardell L, Nasman A, Ohlson CG, Fredrikson M. Case-control study on risk factors for testicular cancer. Int J Oncol 13(6):1299-1303, 1998.

Occupational exposures were assessed in a case-control study on testicular cancer using self administered questionnaires. Answers were obtained for 148 (91%) cases and 314 (87%) controls. Of the cases 101 had seminoma and 47 had embryonal testicular cancer. Occupational plastics work yielded odds ratio (OR) 2.9 with 95% confidence interval (CI) 1.3-6.5. Increased risk was found for embryonal cancer regarding farming (OR 3.1; CI 1.03-9.1) and contact with farm animals (OR 3.3; CI 1.00-10.9), but not for seminoma. For all testicular cancer exposure to insects repellents, mostly containing N,N-diethyl-m-toluamide (DEET) gave OR 1.7; CI 1.03-2.8, with a dose-response effect. Somewhat increased risks were found for amateur radio operators (OR 2.2; CI 0.7-6.6), work with radar equipment (OR 2.0; CI 0.3-14.2) and engineers in electronics and telecommunication industry (OR 2.3; CI 0.8-6.7) based on few exposed subjects, however. Video display unit work gave OR 1.5; CI 0.98-2.3 and for exposure 480 working days (median number) the risk increased further to OR 1.8; CI 1.1-3.2. Because of low numbers of exposed subjects in some calculations some of these results might be spurious and need to be further studied.

Hardell, L, Nasman, A, Pahlson, A, Hallquist, A, Hansson Mild, K, Use of cellular telephones and the risk for brain tumours: A case-control study. Int J Oncol 15(1):113-116, 1999.

The use of cellular telephones has increased dramatically during the 1990's in the world. In the 1980's the analogue NMT system was used whereas the digital GSM system was introduced in early 1990's and is now the preferred system. Case reports of brain tumours in users initiated this case-control study on brain tumours and use of cellular telephones. Also other exposures were assessed. All cases, both males and females, with histopathologically verified brain tumour living in Uppsala-Orebro region (1994-96) and Stockholm region (1995-96) aged 20-80 at the time of diagnosis and alive at start of the study were included, 233 in total. Two controls to each case were selected from the Swedish Population Register matched for sex, age and study region. Exposure was assessed by questionnaires supplemented over the phone. The analyses were based on answers from 209 (90%) cases and 425 (91%) controls. Use of cellular telephone gave odds ratio (OR) = 0.98 with 95% confidence interval (CI) = 0. 69-1.41. For the digital GSM system OR = 0.97, CI = 0.61-1.56 and for the analogue NMT system OR = 0.94, CI = 0.62-1.44 were calculated. Dose-response analysis and using different tumour induction periods gave similar results. Non-significantly increased risk was found for tumour in the temporal or occipital lobe on the same side as a cellular phone had been used, right side OR = 2.45, CI = 0.78-7.76, left side OR = 2.40, CI = 0.52-10.9 Increased risk was found only for use of the NMT system. For GSM use the observation time is still too short for

definite conclusions. An increased risk for brain tumour in the anatomical area close to the use of a cellular telephone should be especially studied in the future.

Hardell L, Nasman A, Pahlson A, Hallquist A. Case-control study on radiology work, medical x-ray investigations, and use of cellular telephones as risk factors for brain tumors. Medscape General Medicine May 4, 2000.

Abstract. Context. Ionizing radiation is a well-established risk factor for brain tumors. During recent years, microwave exposure from the use of cellular telephones has been discussed as a potential risk factor. Objective. To determine risk factors for brain tumors. Design. A case-control study, with exposure assessed by questionnaires. Participants. A total of 233 currently living men and women, aged 20 to 80 years, were included. The case patients had histopathologically verified brain tumors and lived in the Uppsala-Orebro region (1994-1996) or the Stockholm region (1995-1996). Two matched controls to each case were selected from the Swedish Population Register. Main Outcome Measures. Ionizing radiation and use of cellular telephones as risk factors for brain tumors. Results. A total of 209 cases (90%) and 425 controls (91%) answered the questionnaire. Work as a physician yielded an odds ratio (OR) of 6.00, with a 95% confidence interval (CI) of 0.62 to 57.7. All three case patients had worked with fluoroscopy. Radiotherapy of the head and neck region yielded an OR of 3.61 (95% CI, 0.65-19.9). Medical diagnostic x-ray examination of the same area yielded an OR of 2.10 (95% CI, 1.25-3.53), with a tumor induction period of 5 years or more. Chemical industry work yielded an OR of 4.10 (95% CI, 1.25-13.4), and laboratory work yielded an OR of 3.21 (95% CI, 1.16-8.85). Ipsilateral use of cellular telephones increased the risk for tumors in the temporal, temporoparietal, and occipital lobes (OR, 2.42; 95% CI, 0.97-6.05), ie, the anatomic areas with highest exposure to microwaves from a mobile telephone. The result was further strengthened (OR, 2.62; 95% CI, 1.02-6.71) in a multivariate analysis that included laboratory work and medical diagnostic x-ray investigations of the head and neck. Conclusion. Exposure to ionizing radiation, work in laboratories, and work in the chemical industry increased the risk of brain tumors. Use of a cellular telephone was associated with an increased risk in the anatomic area with highest exposure.

Hardell L, Hallquist A, Hansson Mild K, Carlberg M, Pahlson A, Lilja A. cellular and cordless telephones and the risk for brain tumours. Europ J Cancer Prevent 11:377-386, 2002.

Microwave exposure from the use of cellular telephones ahs been discussed in recently years as a potential risk factor for brain tumours. We included in a case-control study 1617 patients aged 20-80 years of both sexes with brain tumour diagnosed between 1 January 1997 and 30 June 2000. They were alive at the study time and had histopathologically verified brain tumour. One matched control to each case was selected from the Swedish Population Register. The study area was the Uppsala-Orebro, Stockholm, Linkoping and Goteborg medical regions of Sweden. Exposure was assessed by a questionnaire that was answered by 1429 (88%) cases and 1470 (91%) controls. In total, use of analogue cellular telephones gave an increased risk with an odds ratio (OR) of 1.3 (95% confidence interval (CI) 1.02-1.6). With a tumour induction period of >10 years the risk increased further; OR 1.8 (95% CI 1.1-2.9). No clear association was found

for digital or cordless telephones. With regard to the anatomical area of the tumour and exposure to microwaves, the risk was increased for tumours located in the temporal area on the same side of the brain that was used during phone calls; for analogue cellular telephones the OR was 2.5 (95% CI 1.3-4.9). Use of a telephone on the opposite side of the brain was not associated with an increased risk for brain tumours. With regard to different tumour types, the highest risk was for acoustic neurinoma (OR 3.5, 95% CI 1.8-6.8) among analogue cellular telephone users.

Hardell L, Mild KH, Carlsberg M. Case-control study on the use of cellular and cordless phones and the risk for malignant brain tumours. Int. J. Radiat. Biol. 78:931-936, 2002.

Purpose: To investigate the use of cellular and cordless phones and the risk for malignant brain tumours. Materials and Methods: A case-control study was performed on 649 patents aged 20-80 years of both sexes with malignant brain tumour diagnosed from 1 January 1997 to 30 June 2000. All patients were alive during the time of the study and had histopathology verified brain tumours. One matched control to each case was selected from the Swedish Population Register. The study area was the Uppasala-Orebro, Stockholm, Linkoping and Goteborg medical regions of Sweden. Results: Exposure was assessed by a questionnaire answered by 588 (91%) cases and 581 (90%) controls. Phone usage was defined as 'ever use' and usage starting 1 year before dagnosis was disregarded. Overall, no significantly increased risks were found: analogue cellular phones yielded an odds ratio (OR) =1.13, 95% confidence interval (CI) = 0.82-1.57, digital cellular phones OR = 1.13, CI = 0.86-1.48, and cordless phones OR = 1.13, CI =0.85-1.50. For ipsilateral (same side) radiofrequency exposure, analogue mobile phones gave OR = 1.85, CI = 1.16-2.96, for all malignant brain tumours. For astrocytoma, this risk was OR = 1.95, CI = 1.12-3.39. For all malignant brain tumours, digital mobile phones yielded OR = 1.59, CI = 1.05-2.41, and cordless phones yielded OR = 1.46, CI = 0.96-2.23, in the analysis of ipsilateral exposure. Conclusion: The ipsilateral use of an analogue cellular phone yielded a significantly increased risk for malignant brain tumours.

Hardell L, Mild KH, Carlberg M. Further aspects on cellular and cordless telephones and brain tumours. Int J Oncol 22(2):399-407, 2003.

We included in a case-control study on brain tumours and mobile and cordless telephones 1,617 patients aged 20-80 years of both sexes diagnosed during January 1, 1997 to June 30, 2000. They were alive at the study time and had histopathology verified brain tumour. One matched control to each case was selected from the Swedish Population Register. The study area was the Uppsala-Orebro, Stockholm, Linkoping and Goteborg medical regions of Sweden. Exposure was assessed by a questionnaire that was answered by 1,429 (88%) cases and 1,470 (91%) controls. In total use of analogue cellular telephones gave an increased risk with odds ratio (OR)=1.3, 95% confidence interval (CI)=1.04-1.6, whereas digital and cordless phones did not overall increase the risk significantly. Ipsilateral use of analogue phones gave OR=1.7, 95% CI=1.2-2.3, digital phones OR=1.3, 95% CI=1.02-1.8 and cordless phones OR=1.2, 95% CI=0.9-1.6. The risk for ipsilateral use was significantly increased for astrocytoma for all studied phone types, analogue phones OR=1.8,95% CI=1.1-3.2, digital phones OR=1.8, 95% CI=1.1-2.8, cordless phones OR=1.8, 95% CI=1.1-2.9. Use of a telephone on the opposite side

of the brain was not associated with a significantly increased risk for brain tumours. Regarding anatomical area of the tumour and exposure to microwaves, the risk was increased for tumours located in the temporal area on the same side of the brain that was used during phone calls, significantly so for analogue cellular telephones OR=2.3, 95% CI=1.2-4.1. For acoustic neurinoma OR=4.4, 95% CI=2.1-9.2 was calculated among analogue cellular telephone users. When duration of use was analysed as a continuous variable in the total material, the risk increased per year for analogue phones with OR=1.04, 95% CI=1.01-1.08. For astrocytoma and ipsilateral use the trend was for analogue phones OR=1.10, 95% CI=1.02-1.19, digital phones OR=1.11, 95% CI=1.01-1.22, and cordless phones OR=1.09, 95% CI=1.01-1.19. There was a tendency of a shorter tumour induction period for ipsilateral exposure to microwaves than for contralateral, which may indicate a tumour promotor effect.

Hardell L, Mild KH, Sandstrom M, Carlberg M, Hallquist A, Pahlson A. Vestibular schwannoma, tinitus and cellular telephones. Neuroepidemiol 22:124-129, 2003.

Cases with tinnitus after using analogue cellular telephones are presented. An increased odds radio of 3.45, 95% confidence interval (CI) 1.77-6.76, was found for vestibular schwannoma (VS) associated with the use of analogue cell phones. During the time period 1960-1998, the age-standardized incidence of VS in Sweden significantly increased yearly by +2.53% (CI 1.71-3.35). A significant increases in the incidence of VS was only found for the latter of the two time period 1960-1979 and 1980-1998. For all other brain tumors taken together, the incidence significantly increased yearly by +0.80% (CI 0.59-1.02) for the time period 1960-1998, although the increase was only significant for benign tumors other than VS during 1960-1979.

Hardell L, Hallquist A, Hansson Mild K, Carlberg M, Gertzen H, Schildt EB, Dahlqvist A. No association between the use of cellular or cordless telephones and salivary gland tumours. Occup Environ Med. 61(8):675-679, 2004.

AIM: To investigate the association between the use of cellular or cordless telephones and the risk for salivary gland tumours. METHODS: Cases were assessed from the six regional cancer registries in Sweden. Four controls matched for sex and age in five year age groups were selected for each case. A total of 293 living cases and 1172 controls were included. RESULTS: There were 267 (91%) participating cases and 1053 (90%) controls. Overall no significantly increased risk was found. Odds ratios were 0.92 (95% CI 0.58 to 1.44) for use of analogue phones, 1.01 (95% CI 0.68 to 1.50) for use of digital phones, and 0.99 (95% CI 0.68 to 1.43) for use of cordless phones. Similar results were found for different salivary gland localisations. No effect of tumour induction period or latency was seen, although few subjects reported use for more than 10 years. CONCLUSIONS: No association between the use of cellular or cordless phones and salivary gland tumours was found, although this study does not permit conclusions for long term heavy use.

Hardell L, Carlberg M, Hansson Mild K. Use of cellular telephones and brain tumour risk in urban and rural areas. Occup Environ Med 62:390-394, 2005.

Aim: To investigate the association between the use of cellular or cordless telephones and the risk for brain tumours in different geographical areas, urban and rural. Methods:

patients aged 20-80 years, living in the middle part of Sweden, and diagnosed between 1 January 1997 and 30 June 2000 were included. One control matched for sex and age in five year age groups was selected for each case. Use of different phone types was assessed by a questionnaire. Results: The number of participating cases was 1429; there were 1470 controls. An effect of rural living was most pronounced for digital cellular telephones. Living in rural areas yielded an odd ratio (OR) of 1.4 (95% CI 0.98 to 2.0), increasing to 3.2 (95% CI 1.2 to 8.4) with > 5 year latency time for digital phones. The corresponding Ors for living in urban areas were 0.9 (95% CI 0.8 to 1.2) and 0.9 (95% CI 0.6 to 1.4), respectively. This effect was most obvious for malignant brain tumours. Conclusion: In future studies, place of residence should be considered in assessment of exposure to microwaves from cellular telephone, although the results in this study must be interpreted with caution due to low numbers in some of the calculations.

Hardell L, Carlberg M, Hansson Mild K. Case-control study on cellular and cordless telephones and the risk for acoustic neuroma or meningioma in patients diagnosed 2000-2003. Neuroepidemiology 25:120-128, 2005.

We performed a case-control study on the use of cellular and cordless telephones and the risk for brain tumors. We report the results for benign brain tumors with data from 413 cases (89% response rate), 305 with meningioma, 84 with acoustic neuroma, 24 with other types and 692 controls (84% response rate). For meningioma, analogue phones yielded odds ratio (OR) = 1.7, 95% confidence interval (CI) = 0.97-3.0, increasing to OR = 2.1, 95% CI = 1.1-4.3 with a >10-year latency period. Also digital cellular phones and cordless phones increased the risk to some extent. For acoustic neuroma, analogue phones gave OR = 4.2, 95% CI = 1.8-10 increasing to OR = 8.4, 95% CI = 1.6-45 with a >15-year latency period, but based on low numbers. Digital phones yielded OR = 2.0, 95% CI = 1.05-3.8, whereas for cordless phones OR was not significantly increased. In the multivariate analysis, analogue phones represented a significant risk factor for acoustic neuroma.

Hardell L, Eriksson M, Carlberg M, Sundstrom C, Mild KH. Use of cellular or cordless telephones and the risk for non-Hodgkin's lymphoma. Int Arch Occup Environ Health. 78(8):625-632, 2005.

Objectives: To evaluate the use of cellular and cordless telephones as the risk factor for non-Hodgkin's lymphoma (NHL). Methods: Male and female subjects aged 18-74 years living in Sweden were included during a period from 1 December 1999 to 30 April 2002. Controls were selected from the national population registry. Exposure to different agents was assessed by questionnaire. Results: In total, 910 (91%) cases and 1016 (92%) controls participated. NHL of the B-cell type was not associated with the use of cellular or cordless telephones. Regarding T-cell NHL and >5 year latency period, the use of analogue cellular phones yielded: odds ratio (OR) = 1.46, 95%; confidence interval (CI) = 0.58-3.70, digital: OR=1.92, 95%; CI=0.77-4.80 and cordless phones: OR=2.47; CI=1.09-5.60. The corresponding results for certain, e.g. cutaneous and leukaemia, T-cell lymphoma for analogue phones were: OR=3.41, 95%; CI=0.78-15.0, digital: OR=6.12, 95%; CI=1.26-29.7 and cordless phones: OR=5.48, 95%; CI=1.26-23.9. Conclusions: The results indicate an association between T-cell NHL and the use of cellular and cordless telephones, however based on low numbers and must be interpreted with

caution. Regarding B-cell NHL no association was found.

Hardell, L., Carlberg, M., Mild, K., 2005. Case-control study of the association between the use of cellular and cordless telephones and malignant brain tumors diagnosed during 2000-2003. Environ Res 100(2):232-241, 2006.

We performed a case–control study on the use of cellular and cordless telephones and the risk for brain tumors diagnosed during 2000–2003. We report the results for malignant brain tumors with data from 317 cases (88%) and 692 controls (84%). The use of analog cellular phones yielded odds ratio (OR) of 2.6 and a 95% confidence interval (CI) of 1.5–4.3, increasing to OR=3.5 and 95% CI=2.0–6.4 with a >10-year latency period. Regarding digital cellular telephones, the corresponding results were OR=1.9, 95% CI=1.3–2.7 and OR=3.6, 95% CI=1.7–7.5, respectively. Cordless telephones yielded OR=2.1, 95% CI=1.4–3.0, and with a >10-year latency period, OR=2.9, 95% CI=1.6–5.2. The OR increased with the cumulative number of hours of use and was highest for high-grade astrocytoma. A somewhat increased risk was also found for low-grade astrocytoma and other types of malignant brain tumors, although not significantly so. In multivariate analysis, all three phone types studied showed an increased risk.

Hardell L, Carlberg M, Hansson Mild K. Pooled analysis of two case-control studies on the use of cellular and cordless telephones and the risk of benign brain tumours diagnosed during 1997-2003. Int J Oncol. 28(2):509-518, 2006.

The use of cellular and cordless telephones and the risk of brain tumours is of concern since the brain is a high exposure area. We present the results of a pooled analysis of two case-control studies on benign brain tumours diagnosed during 1997-2003 including answers from 1,254 (88%) cases and 2,162 (89%) controls aged 20-80 years. For acoustic neuroma, the use of analogue cellular phones gave an odds ratio (OR) of 2.9 and a 95% confidence interval (CI) of 2.0-4.3; for digital cellular phones, OR=1.5; 95% CI=1.1-2.1; and for cordless telephones, OR=1.5, 95% CI=1.04-2.0. The highest OR was found for analogue phones with a latency period of >15 years; OR=3.8, 95% CI=1.4-10. Regarding meningioma, the results were as follows: for analogue phones, OR=1.3, 95% CI=0.99-1.7; for digital phones, OR=1.1, 95% CI=0.9-1.3; and for cordless phones, OR=1.1, 95% CI=0.9-1.4. In the multivariate analysis, a significantly increased risk of acoustic neuroma was found with the use of analogue phones.

Hardell L, Carlberg M, Hansson Mild K. Pooled analysis of two case-control studies on use of cellular and cordless telephones and the risk for malignant brain tumours diagnosed in 1997-2003. Int Arch Occup Environ Health. 79(8):630-639, 2006.

Objectives: To study the use of cellular and cordless telephones and the risk for malignant brain tumours. Methods: Two case-control studies on malignant brain tumours diagnosed during 1997-2003 included answers from 905 (90%) cases and 2,162 (89%) controls aged 20-80 years. We present pooled analysis of the results in the two studies. Results: Cumulative lifetime use for >2,000 h yielded for analogue cellular phones odds ratio (OR)=5.9, 95% confidence interval (CI)=2.5-14, digital cellular phones OR=3.7, 95% CI=1.7-7.7, and for cordless phones OR=2.3, 95% CI=1.5-3.6. Ipsilateral exposure increased the risk for malignant brain tumours; analogue OR=2.1, 95% CI=1.5-2.9, digital

OR=1.8, 95% CI=1.4-2.4, and cordless OR=1.7, 95% CI=1.3-2.2. For high-grade astrocytoma using >10 year latency period analogue phones yielded OR=2.7, 95% CI=1.8-4.2, digital phones OR=3.8, 95% CI=1.8-8.1, and cordless phones OR=2.2, 95% CI=1.3-3.9. In the multivariate analysis all phone types increased the risk. Regarding digital phones OR=3.7, 95% CI=1.5-9.1 and cordless phones OR=2.1, 95% CI=0.97-4.6 were calculated for malignant brain tumours for subjects with first use use <20 years of age, higher than in older persons. Conclusion: Increased risk was obtained for both cellular and cordless phones, highest in the group with >10 years latency period.

Hardell L, **Carlberg M**, **Ohlson CG**, **Westberg H**, **Eriksson M**, **Hansson Mild K**. **Use of cellular and cordless telephones and risk of testicular cancer. Int J Androl.30(2):115-122, 2007.**

A case-control study on testicular cancer included use of cellular and cordless telephones. The results were based on answers from 542 (92%) cases with seminoma, 346 (89%) with non-seminoma, and 870 (89%) controls. Regarding seminoma the use of analog cellular phones gave odds ratio (OR) = 1.2, 95% confidence interval (CI) = 0.9-1.6, digital phones OR = 1.3, CI = 0.9-1.8, and cordless phones OR = 1.1, CI = 0.8-1.5. The corresponding results for non-seminoma were OR = 0.7, CI = 0.5-1.1, OR = 0.9, CI = 0.6-1.4, and OR = 1.0, CI = 0.7-1.4, respectively. There was no dose-response effect and OR did not increase with latency time. No association was found with place of keeping the mobile phone during standby, such as trousers pocket. Cryptorchidism was associated both with seminoma (OR = 4.2, CI = 2.7-6.5) and non-seminoma (OR = 3.3, CI = 2.0-5.6), but no interaction was found with the use of cellular or cordless telephones.

Hardell LO, Carlberg M, Soderqvist F, Hansson Mild K, Morgan LL Long-term use of cellular phones and brain tumours - increased risk associated with use for > 10 years. Occup Environ Med.64(9):626-632, 2007.

AIM: To evaluate brain tumour risk among long-term users of cellular telephones. METHODS: One cohort study and 13 case-control studies were identified on this topic. Data were scrutinized for use of mobile phone for > 10 years and ipsilateral exposure if presented. RESULTS: The cohort study was of limit value due to methodological shortcomings in the study. Of the 13 case-control studies, 9 gave results for > 10 years use or latency period. Most of these results were based on low numbers. Clearly an association with acoustic neuroma was found in four studies with two- to three-fold increased risk in the group with at least 10 years use of a mobile phone. No risk was found in one study, but the tumour size was significantly larger among users. Five studies gave results for malignant brain tumours in that latency group. All gave increased OR especially for ipsilateral exposure. Highest OR = 5.4, 95 % CI = 3.0-9.6 was calculated for high-grade glioma and ipsilateral exposure in one study. CONCLUSIONS: Results from present studies on use of mobile phones for > 10 years give a consistent pattern of an increased risk for acoustic neuroma and glioma, most pronounced for high-grade glioma. The risk is highest for ipsilateral exposure.

Hardell L, Carlberg M, Söderqvist F, Hansson Mild K. Meta-analysis of long-term mobile phone use and the association with brain tumours. Int J Oncol. 32(5):1097-

1103, 2008.

We evaluated long-term use of mobile phones and the risk for brain tumours in case-control studies published so far on this issue. We identified ten studies on glioma and meta-analysis yielded OR = 0.9, 95% CI = 0.8-1.1. Latency period of >/=10-years gave OR = 1.2, 95% CI = 0.8-1.9 based on six studies, for ipsilateral use (same side as tumour) OR = 2.0, 95% CI = 1.2-3.4 (four studies), but contralateral use did not increase the risk significantly, OR = 1.1, 95% CI = 0.6-2.0. Meta-analysis of nine studies on acoustic neuroma gave OR = 0.9, 95% CI = 0.7-1.1 increasing to OR = 1.3, 95% CI = 0.6-2.8 using >/=10-years latency period (four studies). Ipsilateral use gave OR = 2.4, 95% CI = 1.1-5.3 and contra-lateral OR = 1.2, 95% CI = 0.7-2.2 in the >/=10-years latency period group (three studies). Seven studies gave results for meningioma yielding overall OR = 0.8, 95% CI = 0.7-0.99. Using >/=10-years latency period OR = 1.3, 95% CI = 0.9-1.8 was calculated (four studies) increasing to OR = 1.7, 95% CI = 0.99-3.1 for ipsilateral use and OR = 1.0, 95% CI = 0.3-3.1 for contralateral use (two studies). We conclude that this meta-analysis gave a consistent pattern of an association between mobile phone use and ipsilateral glioma and acoustic neuroma using >/=10-years latency period.

Hardell L, Carlberg M, Hansson Mild K. Mobile phone use and the risk for malignant brain tumors: A case-control study on deceased cases and controls. Neuroepidemiology. 35(2):109-114, 2010.

We investigated the use of mobile or cordless phones and the risk for malignant brain tumors in a group of deceased cases. Most previous studies have either left out deceased cases of brain tumors or matched them to living controls and therefore a study matching deceased cases to deceased controls is warranted. Recall error is one issue since it has been claimed that increased risks reported in some studies could be due to cases blaming mobile phones as a cause of the disease. This should be of less importance for deceased cases and if cancer controls are used. In this study brain tumor cases aged 20-80 years diagnosed during 1997-2003 that had died before inclusion in our previous studies on the same topic were included. Two control groups were used: one with controls that had died from another type of cancer than brain tumor and one with controls that had died from other diseases. Exposure was assessed by a questionnaire sent to the next-of-kin for both cases and controls. Replies were obtained for 346 (75%) cases, 343 (74%) cancer controls and 276 (60%) controls with other diseases. Use of mobile phones gave an increased risk, highest in the >10 years' latency group yielding odds ratio (OR) = 2.4, and 95% confidence interval (CI) = 1.4-4.1. The risk increased with cumulative number of lifetime hours for use, and was highest in the >2,000 h group (OR = 3.4, 95% CI = 1.6-7.1). No clear association was found for use of cordless phones, although OR = 1.7, 95% CI = 0.8-3.4 was found in the group with >2,000 h of cumulative use. This investigation confirmed our previous results of an association between mobile phone use and malignant brain tumors.

Hardell L, Carlberg M, Söderqvist F, Mild KH. Case-control study of the association between malignant brain tumours diagnosed between 2007 and 2009 and mobile and cordless phone use. Int J Oncol. 43(6):1833-1845, 2013.

Previous studies have shown a consistent association between long-term use of mobile and cordless phones and glioma and acoustic neuroma, but not for meningioma. When used these phones emit radiofrequency electromagnetic fields (RF-EMFs) and the brain is the main target organ for the handheld phone. The International Agency for Research on Cancer (IARC) classified in May, 2011 RF-EMF as a group 2B, i.e. a 'possible' human carcinogen. The aim of this study was to further explore the relationship between especially long-term (>10 years) use of wireless phones and the development of malignant brain tumours. We conducted a new case-control study of brain tumour cases of both genders aged 18-75 years and diagnosed during 2007-2009. One population-based control matched on gender and age (within 5 years) was used to each case. Here, we report on malignant cases including all available controls. Exposures on e.g. use of mobile phones and cordless phones were assessed by a self-administered questionnaire. Unconditional logistic regression analysis was performed, adjusting for age, gender, year of diagnosis and socio-economic index using the whole control sample. Of the cases with a malignant brain tumour, 87% (n=593) participated, and 85% (n=1,368) of controls in the whole study answered the questionnaire. The odds ratio (OR) for mobile phone use of the analogue type was 1.8, 95% confidence interval (CI)=1.04-3.3, increasing with >25 years of latency (time since first exposure) to an OR=3.3, 95% CI=1.6-6.9. Digital 2G mobile phone use rendered an OR=1.6, 95% CI=0.996-2.7, increasing with latency >15-20 years to an OR=2.1, 95% CI=1.2-3.6. The results for cordless phone use were OR=1.7, 95% CI=1.1-2.9, and, for latency of 15-20 years, the OR=2.1, 95% CI=1.2-3.8. Few participants had used a cordless phone for >20-25 years. Digital type of wireless phones (2G and 3G mobile phones, cordless phones) gave increased risk with latency >1-5 years, then a lower risk in the following latency groups, but again increasing risk with latency >15-20 years. Ipsilateral use resulted in a higher risk than contralateral mobile and cordless phone use. Higher ORs were calculated for tumours in the temporal and overlapping lobes. Using the meningioma cases in the same study as reference entity gave somewhat higher ORs indicating that the results were unlikely to be explained by recall or observational bias. This study confirmed previous results of an association between mobile and cordless phone use and malignant brain tumours. These findings provide support for the hypothesis that RF-EMFs play a role both in the initiation and promotion stages of carcinogenesis.

Hardell L, Söderqvist F, Carlberg M, Zetterberg H, Mild KH. Exposure to wireless phone emissions and serum beta-trace protein. Int J Mol Med. 26(2):301-306, 2010.

The lipocalin type of prostaglandin D synthase or beta-trace protein is synthesized in the choroid plexus, lepto-meninges and oligodendrocytes of the central nervous system and is secreted into the cerebrospinal fluid. beta-trace protein is the key enzyme in the synthesis of prostaglandin D2, an endogenous sleep-promoting neurohormone in the brain. Electromagnetic fields (EMF) in the radio frequency (RF) range have in some studies been associated with disturbed sleep. We studied the concentration of beta-trace protein in blood in relation to emissions from wireless phones. This study included 62 persons aged 18-30 years. The concentration of beta-trace protein decreased with increasing number of years of use of a wireless

phone yielding a negative beta coefficient = -0.32, 95% confidence interval -0.60 to -0.04. Also cumulative use in hours gave a negative beta coefficient, although not statistically significant. Of the 62 persons, 40 participated in an experimental study with 30 min exposure to an 890-MHz GSM signal. No statistically significant change of beta-trace protein was found. In a similar study of the remaining 22 participants with no exposure, beta-trace protein increased significantly over time, probably due to a relaxed situation. EMF emissions may down-regulate the synthesis of beta-trace protein. This mechanism might be involved in sleep disturbances reported in persons exposed to RF fields. The results must be interpreted with caution since use of mobile and cordless phones were self-reported. Awareness of exposure condition in the experimental study may have influenced beta-trace protein concentrations.

Hardell L, Carlberg M, Hansson Mild K, Eriksson M. Case-control study on the use of mobile and cordless phones and the risk for malignant melanoma in the head and neck region. Pathophysiology. 18(4):325-333, 2011.

The incidence of cutaneous malignant melanoma has increased during the last decades in Sweden as in many other countries. Besides of ultraviolet radiation and constitutional factors such as light-sensitive skin and poor ability to tan few risk factors are established. Some studies indicate that electromagnetic fields might be of concern. In this case-control study we assessed use of mobile and cordless phones in 347 cases with melanoma in the head and neck region and 1184 controls. These subjects constituted 82% and 80%, respectively, that answered the questionnaire. Overall no increased risk was found. However, in the most exposed area; temporal, cheek and ear, cumulative use >365h of mobile phone yielded in the >1-5-year latency group odds ratio (OR)=2.1, 95% confidence interval (CI)=0.7-6.1 and cordless phone use gave OR=2.1, 95% CI=1.1-3.8. Highest OR was calculated for first use of mobile or cordless phone before the age of 20 years regardless of anatomical localisation in the head and neck region. No interaction was found with established risk factors such as red, medium blond or fair hair colour, blue eyes, skin type I or II (never or sometimes tanned), severe sunburns as teenager or heredity. The results must be interpreted with caution due to low numbers and potential methodological shortcomings in a case-control study. However, the findings might be consistent with a late carcinogenic effect from microwaves, i.e. tumour promotion, but need to be confirmed.

Hardell L, Carlberg M, Hansson Mild K. Pooled analysis of case-control studies on malignant brain tumours and the use of mobile and cordless phones including living and deceased subjects. Int J Oncol. 38(5):1465-1474, 2011.

We studied the association between use of mobile and cordless phones and malignant brain tumours. Pooled analysis was performed of two case-control studies on patients with malignant brain tumours diagnosed during 1997-2003 and matched controls alive at the time of study inclusion and one case-control study on deceased patients and controls diagnosed during the same time period. Cases and controls or relatives to deceased subjects were interviewed using a structured questionnaire. Replies were obtained for 1,251 (85%) cases and 2,438 (84%) controls. The risk increased with latency period and cumulative use in hours for both mobile and

cordless phones. Highest risk was found for the most common type of glioma, astrocytoma, yielding in the >10 year latency group for mobile phone use odds ratio (OR) = 2.7, 95% confidence interval (CI) = 1.9-3.7 and cordless phone use OR = 1.8, 95% CI = 1.2-2.9. In a separate analysis, these phone types were independent risk factors for glioma. The risk for astrocytoma was highest in the group with first use of a wireless phone before the age of 20; mobile phone use OR = 4.9, 95% CI = 2.2-11, cordless phone use OR = 3.9, 95% CI = 1.7-8.7. In conclusion, an increased risk was found for glioma and use of mobile or cordless phone. The risk increased with latency time and cumulative use in hours and was highest in subjects with first use before the age of 20.

Hardell L, Carlberg M. Use of Mobile and Cordless Phones and Survival of Patients with Glioma. Neuroepidemiology. 40(2):101-108, 2012.

Background: We analysed the survival of patients after glioma diagnosis in relation to the use of wireless phones. Methods: All cases diagnosed between 1997 and 2003 with a malignant brain tumour (n = 1,251) in our case-control studies were included and followed from the date of diagnosis to the date of death or until May 30, 2012. Results: For glioma, the use of wireless phones (mobile and cordless phones) gave a hazard ratio (HR) = 1.1 (95% confidence interval, CI = 0.9-1.2), with >10-year latency HR = 1.2 (95% CI = 1.002-1.5, p trend = 0.02). For astrocytoma grade I-II (low-grade), the results were, HR = 0.5 (95% CI = 0.3-0.9) and for astrocytoma grade IV (glioblastoma), HR = 1.1 (95% CI = 0.95-1.4), with >10 year latency HR = 1.3 (95% CI = 1.03-1.7). In the highest tertile (>426 h) of cumulative use, HR = 1.2 (95% CI = 0.95-1.5) was found for glioblastoma. The results were similar for mobile and cordless phones. Conclusions: Decreased survival of glioma cases with long-term and high cumulative use of wireless phones was found. A survival disadvantage for astrocytoma grade IV, but a survival benefit for astrocytoma grade I-II was observed which could be due to exposure-related tumour symptoms leading to earlier diagnosis and surgery in that patient group.

Hardell L, Carlberg M, Cell and cordless phone risk for glioma - Analysis of pooled case-control studies in Sweden, 1997-2003 and 2007-2009, Pathophysiology (2014), *Available online 29 October 2014.* http://dx.doi.org/10.1016/j.pathophys.2014.10.001

We made a pooled analysis of 2 case-control studies on malignant brain tumours with patients diagnosed during 1997-2003 and 2007-2009. They were aged 20-80 years and 18-75 years, respectively, at the time of diagnosis. Only cases with histopathological verification of the tumour were included. Population-based controls, matched on age and gender, were used. Exposures were assessed by questionnaire. The whole reference group was used in the unconditional regression analysis adjusted for gender, age, year of diagnosis and socio-economic index.

In total 1,498 (89%) cases and 3,530 (87%) controls participated. Mobile phone use increased the risk of glioma, OR = 1.3, 95% CI = 1.1-1.6 overall, increasing to OR = 3.0, 95% CI = 1.7-5.2 in the > 25 year latency group. Use of cordless phones increased the risk to OR = 1.4, 95% CI = 1.1-1.7, with highest risk in the >15-20 year latency group

yielding OR = 1.7, 95% CI = 1.1-2.5. The OR increased statistically significant both per 100 h of cumulative use, and per year of latency for mobile and cordless phone use. Highest ORs overall were found for ipsilateral mobile or cordless phone use, OR = 1.8, 95% CI = 1.4-2.2 and OR = 1.7, 95% CI = 1.3-2.1, respectively. The highest risk was found for glioma in the temporal lobe. First use of mobile or cordless phone before the age of 20 gave higher OR for glioma than in later age groups

Hardell L, Carlberg M, Hansson Mild K. Use of mobile phones and cordless phones is associated with increased risk for glioma and acoustic neuroma. Pathophysiology. 2012 Dec 20. pii: S0928-4680(12)00110-1. doi: 10.1016/j.pathophys.2012.11.001. [Epub ahead of print]

The International Agency for Research on Cancer (IARC) at WHO evaluation of the carcinogenic effect of RF-EMF on humans took place during a 24-31 May 2011 meeting at Lyon in France. The Working Group consisted of 30 scientists and categorised the radiofrequency electromagnetic fields from mobile phones, and from other devices that emit similar non-ionising electromagnetic fields (RF-EMF), as Group 2B, i.e., a 'possible', human carcinogen. The decision on mobile phones was based mainly on the Hardell group of studies from Sweden and the IARC Interphone study. We give an overview of current epidemiological evidence for an increased risk for brain tumours including a meta-analysis of the Hardell group and Interphone results for mobile phone use. Results for cordless phones are lacking in Interphone. The meta-analysis gave for glioma in the most exposed part of the brain, the temporal lobe, odds ratio (OR)=1.71, 95% confidence interval (CI)=1.04-2.81 in the ≥10 years (>10 years in the Hardell group) latency group. Ipsilateral mobile phone use ≥1640h in total gave OR=2.29, 95% CI=1.56-3.37. The results for meningioma were OR=1.25, 95% CI=0.31-4.98 and OR=1.35, 95% CI=0.81-2.23, respectively. Regarding acoustic neuroma ipsilateral mobile phone use in the latency group ≥10 years gave OR=1.81, 95% CI=0.73-4.45. For ipsilateral cumulative use ≥1640h OR=2.55, 95% CI=1.50-4.40 was obtained. Also use of cordless phones increased the risk for glioma and acoustic neuroma in the Hardell group studies. Survival of patients with glioma was analysed in the Hardell group studies yielding in the >10 years latency period hazard ratio (HR)=1.2, 95% CI=1.002-1.5 for use of wireless phones. This increased HR was based on results for astrocytoma WHO grade IV (glioblastoma multiforme). Decreased HR was found for low-grade astrocytoma, WHO grades I-II, which might be caused by RF-EMF exposure leading to tumour-associated symptoms and earlier detection and surgery with better prognosis. Some studies show increasing incidence of brain tumours whereas other studies do not. It is concluded that one should be careful using incidence data to dismiss results in analytical epidemiology. The IARC carcinogenic classification does not seem to have had any significant impact on governments' perceptions of their responsibilities to protect public health from this widespread source of radiation.

Hardell L, Carlberg M. Mobile phones, cordless phones and rates of brain tumors in different age groups in the Swedish National Inpatient Register and the Swedish Cancer Register during 1998-2015. PLoS One. 12(10):e0185461, 2017.

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We used the Swedish Inpatient Register (IPR) to analyze rates of brain tumors of unknown type (D43) during 1998-2015. Average Annual Percentage Change (AAPC) per 100,000 increased with +2.06%, 95% confidence interval (CI) +1.27, +2.86% in both genders combined. A joinpoint was found in 2007 with Annual Percentage Change (APC) 1998-2007 of +0.16%, 95% CI -0.94, +1.28%, and 2007-2015 of +4.24%, 95% CI +2.87, +5.63%. Highest AAPC was found in the age group 20-39 years. In the Swedish Cancer Register the age-standardized incidence rate per 100,000 increased for brain tumors, ICD-code 193.0, during 1998-2015 with AAPC in men +0.49%, 95% CI +0.05, +0.94%, and in women +0.33%, 95% CI -0.29, +0.45%. The cases with brain tumor of unknown type lack morphological examination. Brain tumor diagnosis was based on cytology/histopathology in 83% for men and in 87% for women in 1980. This frequency increased to 90% in men and 88% in women in 2015. During the same time period CT and MRI imaging techniques were introduced and morphology is not always necessary for diagnosis. If all brain tumors based on clinical diagnosis with CT or MRI had been reported to the Cancer Register the frequency of diagnoses based on cytology/histology would have decreased in the register. The results indicate underreporting of brain tumor cases to the Cancer Register. The real incidence would be higher. Thus, incidence trends based on the Cancer Register should be used with caution. Use of wireless phones should be considered in relation to the change of incidence rates.

Hareuveny R, Eliyahu I, Luria R, Meiran N, Margaliot M. Cognitive effects of cellular phones: a possible role of non-radiofrequency radiation factors. Bioelectromagnetics. 32(7):585-588, 2011.

Some studies found that cognitive functions of human beings may be altered while exposed to radiofrequency radiation (RFR) emitted by cellular phones. In two recent studies, we have found that experiment duration and exposure side (i.e., phone's location--right or left) may have a major influence on the detection of such effects. In this brief follow-up experiment, 29 right-handed male subjects were divided into two groups. Each subject had two standard cellular phones attached to both sides of his head. The subjects performed a spatial working memory task that required either a left-hand or a right-hand response under one of the two exposure conditions: left side of the head or right side. Contrary to our previous studies, in this work external antennas located far away from the subjects were connected to the cellular phones. This setup prevents any emission of RFR from the internal antenna, thus drastically reducing RFR exposure. Despite that, the results remain similar to those obtained in our previous work. These results indicate that some of the effects previously attributed to RFR can be the result of some confounders.

Hatice Ş. Gürler, Birşen Bilgici, Ayşegül K. Akar, Leman Tomak & Abdülkerim Bedir. Increased DNA oxidation (8-OHdG) and protein oxidation (AOPP) by low level electromagnetic field (2.45 GHz) in rat brain and protective effect of garlic. International Journal of Radiation Biology. Posted online on August 4, 2014.

Purpose: To investigate the oxidative damage and protective effect of garlic on rats exposed to low level of electromagnetic fields (EMF) at 2.45 GHz Microwave radiation (MWR). *Methods*: Thirty-six Wistar rats were divided into three groups. Group I was the control group and not exposed to EMF. Group II and III were exposed to low level EMF (3.68 ± 0.36 V/m) at 2.45 GHz MWR for 1 hour/day for 30 consecutive days. Daily 500

mg/kg garlic was given to Group III during the study period. At the end of the study, thiobarbituric acid reactive substances (TBARS), advanced oxidation protein products (AOPP) and 8-hydroxydeoxyguanosine (8-OHdG) levels were investigated in brain tissue and blood samples. *Results*: Exposure to low level of EMF increased 8-OHdG level in both plasma and brain tissue whereas it increased AOPP level only in plasma. Garlic prevented the increase of 8-OHdG level in brain tissue and plasma AOPP levels. *Conclusions*: It may be concluded that low level EMF at 2.45 GHz MWR increases the DNA damage in both brain tissues and plasma of the rats whereas it increases protein oxidation only in plasma. It may also be argued that the use of garlic decreases these effects.

Hartikka H, Heinävaara S, Mäntylä R, Kähärä V, Kurttio P, Auvinen A. Mobile phone use and location of glioma: A case-case analysis. Bioelectromagnetics. 30(3):176-182, 2009.

We assessed a new approach for evaluating the glioma risk among users of mobile phones to focus on the part of the brain most heavily exposed to radiofrequency electromagnetic fields from mobile phones. The tumor midpoint was defined from radiological imaging. A case-case analysis with 99 gliomas was performed using logistic regression. The exposed cases were those with the tumor mid-point within 4.6 cm from the line between the mouth and the external meatus of the ear, representing the most likely location of the mobile phone (the source of exposure). Alternative analyses based on various indicators of mobile phone use as the outcome were also carried out. The majority of cases were regular mobile phone users. A slightly higher proportion of gliomas among mobile phone users than non-users occurred within 4.6 cm from the presumed location of the mobile phone (28% vs. 14%). Modestly elevated odds ratios were observed for several indicators of mobile phone use, but without an exposure gradient. The highest odds ratios were found for contralateral and short-term use. Our results, though limited by the small sample size, demonstrate that detailed information on tumor location allows evaluation of the risk related to the most heavily exposed part of the brain, representing direct evaluation of the possible local carcinogenic effects of the radiofrequency fields. However, field strength varies between users and over time also within a given anatomic site, due to the output power of the phone. Collaborative analysis of a larger sample is planned.

Harvey C, French PW, Effects on protein kinase C and gene expression in a human mast cell line, HMC-1, following microwave exposure. Cell Biol Int 23(11):739-748, 2000.

We used a resonant cavity which delivered a continuous wave exposure at 864.3 MHz at an average specific absorption rate (SAR) of 7 W/kg to determine non-thermal biological effects of microwave exposure. A human mast cell line, HMC-1, was used as the biological target. Cells were given three exposures each of 20-min duration daily for 7 days. The temperature of the cell culture medium during the exposure fell to 26.5 degrees C. Effects were seen on localization of protein kinase C, and expression of three genes of 588 screened. The affected genes included the proto-oncogene c-kit, the transcription factor Nucleoside diphosphate kinase B and the apoptosis-associated gene DAD-1. Stress response genes were variably upregulated. No significant effect on morphology or

on F-actin distribution was detected. We conclude that low-power microwave exposure may act on HMC-1 cells by altering gene expression via a mechanism involving activation of protein kinase C, and at temperatures well below those known to induce a heat shock response.

Hashemipour MS, Yarbakht M, Gholamhosseinian A, Famori H. Effect of mobile phone use on salivary concentrations of protein, amylase, lipase, immunoglobulin A, lysozyme, lactoferrin, peroxidase and C-reactive protein of the parotid gland. J Laryngol Otol. 2014 Apr 17:1-9. [Epub ahead of print]

Background: The possibility of side effects associated with the electromagnetic waves emitted from mobile phones is a controversial issue. The present study aimed to evaluate the effect of mobile phone use on parotid gland salivary concentrations of protein, amylase, lipase, immunoglobulin A, lysozyme, lactoferrin, peroxidase and C-reactive protein. Methods: Stimulated salivary samples were collected simultaneously from both parotid glands of 86 healthy volunteers. Salivary flow rate and salivary concentrations of proteins, amylase, lipase, lysozyme, lactoferrin, peroxidase, C-reactive protein and immunoglobulin A, were measured. Data were analysed using t-tests and one-way analyses of variance. Results: Salivary flow rate and parotid gland salivary concentrations of protein were significantly higher on the right side compared to the left in those that predominantly held mobile phones on the right side. In addition, there was a decrease in concentrations of amylase, lipase, lysozyme, lactoferrin and peroxidase. Conclusion: The side of dominant mobile phone use was associated with differences in salivary flow rate and parotid gland salivary concentrations, in right-dominant users. Although mobile phone use influenced salivary composition, the relationship was not significant.

Hassanshahi A, Shafeie SA, Fatemi I, Hassanshahi E, Allahtavakoli M, Shabani M, Roohbakhsh A, Shamsizadeh A. The effect of Wi-Fi electromagnetic waves in unimodal and multimodal object recognition tasks in male rats.Neurol Sci. 2017 Mar 22. doi: 10.1007/s10072-017-2920-y. [Epub ahead of print]

Wireless internet (Wi-Fi) electromagnetic waves (2.45 GHz) have widespread usage almost everywhere, especially in our homes. Considering the recent reports about some hazardous effects of Wi-Fi signals on the nervous system, this study aimed to investigate the effect of 2.4 GHz Wi-Fi radiation on multisensory integration in rats. This experimental study was done on 80 male Wistar rats that were allocated into exposure and sham groups. Wi-Fi exposure to 2.4 GHz microwaves [in Service Set Identifier mode (23.6 dBm and 3% for power and duty cycle, respectively)] was done for 30 days (12 h/day). Cross-modal visual-tactile object recognition (CMOR) task was performed by four variations of spontaneous object recognition (SOR) test including standard SOR, tactile SOR, visual SOR, and CMOR tests. A discrimination ratio was calculated to assess the preference of animal to the novel object. The expression levels of M1 and GAT1 mRNA in the hippocampus were assessed by quantitative real-time RT-PCR. Results demonstrated that rats in Wi-Fi exposure groups could not discriminate significantly between the novel and familiar objects in any of the standard SOR, tactile SOR, visual SOR, and CMOR tests. The expression of M1 receptors increased following Wi-Fi exposure. In conclusion,

results of this study showed that chronic exposure to Wi-Fi electromagnetic waves might impair both unimodal and cross-modal encoding of information.

Hässig M, **Jud F**, **Naegeli H**, **Kupper J**, **Spiess B**. **Prevalence of nuclear cataract in Swiss veal calves and its possible association with mobile telephone antenna base stations. Schweiz Arch Tierheilkd. 151(10):471-478, 2009.**

The purpose of this study was to valuate the prevalence of nuclear cataract in veal calves and to elucidate a possible impact by mobile phone base stations (MPBS). For this experiment a cohort study was conducted. A follow-up of the geographical location of each dam and its calf from conception through the fetal period up to slaughter was performed. The first trimester of gestation (organogenesis) was particularly emphasized. The activities of selected protective antioxidants (superoxide dismutase, catalase, glutathione peroxidase [GPx]) were assessed in aqueous humor of the eye to evaluate the redox status. Of 253 calves, 79 (32 %) had various degrees of nuclear cataract, but only 9 (3.6 %) calves had severe nuclear cataract. Results demonstrate a relation between the location of veals calves with nuclear cataracts in the first trimester of gestation and the strength of antennas. The number of antennas within 100 to 199 meters was associated with oxidative stress and there was an association between oxidative stress and the distance to the nearest MPBS. Oxidative stress was increased in eyes with cataract (OR per kilometer: 0.80, confidence interval 95 % 0.62,0.93). It has not been shown that the antennas actually affected stress. Hosmer-Lemeshow statistics showed an accuracy of 100 % in negative cases with low radiation, and only 11.11 % accuracy in positive cases with high radiation. This reflects, that there are a lot of other possibilities for nuclear cataract beside MPBS. Further studies on the influence of electromagnetic fields during embryonic development animal or person at risk are indicated.

Hässig M, Jud F, Spiess B. [Increased occurrence of nuclear cataract in the calf after erection of a mobile phone base station]. Schweiz Arch Tierheilkd. 154(2):82-86, 2012.[Article in German]

We examined and monitored a dairy farm in which a large number of calves were born with nuclear cataracts after a mobile phone base station had been erected in the vicinity of the barn. Calves showed a 3.5 times higher risk for heavy cataract if born there compared to Swiss average. All usual causes such as infection or poisoning, common in Switzerland, could be excluded. The real cause of the increased incidence of cataracts remains unknown.

Hässig M, Wullschleger M, Naegeli HP, Kupper J, Spiess B, Kuster N, Capstick M, Murbach M. Influence of non ionizing radiation of base stations on the activity of redox proteins in bovines. BMC Vet Res. 2014 Jun 19;10(1):136. [Epub ahead of print]

BACKGROUND: The influence of electromagnetic fields on the health of humans and animals is still an intensively discussed and scientifically investigated issue (Prakt Tierarzt 11:15-20, 2003; Umwelt Medizin Gesellschaft 17:326-332, 2004; J Toxicol Environment

Health, Part B 12:572-597, 2009). We are surrounded by numerous electromagnetic fields of variable strength, coming from electronic equipment and its power cords, from high-voltage power lines and from antennas for radio, television and mobile communication. Particularly the latter cause's controversy, as everyone likes to have good mobile reception at anytime and anywhere, whereas nobody wants to have such a base station antenna in their proximity. RESULTS: In this experiment, the non-ionizing radiation (NIR) has resulted in changes in the enzyme activities. Certain enzymes were disabled, others enabled by NIR. Furthermore, individual behavior patterns were observed. While certain cows reacted to NIR, others did not react at all, or even inversely. CONCLUSION: The present results coincide with the information from the literature, according to which NIR leads to changes in redox proteins, and that there are individuals who are sensitive to radiation and others that are not. However, the latter could not be distinctly attributed - there are cows that react clearly with one enzyme while they do not react with another enzyme at all, or even the inverse. The study approach of testing ten cows each ten times during three phases has proven to be appropriate. Future studies should however set the post-exposure phase later on.

Hassoy H, Durusoy R, Karababa AO. Adolescents' risk perceptions on mobile phones and their base stations, their trust to authorities and incivility in using mobile phones: a cross-sectional survey on 2240 high school students in Izmir, Turkey. Environ Health. 2013 Jan 25;12(1):10. [Epub ahead of print]

ABSTRACT: BACKGROUND: Use of mobile phones has rapidly risen among adolescents despite a lack of scientific certainty on their health risks. Risk perception is an important determinant of behavior, and studies on adolescents' risk perceptions of mobile phones or base stations are very scarce. This study aims to evaluate high school students' risk perceptions on mobile phones and base stations, their trust to authorities, their opinions regarding incivility while using mobile phones and to assess associated factors. METHODS: For this cross-sectional study, 2530 students were chosen with stratified cluster sampling among 20,493 high school students studying in Bornova district of Izmir, Turkey, among whom 2240 (88.5%) participated. Risk perceptions and opinions were questioned with a 5-point Likert scale for 24 statements grouped under four dimensions. The mean responses to the four dimensions were categorized as <3.5 (low) and >=3.5 (high) and the determinants were analyzed with logistic regression. RESULTS: Mean risk perception scores for the mobile phone, base station, trust to authority and incivility dimensions were 3.69 +/- 0.89, 4.34 +/- 0.78, 3.77 +/- 0.93, 3.16 +/- 0.93 and the prevalence of high risk perception was 65.1%, 86.7%, 66.2%, 39.7%, respectively. In the mobile phone dimension; students attending industrial technical high school had lower risk perceptions while female students, lower mothers' education groups and students not using mobile phones (OR = 2.82, 95% CI = 1.80-4.40) had higher risk perceptions. In the base station dimension girls had higher risk perceptions (OR = 1.68, 95% CI = 1.20-2.37). Girls and students attending industrial technical high school had significantly lower risk perception however 11-12th grade group perceived the risk higher (OR = 1.45 95% CI = 1.15-1.84) in the trust to authority dimension. For the incivility dimension, female students (OR = 1.44, 95% CI = 1.14-1.82), illiterate/only literate mothers (OR = 1.79, 95% CI = 1.04-2.75) and students not using mobile phones (OR = 2.50, 95% CI = 1.62-3.87)

perceived higher risk. CONCLUSIONS: Understanding the effects of these determinants might aid in developing more effective educational interventions to specific subgroups on this topic. As debates on the health consequences of electromagnetic fields continue, it would be cautious to approach this issue with a preventive perspective. Efforts should be made to equalize the varying level of knowledge and to ensure that students are informed accurately.

Hata K, Yamaguchi H, Tsurita G, Watanabe S, Wake K, Taki M, Ueno S, Nagawa H. Short term exposure to 1439 MHz pulsed TDMA field does not alter melatonin synthesis in rats. Bioelectromagnetics. 26(1):49-53, 2005.

The widespread use of the mobile phone has initiated many studies on the possible adverse effects of a high frequency electromagnetic field (EMF), which is used in mobile phones. A low frequency EMF is reported to suppress melatonin synthesis. The aim of this study was to clarify the effects on melatonin synthesis in rats after short term exposure to a 1439 MHz time division multiple access (TDMA) EMF. The average specific absorption ratio (SAR) of the brain was 7.5 W/kg, and the average SARs of the whole body were 1.9 and 2.0 W/kg for male and female rats, respectively. A total of 208 male and female rats were investigated. After acclimatization to a 12 h light-dark (LD) cycle, serum and pineal melatonin levels together with pineal serotonin level under a dark condition (less than 1 lux) were examined by radioimmunoassay. No significant differences in melatonin and serotonin levels were observed between the exposure, sham, and cage control groups. These results suggest that short term exposure to a 1439 MHz TDMA EMF, which is about four times stronger than that emitted by mobile phones, does not alter melatonin and serotonin synthesis in rats. Further investigations on the effects of long term exposure are warranted.

Hauri DD, Spycher B, Huss A, Zimmermann F, Grotzer M, von der Weid, Spoerri A, Kuehni CE, Röösli M*, the Swiss National Cohort and the Swiss Paediatric Oncology Group. Exposure to Radio-Frequency Electromagnetic Fields From Broadcast Transmitters and Risk of Childhood Cancer: A Census-based Cohort Study. Am. J. Epidemiol. (2014) doi: 10.1093/aje/kwt442 First published online: February 19, 2014.

We investigated the association between exposure to radio-frequency electromagnetic fields (RF-EMFs) from broadcast transmitters and childhood cancer. First, we conducted a time-to-event analysis including children under age 16 years living in Switzerland on December 5, 2000. Follow-up lasted until December 31, 2008. Second, all children living in Switzerland for some time between 1985 and 2008 were included in an incidence density cohort. RF-EMF exposure from broadcast transmitters was modeled. Based on 997 cancer cases, adjusted hazard ratios in the time-to-event analysis for the highest exposure category (>0.2 V/m) as compared with the reference category (<0.05 V/m) were 1.03 (95% confidence interval (CI): 0.74, 1.43) for all cancers, 0.55 (95% CI: 0.26, 1.19) for childhood leukemia, and 1.68 (95% CI: 0.98, 2.91) for childhood central nervous system (CNS) tumors. Results of the incidence density analysis, based on 4,246 cancer cases, were similar for all types of cancer and leukemia but did not indicate a CNS tumor risk (incidence rate ratio = 1.03, 95% CI: 0.73, 1.46). This large census-based cohort

study did not suggest an association between predicted RF-EMF exposure from broadcasting and childhood leukemia. Results for CNS tumors were less consistent, but the most comprehensive analysis did not suggest an association.

Havas M. Electromagnetic hypersensitivity: biological effects of dirty electricity with emphasis on diabetes and multiple sclerosis.Electromagn Biol Med. 25(4):259-268, 2006.

Dirty electricity is a ubiquitous pollutant. It flows along wires and radiates from them and involves both extremely low frequency electromagnetic fields and radio frequency radiation. Until recently, dirty electricity has been largely ignored by the scientific community. Recent inventions of metering and filter equipment provide scientists with the tools to measure and reduce dirty electricity on electrical wires. Several case studies and anecdotal reports are presented. Graham/Stetzer (GS) filters have been installed in schools with sick building syndrome and both staff and students reported improved health and more energy. The number of students needing inhalers for asthma was reduced in one school and student behavior associated with ADD/ADHD improved in another school. Blood sugar levels for some diabetics respond to the amount of dirty electricity in their environment. Type 1 diabetics require less insulin and Type 2 diabetics have lower blood sugar levels in an electromagnetically clean environment. Individuals diagnosed with multiple sclerosis have better balance and fewer tremors. Those requiring a cane walked unassisted within a few days to weeks after GS filters were installed in their home. Several disorders, including asthma, ADD/ADHD, diabetes, multiple sclerosis, chronic fatigue, fibromyalgia, are increasing at an alarming rate, as is electromagnetic pollution in the form of dirty electricity, ground current, and radio frequency radiation from wireless devices. The connection between electromagnetic pollution and these disorders needs to be investigated and the percentage of people sensitive to this form of energy needs to be determined.

Havas M, Marrongelle J. Replication of heart rate variability provocation study with 2.4-GHz cordless phone confirms original findings. Electromagn Biol Med. 32(2):253-266, 2013.

This is a replication of a study that we previously conducted in Colorado with 25 subjects designed to test the effect of electromagnetic radiation generated by the base station of a cordless phone on heart rate variability (HRV). In this study, we analyzed the response of 69 subjects between the ages of 26 and 80 in both Canada and the USA. Subjects were exposed to radiation for 3-min intervals generated by a 2.4-GHz cordless phone base station (3-8 μW/cm²). A few participants had a severe reaction to the radiation with an increase in heart rate and altered HRV indicative of an alarm response to stress. Based on the HRV analyses of the 69 subjects, 7% were classified as being "moderately to very" sensitive, 29% were "little to moderately" sensitive, 30% were "not to little" sensitive and 6% were "unknown". These results are not psychosomatic and are not due to electromagnetic interference. Twenty-five percent of the subjects' self-proclaimed sensitivity corresponded to that based on the HRV analysis, while 32% overestimated

their sensitivity and 42% did not know whether or not they were electrically sensitive. Of the 39 participants who claimed to experience some electrical hypersensitivity, 36% claimed they also reacted to a cordless phone and experienced heart symptoms and, of these, 64% were classified as having some degree of electrohypersensitivity (EHS) based on their HRV response. Novel findings include documentation of a delayed response to radiation. Orthostatic HRV testing combined with provocation testing may provide a diagnostic tool for some sufferers of EHS when they are exposed to electromagnetic emitting devices. The protocol used underestimates reaction to electromagnetic radiation for those who have a delayed autonomic nervous system reaction and it may under diagnose those who have adrenal exhaustion as their ability to mount a response to a stressor is diminished.

Hayes DL, Wang PJ, Reynolds DW, Estes M 3rd, Griffith JL, Steffens RA, Carlo GL, Findlay GK, Johnson CM. Interference with cardiac pacemakers by cellular telephones. N Engl J Med 336(21):1473-1479, 1997.

BACKGROUND: A growing body of evidence suggests that electromagnetic interference may occur between cardiac pacemakers and wireless hand-held (cellular) telephones, posing a potential public health problem. Electromagnetic interference may occur when the pacemaker is exposed to an electromagnetic field generated by the cellular telephone. METHODS: In this multicenter, prospective, crossover study, we tested 980 patients with cardiac pacemakers with five types of telephones (one analogue and four digital) to assess the potential for interference. Telephones were tested in a test mode and were programmed to transmit at the maximal power, simulating the worst-case scenario; in addition, one telephone was tested during actual transmission to simulate actual use. Patients were electrocardiographically monitored while the telephones were tested at the ipsilateral ear and in a series of maneuvers directly over the pacemaker. Interference was classified according to the type and clinical significance of the effect. RESULTS: The incidence of any type of interference was 20 percent in the 5533 tests, and the incidence of symptoms was 7.2 percent. The incidence of clinically significant interference was 6.6 percent. There was no clinically significant interference when the telephone was placed in the normal position over the ear. Interference that was definitely clinically significant occurred in only 1.7 percent of tests, and only when the telephone was held over the pacemaker. Interference was more frequent with dual-chamber pacemakers (25.3 percent) than with single-chamber pacemakers (6.8 percent, $P<0.001$) and more frequent with pacemakers without feed-through filters (28.9 to 55.8 percent) than with those with such filters (0.4 to 0.8 percent, $P=0.01$). CONCLUSIONS: Cellular telephones can interfere with the function of implanted cardiac pacemakers. However, when telephones are placed over the ear, the normal position, this interference does not pose a health risk.

He Q, Sun Y, Zong L, Tong J, Cao Y. Induction of Poly(ADP-ribose) Polymerase in Mouse Bone Marrow Stromal Cells Exposed to 900 MHz Radiofrequency Fields: Preliminary Observations. Biomed Res Int. 2016;2016:4918691.

Background. Several investigators have reported increased levels of poly(ADP-ribose) polymerase-1 (PARP-1), a nuclear enzyme which plays an important role in the repair of

damaged DNA, in cells exposed to extremely low dose ionizing radiation which does not cause measurable DNA damage. Objective. To examine whether exposure of the cells to nonionizing radiofrequency fields (RF) is capable of increasing messenger RNA of PARP-1 and its protein levels in mouse bone marrow stromal cells (BMSCs). Methods. BMSCs were exposed to 900 MHz RF at 120 μW/cm(2) power intensity for 3 hours/day for 5 days. PARP-1 mRNA and its protein levels were examined at 0, 0.5, 1, 2, 4, 6, 8, and 10 hours after exposure using RT-PCR and Western blot analyses. Sham-exposed (SH) cells and those exposed to ionizing radiation were used as unexposed and positive control cells. Results. BMSCs exposed to RF showed significantly increased expression of PARP-1 mRNA and its protein levels after exposure to RF while such changes were not observed in SH-exposed cells. Conclusion. Nonionizing RF exposure is capable of inducing PARP-1.

Hedendahl LK, Carlberg M, Koppel T, Hardell L. Measurements of Radiofrequency Radiation with a Body-Borne Exposimeter in Swedish Schools with Wi-Fi. Front. Public Health, 20 November 2017 | https://doi.org/10.3389/fpubh.2017.00279

Introduction: Wireless access to the Internet is now commonly used in schools. Many schools give each student their own laptop and utilize the laptops and wireless fidelity (Wi-Fi) connection for educational purposes. Most children also bring their own mobile phones to school. Since children are obliged by law to attend school, a safe environment is important. Lately, it has been discussed if radiofrequency (RF) radiation can have long-term adverse effects on children's health. Method: This study conducted exposimetric measurements in schools to assess RF emissions in the classroom by measuring the teachers' RF exposure in order to approximate the children's exposure. Teachers in grades 7–12 carried a body-borne exposimeter, EME-Spy 200, in school during 1–4 days of work. The exposimeter can measure 20 different frequency bands from 87 to 5,850 MHz. Results: Eighteen teachers from seven schools participated. The mean exposure to RF radiation ranged from 1.1 to 66.1 μW/m^2. The highest mean level, 396.6 μW/m^2, occurred during 5 min of a lesson when the teacher let the students stream and watch YouTube videos. Maximum peaks went up to 82,857 μW/m^2 from mobile phone uplink. Discussion: Our measurements are in line with recent exposure studies in schools in other countries. The exposure levels varied between the different Wi-Fi systems, and if the students were allowed to use their own smartphones on the school's Wi-Fi network or if they were connected to GSM/3G/4G base stations outside the school. An access point over the teacher's head gave higher exposure compared with a school with a wired Internet connection for the teacher in the classroom. All values were far below International Commission on Non-Ionizing Radiation Protection's reference values, but most mean levels measured were above the precautionary target level of 3–6 μW/m^2 as proposed by the Bioinitiative Report. The length of time wireless devices are used is an essential determinant in overall exposure. Measures to minimize children's exposure to RF radiation in school would include preferring wired connections, allowing laptops, tablets and mobile phones only in flight mode and deactivating Wi-Fi access points, when not used for learning purposes.

Heikkinen P, Kosma VM, Hongisto T, Huuskonen H, Hyysalo P, Komulainen H,

Kumlin T, Lahtinen T, Lang S, Puranen L, Juutilainen J. Effects of mobile phone radiation on x-ray-induced tumorigenesis in mice. Radiat Res 156(6):775-785, 2001.

The increased use of mobile phones has raised the question of possible health effects of such devices, particularly the risk of cancer. It seems unlikely that the low-level radiofrequency (RF) radiation emitted by them would damage DNA directly, but its ability to act as a tumor promoter is less well characterized. In the current study, we evaluated the effect of low-level RF radiation on the development of cancer initiated in mice by ionizing radiation. Two hundred female CBA/S mice were randomized into four equal groups at the age of 3 to 5 weeks. The mice in all groups except the cage-control group were exposed to ionizing radiation at the beginning of the study and then to RF radiation for 1.5 h per day, 5 days a week for 78 weeks. One group was exposed to continuous NMT (Nordic Mobile Telephones)-type frequency-modulated RF radiation at a frequency of 902.5 MHz and a nominal average specific absorption rate (SAR) of 1.5 W/kg. Another group was exposed to pulsed GSM (Global System for Mobile)-type RF radiation (carrier-wave frequency 902.4 MHz, pulse frequency 217 Hz) at a nominal average SAR of 0.35 W/kg. The control animals were sham-exposed. Body weight, clinical signs, and food and water consumption were recorded regularly. Hematological examinations and histopathological analyses of all lesions and major tissues were performed on all animals. The RF-radiation exposures did not increase the incidence of any neoplastic lesion significantly. We conclude that the results do not provide evidence for cancer promotion by RF radiation emitted by mobile phones.

Heikkinen P, Kosma VM, Alhonen L, Huuskonen H, Komulainen H, Kumlin T, Laitinen JT, Lang S, Puranen L, Juutilainen J. Effects of mobile phone radiation on UV-induced skin tumourigenesis in ornithine decarboxylase transgenic and non-transgenic mice. Int J Radiat Biol 79(4):221-233, 2003.

Purpose: The effects of low-level radiofrequency radiation (RFR) on ultraviolet (UV)-induced skin tumorigenesis were evaluated in ornithine decarboxylase (ODC) and non-transgenic mice. Materials and methods: Transgenic female mice over-expressing the human ODC gene and their non-transgenic littermates (20 animals in the cage control group, and 45-49 animals in the other groups) were exposed for 52 weeks to UV radiation or a combination of UV radiation and pulsed RFR. The UV dose was 240 Jm(-2) (1.2 x human minimum erythemal dose) delivered three times a week. One group of animals was exposed to Digital Advanced Mobile Phone System (DAMPS)-type RFR, the other group to Global System for Mobile (GSM)-type RFR at a nominal average specific absorption rate of 0.5 W kg(-1), 1.5 h day(-1), for 5 days a week. The skin was carefully palpated weekly for macroscopic tumours. Histopathological analyses of all skin lesions and of a specified dorsal skin area were performed on all animals. Results: UV exposure resulted in development of macroscopic skin tumours in 11.5 and 36.8% of non-transgenic and transgenic animals, respectively. The RFR exposures did not give a statistically significant effect on the development of skin tumours in either transgenic or non-transgenic animals, or in combined analysis, but tumour development appeared slightly accelerated especially in non-transgenic animals. No effects of RFR exposures were found on excretion of 6-hydroxymelatonin sulphate into urine or on polyamine levels in dorsal skin. Conclusion: RFR exposures did not significantly enhance skin tumourigenesis. However, the slightly accelerated tumour development may warrant

further evaluation.

Heikkinen, P., Ernst, H., Huuskonen, H., Komulainen, H., Kumlin, T., Maki-Paakkanen, J., Puranen, L. and Juutilainen, J. No effects of radiofrequency radiation on 3-Chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone-Induced tumorigenesis in female Wistar rats. Radiat. Res. 166, 397-408, 2006.

This study evaluated possible effects of radiofrequency (RF) radiation on tumorigenesis induced by the mutagen 3-chloro-4-(dichloromethyl)-5-hydroxy-2(5H)-furanone (MX) given in drinking water. Female Wistar rats aged 7 weeks at the beginning of the experiments were randomly divided into four groups of 72 animals: a cage-control group and three MX-exposed groups (a daily average dose of 1.7 mg MX/kg body weight for 104 weeks), of which two were exposed to 900 MHz pulsed RF radiation and the third served as a sham-RF-radiation group. The RF-radiation groups were exposed 2 h per day, 5 days per week for 104 weeks at nominal whole-body average SARs of 0.3 W/kg and 0.9 W/kg. Complete histopathology was performed on the rats of the three MX-exposed groups. The tumor types and incidences observed in the MX-exposed animals were similar to those reported earlier in MX-exposed female Wistar rats. RF radiation did not statistically significantly affect mortality or organ-specific incidence of any tumor type. The only statistically significant difference was an increase in the combined frequency of vascular tumors of the mesenteric lymph nodes in the high-RF-radiation group compared to the sham-RF-radiation group. However, additional histopathological analysis of the cage-control animals suggested that this difference was due to unusually low frequency of this type of tumor in the sham-RF-radiation group rather than a high frequency in the high-RF-radiation group. With respect to non-neoplastic findings, statistically significant differences between the RF-radiation groups and the sham-RF-radiation group were observed only for single findings in the lacrimal glands, lungs, liver and skin. Such changes are commonly seen in aged rats and were considered to be unrelated to RF radiation. The results of the present study do not support co-carcinogenic effects of low-level long-term RF-radiation exposure in rats.

Heinrich S, Thomas S, Heumann C, von Kries R, Radon K. Association between exposure to radiofrequency electromagnetic fields assessed by dosimetry and acute symptoms in children and adolescents: a population based cross-sectional study. Environ Health. 9:75, 2010.

BACKGROUND: The increase in numbers of mobile phone users was accompanied by some concern that exposure to radiofrequency electromagnetic fields (RF EMF) might adversely affect acute health especially in children and adolescents. The authors investigated this potential association using personal dosimeters. METHODS: A 24-hour exposure profile of 1484 children and 1508 adolescents was generated in a population-based cross-sectional study in Germany between 2006 and 2008 (participation 52%). Personal interview data on socio-demographic characteristics, self-reported exposure and potential confounders were collected. Acute symptoms were assessed twice during the study day using a symptom diary. RESULTS: Only few of the large number of investigated associations were found to be statistically significant. At noon, adolescents

with a measured exposure in the highest quartile during morning hours reported a statistically significant higher intensity of headache (Odd Ratio: 1.50; 95% confidence interval: 1.03, 2.19). At bedtime, adolescents with a measured exposure in the highest quartile during afternoon hours reported a statistically significant higher intensity of irritation in the evening (4th quartile 1.79; 1.23, 2.61), while children reported a statistically significant higher intensity of concentration problems (4th quartile 1.55; 1.02, 2.33). *CONCLUSIONS: We observed few statistically significant results which are not consistent over the two time points.* Furthermore, when the 10% of the participants with the highest exposure are taken into consideration the significant results of the main analysis could not be confirmed.Based on the pattern of these results, we assume that the few observed significant associations are not causal but rather occurred by chance.

Heinrich S, Thomas S, Heumann C, von Kries R, Radon K. The impact of exposure to radio frequency electromagnetic fields on chronic well-being in young people - A cross-sectional study based on personal dosimetry. Environ Int. 37(1):26-30, 2011.

A possible influence of radio frequency electromagnetic field (RF EMF) exposure on health outcomes was investigated in various studies. The main problem of previous studies was exposure assessment. The aim of our study was the investigation of a possible association between RF EMF and chronic well-being in young persons using personal dosimetry. 3022 children and adolescents were randomly selected from the population registries of four Bavarian cities in Germany (participation 52%). Personal interview data on chronic symptoms, socio-demographic characteristics and potential confounders were collected. A 24-h radio frequency exposure profile was generated using a personal dosimeter. Exposure levels over waking hours were expressed as mean percentage of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) reference level. Half of the children and nearly every adolescent owned a mobile phone which was used only for short durations per day. Measured exposure was far below the current ICNIRP reference levels. The most reported chronic symptom in children and adolescents was fatigue. No statistically significant association between measured exposure and chronic symptoms was observed. Our results do not indicate an association between measured exposure to RF EMF and chronic well-being in children and adolescents. Prospective studies investigating potential long-term effects of RF EMF are necessary to confirm our results.

Hekmat A, Saboury AA, Moosavi-Movahedi AA.The toxic effects of mobile phone radiofrequency (940MHz) on the structure of calf thymus DNA.Ecotoxicol Environ Saf. 2012 Nov 16. pii: S0147-6513(12)00368-5. doi: 10.1016/j.ecoenv.2012.10.016. [Epub ahead of print]

Currently, the biological effects of nonionizing electromagnetic fields (EMFs) including radiofrequency (RF) radiation have been the subject of numerous experimental and theoretical studies. The aim of this study is to evaluate the possible biological effects of mobile phone RF (940MHz, 15V/m and SAR=40mW/kg) on the structure of calf thymus DNA (ct DNA) immediately after exposure and 2h after 45min exposure via diverse range of spectroscopic instruments. The UV-vis and circular dichroism (CD) experiments depict

that mobile phone EMFs can remarkably cause disturbance on ct DNA structure. In addition, the DNA samples, immediately after exposure and 2h after 45min exposure, are relatively thermally unstable compared to the DNA solution, which was placed in a small shielded box (unexposed ct DNA). Furthermore, the exposed DNA samples (the DNA samples that were exposed to 940MHz EMF) have more fluorescence emission when compared with the unexposed DNA, which may have occurred attributable to expansion of the exposed DNA structure. The results of dynamic light scattering (DLS) and zeta potential experiments demonstrate that RF-EMFs lead to increment in the surface charge and size of DNA. The structure of DNA immediately after exposure is not significantly different from the DNA sample 2h after 45min exposure. In other words, the EMF-induced conformational changes are irreversible. Collectively, our results reveal that 940MHz can alter the structure of DNA. The displacement of electrons in DNA by EMFs may lead to conformational changes of DNA and DNA disaggregation. Results from this study could have an important implication on the health effects of RF-EMFs exposure. In addition, this finding could proffer a novel strategy for the development of next generation of mobile phone.

Henderson SI, Bangay MJ. Survey of RF exposure levels from mobile telephone base stations in Australia. Bioelectromagnetics. 27(1):73-76, 2006.

This paper reports the results of an exposure level survey of radiofrequency electromagnetic energy originating from mobile telephone base station antennas. Measurements of CDMA800, GSM900, GSM1800, and 3G(UMTS) signals were performed at distances ranging over 50 to 500 m from 60 base stations in five Australian cities. The exposure levels from these mobile telecommunications base stations were found to be well below the general public exposure limits of the ICNIRP guidelines and the Australian radiofrequency standard (ARPANSA RPS3). The highest recorded level from a single base station was 7.8 x 10(-3) W/m(2), which translates to 0.2% of the general public exposure limit.

Hepworth SJ, Schoemaker MJ, Muir KR, Swerdlow AJ, van Tongeren MJ, McKinney PA. Mobile phone use and risk of glioma in adults: case-control study. BMJ.332(7546):883-7, 2006.

OBJECTIVE: To investigate the risk of glioma in adults in relation to mobile phone use. DESIGN: Population based case-control study with collection of personal interview data. SETTING: Five areas of the United Kingdom. PARTICIPANTS: 966 people aged 18 to 69 years diagnosed with a glioma from 1 December 2000 to 29 February 2004 and 1716 controls randomly selected from general practitioner lists. MAIN OUTCOME MEASURES: Odds ratios for risk of glioma in relation to mobile phone use. RESULTS: The overall odds ratio for regular phone use was 0.94 (95% confidence interval 0.78 to 1.13). There was no relation for risk of glioma and time since first use, lifetime years of use, and cumulative number of calls and hours of use. A significant excess risk for reported phone use ipsilateral to the tumour (1.24, 1.02 to 1.52) was paralleled by a significant reduction in risk (0.75, 0.61 to 0.93) for contralateral use. CONCLUSIONS: Use of a mobile phone, either in the short or medium term, is not associated with an increased risk of glioma. This is consistent with most but not all published studies. The complementary positive and negative risks associated with ipsilateral and contralateral

use of the phone in relation to the side of the tumour might be due to recall bias.

Hess DJ, Coley JS. Wireless smart meters and public acceptance: The environment, limited choices, and precautionary politics. Public Underst Sci. 2012 Nov 6. [Epub ahead of print]

Wireless smart meters (WSMs) promise numerous environmental benefits, but they have been installed without full consideration of public acceptance issues. Although societal-implications research and regulatory policy have focused on privacy, security, and accuracy issues, our research indicates that health concerns have played an important role in the public policy debates that have emerged in California. Regulatory bodies do not recognize non-thermal health effects for non-ionizing electromagnetic radiation, but both homeowners and counter-experts have contested the official assurances that WSMs pose no health risks. Similarities and differences with the existing social science literature on mobile phone masts are discussed, as are the broader political implications of framing an alternative policy based on an opt-out choice. The research suggests conditions under which health-oriented precautionary politics can be particularly effective, namely, if there is a mandatory technology, a network of counter-experts, and a broader context of democratic contestation.

Hidisoglu E, Kantar Gok D, Er H, Akpinar D, Uysal F, Akkoyunlu G, Ozen S, Agar A, Yargicoglu P. 2100-MHz electromagnetic fields have different effects on visual evoked potentials and oxidant/antioxidant status depending on exposure duration. Brain Res. 2016 Jan 14. pii: S0006-8993(16)00031-7. doi: 10.1016/j.brainres.2016.01.018. [Epub ahead of print]

The purpose of the present study was to investigate the duration effects of 2100-MHz electromagnetic field (EMF) on visual evoked potentials (VEPs) and to assess lipid peroxidation (LPO), nitric oxide (NO) production and antioxidant status of EMF exposed rats. Rats were randomized to following groups: Sham rats (S1 and S10) and rats exposed to 2100-MHz EMF (E1 and E10) for 2h/day for 1 or 10 weeks, respectively. At the end of experimental periods, VEPs were recorded under anesthesia. Brain thiobarbituric acid reactive substances (TBARS) and 4-hydroxy-2-nonenal (4-HNE) levels were significantly decreased in the E1 whereas increased in the E10 compared with their control groups. While brain catalase (CAT), glutathione peroxidase (GSH-Px) activities and NO and glutathione (GSH) levels were significantly increased in the E1, reduction of superoxide dismutase (SOD) activity was detected in the same group compared with the S1. Conversely, decreased CAT, GSH-Px activities and NO levels were observed in the E10 compared with the S10. Latencies of all VEP components were shortened in the E1 compared with the S1, whereas latencies of all VEP components, except P1, were prolonged in the E10 compared with the S10. There was a positive correlation between all VEP latencies and brain TBARS and 4-HNE values. Consequently, it could be concluded that different effects of EMFs on VEPs depend on exposure duration. Additionally, our results indicated that short-term EMF could provide protective effects, while long-term EMF could have an adverse effect on VEPs and oxidant/antioxidant status.

Hietanen M, Kovala T, Hamalainen AM, Human brain activity during exposure to radiofrequency fields emitted by cellular phones. Scand J Work Environ Health 26(2):87-92, 2000.

OBJECTIVES: The aim of this study was to explore the possible influence of radiofrequency (RF) radiation exposure on human brain function. METHODS: The electroencephalographic (EEG) activity of 19 volunteers was quantitatively analyzed. Ten of the subjects were men (28-48 years of age) and 9 were women (32-57 years of age). The sources of exposure were 5 different cellular phones (analogue and digital models) operating at a frequency of 900 MHz or 1800 MHz. The EEG activity was recorded in an awake, closed-eyes situation. Six 30-minute experiments, including 1 sham exposure, were made for each subject. The duration of a real exposure phase was 20 minutes. RESULTS: Exposure to one of the phones caused a statistically significant change in the absolute power at the delta band of the EEG recording. However, no difference was seen in the relative power of the same band, and no changes occurred during exposure to other phones at any frequency bands. CONCLUSIONS: The findings of this study suggest that exposure to radiofrequency fields emitted by cellular phones has no abnormal effects on human EEG activity. The observed difference in 1 parameter was probably caused by statistical chance.

Hietanen M, Sibakov V, Hallfors S, von Nandelstadh P, Safe use of mobile phones in hospitals. Health Phys 79(5 Suppl):S77-84, 2000.

This research evaluated possibilities to use different types of mobile telephones in the hospital environment by testing the disturbances in medical equipment caused by radiofrequency fields emitted by the phones. The research was carried out by the Finnish Institute of Occupational Health (FIOH) in cooperation with the Technical Research Centre of Finland (VTT), and focused mainly on equipment situated within the Maria Hospital of the City of Helsinki. The Helsinki Hospital District and tile Medical Engineering Centre of the Helsinki University Central Hospital (HUCH) also participated in this project.

Hietanen M, Hämäläinen A-M, Husman T. Hypersensitivity symptoms associated with exposure to cellular telephones: No causal link. Bioelectromagnetics 23:264-270, 2002.

The hypothesis that there exist hypersensitive persons who perceive subjective symptoms from radiofrequency (RF) fields emitted by hand held mobile phones (cellular phones) was tested using double blind provocation experiments. We also tested whether sensitive subjects are able to determine whether the phone is on or off by sensing RF fields. The study group consisted of 20 volunteers (13 women and 7 men) who reported themselves as being sensitive to cellular phones. The RF exposure sources were one analogue NMT phone (900 MHz) and two digital GSM phones (900 and 1800 MHz). The duration of a test session was 30 min, and three or four sessions were performed in random order for each subject during 1 day. The subjects were asked to report symptoms or sensations as soon as they perceived any abnormal feelings. In addition, the subjects' blood pressure, heart rate, and breathing frequency were monitored every 5 min. The results of the study indicated that various symptoms were reported, and most of them appeared in the head region. However, the number of reported symptoms was higher during sham exposure than during real exposure conditions. In addition, none of the test

persons could distinguish real RF exposure from sham exposure. Hence, we conclude that adverse subjective symptoms or sensations, though unquestionably perceived by the test subjects, were not produced by cellular phones.

Higashikubo R, Culbreth VO, Spitz DR, LaRegina MC, Pickard WF, Straube WL, Moros EG, Roti JL, Radiofrequency electromagnetic fields have no effect on the in vivo proliferation of the 9L brain tumor. Radiat Res 152(6):665-671, 1999.

The intracranial 9L tumor model was used to determine if exposure to a radiofrequency (RF) electromagnetic field similar to those used in cellular telephone has any effects on the growth of a central nervous system tumor. Fischer 344 rats implanted with different numbers of 9L gliosarcoma cells were exposed to 835.62 MHz frequency-modulated continuous wave (FMCW) or 847.74 MHz code division multiple access (CDMA) RF field with nominal slot-average specific absorption rates in the brain of 0.75 +/- 0.25 W/kg. The animals were exposed to the RF field for 4 h a day, 5 days a week starting 4 weeks prior to and up to 150 days after the implantation of tumor cells. Among sham-exposed animals injected with 2 to 10 viable cells (group 1), the median survival was 70 days, with 27% of the animals surviving at 150 days. The median survival length and final survival fraction for animals injected with 11 to 36 viable cells (group 2) were 52 days and 14%, respectively, while the values for those injected with 37 to 100 cells (group 3) were 45 days and 0%. The animals exposed to CDMA or FMCW had similar survival parameters, and the statistical comparison of the survival curves for each of the groups 1, 2 and 3 showed no significant differences compared to sham-exposed controls.

Higashikubo R, Ragouzis M, Moros EG, Straube WL, Roti Roti JL. Radiofrequency electromagnetic fields do not alter the cell cycle progression of C3H 10T and U87MG cells. Radiat Res 156(6):786-795, 2001.

The effects of exposure to radiofrequency electromagnetic fields (RF EMFs) on cell cycle progression of mouse fibroblasts C3H 10T(1/2) and human glioma U87MG cells were determined by the flow cytometric bromodeoxyuridine pulse-chase method. Cells were exposed to a frequency-modulated continuous wave at 835.62 MHz or a code division multiple access RF EMF centered on 847.74 MHz at an average specific absorption rate of 0.6 W/kg. Five cell cycle parameters, including the transit of cells through G(1), G(2) and S phase and the probability of cell division, were examined immediately after the cells were placed in the fields or after they had been kept in the fields for up to 100 h. The only significant change observed in the study was that associated with C3H 10T(1/2) cell cultures moving into plateau phase toward the later times in the long-exposure experiment. No changes in the cell cycle parameters were observed in cells exposed to either mode of RF EMFs when compared to sham-exposed cells in either of the cell lines studied during the entire experimental period. The results show that exposure to RF EMFs, at the frequencies and power tested, does not have any effect on cell progression in vitro.

Higuchi Y, Nashold BS Jr, Sluijter M, Cosman E, Pearlstein RD. Exposure of the dorsal root ganglion in rats to pulsed radiofrequency currents activates dorsal horn lamina I and II neurons. Neurosurgery 50(4):850-856, 2002.

OBJECTIVE: Application of pulsed radiofrequency (RF) currents to the dorsal ganglion

has been reported to produce long-term relief of spinal pain without causing thermal ablation. The present study was undertaken to identify spinal cord neurons activated by exposure of the dorsal ganglion to pulsed RF currents in rats. METHODS: Left-sided hemilaminectomy was performed in adult Sprague-Dawley rats to expose the C6 dorsal root ganglion. An RF electrode (0.5 mm diameter) with a thermocouple for temperature monitoring was positioned on the exposed ganglion, and rats were assigned to one of three treatment groups: pulsed RF treatment (20 ms of 500-kHz RF pulses delivered at a rate of 2 Hz for 120 s to produce tissue heated to 38 degrees C), continuous RF (continuous RF currents for 120 s to produce tissue heated to 38 degrees C), or sham treatment (no RF current; electrode maintained in contact with ganglion for 120 s). RESULTS: Treatment with pulsed RF but not continuous RF was associated with a significant increase in the number of cFOS-immunoreactive neurons in the superficial laminae of the dorsal horn as observed 3 hours after treatment. CONCLUSION: Exposure of the dorsal ganglion to pulsed RF currents activates pain-processing neurons in the dorsal horn. This effect is not mediated by tissue heating.

Hinrichs H, Heinze HJ.Effects of GSM electromagnetic field on the MEG during an encoding-retrieval task. Neuroreport. 15(7):1191-1194, 2004.

Potential effects of GSM 1800 electromagnetic fields (EMF) on verbal memory encoding were investigated by recording event-related magnetic fields (ERMF) from the brain during subsequent memory retrieval. Twelve normal subjects participated in the study. After encoding words from a study list presented in the first phase they had to discriminate old from new words mixed together in a test list presented during the second phase. All subjects performed two experimental sessions, one with exposure to EMF during the study phase, and one without. Exposure to EMF changed an early (350-400 ms) task-specific component of the ERMF indicating an interference of EMF and item encoding. Behavioural measures were not significantly affected. Adverse health effects cannot be derived from these data.

Hinrikus H, Parts M, Lass J, Tuulik V. Changes in human EEG caused by low level modulated microwave stimulation. Bioelectromagnetics. 25(6):431-440, 2004.

This study focuses on the effect of low level microwave radiation on human EEG alpha and theta rhythms. During the experiment, 20 healthy volunteers were exposed to a 450 MHz microwaves with 7 Hz on-off modulation. The field power density at the scalp was 0.16 mW/cm2. Signals from the following EEG channels were used: FP1, FP2, P3, P4, T3, T4, O1, and O2. The experimental protocol consisted of one cycle of short term photic and ten cycles of the repetitive microwave stimulation. The changes caused by photic as well as microwave stimulation were more regular on the alpha rhythm. In the majority of cases, photic stimulation caused changes in the EEG energy level in the occipital and microwave stimulation in the frontal region. Our experimental results demonstrated that microwave stimulation effects became apparent, starting from the third stimulation cycle. Changes varied strongly from subject to subject. Therefore, photic and microwave exposure did not cause statistically significant changes in the EEG activity level for the whole group. For some subjects, clear tendencies of changes in microwave on-off cycles were noticeable.

Hinrikus H, Bachmann M, Lass J, Karai D, Tuulik V. Effect of low frequency

modulated microwave exposure on human EEG: individual sensitivity. Bioelectromagnetics. 29(7):527-538, 2008.

The aim of this study was to evaluate the effect of modulated microwave exposure on human EEG of individual subjects. The experiments were carried out on four different groups of healthy volunteers. The 450 MHz microwave radiation modulated at 7 Hz (first group, 19 subjects), 14 and 21 Hz (second group, 13 subjects), 40 and 70 Hz (third group, 15 subjects), 217 and 1000 Hz (fourth group, 19 subjects) frequencies was applied. The field power density at the scalp was 0.16 mW/cm(2). The calculated spatial peak SAR averaged over 1 g was 0.303 W/kg. Ten cycles of the exposure (1 min off and 1 min on) at fixed modulation frequencies were applied. All subjects completed the experimental protocols with exposure and sham. The exposed and sham-exposed subjects were randomly assigned. A computer also randomly assigned the succession of modulation frequencies. Our results showed that microwave exposure increased the EEG energy. Relative changes in the EEG beta1 power in P3-P4 channels were selected for evaluation of individual sensitivity. The rate of subjects significantly affected is similar in all groups except for the 1000 Hz group: in first group 3 subjects (16%) at 7 Hz modulation; in second group 4 subjects (31%) at 14 Hz modulation and 3 subjects (23%) at 21 Hz modulation; in third group 3 subjects (20%) at 40 Hz and 2 subjects (13%) at 70 Hz modulation; in fourth group 3 subjects (16%) at 217 Hz and 0 subjects at 1000 Hz modulation frequency.

Hinrikus H, Bachmann M, Lass J, Tomson R, Tuulik V. Effect of 7, 14 and 21 Hz modulated 450 MHz microwave radiation on human electroencephalographic rhythms. Int J Radiat Biol. 84(1):69-79, 2008.

PURPOSE: The aim of this study was to evaluate the effect of microwaves modulated at different frequencies on human electroencephalographic (EEG) rhythms. MATERIALS AND METHODS: Thirteen healthy volunteers were exposed to microwaves (450 MHz) pulse-modulated at frequencies of 7, 14 and 21 Hz. The field power density at the scalp was 0.16 mW/cm2. Our experimental protocol consisted of two five-cycle (1 min on and 1 min off) series of exposures at fixed modulation frequencies. A relative change in the EEG power with and without exposure was used as a quantitative measure. EEG frequencies recorded in the theta (4-6.8 Hz), alpha (8-13 Hz), betal (15-20 Hz), and beta2 (22-38 Hz) bands were analyzed. RESULTS: Modulated microwaves caused an increase in the average EEG alpha (17%) and beta (7%) power but the theta rhythm remained unaffected. Increases in the EEG alpha and beta power were statistically significant during the first half-period of the exposure interval (30 s) at the modulation frequencies of 14 and 21 Hz. Differences were found in individual sensitivity to exposure. Increases in the EEG beta power appeared statistically significant in the case of four subjects. CONCLUSIONS: Our findings suggest that the effect of the 450 MHz microwave radiation modulated at 7, 14 and 21 Hz varies depending on the modulation frequency. The microwave exposure modulated at 14 and 21 Hz enhanced the EEG power in the alpha and beta frequency bands, whereas no enhancement occurred during exposure to the modulation frequency of 7 Hz.

Hinrikus H, Lass J, Karai D, Pilt K, Bachmann M. Microwave effect on diffusion: a possible mechanism for non-thermal effect. Electromagn Biol Med. 23:1-7, 2014.

In this study, we assume that microwave radiation affects hydrogen bonding between dipolar water molecules and through that diffusion in water at constant temperature. The experimental study was performed on the setup of two identical reservoirs filled with pure water and 0.9% NaCl solution and connected by a thin tube. Alterations of NaCl concentration in the reservoir initially filled with pure water were measured using the resistance of the solution as an indicator. The applied 450 MHz continuous-wave microwave field had the maximal specific absorption rate of 0.4 W/kg on the connecting tube. The standard deviation of water temperature in the setup was 0.02 °C during an experiment. Our experimental data demonstrated that microwave exposure makes faster the process of diffusion in water. The time required for reduction of initial resistance of the solution by 10% was 1.7 times shorter with microwave. This result is consistent with the proposed mechanism of low-level microwave effect: microwave radiation, rotating dipolar water molecules, causes high-frequency alterations of hydrogen bonds between water molecules, thereby affects its viscosity and makes faster diffusion.

Hintzsche H, Stopper H. Micronucleus frequency in buccal mucosa cells of mobile phone users. Toxicol Lett. 193(1):124-130, 2010.

Mobile phones are being used extensively throughout the world, with more than four billion accounts existing in 2009. This technology applies electromagnetic radiation in the microwave range. Health effects of this radiation have been subject of debate for a long time, both within the scientific community and within the general public. This study investigated the effect of mobile phone use on genomic instability of the human oral cavity's mucosa cells. 131 Individuals donated buccal mucosa cells extracted by slightly scraping the oral cavity with a cotton swab. Every participant filled out a questionnaire about mobile phone use including duration of weekly use, overall period of exposure and headset usage. 13 Individuals did not use mobile phones at all, 85 reported using the mobile phone for three hours per week or less, and 33 reported use of more than three hours per week. Additionally, information on age, gender, body weight, smoking status, medication and nutrition was retrieved. For staining of the cells a procedure using alpha-tubulin-antibody and chromomycin A(3) was applied. Micronuclei and other markers were evaluated in 1000 cells per individual at the microscope. A second scorer counted another 1000 cells, resulting in 2000 analyzed cells per individual. Mobile phone use did not lead to a significantly increased frequency of micronuclei.

Hintzsche H, Jastrow C, Kleine-Ostmann T, Schrader T, Stopper H. 900 MHz radiation does not induce micronucleus formation in different cell types. Mutagenesis. 27(4):477-483, 2012.

The exposure of the population to non-ionising electromagnetic radiation is still increasing, mainly due to mobile communication. Whether low-intensity electromagnetic fields can cause other effects apart from heating has been a subject of debate. One of the effects, which were proposed to be caused by mobile phone radiation, is the occurrence of mitotic disturbances. The aim of this study was to investigate possible consequences of these mitotic disturbances as manifest genomic damage, i.e. micronucleus induction. Cells were irradiated at a frequency of 900

MHz, which is located in one of the main frequency bands applied for mobile communication. Two cell types were used, HaCaT cells as human cells and A(L) cells (human-hamster hybrid cells), in which mitotic disturbances had been reported to occur. After different post-exposure incubation periods, cells were fixed and micronucleus frequencies were evaluated. Both cell types did not show any genomic damage after exposure. To adapt the protocol for the micronucleus test into the direction of the protocol for mitotic disturbances, the post-exposure incubation period was reduced and exposure time was extended to one cell cycle length. This did not result in any increase of the genomic damage. In conclusion, micronucleus induction was not observed as a consequence of exposure to non-ionising radiation, even though this agent was reported to cause mitotic disturbances under similar experimental conditions.

Hirata A, Kojima M, Kawai H, Yamashiro Y, Watanabe S, Sasaki H, Fujiwara O. Acute dosimetry and estimation of threshold inducing behavioral signs of thermal stress in rabbits at 2.45-GHz microwave exposure. IEEE Trans Biomed Eng. 57(5):1234-42, 2010.

In the current international guidelines and standards for human exposure to microwaves, the basic restriction is determined by the whole-body average specific absorption rate (SAR). The basis for the guidelines is the adverse effect such as work stoppage in animals for whole-body average SARs above a certain level. Although it is known that absorbed microwave energy causes the behavioral sign of thermal stress, the relationship of whole-body average SAR with temperature/temperature elevation has not been sufficiently investigated. In the present study, we performed experiments on rabbits exposed to 2.45-GHz microwaves. A total of 24 measurements were conducted for power densities from approximately 100 to 1,000 W/m2. Our computational code for electromagnetic-thermal dosimetry was used to set the exposure time duration and incident power density. Our experimental results suggest that a core temperature elevation of 1oC is an estimate of the threshold inducing complex behavioral signs of microwave-induced thermal stress in rabbits for different whole-body average SARs and exposure time durations. The whole-body average SAR required for microwave-induced behavioral sign in rabbits was estimated as approximately 1.3 W/kg for 2.45-GHz microwaves.

Hirose H, Sakuma N, Kaji N, Suhara T, Sekijima M, Nojima T, Miyakoshi J. Phosphorylation and gene expression of p53 are not affected in human cells exposed to 2.1425 GHz band CW or W-CDMA modulated radiation allocated to mobile radio base stations. Bioelectromagnetics.27(6):494-504, 2006.

A large-scale in vitro study focusing on low-level radiofrequency (RF) fields from mobile radio base stations employing the International Mobile Telecommunication 2000 (IMT-2000) cellular system was conducted to test the hypothesis that modulated RF fields induce apoptosis or other cellular stress response that activate p53 or the p53-signaling pathway. First, we evaluated the response 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 by 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 apoptosis or any signs of stress. Human glioblastoma 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 24 or 48 h. Human IMR-90 fibroblasts from fetal lungs were exposed to both W-CDMA and CW radiation at a SAR of 80 mW/kg for 28 h. Under the RF field exposure conditions described above, no significant differences in the percentage of apoptotic cells were observed between the test groups exposed to RF signals and the sham-exposed negative controls, as evaluated by the Annexin V affinity assay. No significant differences in expression levels of phosphorylated p53 at serine 15 or total p53 were observed between the test groups and the negative controls by the bead-based multiplex assay. Moreover, microarray hybridization and real-time RT-PCR analysis showed no noticeable differences in gene expression of the subsequent downstream targets of p53 signaling involved in apoptosis between the test groups and the negative controls. Our results confirm that exposure to low-level RF signals up to 800 mW/kg does not induce p53-dependent apoptosis, DNA damage, or other stress response in human cells.

Hirose H, Sakuma N, Kaji N, Nakayama K, Inoue K, Sekijima M, Nojima T, Miyakoshi J. Mobile phone base station-emitted radiation does not induce phosphorylation of Hsp27. Bioelectromagnetics.28(2):99-108, 2007.

An in vitro study focusing on the effects of low-level radiofrequency (RF) fields from mobile radio base stations employing the International Mobile Telecommunication 2000 (IMT-2000) cellular system was conducted to test the hypothesis that modulated RF fields act to induce phosphorylation and overexpression of heat shock protein hsp27. 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 activation or gene expression of hsp27 and other heat shock proteins (hsps). Human glioblastoma A172 cells were exposed to W-CDMA radiation at SARs of 80 and 800 mW/kg for 2-48 h, and CW radiation at 80 mW/kg for 24 h. Human IMR-90 fibroblasts from fetal lungs were exposed to W-CDMA at 80 and 800 mW/kg for 2 or 28 h, and CW at 80 mW/kg for 28 h. Under the RF field exposure conditions described above, no significant differences in the expression levels of phosphorylated hsp27 at serine 82 (hsp27[pS82]) were observed between the test groups exposed to W-CDMA or CW signal and the sham-exposed negative controls, as evaluated immediately after the exposure periods by bead-based multiplex assays. Moreover, no noticeable differences in the gene expression of hsps were observed between the test groups and the negative controls by DNA Chip analysis. Our results confirm that exposure to low-level RF field up to 800 mW/kg does not induce phosphorylation of hsp27 or expression of hsp gene family.

Hirose H, Suhara T, Kaji N, Sakuma N, Sekijima M, Nojima T, Miyakoshi J. Mobile phone base station radiation does not affect neoplastic transformation in BALB/3T3 cells. Bioelectromagnetics. 29(1): 55-64, 2008.

A large-scale in vitro study focusing on low-level radiofrequency (RF) fields from mobile radio base stations employing the International Mobile Telecommunication 2000 (IMT-2000) cellular system was conducted to test the hypothesis that modulated RF fields affect malignant transformation or other cellular stress responses. Our group previously reported that DNA strand breaks were not induced in human cells exposed to 2.1425 GHz Wideband Code Division Multiple Access (W-CDMA) radiation up to 800 mW/kg from mobile radio base stations employing the IMT-2000 cellular system. In the current study, BALB/3T3 cells were continuously exposed to 2.1425 GHz W-CDMA RF fields at specific absorption rates (SARs) of 80 and 800 mW/kg for 6 weeks and malignant cell transformation was assessed. In addition, 3-methylcholanthrene (MCA)-treated cells were exposed to RF fields in a similar fashion, to assess for effects on tumor promotion. Finally, the effect of RF fields on tumor co-promotion was assessed in BALB/3T3 cells initiated with MCA and co-exposed to 12-O-tetradecanoylphorbol-13-acetate (TPA). At the end of the incubation period, transformation dishes were fixed, stained with Giemsa, and scored for morphologically transformed foci. No significant differences in transformation frequency were observed between the test groups exposed to RF signals and the sham-exposed negative controls in the non-, MCA-, or MCA plus TPA-treated cells. Our studies found no evidence to support the hypothesis that RF fields may affect malignant transformation. Our results suggest that exposure to low-level RF radiation of up to 800 mW/kg does not induce cell transformation, which causes tumor formation.

Hirose H, **Sasaki A**, **Ishii N**, **Sekijima M**, **Iyama T**, **Nojima T**, **Ugawa Y**. **1950 MHz IMT-2000 field does not activate microglial cells in vitro. Bioelectromagnetics.31(2):104-112, 2010.**

Given the widespread use of the cellular phone today, investigation of potential biological effects of radiofrequency (RF) fields has become increasingly important. In particular, much research has been conducted on RF effects on brain function. To examine any biological effects on the central nervous system (CNS) induced by 1950 MHz modulation signals, which are controlled by the International Mobile Telecommunication-2000 (IMT-2000) cellular system, we investigated the effect of RF fields on microglial cells in the brain. We assessed functional changes in microglial cells by examining changes in immune reaction-related molecule expression and cytokine production after exposure to a 1950 MHz Wideband Code Division Multiple Access (W-CDMA) RF field, at specific absorption rates (SARs) of 0.2, 0.8, and 2.0 W/kg. Primary microglial cell cultures prepared from neonatal rats were subjected to an RF or sham field for 2 h. Assay samples obtained 24 and 72 h after exposure were processed in a blind manner. Results showed that the percentage of cells positive for major histocompatibility complex (MHC) class II, which is the most common marker for activated microglial cells, was similar between cells exposed to W-CDMA radiation and sham-exposed controls. No statistically significant differences were observed between any of the RF field exposure groups and the sham-exposed controls in percentage of MHC class II positive cells. Further, no remarkable differences in the production of tumor necrosis factor-alpha (TNF-alpha), interleukin-1beta (IL-1beta), and interleukin-6 (IL-6) were observed between the test groups exposed to W-CDMA signal and the sham-exposed negative controls. These

findings suggest that exposure to RF fields up to 2 W/kg does not activate microglial cells in vitro.

Hirsch J, Menzebach A, Welters ID, Dietrich GV, Katz N, Hempelmann G. Indicators of erythrocyte damage after microwave warming of packed red blood cells. Clin Chem 49(5):792-799, 2003.

BACKGROUND: Localized overheating of packed red blood cells (PRBCs) after microwave warming with consequent damage to erythrocytes has been reported. We therefore compared possible cellular markers of erythrocyte damage, as measured by flow cytometry, with laboratory indicators of hemolysis to evaluate the effects of microwave warming on PRBCs. METHODS: PRBC samples were warmed to room temperature or to 37, 42, 47, 52, or 57 degrees C in a water bath. Flow cytometry was performed after fluorescein labeling using antibodies to spectrin, Ca(2+)-ATPase, and Na(+)-K(+)-ATPase. The forward-to-sideward scatter (FSC/SSC) ratio and antibody binding were evaluated. Plasma free hemoglobin (FHb) and alpha-hydroxybutyrate dehydrogenase (HBDH) were measured immediately after heating and after 48 h. In addition, all measurements were made before and after the heating of PRBCs to 35 degrees C by a microwave blood warmer. RESULTS: Analysis of 15 000 erythrocytes showed a decrease in the FSC/SSC ratio and antibody binding above 47 degrees C [at 37 degrees C, median (SD) of 94.2 (7.4) with 0.07 (0.05)% fluorescein-positive; at 52 degrees C, median (SD) of 177.0 (19.0) with 18.5 (6.4)% positively gated; P <0.001]. FHb [room temperature, 0.3 (0.2) g/L] was increased 2-fold at 37 and 42 degrees C, 4-fold at 47 degrees C, and 25-fold at 52 degrees C. HBDH increased in parallel. Hemolysis markers showed an additional twofold increase 48 h after heating to 42 and 47 degrees C. Microwave heating to 35 degrees C did not produce significant changes of any marker. CONCLUSIONS: All markers of cellular damage were altered after heating to >47 degrees C, and a substantial part of hemolysis was delayed. The methodology can be used for future testing of other blood warming devices.

Hjollund NH, Bonde JP, Skotte J, Semen analysis of personnel operating military radar equipment. Reprod Toxicol 11(6):897, 1997.

This is a preliminary survey of semen quality among Danish military personnel operating mobile ground-to-air missile units that use several microwave emitting radar systems. The maximal mean exposure was estimated to be 0.01 mW/cm2. The median sperm density of the military personnel was significantly low compared to the references. The difference is either due to chance, uncontrolled bias, or nonthermal effects of transitory microwaves.

Hladky, A, Musil, J, Roth, Z, Urban, P, Blazkova, V, Acute effects of using a mobile phone on CNS functions. Cent Eur J Public Health 7(4):165-167. 1999.

Twenty volunteers participated in two experiments exploring the acute effects of using the mobile phone Motorola GSM 8700 on the functions of the CNS. When speaking (5 minutes reading a text from daily newspapers) the electromagnetic fields from the mobile apparatus did not affect the visual evoked potentials. Also a 6-min exposure did not reveal any effect of electromagnetic fields on the results in two tests (memory and attention) performed while speaking into the mobile. On the other hand the phone call

itself strongly influenced the performance in a secondary task applying a test of switching attention which is a good model for driving a car. The response and decision speed were significantly worse. This is a proof that even a slight psychological stress involved in calling while driving can be a great risk.

Hocking, B, Preliminary report: symptoms associated with mobile phone use. Occup Med (Lond);48(6):357-360, 1998.

Mobile phone use is ubiquitous, although the alleged health effects of low level radio-frequency radiation (RFR) used in transmission are contentious. Following isolated reports of headache-like symptoms arising in some users, a survey has been conducted to characterize the symptoms sometimes associated with mobile phone usage. A notice of interest in cases was placed in a major medical journal and this was publicized by the media. Respondents were interviewed by telephone using a structured questionnaire. Forty respondents from diverse occupations described unpleasant sensations such as a burning feeling or a dull ache mainly occurring in the temporal, occipital or auricular areas. The symptoms often began minutes after beginning a call, but could come on later during the day. The symptoms usually ceased within an hour after the call, but could last until evening. Symptoms did not occur when using an ordinary handset, and were different from ordinary headaches. There were several reports suggestive of intra-cranial effects. Three respondents reported local symptoms associated with wearing their mobile phone on their belts. There was one cluster of cases in a workplace. Seventy-five per cent of cases were associated with digital mobile phones. Most of the respondents obtained relief by altering their patterns of telephone usage or type of phone. Cranial and other diverse symptoms may arise associated with mobile phone usage. Physicians and users alike should be alert to this. Further work is needed to determine the range of effects, their mechanism and the possible implications for safety limits of RFR.

Hocking B , Microwave sickness: a reappraisal. Occup Med (Lond) 51(1):66-69, 2001.

Microwave sickness (MWS) has been a disputed condition. The syndrome involves the nervous system and includes fatigue, headaches, dysaesthesia and various autonomic effects in radiofrequency radiation workers. This paper describes the early reports of the syndrome from Eastern Europe and notes the scepticism expressed about them in the West, before considering comprehensive recent reports by Western specialists and a possible neurological basis for the condition. It is concluded that MWS is a medical entity which should be recognized as a possible risk for radiofrequency radiation workers.

Hocking B. Management of radiofrequency radiation overexposures. Aust Fam Physician 30(4):339-342, 2001.

BACKGROUND: Radiofrequency radiation (RFR) has been in use for some time but is now proliferative with the burgeoning radiocommunications industry. OBJECTIVE: To inform the profession of the possible health effects from overexposure to radiofrequency radiation (RFR) and the clinical approach to cases. An introduction to the health effects of overexposure to RFR is given. A clinical approach to integrating the patient's symptoms and the circumstances of the exposure is given. Emergency treatment and ongoing care is outlined, and sources of expert advice given. CONCLUSION: Overexposure to RFR is

a complex injury. Advice is given in this article for emergency care and planning ongoing care.

Hocking B, Gordon IR, Grain HL, Hatfield GE, Cancer incidence and mortality and proximity to TV towers. Med J Aust 165(11-12):601-605, 1996. (Published erratum appears in Med J Aust 166(2):80, 1997.)

OBJECTIVE: To determine whether there is an increased cancer incidence and mortality in populations exposed to radiofrequency radiations from TV towers. DESIGN: An ecological study comparing cancer incidence and mortality, 1972-1990, in nine municipalities, three of which surround the TV towers and six of which are further away from the towers. (TV radiofrequency radiation decreases with the square of the distance from the source.) Cancer incidence and mortality data were obtained from the then Commonwealth Department of Human Services and Health. Data on frequency, power, and period of broadcasting for the three TV towers were obtained from the Commonwealth Department of Communications and the Arts. The calculated power density of the radiofrequency radiation in the exposed area ranged from 8.0 microW/cm2 near the towers to 0.2 microW/cm2 at a radius of 4km and 0.02 microW/cm2 at 12 km. SETTING: Northern Sydney, where three TV towers have been broadcasting since 1956. OUTCOME MEASURES: Rate ratios for leukaemia and brain tumour incidence and mortality, comparing the inner with the outer areas. RESULTS: For all ages, the rate ratio for total leukaemia incidence was 1.24 (95% confidence interval [CI], 1.09-1.40). Among children, the rate ratio for leukaemia incidence was 1.58 (95% CI, 1.07-2.34) and for mortality it was 2.32 (95% CI, 1.35-4.01). The rate ratio for childhood lymphatic leukaemia (the most common type) was 1.55 (95% CI, 1.00-2.41) for incidence and 2.74 (95% CI, 1.42-5.27) for mortality. Brain cancer incidence and mortality were not increased. CONCLUSION: We found an association between increased childhood leukaemia incidence and mortality and proximity to TV towers.

Hocking B, Gordon I. Decreased survival for childhood leukemia in proximity to television towers. Arch Environ Health. 58(9):560-564, 2003.

Previously, an increased risk of childhood leukemia was identified among children who resided in an inner ring (radius -4 km) of 3 municipalities surrounding television towers, compared with children who resided in an outer ring (radius approximately 4-12 km) of 6 municipalities surrounding, but farther away from, the towers, which are situated in North Sydney, Australia. In the current study, the authors examined the survival experience of these children for all childhood leukemias, and for acute lymphatic leukemia (International Statistical Classification of Diseases and Related Health Problems, 9th revision [ICD-9] rubric 204.0) in particular. Of 123 cases of acute lymphatic leukemia, 29 cases (16 of whom died) were in the inner ring of municipalities nearest the towers, and 94 cases (34 of whom died) occurred in the outer, more-distant ring. There was a significant difference in survival rates between the 2 groups (log-rank test, p = 0.03; Wilcoxon, p = 0.05). The 5-yr survival in the inner ring of municipalities was 55%, and in the outer ring was 71% (i.e., subjects in the inner ring were 23% less likely to survive than those in the outer ring); at 10 yr, survival in the inner and outer rings was 33% and 62%, respectively. Following adjustment, the mortality rate ratio that the authors used to compare the inner ring with the outer ring was 2.1 (95% confidence interval = 1.1, 4.0). There was an association

between residential proximity to the television towers and decreased surv

Hocking B, Westerman R, Neurological abnormalities associated with Mobile phone use. Occup Med 50: 366-368, 2000.

Dysaesthesiae of the scalp after mobile phone use have been previously reported but the pathological basis of these symptoms has been unclear. We report finding a neurological abnormality in a patient after prolonged use of a mobile phone. He had permanent unilateral dysaesthesiae of the scalp, slight loss of sensation, and abnormalities on current perception threshold testing of cervical and trigeminal nerves. A neurologist found no other disease. The implications regarding health effects of mobile phones and radio-frequency radiation is discussed.

Hocking B, Westerman R. Neurological abnormalities associated with CDMA exposure. Occup Med (Lond) 51(6):410-413, 2001.

Dysaesthesiae of the scalp and neurological abnormality after mobile phone use have been reported previously, but the roles of the phone per se or the radiations in causing these findings have been questioned. We report finding a neurological abnormality in a patient after accidental exposure of the left side of the face to mobile phone radiation [code division multiple access (CDMA)] from a down-powered mobile phone base station antenna. He had headaches, unilateral left blurred vision and pupil constriction, unilateral altered sensation on the forehead, and abnormalities of current perception thresholds on testing the left trigeminal ophthalmic nerve. His nerve function recovered during 6 months follow-up. His exposure was 0.015-0.06 mW/cm(2) over 1-2 h. The implications regarding health effects of radiofrequency radiation are discussed.

Hocking B, Westerman R. Neurological changes induced by a mobile phone. Occup Med (Lond) 52(7):413-415, 2002.

Dysaesthesiae of the scalp after mobile phone use have been previously reported, but the basis for this has not been clear. We report a case of a 34-year-old journalist who complained of symptoms associated with use of a mobile phone. She agreed to a provocation study with her phone. Current perception threshold testing before and after exposure showed marked changes in the C-fibre nerves of the affected area compared with the opposite side. The case is supportive of a neurological basis for some cases of dysaesthesiae associated with mobile phone use.

Hocking B, Westerman R. Neurological effects of radiofrequency radiation. Occup Med (Lond) 53(2):123-127, 2003.

BACKGROUND: The health effects of radiofrequency radiation (RFR) and the adequacy of the safety standards are a subject of debate. One source of human data is case reports regarding peripheral neurological effects of RFR, mainly noxious sensations or dysaesthesiae. Aim To investigate health effects, neurophysiological mechanisms and safety levels for RFR. METHODS: We conducted a literature search for case reports and case series associated with mobile phone technology as well as other RFR sources using specific search terms on PubMed. RESULTS: We identified 11 original articles detailing case reports or case series and matching the search criteria. Five of the identified papers were written by at least one of the authors (B.H. or R.W.). CONCLUSIONS: Cases have

arisen after exposure to much of the radiofrequency range. In some cases, symptoms are transitory but lasting in others. After very high exposures, nerves may be grossly injured. After lower exposures, which may result in dysaesthesia, ordinary nerve conduction studies find no abnormality but current perception threshold studies have found abnormalities. Only a small proportion of similarly exposed people develop symptoms. The role of modulations needs clarification. Some of these observations are not consistent with the prevailing hypothesis that all health effects of RFR arise from thermal mechanisms.

Hofgartner F, Muller T, Sigel H, [Could C- and D-network mobile phones endanger patients with pacemakers]? Dtsch Med Wochenschr 121(20):646-652, 1996. [Article in German]

OBJECTIVE: To investigate prospectively the extent of potentially harmful interference of cardiac pacemakers by mobile phones in the C (analog) and D (digital) networks in use in Germany. PATIENTS AND METHODS: 104 patients (54 men, 50 women; mean age 75.8 [40-100] years) with 58 different implanted pacemaker models (43 one-chamber and 15 two-chamber systems) underwent uniform tests at various functional states with three different telephones (D1 portable 8 Watt, D1 Handy model 2 Watt, C Handy model 0.5 Watt). The distances between telephone aerial and pacemaker, as well as reception sensitivity and polarity of the pacemaker were varied. All tests were done during continuous ECG monitoring. RESULTS: 28 different pacemaker types (48.3%) in 43 patients (41.3%) showed interference in the form of pacemaker inhibition and switching to interference frequencies as well as triggering of pacemaker-mediated tachycardias in the DDD mode, as well as in the temperature-regulated frequency-adaptive function. D portables influenced pacemaker function more often and at greater distance than the D Handy model, which was little different from the c network hand phone. Reduction in pacemaker sensitivity as well as switching to bipolar reception only partly eliminated the interference. CONCLUSIONS: Patients with implanted pacemakers should if possible not use mobile phones in the C and D networks. Individual testing with suitable programming of pacemaker sensitivity and polarity can reduce the risk of interference.

Holly EA, Aston DA, Ahn DK, Smith AH. Intraocular melanoma linked to occupations and chemical exposures. Epidemiology 7(1):55-61, 1996.

We conducted a case-control study in the western United States to determine the relation between occupations or chemical exposures and increased risk of uveal melanoma. Among men (221 patients, 447 controls), we found increased risks for occupational groups who had intense exposure to ultraviolet light [odds ratio (OR) = 3.0; 95% confidence interval (CI) = 1.2-7.8], welding exposure (OR = 2.2; 95% CI = 1.3-3.5), and asbestos exposure (OR = 2.4; 95% CI = 1.5-3.9 for most likely exposed). The highest odds ratio was for the small number of men (nine cases, three controls) who were chemists, chemical engineers, and chemical technicians (OR = 5.9; 95% CI = 1.6-22.7). Odds ratios also were elevated for exposures to antifreeze, formaldehyde, pesticides, and carbon tetrachloride, but these findings, based on recall of specific chemical exposures, are more subject to recall bias than the findings based on occupational groups. (Also reported a significant increase risk in uveal melanoma with microwave/radar exposure.)

Holovská K, Almášiová V, Cigánková V, Beňová K, Račeková E, Martončíková M.

Structural and Ultrastructural Study of Rat Liver Influenced by Electromagnetic Radiation. J Toxicol Environ Health A. 78(6):353-356, 2015.

Mobile communication systems are undoubtedly an environmental source of electromagnetic radiation (EMR). There is an increasing concern regarding the interactions of EMR with the humans. The aim of this study was to examine the effects of EMR on Wistar rat liver. Mature rats were exposed to electromagnetic field of frequency 2.45 GHz and mean power density of 2.8 mW/cm^2 for 3 h/d for 3 wk. Samples of the liver were obtained 3 h after the last irradiation and processed histologically for light and transmission electron microscopy. Data demonstrated the presence of moderate hyperemia, dilatation of liver sinusoids, and small inflammatory foci in the center of liver lobules. Structure of hepatocytes was not altered and all described changes were classified as moderate. Electron microscopy of hepatocytes revealed vesicles of different sizes and shapes, lipid droplets, and proliferation of smooth endoplasmic reticulum. Occasionally necrotizing hepatocytes were observed. Our observations demonstrate that EMR exposure produced adverse effects on rat liver.

Hong MN, Kim BC, Ko YG, Lee YS, Hong SC, Kim T, Pack JK, Choi HD, Kim N, Lee JS. Effects of 837 and 1950 MHz radiofrequency radiation exposure alone or combined on oxidative stress in MCF10A cells. Bioelectromagnetics. 33(7):604-11, 2012.

The aim of this study was to determine whether the exposure to either single or multiple radio-frequency (RF) radiation frequencies could induce oxidative stress in cell cultures. Exposures of human MCF10A mammary epithelial cells to either a single frequency (837 MHz alone or 1950 MHz alone) or multiple frequencies (837 and 1950 MHz) were conducted at specific absorption rate (SAR) values of 4 W/kg for 2 h. During the exposure period, the temperature in the exposure chamber was maintained isothermally. Intracellular levels of reactive oxygen species (ROS), the antioxidant enzyme activity of superoxide dismutase (SOD), and the ratio of reduced/oxidized glutathione (GSH/GSSG) showed no statistically significant alterations as the result of either single or multiple RF radiation exposures. In contrast, ionizing radiation-exposed cells, used as a positive control, showed evident changes in all measured biological endpoints. These results indicate that single or multiple RF radiation exposure did not elicit oxidative stress in MCF10A cells under our exposure conditions.

Hook GJ, Zhang P, Lagroye I, Li L, Higashikubo R, Moros EG, Straube WL, Pickard WF, Baty JD, Roti Roti JL. Measurement of DNA damage and apoptosis in molt-4 cells after in vitro exposure to radiofrequency radiation. Radiat Res. 161(2): 193-200, 2004.

To determine whether exposure to radiofrequency (RF) radiation can induce DNA damage or apoptosis, Molt-4 T lymphoblastoid cells were exposed with RF fields at frequencies and modulations of the type used by wireless communication devices. Four types of frequency/modulation forms were studied: 847.74 MHz code-division multiple-access (CDMA), 835.62 MHz frequency-division multiple-access (FDMA), 813.56 MHz iDEN(R) (iDEN), and 836.55 MHz time-division multiple-access (TDMA). Exponentially

growing cells were exposed to RF radiation for periods up to 24 h using a radial transmission line (RTL) exposure system. The specific absorption rates used were 3.2 W/kg for CDMA and FDMA, 2.4 or 24 mW/kg for iDEN, and 2.6 or 26 mW/kg for TDMA. The temperature in the RTLs was maintained at 37 degrees C +/- 0.3 degrees C. DNA damage was measured using the single-cell gel electrophoresis assay. The annexin V affinity assay was used to detect apoptosis. No statistically significant difference in the level of DNA damage or apoptosis was observed between sham-treated cells and cells exposed to RF radiation for any frequency, modulation or exposure time. Our results show that exposure of Molt-4 cells to CDMA, FDMA, iDEN or TDMA modulated RF radiation does not induce alterations in level of DNA damage or induce apoptosis.

Hook, G. J., Spitz, D. R., Sim, J. E., Higashikubo, R., Baty, J. D., Moros, E. G. and Roti Roti, J. L. Evaluation of parameters of oxidative stress after in vitro exposure to FMCW- and CDMA-modulated radiofrequency radiation fields. Radiat. Res. 162, 497–504, 2004.

The goal of this study was to determine whether radiofrequency (RF) radiation is capable of inducing oxidative stress or affecting the response to oxidative stress in cultured mammalian cells. The two types of RF radiation investigated were frequency-modulated continuous-wave with a carrier frequency of 835.62 MHz (FMCW) and code division multiple access centered on 847.74 MHz (CDMA). To evaluate the effect of RF radiation on oxidative stress, J774.16 mouse macrophage cells were stimulated with γ-interferon (IFN) and bacterial lipopolysaccharide (LPS) prior to exposure. Cell cultures were exposed for 20–22 h to a specific absorption rate of 0.8 W/kg at a temperature of 37.0 ± 0.3°C. Oxidative stress was evaluated by measuring oxidant levels, antioxidant levels, oxidative damage and nitric oxide production. Oxidation of thiols was measured by monitoring the accumulation of glutathione disulfide (GSSG). Cellular antioxidant defenses were evaluated by measuring superoxide dismutase activity (CuZnSOD and MnSOD) as well as catalase and glutathione peroxidase activity. The trypan blue dye exclusion assay was used to measure any changes in viability. The results of these studies indicated that FMCW- and CDMA-modulated RF radiation did not alter parameters indicative of oxidative stress in J774.16 cells. FMCW- and CDMA-modulated fields did not alter the level of intracellular oxidants, accumulation of GSSG or induction of antioxidant defenses in IFN/LPS-stimulated cells. Consistent with the lack of an effect on oxidative stress parameters, no change in toxicity was observed in J774.16 cells after either optimal (with or without inhibitors of nitric oxide synthase) or suboptimal stimulation.

Horberry T, Anderson J, Regan MA, Triggs TJ, Brown J. Driver distraction: The effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance. Accid Anal Prev. 38(1):185-191. 2006.

This paper presents the findings of a simulator study that examined the effects of distraction upon driving performance for drivers in three age groups. There were two in-vehicle distracter tasks: operating the vehicle entertainment system and conducting a simulated hands-free mobile phone conversation. The effect of visual clutter was examined by requiring participants to drive in simple and complex road environments. Overall measures of driving performance were collected, together with responses to roadway hazards and subjective measures of driver perceived workload. The two in-

vehicle distraction tasks degraded overall driving performance, degraded responses to hazards and increased subjective workload. The performance decrements that occurred as a result of in-vehicle distraction were observed in both the simple and complex highway environments and for drivers in different age groups. One key difference was that older drivers traveled at lower mean speeds in the complex highway environment compared with younger drivers. The conclusions of the research are that both in-vehicle tasks impaired several aspects of driving performance, with the entertainment system distracter having the greatest negative impact on performance, and that these findings were relatively stable across different driver age groups and different environmental complexities.

Hossain MI, Faruque MRI, Islam MT. Analysis on the Effect of the Distances and Inclination Angles between Human Head and Mobile Phone on SAR. Prog Biophys Mol Biol. 119(2):103-110, 2015.

The aim of this paper is to investigate the effects of the distances between the human head and internal cellular device antenna on the specific absorption rate (SAR). This paper also analyzes the effects of inclination angles between user head and mobile terminal antenna on SAR values. The effects of the metal-glass casing of mobile phone on the SAR values were observed in the vicinity of the human head model. Moreover, the return losses were investigated in all cases to mark antenna performance. This analysis was performed by adopting finite-difference time-domain (FDTD) method on Computer Simulation Technology (CST) Microwave Studio. The results indicate that by increasing the distance between the user head and antenna, SAR values are decreased. But the increase in inclination angle does not reduce SAR values in all cases. Additionally, this investigation provides some useful indication for future design of low SAR mobile terminal antenna.

Hou Q, Wang M, Wu S, Ma X, An G, Liu H, Xie F. Oxidative changes and apoptosis induced by 1800-MHz electromagnetic radiation in NIH/3T3 cells. Electromagn Biol Med. 2014 Mar 25. [Epub ahead of print]

To investigate the potential adverse effects of mobile phone radiation, we studied reactive oxygen species (ROS), DNA damage and apoptosis in mouse embryonic fibroblasts (NIH/3T3) after intermittent exposure (5 min on/10 min off, for various durations from 0.5 to 8 h) to an 1800-MHz GSM-talk mode electromagnetic radiation (EMR) at an average specific absorption rate of 2 W/kg. A 2',7'-dichlorofluorescin diacetate fluorescence probe was used to detect intracellular ROS levels, immunofluorescence was used to detect γH2AX foci as a marker for DNA damage, and flow cytometry was used to measure apoptosis. Our results showed a significant increase in intracellular ROS levels after EMR exposure and it reached the highest level at an exposure time of 1 h ($p < 0.05$) followed by a slight decrease when the exposure continued for as long as 8 h. No significant effect on the number of γH2AX was detected after EMR exposure. The percentage of late-apoptotic cells in the EMR-exposed group was significantly higher than that in the sham-exposed groups ($p < 0.05$). These results indicate that an 1800-MHz EMR enhances ROS formation and promotes apoptosis in NIH/3T3 cells.

Hountala CD, Maganioti AE, Papageorgiou CC, Nanou ED, Kyprianou MA, Tsiafakis VG, Rabavilas AD, Capsalis CN.The spectral power coherence of the EEG under different EMF conditions.Neurosci Lett.441(2):188-192, 2008.

The present study introduces the concept of spectral power coherence (SPC), which reflects the pattern of coordination of the four basic EEG bands (delta, theta, alpha, and beta) at a specific location of the brain. The SPC was calculated for the pre-stimulus EEG signal during an auditory memory task under different electromagnetic field (EMF) conditions (900 MHz and 1800 MHz). The results showed that delta rhythm is less consequential in the overall cooperation between the bands than the higher frequency theta, alpha and beta rhythms. Additionally, it has been shown that the radiation effect on SPC is different for the two genders. In the absence of radiation males exhibit higher overall SPC than females. These differences disappear in the presence of 900 MHz and are reversed in the presence of 1800 MHz.

Hours M, Bernard M, Montestrucq L, Arslan M, Bergeret A, Deltour I, Cardis E. [Cell Phones and Risk of brain and acoustic nerve tumours: the French INTERPHONE case-control study.] Rev Epidemiol Sante Publique.55(5):321-32,2007. [Article in French]

BACKGROUND: Use of cell phones has increased dramatically since 1992 when they were first introduced in France. Certain electromagnetic fields (at extremely low frequency) have been recognized as possibly carcinogenic by the International Agency for Research on Cancer. Given the use of radiofrequency technology in cell phones, the rapid increase in the number of cell phones has generated concerns about the existence of a potential health hazard. To evaluate the relationship between the use of cell phones and the development of tumors of the head, a multicentric international study (INTERPHONE), coordinated by the International Agency for Research on Cancer, was carried out in 13 countries. This publication reports the results of the French part of the INTERPHONE study. METHODS: INTERPHONE is a case-control study focused on tumors of the brain and central nervous system: gliomas, meningiomas and neuromas of cranial nerves. Eligible cases were men and women, residents of Paris or Lyon, aged 30-59, newly diagnosed with a first primary tumor between February 2001 and August 2003. The diagnoses were all either histologically confirmed or based upon unequivocal radiological images. Controls were matched for gender, age (+/-5 years) and place of residence. They were randomly drawn from electoral rolls. Detailed information was collected for all subjects during a computer-assisted face-to-face interview. Conditional logistic regression was used to estimate the odds ratio (OR) for an association between the use of cell phones and risk of each type of cancer. RESULTS: Regular cell phone use was not associated with an increased risk of neuroma (OR=0,92; 95% confidence interval=[0.53-1.59]), meningioma (OR=0,74; 95% confidence interval=[0.43-1.28]) or glioma (OR=1.15; 95% confidence interval=[0.65-2.05]). Although these results are not statistically significant, a general tendency was observed for an increased risk of glioma among the heaviest users: long-term users, heavy users, users with the largest numbers of telephones. CONCLUSION: No significant increased risk for glioma, meningioma or neuroma was

observed among cell phone users participating in Interphone. The statistical power of the study is limited, however. Our results, suggesting the possibility of an increased risk among the heaviest users, therefore need to be verified in the international INTERPHONE analyses.

Hoyto A, Sihvonen AP, Alhonen L, Juutilainen J, Naarala J Modest increase in temperature affects ODC activity in L929 cells: low-level radiofrequency radiation does not. Radiat Environ Biophys.45(3):231-235, 2006.

The effects of low-level radiofrequency (RF) radiation and elevated temperature on ornithine decarboxylase (ODC) activity were investigated in murine L929 fibroblasts. The cells were exposed at 900 MHz either to a pulse-modulated (pulse frequency 217 Hz; GSM-type modulation) or a continuous wave signal at specific absorption rate (SAR) levels of 0.2 W kg(-1) (0.1-0.3 W kg(-1)) and 0.4 W kg(-1) (0.3-0.5 W kg(-1)) for 2, 8, or 24 h. RF radiation did not affect cellular ODC activity. However, a slight increase in temperature (0.8-0.9 degrees C) in the exposure system lead to decreased ODC activity in cell cultures. This was verified by tests in which cells were exposed to different temperatures in incubators. The results show that ODC activity is sensitive to small temperature differences in cell cultures. Hence, a precise temperature control in cellular ODC activity studies is needed.

Höytö A, **Luukkonen J**, **Juutilainen J**, **Naarala J**. **Proliferation, oxidative stress and cell death in cells exposed to 872 MHz radiofrequency radiation and oxidants. Radiat. Res. 170(2):235-243, 2008.**

Human SH-SY5Y neuroblastoma and mouse L929 fibroblast cells were exposed to 872 MHz radiofrequency (RF) radiation using continuous waves (CW) or a modulated signal similar to that emitted by GSM mobile phones at a specific absorption rate (SAR) of 5 W/kg in isothermal conditions. To investigate possible combined effects with other agents, menadione was used to induce reactive oxygen species, and tert-butylhydroperoxide (t-BOOH) was used to induce lipid peroxidation. After 1 or 24 h of exposure, reduced cellular glutathione levels, lipid peroxidation, proliferation, caspase 3 activity, DNA fragmentation and viability were measured. Two statistically significant differences related to RF radiation were observed: Lipid peroxidation induced by t-BOOH was increased in SH-SY5Y (but not in L929) cells, and menadione-induced caspase 3 activity was increased in L929 (but not in SH-SY5Y) cells. Both differences were statistically significant only for the GSM-modulated signal. The other end points were not significantly affected in any of the experimental conditions, and no effects were observed from exposure to RF radiation alone. The positive findings may be due to chance, but they may also reflect effects that occur only in cells sensitized by chemical stress. Further studies are required to investigate the reproducibility and dose response of the possible effects.

Hruby R, Neubauer G, Kuster N, Frauscher M Study on potential effects of "902-MHz GSM-type Wireless Communication Signals" on DMBA-induced mammary tumours in Sprague-Dawley rats. Mutat Res. 649(1-2):34-44, 2008.

The aim of the study was to detect whether long-term exposure to "902-MHz GSM-type Wireless Communication Signals" ("radio-frequency (RF)-exposure") would affect 7,12-

dimethylbenz(a)anthracene (DMBA)-induced mammary tumours in female Sprague-Dawley rats. Five hundred female rats were each given a single oral dose of 17mg DMBA per kg body weight (bw) at an age of 46-48 days. Three groups of 100 animals each were RF-exposed (902MHz; crest factor 8; pulse width=0.57ms) from the next day onwards to normal whole-body averaged doses (expressed as specific absorption rate, SAR) of 0.4, 1.3 or 4.0W/kg bw (low/mid/high-dose group) for 4h/d, 5d/week, during 6 months. A sham-exposed and a cage-control group remained without RF-exposure (<<0.01mW/kg). Animals were weekly weighed and palpated for mammary tumours; all mammary glands were examined histopathologically. There were several statistically significant differences between RF-exposed groups and the sham-exposed group, as follows: All RF-exposed groups had, at different times, significantly more palpable tissue masses. There were fewer animals with benign neoplasms, but more with malignant tumours in the high-dose group. In addition, there were more adenocarcinomas in the low-dose group, more malignant neoplasms in the low- and high-dose groups, more animals with adenocarcinomas in the high-dose group, and fewer animals with fibroadenomas in the low- and mid-dose groups. The cage-control group had, when compared with the sham-exposed group, statistically significantly more palpable tissue masses, more benign and also more malignant neoplasms. The cage-control group had in most aspects the highest incidence and malignancy of neoplasms among all groups. None of the above findings in RF-exposed animals produced a clear dose-response relation and the responses of the cage-control group were either similar to or stronger than those of any of the RF-exposed group. The significant differences between the sham-exposed animals and one or more RF-exposed groups may be interpreted as evidence of an effect of RF-exposure. In the context of the results of the cage-control group, in the light of controversial results reported in the literature, and given the fact that the DMBA-mammary tumour model is known to be prone to high variations in the results, it is the authors' opinion that the differences between the groups are rather incidental ones.

Hsu MH, Syed-Abdul S, Scholl J, Jian WS, Lee P, Iqbal U, Li YC. The incidence rate and mortality of malignant brain tumors after 10 years of intensive cell phone use in Taiwan. Eur J Cancer Prev. 2013 Apr 14. [Epub ahead of print]

The issue of whether cell phone usage can contribute toward the development of brain tumors has recently been reignited with the International Agency for Research on Cancer classifying radiofrequency electromagnetic fields as 'possibly' carcinogenic to humans in a WHO report. To our knowledge, this is the largest study reporting on the incidence and mortality of malignant brain tumors after long-term use of the cell phone by more than 23 million users. A population-based study was carried out the numbers of cell phone users were collected from the official statistics provided by the National Communication Commission. According to National Cancer Registry, there were 4 incidences and 4 deaths due to malignant neoplasms in Taiwan during the period 2000-2009. The 10 years of observational data show that the intensive user rate of cell phones has had no significant effect on the incidence rate or on the mortality of malignant brain tumors in Taiwan. In conclusion, we do not detect any correlation between the morbidity/mortality of malignant brain tumors and cell phone use in Taiwan. We thus urge international agencies to publish only confirmatory reports with more applicable conclusions in public. This will help spare the public from unnecessary worries.

Hu J, Lu Y, Zhang H, Xie H, Yang X. [Level of microwave radiation from mobile phone base stations built in residential districts] Wei Sheng Yan Jiu. 38(6):712-716, 2009. [Article in Chinese]

OBJECTIVE: To investigate the condition of microwave radiation pollution from mobile phone base station built in populated area. METHODS: Random selected 18 residential districts where had base station and 10 residential districts where had no base stations. A TES-92 electromagnetic radiation monitor were used to measure the intensity of microwave radiation in external and internal living environment. RESULTS: The intensities of microwave radiation in the exposure residential districts were more higher than those of the control residential districts ($p < 0.05$). There was a intensity peak at about 10 m from the station, it would gradually weaken with the increase of the distance. The level of microwave radiation in antenna main lobe region is not certainly more higher than the side lobe direction, and the side lobe direction also is not more lower. At the same district, where there were two base stations, the electromagnetic field nestification would take place in someplace. The intensities of microwave radiation outside the exposure windows in the resident room not only changed with distance but also with the height of the floor. The intensities of microwave radiation inside the aluminum alloys security net were more lower than those of outside the aluminum alloys security net ($p < 0.05$), but the inside or outside of glass-window appears almost no change ($p > 0.05$). CONCLUSIONS: Although all the measure dates on the ground around the base station could be below the primary standard in "environment electromagnetic wave hygienic standard" (GB9175-88), there were still a minorities of windows which exposed to the base station were higher, and the outside or inside of a few window was even higher beyond the primary safe level defined standard. The aluminum alloys security net can partly shield the microwave radiation from the mobile phone base station.

Hu S, Peng R, Wang C, Wang S, Gao Y, Dong J, Zhou H, Su Z, Qiao S, Zhang S, Wang L, Wen X.Neuroprotective effects of dietary supplement Kang-fu-ling against high-power microwave through antioxidant action. Food Funct. 2014 Jul 24. [Epub ahead of print]

Kang-fu-ling (KFL) is a polybotanical dietary supplement with antioxidant properties. This study aimed to evaluate the potential protective effects of KFL on cognitive deficit induced by high-power microwave (HPM) and the underlying mechanism for this neuroprotection. The electron spin resonance technique was employed to evaluate the free radical scavenging activity of KFL in vitro and KFL exhibited scavenging hydroxyl radical activity. KFL at doses of 0.75, 1.5 and 3 g kg-1 and vehicle were administered orally once daily for 14 days to male Wistar rats after being exposed to 30 mW cm-2 HPM for 15 minutes. KFL reversed HPM-induced memory loss and the histopathological changes in hippocampus of rats. In addition, KFL displayed a protective effect against HPM-induced oxidative stress and activated the nuclear factor-E2-related factor 2 (Nrf2) and its target genes in the hippocampus of rats. The Nrf2-antioxidant response element (ARE) signaling pathway may be involved in the neuroprotective effects of KFL against HPM-induced oxidative stress. In summary, the dietary supplement KFL is a promising natural complex, which ameliorates oxidative stress, with neuroprotective effects against HPM.

Huang D, Dong ZF, Chen Y, Wang FB, Wei Z, Zhao WB, Li S, Liu MY, Zhu W, Wei M, Li JB. Interference of GSM mobile phones with communication between Cardiac Rhythm Management devices and programmers: A combined in vivo and in vitro study. Bioelectromagnetics. 2015 Apr 10. doi: 10.1002/bem.21911. [Epub ahead of print]

To investigate interference, and how to avoid it, by high-frequency electromagnetic fields (EMFs) of Global System for Mobile Communications (GSM) mobile phone with communication between cardiac rhythm management devices (CRMs) and programmers, a combined in vivo and in vitro testing was conducted. During in vivo testing, GSM mobile phones interfered with CRM-programmer communication in 33 of 65 subjects tested (50.8%). Losing ventricle sensing was representative in this study. In terms of clinical symptoms, only 4 subjects (0.6%) felt dizzy during testing. CRM-programmer communication recovered upon termination of mobile phone communication. During in vitro testing, electromagnetic interference by high-frequency (700-950 MHz) EMFs reproducibly occurred in duplicate testing in 18 of 20 CRMs (90%). During each interference, the pacing pulse signal on the programmer would suddenly disappear while the synchronous signal was normal on the amplifier-oscilloscope. Simulation analysis showed that interference by radiofrequency emitting devices with CRM-programmer communication may be attributed to factors including materials, excitation source distance, and implant depth. Results suggested that patients implanted with CRMs should not be restricted from using GSM mobile phones; however, CRMs should be kept away from high-frequency EMFs of GSM mobile phone during programming.

Huang TQ, Lee JS, Kim TH, Pack JK, Jang JJ, Seo JS. Effect of radiofrequency radiation exposure on mouse skin tumorigenesis initiated by 7,12-dimethybenz[alpha]anthracene. Int J Radiat Biol. 81(12):861-867, 2005.

Purpose: Although radiofrequency (RF) radiation is not considered mutagenic, it has been suggested as a promoter of tumorigenesis. To study if RF radiation has a tumor promoting effect, we exposed mice with skin tumorigenesis initiated by 7,12-dimethybenz[a]anthracene (DMBA) to RF radiation.Materials and methods: Eighty male ICR mice were subjected to a single DMBA application (100 microg/100 microl acetone/mouse) on shaved dorsal skin at the age of 7 weeks. After one week, the mice were randomized into four equal groups of 20 mice each: i.e., sham-, 849 MHz-, 1,763 MHz-exposed, and 12-O-tetradecanoylphorbol-13-acetate (TPA)-treated groups. The RF exposure was conducted at a whole body average specific absorption rate (SAR) of 0.4 W/Kg, for 2 cycles of 45 min exposure with a 15 min interval each day, 5 days a week for 19 weeks. The TPA-treated group served as a positive control for skin tumorigenesis and were administered TPA (4 microg/100 microl acetone/mouse) twice weekly without RF exposure.Results: All mice were examined weekly at a macroscopic level. No skin tumors were observed in any groups except in the TPA-treated positive control group. TPA is known tumor promoter in DMBA-induced skin carcinogenesis and tumor incidence in the TPA treated group was 95%. At week 20 after DMBA initiation, skin tissues were analyzed immunohistochemically using anti-proliferating cell nuclear antigen (PCNA)

antibody. No differences were observed by pathological examination or by PCNA staining between the sham- and the RF-exposed groups. The expression of cyclin D1 and c-fos were detected only in the tumorous skin tissues of the TPA-treated group.Conclusion: No evidence was found that RF radiation serves as a tumor promoter for skin tumors. Our data suggests that 849 MHz and 1,763 MHz RF radiations, similar to those emitted from mobile phones, do not have any promoting effect on skin tumor development in DMBA-initiated mice.

Huang TQ, Lee MS, Oh E, Zhang BT, Seo JS, Park WY. Molecular responses of Jurkat T-cells to 1763 MHz radiofrequency radiation. Int J Radiat Biol. 84(9):734-741, 2008.

PURPOSE: The biological effects of exposure to mobile phone emitted radiofrequency (RF) radiation are the subject of intense study, yet the hypothesis that RF exposure is a potential health hazard remains controversial. In this paper, we monitored cellular and molecular changes in Jurkat human T lymphoma cells after irradiating with 1763 MHz RF radiation to understand the effect on RF radiation in immune cells. MATERIALS AND METHODS: Jurkat T-cells were exposed to RF radiation to assess the effects on cell proliferation, cell cycle progression, DNA damage and gene expression. Jurkat cells were exposed to 1763 MHz RF radiation at 10 W/kg specific absorption rate (SAR) and compared to sham exposed cells. RESULTS: RF exposure did not produce significant changes in cell numbers, cell cycle distributions, or levels of DNA damage. In genome-wide analysis of gene expressions, there were no genes changed more than two-fold upon RF-radiation while ten genes change to 1.3 approximately 1.8-fold. Among ten genes, two cytokine receptor genes such as chemokine (C-X-C motif) receptor 3 (CXCR3) and interleukin 1 receptor, type II (IL1R2) were down-regulated upon RF radiation, but they were not directly related to cell proliferation or DNA damage responses. CONCLUSION: These results indicate that the alterations in cell proliferation, cell cycle progression, DNA integrity or global gene expression was not detected upon 1763 MHz RF radiation under 10 W/kg SAR for 24 h to Jurkat T cells.

Huang TQ, Lee MS, Oh EH, Kalinec F, Zhang BT, Seo JS, Park WY. Characterization of biological effect of 1763 MHz radiofrequency exposure on auditory hair cells. Int J Radiat Biol. 84(11):909-915, 2008.

Purpose: Radiofrequency (RF) exposure at the frequency of mobile phones has been reported not to induce cellular damage in in vitro and in vivo models. We chose HEI-OC1 immortalized mouse auditory hair cells to characterize the cellular response to 1763 MHz RF exposure, because auditory cells could be exposed to mobile phone frequencies. Materials and methods: Cells were exposed to 1763 MHz RF at a 20 W/kg specific absorption rate (SAR) in a code division multiple access (CDMA) exposure chamber for 24 and 48 h to check for changes in cell cycle, DNA damage, stress response, and gene expression. Results: Neither of cell cycle changes nor DNA damage was detected in RF-exposed cells. The expression of heat shock proteins (HSP) and the phosphorylation of mitogen-activated protein kinases (MAPK) did not change, either. We tried to identify any alteration in gene expression using microarrays. Using the Applied Biosystems 1700 full genome expression mouse

microarray, we found that only 29 genes (0.09% of total genes examined) were changed by more than 1.5-fold on RF exposure. Conclusion: From these results, we could not find any evidence of the induction of cellular responses, including cell cycle distribution, DNA damage, stress response and gene expression, after 1763 MHz RF exposure at an SAR of 20 W/kg in HEI-OC1 auditory hair cells.

Huber R, Graf T, Cote KA, Wittmann L, Gallmann E, Matter D, Schuderer J, Kuster N, Borbely AA, Achermann P, Exposure to pulsed high-frequency electromagnetic field during waking affects human sleep EEG. Neuroreport 11(15):3321-3325, 2000.

The aim of the study was to investigate whether the electromagnetic field (EMF) emitted by digital radiotelephone handsets affects brain physiology. Healthy, young male subjects were exposed for 30 min to EMF (900 MHz; spatial peak specific absorption rate 1 W/kg) during the waking period preceding sleep. Compared with the control condition with sham exposure, spectral power of the EEG in non-rapid eye movement sleep was increased. The maximum rise occurred in the 9.75-11.25 Hz and 12.5-13.25 Hz band during the initial part of sleep. These changes correspond to those obtained in a previous study where EMF was intermittently applied during sleep. Unilateral exposure induced no hemispheric asymmetry of EEG power. The present results demonstrate that exposure during waking modifies the EEG during subsequent sleep. Thus the changes of brain function induced by pulsed high-frequency EMF outlast the exposure period.

HuberR, TreyerV, BorbélyAA, SchudererJ, GottseligJM, LandoltH-P, WerthE, BertholdT, KusterN, BuckA, AchermannP, 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.

Usage of mobile phones is rapidly increasing, but there is limited data on the possible effects of electromagnetic field (EMF) exposure on brain physiology. We investigated the effect of EMF vs. sham control exposure on waking regional cerebral blood flow (rCBF) and on waking and sleep electroencephalogram (EEG) in humans. In Experiment 1, positron emission tomography (PET) scans were taken after unilateral head exposure to 30-min pulse-modulated 900 MHz electromagnetic field (pm-EMF). In Experiment 2, night-time sleep was polysomnographically recorded after EMF exposure. Pulse-modulated EMF exposure increased relative rCBF in the dorsolateral prefrontal cortex ipsilateral to exposure. Also, pm-EMF exposure enhanced EEG power in the alpha frequency range prior to sleep onset and in the spindle frequency range during stage 2 sleep. Exposure to EMF without pulse modulation did not enhance power in the waking or sleep EEG. We previously observed EMF effects on the sleep EEG (A. A. Borbély, R. Huber, T. Graf, B. Fuchs, E. Gallmann and P. Achermann. Neurosci. Lett., 1999, 275: 207-210; R. Huber, T. Graf, K. A. Cote, L. Wittmann, E. Gallmann, D. Matter, J. Schuderer, N. Kuster, A. A. Borbély, and P. Achermann. Neuroreport, 2000, 11: 3321-3325), but the basis for these effects was unknown. The present results show for the first time that (1) pm-EMF alters waking rCBF and (2) pulse modulation of EMF is necessary to induce waking and sleep EEG changes. Pulse-modulated EMF exposure may provide a new, non-invasive method for modifying brain function for experimental, diagnostic and therapeutic purposes.

Huber R, Schuderer J, Graf T, Jutz K, Borbely AA, Kuster N, Achermann P. Radio

frequency electromagnetic field exposure in humans: Estimation of SAR distribution in the brain, effects on sleep and heart rate. Bioelectromagnetics 24(4):262-276, 2003.

In two previous studies we demonstrated that radiofrequency electromagnetic fields (RF EMF) similar to those emitted by digital radiotelephone handsets affect brain physiology of healthy young subjects exposed to RF EMF (900 MHz; spatial peak specific absorption rate [SAR] 1 W/kg) either during sleep or during the waking period preceding sleep. In the first experiment, subjects were exposed intermittently during an 8 h nighttime sleep episode and in the second experiment, unilaterally for 30 min prior to a 3 h daytime sleep episode. Here we report an extended analysis of the two studies as well as the detailed dosimetry of the brain areas, including the assessment of the exposure variability and uncertainties. The latter enabled a more in depth analysis and discussion of the findings. Compared to the control condition with sham exposure, spectral power of the non-rapid eye movement sleep electroencephalogram (EEG) was initially increased in the 9-14 Hz range in both experiments. No topographical differences with respect to the effect of RF EMF exposure were observed in the two experiments. Even unilateral exposure during waking induced a similar effect in both hemispheres. Exposure during sleep reduced waking after sleep onset and affected heart rate variability. Exposure prior to sleep reduced heart rate during waking and stage 1 sleep. The lack of asymmetries in the effects on sleep EEG, independent of bi- or unilateral exposure of the cortex, may indicate involvement of subcortical bilateral projections to the cortex in the generation of brain function changes, especially since the exposure of the thalamus was similar in both experiments (approx. 0.1 W/kg).

Huber R, Treyer V, Schuderer J, Berthold T, Buck A, Kuster N, Landolt HP, Achermann P. Exposure to pulse-modulated radio frequency electromagnetic fields affects regional cerebral blood flow. Eur J Neurosci. 21(4):1000-1006, 2005.

We investigated the effects of radio frequency electromagnetic fields (RF EMF) similar to those emitted by mobile phones on waking regional cerebral blood flow (rCBF) in 12 healthy young men. Two types of RF EMF exposure were applied: a 'base-station-like' and a 'handset-like' signal. Positron emission tomography scans were taken after 30 min unilateral head exposure to pulse-modulated 900 MHz RF EMF (10 g tissue-averaged spatial peak-specific absorption rate of 1 W/kg for both conditions) and sham control. We observed an increase in relative rCBF in the dorsolateral prefrontal cortex on the side of exposure. The effect depended on the spectral power in the amplitude modulation of the RF carrier such that only 'handset-like' RF EMF exposure with its stronger low-frequency components but not the 'base-station-like' RF EMF exposure affected rCBF. This finding supports our previous observation that pulse modulation of RF EMF is necessary to induce changes in the waking and sleep EEG, and substantiates the notion that pulse modulation is crucial for RF EMF-induced alterations in brain physiology.

Hung CS, Anderson C, Horne JA, McEvoy P. Mobile phone 'talk-mode' signal delays EEG-determined sleep onset. Neurosci Lett. 421: 82-86, 2007.

Mobile phones signals are pulse-modulated microwaves, and EEG studies suggest that the extremely low-frequency (ELF) pulse modulation has sleep effects. However, 'talk', 'listen' and 'standby' modes differ in the ELF (2, 8, and 217Hz) spectral

components and specific absorption rates, but no sleep study has differentiated these modes. We used a GSM900 mobile phone controlled by a base-station simulator and a test SIM card to simulate these three specific modes, transmitted at 12.5% (23dBm) of maximum power. At weekly intervals, 10 healthy young adults, sleep restricted to 6h, were randomly and single-blind exposed to one of: talk, listen, standby and sham (nil signal) modes, for 30min, at 13:30h, whilst lying in a sound-proof, lit bedroom, with a thermally insulated silent phone beside the right ear. Bipolar EEGs were recorded continuously, and subjective ratings of sleepiness obtained every 3min (before, during and after exposure). After exposure the phone and base-station were switched off, the bedroom darkened, and a 90min sleep opportunity followed. We report on sleep onset using: (i) visually scored latency to onset of stage 2 sleep, (ii) EEG power spectral analysis. There was no condition effect for subjective sleepiness. Post-exposure, sleep latency after talk mode was markedly and significantly delayed beyond listen and sham modes. This condition effect over time was also quite evident in 1-4Hz EEG frontal power, which is a frequency range particularly sensitive to sleep onset. It is possible that 2, 8, 217Hz modulation may differentially affect sleep onset.

Hunton J, Rose JM. Cellular telephones and driving performance: the effects of attentional demands on motor vehicle crash risk. Risk Anal. 25(4):855-866, 2005.

This study examines the effects of conversation mode and split-attention communication training on driving performance. The study is based on an experiment where drivers with and without communication training (pilots vs. nonpilots) completed a simulated driving course while involved in one of three conversation modes: no conversation, conversation with passenger, or conversation on a hands-free cellular telephone. Results indicate that cellular telephone conversations consume more attention and interfere more with driving than passenger conversations. Cell phone conversations lack the nonverbal cues available during close-contact conversations and conversation participants expend significant cognitive resources to compensate for the lack of such cues. The results also demonstrate that communication training may reduce the hazardous effects of cell phone conversations on driving performance.

Huss A, Egger M, Hug K, Huwiler-Müntener K, Röösli M, Gomes D, Da Ros MA Source of funding and results of studies of health effects of mobile phone use: systematic review of experimental studies. Cien Saude Colet. 13(3):1005-1012, 2008.

There is concern regarding the possible health effects of cellular telephone use. We conducted a systematic review of studies of controlled exposure to radiofrequency radiation with health-related outcomes (electroencephalogram, cognitive or cardiovascular function, hormone levels, symptoms, and subjective well-being). We searched Embase, Medline, and a specialist database in February 2005 and scrutinized reference lists from relevant publications. Data on the source of funding, study design, methodologic quality, and other study characteristics were extracted. The primary outcome was the reporting of at least one statistically significant association between the exposure and a health-related outcome. Data were analyzed using logistic regression models. Of 59 studies, 12 (20%) were funded exclusively by the telecommunications industry, 11 (19%) were funded by public agencies or

charities, 14 (24%) had mixed funding (including industry), and in 22 (37%) the source of funding was not reported. Studies funded exclusively by industry reported the largest number of outcomes, but were least likely to report a statistically significant result. The interpretation of results from studies of health effects of radiofrequency radiation should take sponsorship into account.

Hutter HP, Moshammer H, Wallner P, Kundi M. Public perception of risk concerning cell towers and mobile phones. Soz Praventivmed. 49(1):62-66, 2004.

OBJECTIVE: The controversy about health risks of electromagnetic fields (EMF) has contributed in raising fears concerning emissions from celltowers. The study was to examine whether or not neighbours of celltowers are particularly concerned about adverse health effects of mobile phones and their base stations. METHODS: Prior to information delivered by medical doctors of the Institute of Environmental Health at public hearings a questionnaire was handed out to participants asking for their personal rating of several environmental health risks including those of mobile telecommunication (n = 123, response rate approx. 48%). Medical students (n = 366) served as a contrast group. RESULTS: Participants rated health risk for both, mobile phones and celltowers higher as students. A trend for higher ratings was also seen with older subjects and female sex. The risk ratings of both exposures correlated well with each other. The magnitude of the perceived risks, however, resembled that of other ubiquitous exposures like traffic noise and air pollution. CONCLUSION: Contrary to the claims of the telecommunication industry, opponents of celltowers generally do not express unusual fears concerning electromagnetic field exposure. The outcome of our study indicates that the risk rating is comparable with other perceived common hazards of the civilised world. It is hypothesised that offering information and participation to the concerned population will be efficient in reducing exaggerated fears.

Hutter HP, Moshammer H, Wallner P, Kundi M. Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. Occup Environ Med. 63(5):307-313, 2006.

BACKGROUND: The erection of mobile telephone base stations in inhabited areas has raised concerns about possible health effects caused by emitted microwaves. METHODS: In a cross-sectional study of randomly selected inhabitants living in urban and rural areas for more than one year near to 10 selected base stations, 365 subjects were investigated. Several cognitive tests were performed, and wellbeing and sleep quality were assessed. Field strength of high-frequency electromagnetic fields (HF-EMF) was measured in the bedrooms of 336 households. RESULTS: Total HF-EMF and exposure related to mobile telecommunication were far below recommended levels (max. 4.1 mW/m2). Distance from antennae was 24-600 m in the rural area and 20-250 m in the urban area. Average power density was slightly higher in the rural area (0.05 mW/m2) than in the urban area (0.02 mW/m2). Despite the influence of confounding variables, including fear of adverse effects from exposure to HF-EMF from the base station, there was a significant relation of some symptoms to measured power density; this was highest for headaches. Perceptual speed increased, while accuracy decreased insignificantly with increasing exposure levels. There was no significant effect on sleep quality. CONCLUSION: Despite very low exposure to HF-EMF, effects on wellbeing and

performance cannot be ruled out, as shown by recently obtained experimental results; however, mechanisms of action at these low levels are unknown.

Hutter HP, Moshammer H, Wallner P, Cartellieri M, Denk-Linnert DM, Katzinger M, Ehrenberger K, Kundi M. Tinnitus and mobile phone use. Occup Environ Med. 67(12):804-808, 2010.

Objectives The mechanisms that produce tinnitus are not fully understood. While tinnitus can be associated with diseases and disorders of the ear, retrocochlear diseases and vascular pathologies, there are few known risk factors for tinnitus apart from these conditions. There is anecdotal evidence of an link between mobile phone use and tinnitus, but so far there have been no systematic investigations into this possible association. Methods 100 consecutive patients presenting with tinnitus were enrolled in an individually matched case-control study. For each case a control subject was randomly selected from visiting outpatients matched for sex and age. The patient's history was obtained and clinical examinations were conducted to exclude patients with known underlying causes of tinnitus. Mobile phone use was assessed based on the Interphone Study protocol. ORs were computed by conditional logistic regression with years of education and living in an urban area as covariates. Results Mobile phone use up to the index date (onset of tinnitus) on the same side as the tinnitus did not have significantly elevated ORs for regular use and intensity or for cumulative hours of use. The risk estimate was significantly elevated for prolonged use (>/=4 years) of a mobile phone (OR 1.95; CI 1.00 to 3.80). Conclusions Mobile phone use should be included in future investigations as a potential risk factor for developing tinnitus.

Hutter HP, Ehrenhöfer L, Freuis E, Hartl P, Kundi M.Poor-to-moderate agreement between self and proxy interviews of mobile phone use.Bioelectromagnetics. 33(7):561-567, 2012.

In epidemiological studies, cases cannot always be interviewed due to them being too ill or already deceased. Under these circumstances, proxy interviews are often conducted; however, the veridicality of information about mobile phone use gained by proxy interviews has been doubted. The issue is undecided due to the lack of empirical data. We conducted a study of 119 heterosexual couples. Both partners answered two questionnaires about mobile phone use, one about their own use and one about their partner's use. Overall agreement assessed using Cohen's kappa, Passing and Bablok regression, and concordance coefficients between self and proxy data was poor to moderate (e.g., concordance coefficients of 0.55 for duration of use). The only item with good agreement was whether or not a prepaid phone was used (Cohen's kappa 0.78 and 0.63 for male and female estimates, respectively), and to a lesser degree, the onset of mobile phone use (concordance coefficients of 0.66 and 0.61). Poorest agreement was obtained for the side of the head the mobile phone was held during calls (kappa coefficients of 0.20 and 0.24 for female and male estimates, respectively). We conclude that the assessment of mobile phone use by proxy data cannot be relied on except for information about onset of mobile phone use, use of prepaid or contract phones, and, to a lesser degree, duration of daily use. Agreement concerning the important information

about side of the head the mobile phone is held during calls was poorest and only slightly better than chance.

Hwang Y, Ahn J, Mun J, Bae S, Jeong YU, Vinokurov NA, Kim P. In vivo analysis of THz wave irradiation induced acute inflammatory response in skin by laser-scanning confocal microscopy. Opt Express. 22(10):11465-11475, 2014.

The recent development of THz sources in a wide range of THz frequencies and power levels has led to greatly increased interest in potential biomedical applications such as cancer and burn wound diagnosis. However, despite its importance in realizing THz wave based applications, our knowledge of how THz wave irradiation can affect a live tissue at the cellular level is very limited. In this study, an acute inflammatory response caused by pulsed THz wave irradiation on the skin of a live mouse was analyzed at the cellular level using intravital laser-scanning confocal microscopy. Pulsed THz wave (2.7 THz, 4 μs pulsewidth, 61.4 μJ per pulse, 3Hz repetition), generated using compact FEL, was used to irradiate an anesthetized mouse's ear skin with an average power of 260 mW/cm² for 30 minutes using a high-precision focused THz wave irradiation setup. In contrast to in vitro analysis using cultured cells at similar power levels of CW THz wave irradiation, no temperature change at the surface of the ear skin was observed when skin was examined with an IR camera. To monitor any potential inflammatory response, resident neutrophils in the same area of ear skin were repeatedly visualized before and after THz wave irradiation using a custom-built laser-scanning confocal microscopy system optimized for in vivo visualization. While non-irradiated control skin area showed no changes in the number of resident neutrophils, a massive recruitment of newly infiltrated neutrophils was observed in the THz wave irradiated skin area after 6 hours, which suggests an induction of acute inflammatory response by the pulsed THz wave irradiation on the skin via a non-thermal process.

Ibitayo AO, Afolabi OB, Akinyemi AJ, Ojiezeh TI, Adekoya KO, Ojewunmi OO. RAPD Profiling, DNA Fragmentation, and Histomorphometric Examination in Brains of Wistar Rats Exposed to Indoor 2.5 Ghz Wi-Fi Devices Radiation. Biomed Res Int. 2017;2017:8653286.

The advent of Wi-Fi connected high technology devices in executing day-to-day activities is fast evolving especially in developing countries of the world and hence the need to assess its safety among others. The present study was conducted to investigate the injurious effect of radiofrequency emissions from installed Wi-Fi devices in brains of young male rats. Animals were divided into four equal groups; group 1 served as control while groups 2, 3, and 4 were exposed to 2.5 Ghz at intervals of 30, 45, and 60 consecutive days with free access to food and water ad libitum. Alterations in harvested brain tissues were confirmed by histopathological analyses which showed vascular congestion and DNA damage in the brain was assayed using agarose gel electrophoresis. Histomorphometry analyses of their brain tissues showed perivascular congestion and tissue damage as well.

Ibitoye ZA, Aweda AM. Assessment of radiofrequency power density distribution

around GSM and broadcast antenna masts in Lagos City, Nigeria.Nig Q J Hosp Med. 21(1):35-40, 2011.

BACKGROUND: Global system of mobile communication (GSM) and other telecommunication technologies are now common place in Lagos state Nigeria. The introduction of GSM in 2002 considerably increased radiofrequency (RF) radiation exposure of the public from telecommunications transmitting and receiving antennae. The RF radiation emanating from these devices, if above international limits may pose health risk to the public. **OBJECTIVE:** There is need for database of RF distribution level in Nigeria for safety assessment. The purpose of this study is to determine power density around different telecommunications antenna base stations and compare the measured values with the international recommended exposure limits in order to assess the safety of the members of the public. **METHODS:** A radiofrequency meter, Electrosmog from LESSEMF USA was used for the measurement. It is a highly sensitive device capable of measuring frequency between 50 MHz and 3.5 GHz. Measurements were taken at distances of 25, 50, 100, 150 and 200 m from selected antenna base stations in Lagos state. The results were compared with the International Commission of NonIonizing Radiation and Protection (ICNIRP) and the Institute of Electrical and Electronics Engineering/American National Standard Institute (IEEE/ANSI). **RESULTS:** Power densities obtained varied between 0.219 and 302.40 mW.m(-2) from the studied base stations. Comparison of the results with the ICNIRP and IEEE/ANSI recommended safety standards of 12000 mW x m(-2) and 5700 mW x m(-2) showed that the exposure levels are very low. **CONCLUSION:** Power densities of the RF radiation from telecommunication transmitting/receiving antennae were far below international standard limits. The measured values are not likely capable of inducing significant hazardous health effects among the people that are at least 6 m away from the antennae.

Ikeda K, Nakamura K. Association between mobile phone use and depressed mood in Japanese adolescents: a cross-sectional study. Environ Health Prev Med. 2013 Dec 18. [Epub ahead of print]

OBJECTIVES: Mobile phones are commonly used by adolescents. The aim of this study was to clarify associations between duration of mobile phone use and psychological mood in high school students. METHODS: This cross-sectional study included 2,785 high school students in Niigata, Japan. A self-administered questionnaire was used to elicit information on sex, school year, hours of mobile phone use, psychological mood status, and possible confounders. Psychological mood outcomes were evaluated with the Mood Inventory, developed and validated in 1994, which includes five subcomponents with total scores ranging from 8 to 32 (higher score indicates stronger feeling): "Tension and excitement," "Refreshing mood," "Fatigue," "Depressed mood," and "Anxious mood." Analysis of covariance with Bonferroni's multiple comparison was used to compare mean values among quartiles of hours of mobile phone use. RESULTS: Among the respondents, mean mobile phone use per week was 24 (median 18) h. Long-duration mobile phone use was associated with female students, no participation in sports club activities, early mobile phone use, and fewer hours spent sleeping (all $P < 0.001$). Overall associations between hours of mobile phone use and total scores were significant for "Depressed mood" (P for trend = 0.005), "Tension and excitement" (P for trend <0.001),

and "Fatigue" (P for trend < 0.001). Total scores for "Depressed mood," "Tension and excitement," and "Fatigue" of the fourth quartile (≥33 h/week) of mobile phone use were significantly higher than for other quartiles (all P < 0.05). CONCLUSIONS: Increased duration of mobile phone use is associated with unfavorable psychological mood, in particular, a depressed mood. Decreasing mobile phone use may help maintain appropriate mental health in very long-duration users.

Ikeda N, Hayashida O, Kameda H, Ito H, Matsuda T, **Experimental study on thermal damage to dog normal brain.Int J Hyperthermia 10(4):553-561, 1994**.

We investigated the temperature changes and their distribution in agar phantoms and dog normal brains induced by 8 MHz radiofrequency interstitial hyperthermia and observed the histological changes, with respect to the neurons and myelinated nerve fibres, induced by the same heat source in dog normal brains. We also examined the change of blood-brain barrier permeability using Evans blue solution. The heating limits of dog normal brain were 42 degrees C for 45 min or 43 degrees C for 15 min and the breakdown of the BBB was observed at 43 degrees C for 60 min.

İkinci A, Mercantepe T, Unal D, Erol HS, Şahin A, Aslan A, Baş O, Erdem H, Sönmez OF, Kaya H, Odacı E. Morphological and antioxidant impairments in the spinal cord of male offspring rats following exposure to a continuous 900-MHz electromagnetic field during early and mid-adolescence. J Chem Neuroanat. 2015 Dec 17. pii: S0891-0618(15)00096-4. doi: 10.1016/j.jchemneu.2015.11.006. [Epub ahead of print]

The effects on human health of devices emitting electromagnetic field (EMF) have become the subject of intense research among scientists due to the rapid increase in their use. Children and adolescents are particularly attracted to the use of devices emitting EMF, such as mobile phones. The aim of this study was therefore to investigate changes in the spinal cords of male rat pups exposed to the effect of 900 megahertz (MHz) EMF. The study began with 24 Sprague Dawley male rats aged 3 weeks. Three groups containing equal numbers of rats were established - control group (CG), sham group (SG) and EMF group (EMFG). EMFG rats were placed inside an EMF cage every day between postnatal days (PD) 21 and 46 and exposed to the effect of 900MHz EMF for 1hour. SG rats were kept in the EMF cage for 1hour without being exposed to the effect of EMF. At the end of the study, the spinal cords in the upper thoracic region of all rats were removed. Tissues were collected for biochemistry, light microscopy (LM) and transmission electron microscopic (TEM) examination. Biochemistry results revealed significantly increased malondialdehyde and glutathione levels in EMFG compared to CG and SG, while SG and EMFG catalase and superoxide dismutase levels were significantly higher than those in CG. In EMFG, LM revealed atrophy in the spinal cord, vacuolization, myelin thickening and irregularities in the perikarya. TEM revealed marked loss of myelin sheath integrity and invagination into the axon and broad vacuoles in axoplasm. The study results show that biochemical alterations and pathological changes may occur in the spinal cords of male rats following exposure to 900MHz EMF for 1hour a day on PD 21-46.

İkinci A, Odacı E, Yıldırım M, Kaya H, Akça M, Hancı H, Aslan A, Sönmez OF, Baş O.The Effects of Prenatal Exposure to a 900 Megahertz Electromagnetic Field on Hippocampus Morphology and Learning Behavior in Rat Pups. NeuroQuantology. 11(4):582-590, 2013.

The purpose of this study was to examine the effect on hippocampus morphology and learning behavior in rat pups following prenatal exposure to a 900 megahertz (MHz) electromagnetic field (EMF). Female Sprague Dawley rats weighing 180-250 g were left to mate with males. The following day, pregnant rats identified as such by the vaginal smear test were divided into two groups, control (n=3) and EMF (n=3). No procedures were performed on the control group. The rats in the EMF group were exposed to 900 MHz EMF on days 13 to 21 of pregnancy, for 1 h a day. Female rat pups were removed from their mothers at 22 days old. We then established two newborn rat groups, a 13 member control group and a 10 member EMF group. Radial arm maze and passive avoidance tests were used to measure rat pups' learning and memory performance. All rats were decapitated on the postnatal 32nd day. Routine histological procedures were performed on the brain tissues, and sections were stained with Cresyl fast violet. The radial arm maze (p=0.007) and passive avoidance (p=0.032) tests were administered to both groups under identical conditions, and compromised learning behavior was determined in the EMF group rats. Morphological compromise was also determined in the EMF group sections. Our results show that the application of a 900 MHz EMF in the prenatal period adversely affected female pups' learning behavior and also resulted in histopathological changes appearing in the hippocampus.

Ilhan A, Gurel A, Armutcu F, Kamisli S, Iraz M, Akyol O, Ozen S. Ginkgo biloba prevents mobile phone-induced oxidative stress in rat brain. Clin Chim Acta. 340(1-2): 153-162, 2004.

BACKGROUND: The widespread use of mobile phones (MP) in recent years has raised the research activities in many countries to determine the consequences of exposure to the low-intensity electromagnetic radiation (EMR) of mobile phones. Since several experimental studies suggest a role of reactive oxygen species (ROS) in EMR-induced oxidative damage in tissues, in this study, we investigated the effect of Ginkgo biloba (Gb) on MP-induced oxidative damage in brain tissue of rats. METHODS: Rats (EMR+) were exposed to 900 MHz EMR from MP for 7 days (1 h/day). In the EMR+Gb groups, rats were exposed to EMR and pretreated with Gb. Control and Gb-administrated groups were produced by turning off the mobile phone while the animals were in the same exposure conditions. Subsequently, oxidative stress markers and pathological changes in brain tissue were examined for each groups. RESULTS: Oxidative damage was evident by the: (i) increase in malondialdehyde (MDA) and nitric oxide (NO) levels in brain tissue, (ii) decrease in brain superoxide dismutase (SOD) and glutathione peroxidase (GSH-Px) activities and (iii) increase in brain xanthine oxidase (XO) and adenosine deaminase (ADA) activities. These alterations were prevented by Gb treatment. Furthermore, Gb prevented the MP-induced cellular injury in brain tissue histopathologically. CONCLUSION: Reactive oxygen species may play a role in the mechanism that has been proposed to explain the biological side effects of MP, and Gb prevents the MP-

induced oxidative stress to preserve antioxidant enzymes activity in brain tissue.

Ilvonen S, Sihvonen AP, Karkkainen K, Sarvas J. Numerical assessment of induced ELF Currents in the human head due to the battery current of a digital mobile phone. Bioelectromagnetics. 26(8):648-656,2005.

In this study, the extremely low frequency (ELF) fields induced in the human head by the battery currents of a mobile phone are considered. The magnetic field induced by the phone was measured, and this data was used to calculate the resulting currents induced in the human head and brain. Both the finite element method (FEM) and finite integration technique (FIT) were used for numerical computations. The computed current density values were then compared with the guidelines given by the International Commission on Non-Ionising Radiation Protection (ICNIRP). The comparison showed that the computed exposure is well within the limits of those guidelines

Imai N, Kawabe M, Hikage T, Nojima T, Takahashi S, Shirai T. Effects on rat testis of 1.95-GHz W-CDMA for IMT-2000 cellular phones. Syst Biol Reprod Med. 57(4):204-209,2011.

Abstract. In recent years concern has arisen whether carrying a cellular phone near the reproductive organs such as the testes may cause dysfunction and particularly decrease in sperm development and production, and thus fertility in men. The present study was performed to investigate the effects of a 1.95GHz electromagnetic field on testicular function in male Sprague-Dawley rats. Five week old animals were divided into 3 groups of 24 each and a 1.95-GHz wide-band code division multiple access (W-CDMA) signal, which is used for the freedom of mobile multimedia access (FOMA), was employed for whole body exposure for 5 hours per day, 7 days a week for 5 weeks (the period from the age of 5 to 10 weeks, corresponding to reproductive maturation in the rat). Whole-body average specific absorption rates (SAR) for individuals were designed to be 0.4 and 0.08 W/kg respectively. The control group received sham exposure. There were no differences in body weight gain or weights of the testis, epididymis, seminal vesicles, and prostate among the groups. The number of sperm in the testis and epididymis were not decreased in the electromagnetic field (EMF) exposed groups, and, in fact, the testicular sperm count was significantly increased with the 0.4 SAR. Abnormalities of sperm motility or morphology and the histological appearance of seminiferous tubules, including the stage of the spermatogenic cycle, were not observed. Thus, under the present exposure conditions, no testicular toxicity was evident.

Imaida, K, Taki, M, Watanabe, S, Kamimura, Y, Ito, T, Yamaguchi, T, Ito, N, Shirai, T, The 1.5 GHz electromagnetic near-field used for cellular phones does not promote rat liver carcinogenesis in a medium-term liver bioassay. Jpn J Cancer Res 89(10):995-1002, 1998.

We have recently established that local exposure to a 929.2 MHz electromagnetic near-field, used for cellular phones, does not promote rat liver carcinogenesis in a medium-term bioassay system. In the present study, a 1.439 GHz electromagnetic near-field (EMF), another microwave band employed for cellular phones in Japan, was similarly investigated. Time division multiple access (TDMA) signals for the Personal Digital

Cellular (PDC) Japanese cellular telephone standard system were directed to rats through a quarter-wavelength monopole antenna. Numerical dosimetry showed that the peak SARs within the liver were 1.91-0.937 W/kg, while the whole-body average specific absorption rates (SARs) were 0.680-0.453 W/kg, when the time-averaged antenna radiation power was 0.33 W. Exposure was for 90 min a day, 5 days a week, over 6 weeks, to male F344 rats given a single dose of diethylnitrosamine (200 mg/kg, i.p.) 2 weeks previously. At week 3, all rats were subjected to a two-thirds partial hepatectomy. At week 8, the experiment was terminated and the animals were killed. Carcinogenic potential was scored by comparing the numbers and areas of the induced glutathione S-transferase placental form (GST-P)-positive foci in the livers of exposed (48) and sham-exposed rats (48). Despite increased serum levels of corticosterone, adrenocorticotropic hormone (ACTH) and melatonin, the numbers and the areas of GST-P-positive foci were not significantly altered by the exposure. These findings clearly indicated that local body exposure to a 1.439 GHz EMF, as in the case of a 929.2 MHz field, has no promoting effect on rat liver carcinogenesis in the present model.

Imaida K, Taki M, Yamaguchi T, Ito T, Watanabe S, Wake K, Aimoto A, Kamimura Y, Ito N, Shirai T, Lack of promoting effects of the electromagnetic near-field used for cellular phones (929.2 MHz) on rat liver carcinogenesis in a medium-term liver bioassay. Carcinogenesis 19(2):311-314, 1998.

The possible cancer promotion potential of local exposure to a pulse modulated 929.2 MHz electromagnetic near-field on chemically-initiated rat liver carcinogenesis was investigated employing a medium-term bioassay. A 929.2-MHz electromagnetic near-field of time division multiple access (TDMA) signal for PDC (Personal Digital Cellular, Japanese cellular telephone standard) system was directed to rats through a quarter-wavelength monopole antenna. Maximum local specific absorption rates (SARs) on temporal average were 7.2-6.6 W/kg within the whole body and 2.0-1.7 W/kg within the liver, which was the target organ. The whole-body average SARs on temporal average were 0.80-0.58 W/kg. Temporal peak SARs had three times these values due to the duty ratio of the PDC signal. Exposure was for 90 min a day, 5 days a week, over 6 weeks. The exposure apparatus was specially designed for this experiment, to allow exposure of the lateral mid-section of the rat body to the electromagnetic near-field. Male F344 rats, 6 week-old, were initially (at week 0) given a single dose of diethylnitrosamine (DEN, 200 mg/kg body wt, i.p.). At 2 weeks later, exposure (48 rats) or sham-exposure (48 rats) was started. The exposure of electromagnetic near-fields was performed using the exposure apparatus mentioned above. At week 3, all rats were subjected to a 2/3 partial hepatectomy. At week 8 (i.e. after 6 weeks exposure or sham-exposure), the experiment was terminated and all rats were killed. Carcinogenic potential was scored by comparing the numbers and areas of the induced glutathione S-transferase placental form (GST-P) positive foci in the livers of the exposed and sham-exposed rats. A further group of 24 animals, given only DEN and partial hepatectomy, served as the controls. The numbers (no./cm2) of GST-P positive foci were 4.61 +/- 1.77, 5.21 +/- 1.92 ($P < 0.05$, versus control) and 4.09 +/- 1.47 and the areas (mm2/cm2) were 0.30 +/- 0.16, 0.36 +/- 0.21 and 0.28 +/- 0.15, for the exposed, sham-exposed and control groups, respectively. There were no significant differences between the exposed and sham-exposed groups. These findings clearly indicated that local body exposure to a 929.2-MHz field, modulated in a

PDC waveform, has no significant effect on rat liver carcinogenesis under the experimental conditions employed.

Imaida K, Hagiwara A, Yoshino H, Tamano S, Sano M, Futakuchi M, Ogawa K, Asamoto M, Shirai T, Inhibitory effects of low doses of melatonin on induction of preneoplastic liver lesions in a medium-term liver bioassay in F344 rats: relation to the influence of electromagnetic near field exposure. Cancer Lett 155(1):105-114, 2000.

We have previously reported that exposures of F344 male rats to both 900 MHz and 1.5 GHz electro-magnetic near fields (EMFs) results in slightly decreased numbers and areas of glutathione S-transferase (GST-P)-positive liver foci, liver preneoplastic lesions in rats, in a medium-term liver bioassay (K. Imaida, M. Taki, T. Yamaguchi, T. Ito, S. Watanabe, K. Wake, A. Aimoto, Y. Kamimura, N. Ito, T. Shirai, Lack of promoting effects of the electromagnetic near-field used for cellular phones (929.2 MHz) on rat liver carcinogenesis in a medium-term liver bioassay, Carcinogenesis 19 (1998) 311-314; K. Imaida, M. Taki, S. Watanabe, Y. Kamimura, T. Ito, T. Yamaguchi, N. Ito, T. Shirai, The 1.5 GHz electromagnetic near-field used for cellular phones does not promote rat liver carcinogenesis in a medium-term liver bioassay, Jpn. J. Cancer Res. 89 (1998) 995-1002.). In both experiments, the melatonin serum levels were significantly decreased in both 900 MHz and 1.5 GHz exposed groups as compared with sham-exposed control group values. Therefore, changes of serum melatonin levels may modify the development of preneoplastic lesions in the livers of rats exposed by EMF. In order to clarify this question, the effects of different doses of melatonin (1, 5, 10 and 20 ppm in the drinking water) were analyzed in the same bioassay system employed for our previously reported EMF exposure studies. Six-week-old male F344 rats were given a single dose of diethylnitrosamine (DEN, 200 mg/kg b.w., i.p.). Starting 2 weeks later, they were treated with 0, 1, 5, 10 and 20 ppm melatonin in their drinking water for 6 weeks. Melatonin treatment were performed only during the night (between 18:00 to 09:00) in order to maintain their circadian rhythm, since serum melatonin levels are high at midnight. At week 3, all rats were subjected to a two-thirds partial hepatectomy. At week 8, the experiment was terminated and the animals were sacrificed. Serum hormone levels of melatonin, adrenocorticotropic hormone (ACTH), corticosterone, luteinizing hormone (LH), follicle-stimulating hormone (FSH) and testosterone at this time point were measured, only the first being elevated, while LH and testosterone were reduced. Although clear dose dependence was not apparent, both numbers and areas of GST-P-positive foci in the liver were decreased in the melatonin treated groups, this being significant for numbers in the 10 ppm melatonin group. Comparison of the current results with the previously reported findings for EMF exposure experiments, suggests that increase in melatonin serum levels is a possible reason for the associated tendency for decreased preneoplastic hepatocyte foci development.

Imge EB, Kiliçoğlu B, Devrim E, Cetin R, Durak I. Effects of mobile phone use on brain tissue from the rat and a possible protective role of vitamin C - a preliminary study. Int J Radiat Biol.86(12):1044-1049, 2010.

Purpose: To evaluate effects of mobile phone use on brain tissue and a possible

protective role of vitamin C. Materials and methods: Forty female rats were divided into four groups randomly (Control, mobile phone, mobile phone plus vitamin C and, vitamin C alone). The mobile phone group was exposed to a mobile phone signal (900 MHz), the mobile phone plus vitamin C group was exposed to a mobile phone signal (900 MHz) and treated with vitamin C administered orally (per os). The vitamin C group was also treated with vitamin C per os for four weeks. Then, the animals were sacrificed and brain tissues were dissected to be used in the analyses of malondialdehyde (MDA), antioxidant potential (AOP), superoxide dismutase, catalase (CAT), glutathione peroxidase (GSH-Px), xanthine oxidase, adenosine deaminase (ADA) and 5'nucleotidase (5'-NT). Results: Mobile phone use caused an inhibition in 5'-NT and CAT activities as compared to the control group. GSH-Px activity and the MDA level were also found to be reduced in the mobile phone group but not significantly. Vitamin C caused a significant increase in the activity of GSH-Px and non-significant increase in the activities of 5'-NT, ADA and CAT enzymes. Conclusion: Our results suggest that vitamin C may play a protective role against detrimental effects of mobile phone radiation in brain tissue.

Inaba R, Shishido K, Okada A, Moroji T. Effects of whole body microwave exposure on the rat brain contents of biogenic amines. Eur J Appl Physiol Occup Physiol. 65(2):124-128, 1992.

The effects of whole body microwave exposure on the central nervous system (CNS) of the rat were investigated. Rats weighing from 250 to 320 g were exposed for 1 h to whole body microwave with a frequency of 2450 MHz at power densities of 5 and 10 mW.cm-2 at an ambient temperature of 21-23 degrees C. The rectal temperatures of the rats were measured just before and after microwave exposure and mono-amines and their metabolites in various discrete brain regions were determined after microwave exposure. Microwave exposure at power densities of 5 and 10 mW.cm-2 increased the mean rectal temperature by 2.3 degrees C and 3.4 degrees C, respectively. The noradrenaline content in the hypothalamus was significantly reduced after microwave exposure at a power density of 10 mW.cm-2. There were no differences in the dopamine (DA) content of any region of the brain between microwave exposed rats and control rats. The dihydroxyphenyl acetic acid (DOPAC) content, the main metabolite of DA, was significantly increased in the pons plus medulla oblongata only at a power density of 10 mW.cm-2. The DA turnover rates, the DOPAC:DA ratio, in the striatum and cerebral cortex were significantly increased only at a power density of 10 mW.cm-2. The serotonin (5-hydroxytryptamine, 5-HT) content in all regions of the brain of microwave exposed rats was not different from that of the control rats. The 5-hydroxyindoleacetic acid (5-HIAA) content in the cerebral cortex of microwave exposed rats was significantly increased at power densities of 5 and 10 mW.cm-2.

Indulski JA, Makowiec-Dabrowska T, Zmyslony M, Siedlecka J, [Electromagnetic poles and reproduction]. Med Pr 48(5):585-603, 1997. [Article in Polish]

The authors review epidemiological data concerning the relationship between reproduction disorders and the exposure to electromagnetic fields (EMF) emitted by power lines, industrial power-charged devices, diagnostic and therapeutical appliances, video display terminals (VDTs) and electric household devices. The studies involved the

analysis of the EMF effect on female and male reproduction, including the risk of spontaneous abortion, still birth and premature birth, low birth weight and congenital malformations as well as on the progeny gender proportion, among persons employed under the condition of EMF exposure. It was observed that the findings were frequently inconsistent, i.e. under the same conditions of EMF exposure some date indicated its negative effect on the reproduction process and some did not. No data confirming an acute effect of occupational exposure to EMF on the risk of spontaneous abortion, low birth weight, congenital malformations or other reproduction disorders were obtained, however, the negative effect of EMF cannot be explicitly excluded.

Ingole IV, Ghosh SK. **Effect of exposure to radio frequency radiation emitted by cell phone on the developing dorsal root ganglion of chick embryo: a light microscopic study.** Nepal Med Coll J. **14(4):337-341, 2012.**

With an ever increasing number of cell phone users since late twenty first century, magnitude of the problem of exposure to radiation emitted by cell phone is self evident. Extensive research had been devoted to incriminate or absolve it as a health hazard. Radiofrequency radiation emitted by cell phone had been stated to be a potent carcinogen, cytotoxic, genotoxic, mutagenic and neurobehavioral teratogen. Its effect on the brain had been a subject of extensive research evidently due to its proximity to the user's brain. While considering the biological effects of radiofrequency radiation, its intensity, frequency and the duration of exposure are important determinants. Nevertheless the results of these different studies have not been unequivocal. Considering the contradictory reports, the present work was undertaken to study the effect of such an exposure on the developing neural tissue of chick embryo. The processes of cell division and differentiation are fundamental to the development of any living being and are a sensitive index of any insult sustained at this stage. Neurons of dorsal root ganglion were selected for the present study as these ganglia were fully differentiated as early as fourth day of embryonic life. By varying duration of exposure, the embryos were exposed to different doses of radiation, sacrificed at different periods of incubation and subjected to histological processing. On light microscopic study it was observed that developing neurons of dorsal root ganglion suffered a damage which was dose dependent and persisted in spite of giving the exposure-free period between two exposures.

Inomata-Terada S, Okabe S, Arai N, Hanajima R, Terao Y, Frubayashi T, Ugawa Y. Effects of high frequency electromagnetic field (EMF) emitted by mobile phones on the human motor cortex. Bioelectromagnetics.28(7):553-561, 2007.

We investigated whether the pulsed high frequency electromagnetic field (EMF) emitted by a mobile phone has short term effects on the human motor cortex. We measured motor evoked potentials (MEPs) elicited by single pulse transcranial magnetic stimulation (TMS), before and after mobile phone exposure (active and sham) in 10 normal volunteers. Three sites were stimulated (motor cortex (CTX), brainstem (BST) and spinal nerve (Sp)). The short interval intracortical inhibition (SICI) of the motor cortex reflecting GABAergic interneuronal function was also studied by paired pulse TMS method. MEPs to single pulse TMS were also recorded

in two patients with multiple sclerosis showing temperature dependent neurological symptoms (hot bath effect). Neither MEPs to single pulse TMS nor the SICI was affected by 30 min of EMF exposure from mobile phones or sham exposure. In two MS patients, mobile phone exposure had no effect on any parameters of MEPs even though conduction block occurred at the corticospinal tracts after taking a bath. As far as available methods are concerned, we did not detect any short-term effects of 30 min mobile phone exposure on the human motor cortical output neurons or interneurons even though we can not exclude the possibility that we failed to detect some mild effects due to a small sample size in the present study. This is the first study of MEPs after electromagnetic exposure from a mobile phone in neurological patients.

Inoue S, Motoda H, Koike Y, Kawamura K, Hiragami F, Kano Y. Microwave irradiation induces neurite outgrowth in PC12m3 cells via the p38 mitogen-activated protein kinase pathway. Neurosci Lett.432(1):35-39,2008.

The increasing use of mobile phone communication has raised concerns about possible health hazard effects of microwave irradiation. We investigated damage and differentiation caused by microwave irradiation on drug-hypersensitive PC12 cell line (PC12m3). These cells showed enhancement of neurite outgrowth to various stimulants. The frequency of neurite outgrowth induced by 2.45GHz (200W) of microwave irradiation was approximately 10-fold greater than that of non-irradiated control cells. Incubation of PC12m3 cells with SB203580, a specific inhibitor of p38 MAPK, resulted in marked inhibition of the microwave radiation-induced neurite outgrowth. Also, activation of the transcription factor CREB induced by microwave irradiation was inhibited by SB203580. Heat shock treatment at 45 degrees C had a strong toxic effect on PC12m3 cells, whereas microwave treatment had no toxic effect on PC12m3 cells. These findings indicate that p38 MAPK is responsible for the survival of PC12m3 cells and might induce neurite outgrowth via a CREB signaling pathway when subjected to microwave irradiation.

Inskip PD, Tarone RE, Hatch EE, Wilcosky TC, Shapiro WR, Selker RG, Fine HA, Black PM, Loeffler JS, Linet MS, Cellular-telephone use and brain tumors. N Engl J Med 344(2):79-86, 2001.

Background: Concern has arisen that the use of hand-held cellular telephones might cause brain tumors. If such a risk does exist, the matter would be of considerable public health importance, given the rapid increase worldwide in the use of these devices. Methods: We examined the use of cellular telephones in a case-control study of intracranial tumors of the nervous system conducted between 1994 and 1998. We enrolled 782 patients through hospitals in Phoenix, Arizona; Boston; and Pittsburgh; 489 had histologically confirmed glioma, 197 had meningioma, and 96 had acoustic neuroma. The 799 controls were patients admitted to the same hospitals as the patients with brain tumors for a variety of nonmalignant conditions. Results: As compared with never, or very rarely, having used a cellular telephone, the relative risks associated with a cumulative use of a cellular telephone for more than 100 hours were 0.9 for glioma (95 percent confidence interval, 0.5 to 1.6), 0.7 for meningioma (95 percent confidence interval, 0.3 to 1.7), 1.4 for acoustic neuroma (95 percent confidence interval, 0.6 to 3.5), and 1.0 for all

types of tumors combined (95 percent confidence interval, 0.6 to 1.5). There was no evidence that the risks were higher among persons who used cellular telephones for 60 or more minutes per day or regularly for five or more years. Tumors did not occur disproportionately often on the side of head on which the telephone was typically used. Conclusions: These data do not support the hypothesis that the recent use of hand-held cellular telephones causes brain tumors, but they are not sufficient to evaluate the risks among long-term, heavy users and for potentially long induction periods.

Inskip PD, Hoover RN, Devesa SS. Brain cancer incidence trends in relation to cellular telephone use in the United States. Neuro Oncol.12(11):1147-1151, 2010.

The use of cellular telephones has grown explosively during the past two decades, and there are now more than 279 million wireless subscribers in the United States. If cellular phone use causes brain cancer, as some suggest, the potential public health implications could be considerable. One might expect the effects of such a prevalent exposure to be reflected in general population incidence rates, unless the induction period is very long or confined to very long-term users. To address this issue, we examined temporal trends in brain cancer incidence rates in the United States, using data collected by the Surveillance, Epidemiology, and End Results (SEER) Program. Log-linear models were used to estimate the annual percent change in rates among whites. With the exception of the 20-29-year age group, the trends for 1992-2006 were downward or flat. Among those aged 20-29 years, there was a statistically significant increasing trend between 1992 and 2006 among females but not among males. The recent trend in 20-29-year-old women was driven by a rising incidence of frontal lobe cancers. No increases were apparent for temporal or parietal lobe cancers, or cancers of the cerebellum, which involve the parts of the brain that would be more highly exposed to radiofrequency radiation from cellular phones. Frontal lobe cancer rates also rose among 20-29-year-old males, but the increase began earlier than among females and before cell phone use was highly prevalent. Overall, these incidence data do not provide support to the view that cellular phone use causes brain cancer.

The INTERPHONE Study Group. Brain tumour risk in relation to mobile telephone use: results of the INTERPHONE international case-control study. Int J Epidemiol.39(3):675-94,2010.

BACKGROUND: The rapid increase in mobile telephone use has generated concern about possible health risks related to radiofrequency electromagnetic fields from this technology. METHODS: An interview-based case-control study with 2708 glioma and 2409 meningioma cases and matched controls was conducted in 13 countries using a common protocol. RESULTS: A reduced odds ratio (OR) related to ever having been a regular mobile phone user was seen for glioma [OR 0.81; 95% confidence interval (CI) 0.70-0.94] and meningioma (OR 0.79; 95% CI 0.68-0.91), possibly reflecting participation bias or other methodological limitations. No elevated OR was observed >/=10 years after first phone use (glioma: OR 0.98; 95% CI 0.76-1.26; meningioma: OR 0.83; 95% CI 0.61-1.14). ORs were <1.0 for all deciles of lifetime number of phone calls and nine deciles of cumulative call time. In the 10th decile of

recalled cumulative call time, >/=1640 h, the OR was 1.40 (95% CI 1.03-1.89) for glioma, and 1.15 (95% CI 0.81-1.62) for meningioma; but there are implausible values of reported use in this group. ORs for glioma tended to be greater in the temporal lobe than in other lobes of the brain, but the CIs around the lobe-specific estimates were wide. ORs for glioma tended to be greater in subjects who reported usual phone use on the same side of the head as their tumour than on the opposite side. CONCLUSIONS: Overall, no increase in risk of glioma or meningioma was observed with use of mobile phones. There were suggestions of an increased risk of glioma at the highest exposure levels, but biases and error prevent a causal interpretation. The possible effects of long-term heavy use of mobile phones require further investigation.

Irgens A, Kruger K, Ulstein M, The effect of male occupational exposure in infertile couples in Norway. J Occup Environ Med 41(12):1116-1120, 1999.

The objective of the study was to assess whether reduced semen quality in infertile couples is associated with occupational exposures known to be hazardous to fertility. Results of the first semen analysis were linked to occupational exposure data from a self-administered questionnaire. Reduced semen quality was found in men exposed to electromagnetic fields (odds ratio, 3.22; confidence interval, 1.46 to 7.09). A tendency toward reduced semen quality was seen in commuters (OR, 1.52; CI, 0.89 to 2.59), shift workers (OR, 1.46; CI, 0.89 to 2.40), and men exposed to heavy metals (OR, 1.47; CI, 0.76 to 2.87). In general, the impact of occupational exposure on semen quality in infertile couples in Norway seemed to be minor. However, occupational exposure mapping is still important in individual infertility investigations.

Irlenbusch L, Bartsch B, Cooper J, Herget I, Marx B, Raczek J, Thoss F. Influence of a 902.4 MHz GSM signal on the human visual system: investigation of the discrimination threshold.Bioelectromagnetics. 28(8):648-654, 2007.

The proximity of a mobile phone to the human eye raises the question as to whether radiofrequency (RF) electromagnetic fields (EMF) affect the visual system. A basic characteristic of the human eye is its light sensitivity, making the visual discrimination threshold (VDThr) a suitable parameter for the investigation of potential effects of RF exposure on the eye. The VDThr was measured for 33 subjects under standardized conditions. Each subject took part in two experiments (RF-exposure and sham-exposure experiment) on different days. In each experiment, the VDThr was measured continuously in time intervals of about 10 s for two periods of 30 min, having a break of 5 min in between. The sequence of the two experiments was randomized, and the study was single blinded. During the RF exposure, a GSM signal of 902.4 MHz (pulsed with 217 Hz) was applied to the subjects. The power flux density of the electromagnetic field at the subject location (in the absence of the subject) was 1 W/m(2), and numerical dosimetry calculations determined corresponding maximum local averaged specific absorption rate (SAR) values in the retina of SAR(1 g) = 0.007 W/kg and SAR(10 g) = 0.003 W/kg. No statistically significant differences in the VDThr were found in comparing the data obtained for RF exposure with those for sham exposure.

Irmak MK, Fadillioglu E, Gulec M, Erdogan H, Yagmurca M, Akyol O. Effects of electromagnetic radiation from a cellular telephone on the oxidant and antioxidant levels in rabbits. Cell Biochem Funct. 20(4):279-283, 2002.

The number of reports on the effects induced by electromagnetic radiation (EMR) in various cellular systems is still increasing. Until now no satisfactory mechanism has been proposed to explain the biological effects of this radiation. Oxygen free radicals may play a role in mechanisms of adverse effects of EMR. This study was undertaken to investigate the influence of electromagnetic radiation of a digital GSM mobile telephone (900 MHz) on oxidant and antioxidant levels in rabbits. Adenosine deaminase, xanthine oxidase, catalase, myeloperoxidase, superoxide dismutase (SOD) and glutathione peroxidase activities as well as nitric oxide (NO) and malondialdehyde levels were measured in sera and brains of EMR-exposed and sham-exposed rabbits. Serum SOD activity increased, and serum NO levels decreased in EMR-exposed animals compared to the sham group. Other parameters were not changed in either group. This finding may indicate the possible role of increased oxidative stress in the pathophysiology of adverse effect of EMR. Decreased NO levels may also suggest a probable role of NO in the adverse effect.

Irmak MK, Oztas E, Yagmurca M, Fadillioglu E, Bakir B. Effects of electromagnetic radiation from a cellular telephone on epidermal Merkel cells. J Cutan Pathol. 30(2):135-138, 2003.

The number of reports on the effects induced by electromagnetic radiation (EMR) from cellular telephones in various cellular systems is still increasing. Until now, no satisfactory mechanism has been proposed to explain the biological effects of this radiation except a role suggested for mast cells. Merkel cells may also play a role in the mechanisms of biological effects of EMR. This study was undertaken to investigate the influence of EMR from a cellular telephone (900 MHz) on Merkel cells in rats. A group of rats was exposed to a cellular telephone in speech position for 30 min. Another group of rats was sham-exposed under the same environmental conditions for 30 min. Exposure led to significantly higher exocytotic activity in Merkel cells compared with the sham exposure group. This finding may indicate the possible role of Merkel cells in the pathophysiology of the effects of EMR.

Irnich W, Tobisch R, [Effect of mobile phone on life-saving and life-sustaining systems]. Biomed Tech (Berl) 43(6):164-173, 1998. [Article in German]

Since the beginning of the nineties there have been warnings not to use mobile phones in the vicinity of medical devices. Functional failures of dialysis machines, respirators and defibrillators prompted the banning of their use in many hospitals in Scandinavia, and then in other countries. Since we believe that a general ban in hospitals is problematic, we decided to investigate the influence of mobile telephone on life-saving and/or life-support systems, with the aim of establishing rules for its use in hospitals. We investigated available phones of varying power of the C-, D- and E-net, as also of a cordless phone meeting the DECT standard. The aim was to identify the devices susceptible to interference and determine the minimum distances at which interference occurred. A total of 224 devices classified into 23 types of devices were examined. Nine different sets of transmission conditions were applied, giving a total of 2016 tests. Our

results permit the conclusion that the ban on mobile phones in hospitals is based not on actual events, but on theoretical considerations in the absence of any practical information on the actual susceptibility of devices and their reaction to the electromagnetic fields involved. The fact that hazardous situations are very rare is due firstly to the need for the simultaneous occurrence of four coincidences, and the fail-save feature of medical devices. We would therefore recommend that all life-saving and life-support systems that can also be used outside the hospital should be made mobile phone-proof. When apnoea monitors and respirators are protected from such interference, hazardous situations could be avoided by establishing the rule: "No portables, and mobile phones only at a distance of at least 1 metre from medical devices". With regard to emergency telephones, the minimum distance to medical devices should be at least 1.5 metres.

Irnich W, Batz L, Muller R, Tobisch R, electromagnetic interference of pacemakers by mobile phones. Pacing Clin Electrophysiol 19(10):1431-1446, 1996.

The topic of interference of pacemakers by mobile phones has evoked a surprisingly strong interest, not only in pacemaker patients, but also in the public opinion. The latter is the more surprising, as in the past, the problem of interference has scarcely found the attention that it deserves in the interest of the patient. It was the intention of our investigation to test as many pacemaker models as possible to determine whether incompatibility with mobile phones of different modes may exist, using an in vitro measuring setup. We had access to 231 different models of 20 manufacturers. During the measurements, a pulse generator together with a suitable lead was situated in a 0.9 g/L saline solution, and the antenna of a mobile phone was positioned as close as possible. If the pulse generator was disturbed, the antenna was elevated until interference ceased. The gap in which interference occurred was defined as "maximum interference distance." All three nets existing in Germany, the C-net (450 MHz, analogue), the D-net (900 MHz, digital pulsed), and the E-net (1,800 MHz, digital pulsed) were tested in succession. Out of 231 pulse generator models, 103 pieces corresponding to 44.6% were influenced either by C- or D-net, if both results were totaled. However, this view is misleading as no patient will use C- and D-net phones simultaneously. Separated into C- or D-net interference, the result is 30.7% for C or 34.2% for D, respectively, of all models tested. The susceptible models represent 18.6% or 27% of today's living patients, respectively. All models were resistant to the E-net. With respect to D-net phones, all pacemakers of six manufacturers proved to be unaffected. Eleven other manufacturers possessed affected and unaffected models as well. A C-net phone only prolonged up to five pacemaker periods within 10 seconds during dialing without substantial impairment to the patient. Bipolar pacemakers are as susceptible as unipolar ones. The following advice for patients and physicians can be derived from our investigations: though 27% of all patients may have problems with D-net phones (not C- or E-net), the application should generally not be questioned. On the contrary, patients with susceptible devices should be advised that a distance of 20 cm is sufficient to guarantee integrity of the pacemaker with respect to hand held phones. Portables, on the other hand, should have a distance of about 0.5 m. Pacemaker patients really suffering from mobile phones are very rare unless the phone is just positioned in the pocket over the pulse generator. The contralateral pocket or the belt position guarantees, in 99% of all patients, undisturbed operation of the pacemaker. A risk analysis reveals that the portion of patients really suffering from mobile

phones is about 1 out of 100,000. Nevertheless, it would be desirable in the future if implanting physicians would use only pacemakers with immunity against mobile phones as guaranteed by the manufacturers.

Isa AR, Noor M, Non-ionizing radiation exposure causing ill-health and alopecia areata. Med J Malaysia 46(3):235-238, 1991.

Three cases of occupational exposure to radio-frequency and microwave radiation were seen at the out-patient clinic, Hospital Universiti Sains Malaysia. They presented with run-down symptoms of neck strain associated with throbbing headache, irritability, loss of appetite, fatigue, memory difficulties, and numbness of extremities. They also presented with alopecia areata which is felt to be causally linked to the radiation exposure.

Iudice A, Bonanni E, Gelli A, Frittelli C, Iudice G, Cignoni F, Ghicopulos I, Murri L. Effects of prolonged wakefulness combined with alcohol and hands-free cell phone divided attention tasks on simulated driving. Hum Psychopharmacol.20(2):125-132, 2005.

Simulated driving ability was assessed following administration of alcohol, at an estimated blood level of 0.05%, and combined prolonged wakefulness, while participants were undertaking divided attention tasks over a hands-free mobile phone. Divided attention tasks were structured to provide a sustained cognitive workload to the subjects. Twenty three young healthy individuals drove 10 km simulated driving under four conditions in a counterbalanced, within-subject design: alcohol, alcohol and 19 h wakefulness, alcohol and 24 h wakefulness, and while sober. Study measures were: simulated driving, self-reported sleepiness, critical flicker fusion threshold (CFFT), Stroop word-colour interference test (Stroop) and simple visual reaction times (SVRT). As expected, subjective sleepiness was highly correlated with both sleep restriction and alcohol consumption. The combination of alcohol and 24 h sustained wakefulness produced the highest driving impairment, significantly beyond the alcohol effect itself. Concurrent alcohol and 19 h wakefulness significantly affected only driving time-to-collision. No significant changes of study measures occurred following alcohol intake in unrestricted sleep conditions. CFFT, SVRT and Stroop results showed a similar trend in the four study conditions. Thus apparently 'safe' blood alcohol levels in combination with prolonged wakefulness resulted in significant driving impairments. In normal sleep conditions alcohol effects on driving were partially counteracted by the concomitant hands-free phone based psychometric tasks.

Ivanova VIu, Martynova OV, Aleinik SV, Limarenko AV. [Effect of modified SHF and acoustic stimulation on spectral characteristics of the electroencephalograms of the cat brain] Biofizika. 45(5):935-940, 2000. [Article in Russian]

The effect of modulated electromagnetic fields on the spectral parameters of bioelectric brain activity in awake cats was studied by registering the electroencephalogram from the skin surface in the vertex area using carbon electrodes. In the normal electroencephalogram, spectral components in the range above 20 Hz predominated. It was shown that, upon irradiation with electromagnetic field (basic frequency 980 MHz, power density 30-50 microW/cm2), spectral components in the range of 12-18 Hz begin to prevail. A similarity in the redistribution of the power of spectral components upon both

acoustic and modulated electromagnetic influences was revealed. The results suggest that there is a a common neurophysiological mechanism by which modulated electromagnetic radiation and acoustic stimulation affect the electrical activity of the brain. This ia consistent with the assumption that the effect of the electromagnetic field on the central nervous system is mediated through the acoustic sensory system.

Ivaschuk OI, Jones RA, Ishida-Jones T, Haggren W, Adey WR, Phillips JL, Exposure of nerve growth factor-treated PC12 rat pheochromocytoma cells to a modulated radiofrequency field at 836.55 MHz: effects on c-jun and c-fos expression. Bioelectromagnetics 18(3):223-229, 1997.

Rat PC12 pheochromocytoma cells have been treated with nerve growth factor And then exposed to athermal levels of a packet-modulated radiofrequency field At 836.55 MHz. This signal was produced by a prototype time-domain multiple-access (TDMA) transmitter that conforms to the North American digital cellular telephone standard. Three slot average power densities were used: 0.09, 0.9, and 9 mW/cm2. Exposures were for 20, 40, and 60 min and included an intermittent exposure regimen (20 min on/20 min off), resulting in total incubation times of 20, 60, and 100 min, respectively. Concurrent controls were sham exposed. After extracting total cellular RNA, Northern blot analysis was used to assess the expression of the immediate early genes, c-fos and c-jun, in all cell populations. No change in c-fos transcript levels were detected after 20 min exposure at each field intensity (20 min was the only time period at which c-fos message could be detected consistently). Transcript levels for c-jun were altered only after 20 min exposure to 9 mW/cm2 (average 38% decrease).

Janssen T, Boege P, von Mikusch-Buchberg J, Raczek J. Investigation of potential effects of cellular phones on human auditory function by means of distortion product otoacoustic emissions. J Acoust Soc Am. 117(3 Pt 1):1241-1247, 2005.

Outer hair cells (OHC) are thought to act like piezoelectric transducers that amplify low sounds and hence enable the ear's exquisite sensitivity. Distortion product otoacoustic emissions (DPOAE) reflect OHC function. The present study investigated potential effects of electromagnetic fields (EMF) of GSM (Global System for Mobile Communication) cellular phones on OHCs by means of DPOAEs. DPOAE measurements were performed during exposure, i.e., between consecutive GSM signal pulses, and during sham exposure (no EMF) in 28 normally hearing subjects at tone frequencies around 4 kHz. For a reliable DPOAE measurement, a 900-MHz GSM-like signal was used where transmission pause was increased from 4.034 ms (GSM standard) to 24.204 ms. Peak transmitter power was set to 20 W, corresponding to a specific absorption rate (SAR) of 0.1 W/kg. No significant change in the DPOAE level in response to the EMF exposure was found. However, when undesired side effects on DPOAEs were compensated, in some subjects an extremely small EMF-exposure-correlated change in the DPOAE level (< 1 dB) was observed. In view of the very large dynamic range of hearing in humans (120 dB), it is suggested that this observation is physiologically irrelevant.

Jarupat S, Kawabata A, Tokura H, Borkiewicz A. Effects of the 1900 MHz electromagnetic field emitted from cellular phone on nocturnal melatonin secretion. J Physiol Anthropol Appl Human Sci 22(1):61-63, 2003.

Exposure to cellular phone EMF caused a significant reduction in salivary melatonin in female human subjects.

Jauchem, JR, Exposure to extremely-low-frequency electromagnetic fields and radiofrequency radiation: cardiovascular effects in humans. Int Arch Occup Environ Health 70(1):9-21, 1997.

Cardiovascular changes in humans exposed to nonionizing radiation [including extremely-low-frequency electromagnetic fields (ELF EMFs) and radiofrequency radiation (RFR)] are reviewed. Both acute and long-term effects have been investigated. In general, if heating does not occur during exposure, current flow appears to be necessary for major cardiovascular effects to ensue, such as those due to electric shock. Whereas most studies have revealed no acute effect of static or time-varying ELF EMFs on the blood pressure, heart rate, or electrocardiogram waveform, others have reported subtle effects on the heart rate. The possible health consequences of these results are unknown. Regarding long-term effects of ELF EMFs, reports from the former Soviet Union in the early 1960s indicated arrhythmias and tachycardia in high-voltage-switchyard workers. Subsequent studies in Western countries, however, did not confirm these findings. These studies are limited by uncertainties regarding exposure durations and appropriate control groups. Investigations of acute cardiovascular changes in humans purposely exposed to RFR have been limited to studies of magnetic resonance imaging (which, in addition to RFR, involves static and time-varying magnetic fields). It has been concluded that such exposures, as presently performed, are not likely to cause adverse cardiovascular effects. Reports of hypertension in workers potentially exposed to high levels of RFR during accidents are considered to be incidental (due to anxiety and posttraumatic stress). Soviet investigators have also indicated that long-term RFR exposure may result in hypotension and bradycardia or tachycardia. Otherresearchers, however, have been incapable of replicating these results, and some scientists have attributed the effects to chance variations and mishandling of data. In summary, studies have not yielded any obvious cardiovascular-related hazards of acute or long-term exposures to ELF EMFs or RFR at levels below current exposure standards.

Jauchem JR, Seaman RL, Lehnert HM, Mathur SP, Ryan KL, Frei MR, Hurt WD. Ultra-wideband electromagnetic pulses: lack of effects on heart rate and blood pressure during two-minute exposures of rats. Bioelectromagnetics 19(5):330-333, 1998.

Exposure to fast-rise-time ultra-wideband (UWB) electromagnetic pulses has been postulated to result in effects on biological tissue (including the cardiovascular system). In the current study, 10 anesthetized Sprague-Dawley rats were exposed to pulses produced by a Sandia UWB pulse generator (average values of exposures over three different pulse repetition rates: rise time, 174-218 ps; peak E field, 87-104 kV/m; pulse duration, 0.97-0.99 ns). Exposures to 50, 500 and 1000 pulses/s resulted in no significant changes in heart rate or mean arterial blood pressure measured every 30 s during 2 min of exposure and for 2 min after the exposure. The results suggest that acute UWB whole-body exposure under these conditions does not have an immediate detrimental effect on these cardiovascular system variables in anesthetized rats.

Jauchem JR, Frei MR, Ryan KL, Merritt JH, Murphy MR, Lack of effects on heart

rate and blood pressure in ketamine-anesthetized rats briefly exposed to ultra-wideband electromagnetic pulses. IEEE Trans Biomed Eng 46(1):117-120, 1999.

Fourteen Sprague-Dawley rats were exposed to pulses produced by a Bournlea ultra-wideband (UWB) pulse generator (rise time, 318-337 ps; maximum E field, 19-21 kV/m). Exposures at a repetition frequency of 1 kHz for 0.5 s or to repetitive pulse trains (2-s exposure periods alternating with 2 s of no exposure, for a total of 2 min) resulted in no significant changes in heart rate or mean arterial blood pressure. These results suggest that acute whole-body exposure to UWB pulses does not have a detrimental effect on the cardiovascular system.

Jauchem JR, Ryan KL, Freidagger MR, Cardiovascular and thermal effects of microwave irradiation at 1 and/or 10 GHz in anesthetized rats. Bioelectromagnetics 21(3):159-166, 2000.

Relatively large thermal gradients may exist during exposure of an animal to microwaves (MWs), particularly at high frequencies. Differences in thermal gradients within the body may lead to noticeable differences in the magnitude of cardiovascular changes resulting from MW exposure. This study compares the thermal distribution and cardiovascular effects of exposure to a single MW frequency with effects of simultaneous exposure to two frequencies. Ketamine-anesthetized male Sprague-Dawley rats (n = 58) were exposed individually to one of three conditions: 1-GHz, 10-GHz, or combined 1- and 10-GHz MWs at an equivalent whole-body specific absorption rate of 12 W/kg. The continuous-wave irradiation was conducted under far-field conditions with animals in E orientation (left lateral exposure, long axis parallel to the electric field) or in H orientation (left lateral exposure, long axis perpendicular to the electric field). Irradiation was started when colonic temperature was 37.5 degrees C and was continued until lethal temperatures were attained. Colonic, tympanic, left and right subcutaneous, and tail temperatures, and arterial blood pressure, heart rate, and respiratory rate were continuously recorded. In both E and H orientations, survival time (i.e., time from colonic temperat ure of 37.5 degrees C until death) was lowest in animals exposed at 1-GHz, intermediate in those exposed at 1- and 10-GHz combined, and greatest in the 10-GHz group (most differences statistically significant). At all sites (with the exception of right subcutaneous), temperature values in the 1- and 10-GHz combined group were between those of the single-frequency exposure groups in both E and H orientations. During irradiation, arterial blood pressure initially increased and then decreased until death. Heart rate increased throughout the exposure period. The general, overall patterns of these changes were similar in all groups. The results indicate that no unusual physiological responses occur during multi-frequency MW exposure, when compared with results of single-frequency exposure.

Jauchem JR, Frei MR, Dusch SJ, Lehnert HM, Kovatch RM, Repeated exposure of C3H/HeJ mice to ultra-wideband electromagnetic pulses: Lack of effects on mammary tumors. Radiat Res 155(2):369-377, 2001.

Jauchem, J. R., Ryan, K. L., Frei, M. R., Dusch, S. J., Lehnert, H. M. and Kovatch, R. M. Repeated Exposure of C3H/HeJ Mice to Ultra-wideband Electromagnetic Pulses: Lack of Effects on Mammary Tumors. It has been suggested that chronic, low-level exposure to radiofrequency (RF) radiation may promote the formation of tumors. Previous studies,

however, showed that low-level, long-term exposure of mammary tumor-prone mice to 435 MHz or 2450 MHz RF radiation did not affect the incidence of mammary tumors. In this study, we investigated the effects of exposure to a unique type of electromagnetic energy: pulses composed of an ultra-wideband (UWB) of frequencies, including those in the RF range. One hundred C3H/HeJ mice were exposed to UWB pulses (rise time 176 ps, fall time 3.5 ns, pulse width 1.9 ns, peak E-field 40 kV/m, repetition rate 1 kHz). Each animal was exposed for 2 min once a week for 12 weeks. One hundred mice were used as sham controls. There were no significant differences between groups with respect to incidence of palpated mammary tumors, latency to tumor onset, rate of tumor growth, or animal survival. Histopathological evaluations revealed no significant differences between the two groups in numbers of neoplasms in all tissues studied (lymphoreticular tissue, thymus, respiratory, digestive and urinary tracts, reproductive, mammary and endocrine systems, and skin). Our major finding was the lack of effects of UWB-pulse exposure on promotion of mammary tumors in a well-established animal model of mammary cancer.

Jauchem JR. Effects of low-level radio-frequency (3kHz to 300GHz) energy on human cardiovascular, reproductive, immune, and other systems: A review of the recent literature. Int J Hyg Environ Health.211(1-2):1-29, 2008.

OBJECTIVES: Occupational or residential exposures to radio-frequency energy (RFE), including microwaves, have been alleged to result in health problems. A review of recent epidemiological studies and studies of humans as subjects in laboratory investigations would be useful. METHODS: This paper is a narrative review of the recent medical and scientific literature (from mid-1998 through early 2006) dealing with possible effects of RFE on humans, relating to topics other than cancer, tumors, and central nervous system effects (areas covered in a previous review). Subject areas in this review include effects on cardiovascular, reproductive, and immune systems. RESULTS: A large number of studies were related to exposures from cellular telephones. Although both positive and negative findings were reported in some studies, in a majority of instances no significant health effects were found. Most studies had some methodological limitations. Although some cardiovascular effects due to RFE were reported in epidemiological studies (e.g., lower 24-h heart rate, blunted circadian rhythm of heart rate), there were no major effects on a large number of cardiovascular parameters in laboratory studies of volunteers during exposure to cell-phone RFE. In population-based studies of a wide range of RFE frequencies, findings were equivocal for effects on birth defects, fertility, neuroblastoma in offspring, and reproductive hormones. Some changes in immunoglobulin levels and in peripheral blood lymphocytes were reported in different studies of radar and radio/television-transmission workers. Due to variations in results and difficulties in comparing presumably exposed subjects with controls, however, it is difficult to propose a unifying hypothesis of immune-system effects. Although subjective symptoms may be produced in some sensitive individuals exposed to RFE, there were no straightforward differences in such symptoms between exposed and control subjects in most epidemiological and laboratory studies. Consistent, strong associations were not found for RFE exposure and adverse health effects. The majority of changes relating to each of the diseases or conditions were small and not significant. CONCLUSIONS: On the basis of previous reviews of older literature and

the current review of recent literature, there is only weak evidence for a relationship between RFE and any endpoint studied (related to the topics above), thus providing at present no sufficient foundation for establishing RFE as a health hazard.

Jayanand, Behari J, Lochan R. Effects of low level pulsed radio frequency fields on induced osteoporosis in rat bone. Indian J Exp Biol. 41(6):581-586, 2003.

Effect of modulated pulsed electromagnetic fields (PEMFs; carrier frequency, 14 MHz. modulated at 16 Hz of amplitude 10 V peak to peak) on sciatic neurectomy induced osteoporosis in rat femur and tibia resulted in statistically significant increase in bone mineral density, and deceleration in bone resorption process and consequently further osteoporosis in rat bone. These results suggest that such an effective window of pulsed radio frequency fields may be used therapeutically for the treatment of osteoporosis.

Jech R, Sonka K, Ruzicka E, Nebuzelsky A, Bohm J, Juklickova M, Nevsimalova S. Electromagnetic field of mobile phones affects visual event related potential in patients with narcolepsy. Bioelectromagnetics 22(7):519-528, 2001.

The effects of the mobile phone (MP) electromagnetic fields on electroencephalography (EEG) and event-related potentials (ERP) were examined. With regard to the reported effects of MP on sleep, 22 patients with narcolepsy-cataplexy were exposed or sham exposed for 45 min to the MP (900 MHz, specific absorption rate 0.06 W/kg) placed close to the right ear in a double blind study. There were no changes of the EEG recorded after the MP exposure. A subgroup of 17 patients was studied on visual ERP recorded during the MP exposure. Using an adapted "odd-ball" paradigm, each patient was instructed to strike a key whenever rare target stimuli were presented. There were three variants of target stimuli (horizontal stripes in (i) left, (ii) right hemifields or (iii) whole field of the screen). The exposure enhanced the positivity of the ERP endogenous complex solely in response to target stimuli in the right hemifield of the screen ($P < 0.01$). The reaction time was shortened by 20 ms in response to all target stimuli ($P < 0.05$). In conclusion, the electromagnetic field of MP may suppress the excessive sleepiness and improve performance while solving a monotonous cognitive task requiring sustained attention and vigilance.

Jelodar G, Akbari A, Nazifi S. The prophylactic Effect of Vitamin C on Oxidative Stress Indexes in Rat Eyes Following Exposure to Radiofrequency Wave Generated by a BTS Antenna Model. Int J Radiat Biol. 89(2):128-131, 2013.

Purpose: This study was conducted to evaluate the effect of radiofrequency wave (RFW)-induced oxidative stress in the eye and the prophylactic effect of vitamin C on this organ by measuring the antioxidant enzymes activity including: glutathione peroxidase (GPx), superoxide dismutase (SOD) and catalase (CAT), and malondialdehyde (MDA). Materials and methods: Thirty-two adult male Sprague-Dawley rats were randomly divided into four experimental groups and treated daily for 45 days as follows: control, vitamin C (L-ascorbic acid 200 mg/kg of body weight/day by gavage), test (exposed to 900 MHz RFW) and the treated group (received vitamin C in addition to exposure to RFW). At the end of the experiment all animals were killed, their eyes were removed and were used for measurement of antioxidant enzymes and MDA activity. Results: The results indicate that exposure to RFW in the test group decreased antioxidant enzymes activity and increased

MDA compared with the control groups (P<0.05). In the treated group vitamin C improved antioxidant enzymes activity and reduced MDA compared to the test group (P<0.05). Conclusions: It can be concluded that RFW causes oxidative stress in the eyes and vitamin C improves the antioxidant enzymes activity and decreases MDA.

Jelodar G, Nazifi S, Akbari A. The prophylactic effect of vitamin C on induced oxidative stress in rat testis following exposure to 900 MHz radio frequency wave generated by a BTS antenna model. Electromagn Biol Med. 2013 Jan 16. [Epub ahead of print]

Radio frequency wave (RFW) generated by base transceiver station (BTS) has been reported to make deleterious effects on reproduction, possibly through oxidative stress. This study was conducted to evaluate the effect of RFW generated by BTS on oxidative stress in testis and the prophylactic effect of vitamin C by measuring the antioxidant enzymes activity, including glutathione peroxidase, superoxide dismutase (SOD) and catalase, and malondialdehyde (MDA). Thirty-two adult male Sprague-Dawley rats were randomly divided into four experimental groups and treated daily for 45 days as follows: sham, sham+vitamin C (l-ascorbic acid 200 mg/kg of body weight/day by gavage), RFW (exposed to 900 MHz RFW) 'sham' and 'RFW' animals were given the vehicle, i.e., distilled water and the RFW+vitamin C group (received vitamin C in addition to exposure to RFW). At the end of the experiment, all the rats were sacrificed and their testes were removed and used for measurement of antioxidant enzymes and MDA activity. The results indicate that exposure to RFW in the test group decreased antioxidant enzymes activity and increased MDA compared with the control groups ($p < 0.05$). In the treated group, vitamin C improved antioxidant enzymes activity and reduced MDA compared with the test group ($p < 0.05$). It can be concluded that RFW causes oxidative stress in testis and vitamin C improves the antioxidant enzymes activity and decreases MDA.

Jenness JW, Lattanzio RJ, O'Toole M, Taylor N, Pax C. Effects of manual versus voice-activated dialing during simulated driving. Percept Mot Skills 94(2):363-379, 2002.

We measured driving performance (lane-keeping errors, driving times, and glances away from the road scene) in a video driving simulator for 24 volunteers who each drove alone on a 10.6-km multicurved course while simultaneously placing calls on a mobile phone subscribed to a voice-activated dialing system. Driving performance also was measured for the same distance while participants manually dialed phone numbers and while they drove without dialing. There were 22% fewer lane-keeping errors (p<.01) and 56% fewer glances away from the road scene (p<.01) when they used voice-activated dialing as compared to manual dialing. Significantly longer driving times in both of the dialing conditions as compared to the No Dialing condition are discussed in terms of the hypothesis that drivers decrease driving speed to compensate for the demands of the secondary phone tasks.

Jensh RP, Behavioral teratologic studies using microwave radiation: is there an increased risk from exposure to cellular phones and microwave ovens?

Reprod Toxicol 11(4):601-611, 1997.

The objective of the investigations presented in this review was to determine if there are adverse effects due to chronic prenatal microwave exposure in rats at term and/or alterations in neonatal and adult offspring psychophysiologic development and growth. Following the establishment of a nonhyperthermal power density level of microwave radiation, pregnant rats were exposed throughout pregnancy to continuous wave 915 MHz, 2450 MHz, or 6000 MHz radiation at power density levels of 10, 20, or 35 mW/cm2, respectively. Teratologic evaluation included the following parameters: maternal weight and weight gain; mean litter size; maternal organ weight and organ weight/body weight ratios; body weight ratios of brain, liver, kidneys, and ovaries; maternal peripheral blood parameters including hematocrit, hemoglobin, and white cell counts; number of resorptions and resorption rate; number of abnormalities and abnormality rate; mean term fetal weight. Mothers were rebred, and the second, nonexposed litters were evaluated for teratogenic effects. Exposed offspring were evaluated using the following perinatal and adult tests: eye opening, surface righting, negative geotaxis, auditory startle, air righting, open field, activity wheel, swimming, and forelimb hanging. Offspring were also monitored for weekly weight and weight gain. Animals exposed to 915 MHz did not exhibit any consistent significant alterations in any of the above parameters. Exposure to 2450 MHz resulted only in a significantly increased adult offspring activity level compared to nonexposed offspring. Offspring exposed to 6000 MHz radiation exhibited an initial slight, but significant, retardation in term weight, while mothers had a significantly reduced monocyte count. No changes in any of the other term parameters were observed. A few postnatal parameters were affected in offspring exposed to 6000 MHz. Weekly weights were lower in the exposed offspring, but they recovered by the fifth week. Eye opening was delayed, and there were changes in the water T-maze and open field performance levels. Several organ/body weight ratios differed from those of the control offspring. These results indicate that exposure to 6000 MHz radiation at this power density level may result in subtle long-term neurophysiologic alterations. However, in the absence of a hyperthermic state, the microwave frequencies tested, which included frequencies used in cellular phones and microwave ovens, do not induce a consistent, significant increase in reproductive risk as assessed by classical morphologic and postnatal psychophysiologic parameters.

Ji S, Oh E, Sul D, Choi JW, Park H, Lee E. DNA Damage of Lymphocytes in Volunteers after 4 hours Use of Mobile Phone. J Prev Med Public Health. 37(4):373-380, 2004.

OBJECTIVES: There has been gradually increasing concern about the adverse health effects of electromagnetic radiation originating from cell phones which are widely used in modern life. Cell phone radiation may affect human health by increasing free radicals of human blood cells. This study has been designed to identify DNA damage of blood cells by electromagnetic radiation caused by cell phone use. **METHODS:** This study investigated the health effect of acute exposure to commercially available cell phones on certain parameters such as an indicator of DNA damage for 14 healthy adult volunteers. Each volunteer during the experiment talked over the cell phone with the keypad facing

the right side of the face for 4 hours. The single cell gel electrophoresis assay (Comet assay), which is very sensitive in detecting the presence of DNA strand-breaks and alkali-labile damage in individual cells, was used to assess peripheral blood cells (T-cells, B-cells, granulocytes) from volunteers before and after exposure to cell phone radiation. The parameters of Comet assay measured were Olive Tail Moment and Tail DNA %. **RESULTS:** The Olive Tail Moment of B-cells and granulocytes and Tail DNA % of B-cells and granulocytes were increased by a statistically significant extent after 4- hour use of a cell phone compared with controls. **CONCLUSIONS:** It is concluded that cell phone radiation caused the DNA damage during the 4 hours of experimental condition. Nonetheless, this study suggested that cell phone use may increase DNA damage by electromagnetic radiation and other contributing factors.

Ji Y, He Q, Sun Y, Tong J, Cao Y. Adaptive response in mouse bone-marrow stromal cells exposed to 900-MHz radiofrequency fields: Gamma-radiation-induced DNA strand breaks and repair. J Toxicol Environ Health A. 79(9-10):419-426, 2016.

The aim of this study was to examine whether radiofrequency field (RF) preexposure induced adaptive responses (AR) in mouse bone-marrow stromal cells (BMSC) and the mechanisms underlying the observed findings. Cells were preexposed to 900-MHz radiofrequency fields (RF) at 120 μW/cm(2) power intensity for 4 h/d for 5 d. Some cells were subjected to 1.5 Gy γ-radiation (GR) 4 h following the last RF exposure. The intensity of strand breaks in the DNA was assessed immediately at 4 h. Subsequently, some BMSC were examined at 30, 60, 90, or 120 min utilizing the alkaline comet assay and γ-H2AX foci technique. Data showed no significant differences in number and intensity of strand breaks in DNA between RF-exposed and control cells. A significant increase in number and intensity of DNA strand breaks was noted in cells exposed to GR exposure alone. RF followed by GR exposure significantly decreased number of strand breaks and resulted in faster kinetics of repair of DNA strand breaks compared to GR alone. Thus, data suggest that RF preexposure protected cells from damage induced by GR. Evidence indicates that in RF-mediated AR more rapid repair kinetics occurs under conditions of GR-induced damage, which may be attributed to diminished DNA strand breakage.

Jia F, Ushiyama A, Masuda H, Lawlor GF, Ohkubo C. Role of blood flow on RF exposure induced skin temperature elevations in rabbit ears. Bioelectromagnetics.28(3):163-172,2007.

In this in vivo study, we measured local temperature changes in rabbit pinnae, which were evoked by radiofrequency (RF) exposure for 20 min at localized SAR levels of 0 (sham exposure), 2.3, 10.0, and 34.3 W/kg over 1.0 g rabbit ear tissue. The effects of RF exposures on skin temperature were measured under normal blood flow and without blood flow in the ear. The results showed: (1) physiological blood flow clearly modified RF induced thermal elevation in the pinna as blood flow significantly suppressed temperature increases even at 34.3 W/kg; (2) under normal blood flow conditions, exposures at 2.3 and 10.0 W/kg, approximating existing safety limits for

the general public (2 W/kg) and occupational exposure (10 W/kg), did not induce significant temperature rises in the rabbit ear. However, 2.3 W/kg induced local skin temperature elevation under no blood flow conditions. Our results demonstrate that the physiological effects of blood flow should be considered when extrapolating modeling data to living animals, and particular caution is needed when interpreting the results of modeling studies that do not include blood flow.

Jiang B, Nie J, Zhou Z, Zhang J, Tong J, Cao Y. Adaptive response in mice exposed to 900 MHz radiofrequency fields: primary DNA damage. PLoS One. 7(2):e32040, 2012.

The phenomenon of adaptive response (AR) in animal and human cells exposed to ionizing radiation is well documented in scientific literature. We have examined whether such AR could be induced in mice exposed to non-ionizing radiofrequency fields (RF) used for wireless communications. Mice were pre-exposed to 900 MHz RF at 120 µW/cm(2) power density for 4 hours/day for 1, 3, 5, 7 and 14 days and then subjected to an acute dose of 3 Gy γ-radiation. The primary DNA damage in the form of alkali labile base damage and single strand breaks in the DNA of peripheral blood leukocytes was determined using the alkaline comet assay. The results indicated that the extent of damage in mice which were pre-exposed to RF for 1 day and then subjected to γ-radiation was similar and not significantly different from those exposed to γ-radiation alone. However, mice which were pre-exposed to RF for 3, 5, 7 and 14 days showed progressively decreased damage and was significantly different from those exposed to γ-radiation alone. Thus, the data indicated that RF pre-exposure is capable of inducing AR and suggested that the pre-exposure for more than 4 hours for 1 day is necessary to elicit such AR.

Jiang B, Zong C, Zhao H, Ji Y, Tong J, Cao Y Induction of adaptive response in mice exposed to 900 MHz radiofrequency fields: Application of micronucleus assay Mutat Res 751(2): 127-129, 2013.

Adult male ICR mice were pre-exposed to non-ionizing radiofrequency fields (RF), 900 MHz at 120 µW/cm^2 power density for 4 h/day for 7 days (adaptation dose, AD) and then subjected to an acute whole body dose of 3 Gy γ-radiation (challenge dose, CD). The classical micronucleus (MN) assay was used to determine the extent of genotoxicity in immature erythrocytes in peripheral blood and bone marrow. The data obtained in mice exposed to AD + CD were compared with those exposed to CD alone. The results indicated that in both tissues, the MN indices were similar in un-exposed controls and those exposed to AD alone while a significantly increased MN frequency was observed in mice exposed to CD alone. Exposure of mice to AD + CD resulted in a significant decrease in MN indices compared to those exposed to CD alone. Thus, the data suggested that pre-exposure of mice to non-ionizing RF is capable of 'protecting' the erythrocytes in the blood and bone marrow from genotoxic effects of subsequent γ-radiation. Such protective phenomenon is generally described as 'adaptive response' (AR) and is well documented in human and animal cells which were pre-exposed to very low doses of ionizing radiation. It is interesting to observe AR being induced by non-ionizing RF.

Jimenez A, Hernandez Madrid A, Pascual J, Gonzalez Rebollo JM, Fernandez E, Sanchez A, Ortega J, Lozano F, Munoz R, Moro C, [Electromagnetic interference between automatic defibrillators and digital and analog cellular telephones]. Rev Esp Cardiol 51(5):375-382, 1998. [Article in Spanish]

BACKGROUND AND OBJECTIVES: Functional pacemaker interference by mobile telephones has been described with analogical systems and with possible greater influence, digital systems, including inhibition and inadequate pacing. The influence of both system has not been extensively studied in patients with implantable cardioverter defibrillators (ICD). PATIENTS AND METHODS: We studied the influence of mobile phones, both digital and analogic network, on the performance of several models of defibrillators, in a standardised test set up designed to provide high sensitivity. The purpose of our study was to establish whether there are any influences on ICD functions, both in in vivo and in in vitro models. Several mobile phones, with different transmission powers, were moved towards the defibrillator and the electrode, under continuous documentation of defibrillator sensing and interrogation afterwards. The experimental model was performed with the aid of an arrhythmia simulator (Intersim) and demo-defibrillators. The tests were repeated both in and out of a solution of saline water with an impedance within normal human limits. RESULTS: Partial loss of telemetry was found in 14 patients, 8 with analogical phones and 6 with digital phones. Fourteen patients showed alterations only on the surface electrocardiogram channel and five on the intracavitary channel. The same results were reproduced in the in vitro model. However, the in vitro test allowed us to simulate multiple ventricular arrhythmias, and demonstrate the normal sensing and functioning of the defibrillator during a "spontaneous" arrhythmia. After testing, we demonstrate that no real oversensing/undersensing was documented in any device. There was no evidence of ICD reprogramming or pacing inhibition. In particular, no inadequate therapies were delivered. CONCLUSIONS: a) in our series, we have not demonstrated clinically significant electromagnetic interferences with mobile phones of digital or analogical networks: b) the in vitro model allowed us to conclude that even if a spontaneous arrhythmia appears, the function of the defibrillator is not altered; c) the use of mobile phones seems to be safe for defibrillator patients, and d) however, some basic rules, such as to maintain the phone at least 15 cm away from the defibrillator, are advised.

Jin YB, Lee HJ, Seon Lee J, Pack JK, Kim N, Lee YS. One-year, simultaneous combined exposure of CDMA and WCDMA radiofrequency electromagnetic fields to rats.Int J Radiat Biol. 87(4):416-423, 2011.

PURPOSE: We investigated whether one-year, long-term, simultaneous exposure to code division multiple access (CDMA; 849 MHz) and wideband code division multiple access (WCDMA; 1.95 GHz) radiofrequencies (RF) would induce chronic illness in Sprague-Dawley (SD) rats. **MATERIALS AND METHODS:** Two groups of 40 SD rats (50% males and females in sham and exposed groups) were exposed to CDMA and WCDMA RF simultaneously at 2.0 W/kg for 45 min/day (total 4.0 W/kg), 5 days per week for a total of one year. Body and organ weight measurements, urinalysis, haematological and blood biochemical analysis, and histopathological evaluations were performed. **RESULTS:** The mortality patterns in male and female rats exposed to RF were

compared with those found in gender-matched sham control animals. No significant alteration in body weight was observed with the simultaneous combined RF exposure. Most RF-exposed rats showed no significant alteration, based on urinalysis, haematology, blood biochemistry, or histopathology. However, some altered parameters of the complete blood count and serum chemistry were seen in RF-exposed rats. The total tumour incidence was not different between sham-exposed and RF-exposed animals. **CONCLUSIONS:** Our results suggest that one-year chronic exposure to CDMA (849 MHz) and WCDMA (1.95 GHz) RF simultaneously at 2.0 W/kg for 45-min RF exposure periods (total, 4 W/kg) did not increase chronic illness in rats, although there were some altered parameters in the complete blood count and serum chemistry.

Jin Z, Zong C, Jiang B, Zhou Z, Tong J, Cao Y.The Effect of Combined Exposure of 900MHz Radiofrequency Fields and Doxorubicin in HL-60 Cells. PLoS One.7(9):e46102, 2012.

Human promyelocytic leukemia HL-60 cells were pre-exposed to non-ionizing 900MHz radiofrequency fields (RF) at 12 μW/cm(2) power density for 1 hour/day for 3 days and then treated with a chemotherapeutic drug, doxorubicin (DOX, 0.125 mg/L). Several end-points related to toxicity, viz., viability, apoptosis, mitochondrial membrane potential (MMP), intracellular free calcium (Ca(2+)) and Ca(2+)-Mg(2+) -ATPase activity were measured. The results obtained in un-exposed and sham-exposed control cells were compared with those exposed to RF alone, DOX alone and RF+DOX. The results indicated no significant differences between un-exposed, sham-exposed control cells and those exposed to RF alone while treatment with DOX alone showed a significant decrease in viability, increased apoptosis, decreased MMP, increased Ca(2+) and decreased Ca(2+)-Mg(2+-)ATPase activity. When the latter results were compared with cells exposed RF+DOX, the data showed increased cell proliferation, decreased apoptosis, increased MMP, decreased Ca(2+) and increased Ca(2+)-Mg(2+)-ATPase activity. Thus, RF pre-exposure appear to protect the HL-60 cells from the toxic effects of subsequent treatment with DOX. These observations were similar to our earlier data which suggested that pre-exposure of mice to 900MHz RF at 120 μW/cm(2) power density for 1 hours/day for 14 days had a protective effect in hematopoietic tissue damage induced by subsequent gamma-irradiation.

Jing J, Yuhua Z, Xiao-qian Y, Rongping J, Dong-mei G, Xi C. The influence of microwave radiation from cellular phone on fetal rat brain. Electromagn Biol Med. 31(1):57-66, 2012.

The increasing use of cellular phones in our society has brought focus on the potential detrimental effects to human health by microwave radiation. The aim of our study was to evaluate the intensity of oxidative stress and the level of neurotransmitters in the brains of fetal rats chronically exposed to cellular phones. The experiment was performed on pregnant rats exposed to different intensities of microwave radiation from cellular phones. Thirty-two pregnant rats were randomly divided into four groups: CG, GL, GM, and GH. CG accepted no microwave radiation,

GL group radiated 10 min each time, GM group radiated 30 min, and GH group radiated 60 min. The 3 experimental groups were radiated 3 times a day from the first pregnant day for consecutively 20 days, and on the 21st day, the fetal rats were taken and then the contents of superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), malondialdehyde (MDA), noradrenaline (NE), dopamine (DA), and 5-hydroxyindole acetic acid (5-HT) in the brain were assayed. Compared with CG, there were significant differences ($P<0.05$) found in the contents of SOD, GSH-Px, and MDA in GM and GH; the contents of SOD and GSH-Px decreased and the content of MDA increased. The significant content differences of NE and DA were found in fetal rat brains in GL and GH groups, with the GL group increased and the GH group decreased. Through this study, we concluded that receiving a certain period of microwave radiation from cellular phones during pregnancy has certain harm on fetal rat brains.

Johansen C, Boice JD, McLaughlin JK, Olsen JH, Cellular Telephones and Cancer-a Nationwide Cohort Study in Denmark. J Natl Cancer Inst 93(3):203-207, 2001.

BACKGROUND: Use of cellular telephones is increasing exponentially and has become part of everyday life. Concerns about possible carcinogenic effects of radiofrequency signals have been raised, although they are based on limited scientific evidence. METHODS: A retrospective cohort study of cancer incidence was conducted in Denmark of all users of cellular telephones during the period from 1982 through 1995. Subscriber lists from the two Danish operating companies identified 420 095 cellular telephone users. Cancer incidence was determined by linkage with the Danish Cancer Registry. All statistical tests are two-sided. RESULTS: Overall, 3391 cancers were observed with 3825 expected, yielding a significantly decreased standardized incidence ratio (SIR) of 0.89 (95% confidence interval [CI] = 0.86 to 0.92). A substantial proportion of this decreased risk was attributed to deficits of lung cancer and other smoking-related cancers. No excesses were observed for cancers of the brain or nervous system (SIR = 0.95; 95% CI = 0.81 to 1.12) or of the salivary gland (SIR = 0.72; 95% CI = 0.29 to 1.49) or for leukemia (SIR = 0.97; 95% CI = 0.78-1.21), cancers of a priori interest. Risk for these cancers also did not vary by duration of cellular telephone use, time since first subscription, age at first subscription, or type of cellular telephone (analogue or digital). Analysis of brain and nervous system tumors showed no statistically significant SIRs for any subtype or anatomic location. CONCLUSIONS: The results of this investigation, the first nationwide cancer incidence study of cellular phone users, do not support the hypothesis of an association between use of these telephones and tumors of the brain or salivary gland, leukemia, or other cancers.

Johansen C, Boice JD Jr, McLaughlin JK, Christensen HC, Olsen JH. Mobile phones and malignant melanoma of the eye. Brit J Cancer 86:348-349, 2002.

Recently a four-fold increase in the risk of malignant melanoma of the eye was associated with the use of radiofrequency transmitting devices, including mobile phones in Germany. We contrasted the incidence rates of this rare cancer with the number of mobile phone subscribers in Denmark. We observed no increasing trend in the incidence rate of melanoma, which was in sharp contrast to the exponentially increasing number of mobile phone subscribers starting in the early 1980s. Our study provides no support for

an association between mobile phones and ocular melanoma.

Johansson A, Forsgren S, Stenberg B, Wilén J, Kalezic N, Sandström M. No effect of mobile phone-like RF exposure on patients with atopic dermatitis.Bioelectromagnetics. 29(5):353-362, 2008.

This study investigates the effect of exposure to a mobile phone-like radiofrequency (RF) electromagnetic field on people with atopic dermatitis (AD). Fifteen subjects with AD were recruited and matched with 15 controls without AD. The subjects were exposed for 30 min to an RF field at 1 W/kg via an indoor base station antenna attached to a 900 MHz GSM mobile phone. Blood samples for ELISA analysis of the concentration of substance P (SP), tumor necrosis factor receptor 1 (TNF R1), and brain derived neurotrophic factor (BDNF) in serum were drawn before and after the provocation (exposure/sham). Baseline heart rate and heart rate variability, local blood flow, and electrodermal activity were also recorded. No significant differences between the subject groups were found for baseline neurophysiological data. The cases displayed a serum concentration of TNF R1 significantly higher than the control subjects and a significantly lower serum concentration of BDNF in the baseline condition. For SP there was no difference between groups. However, no effects related to RF exposure condition were encountered for any of the measured substances. As to symptoms, a possible correlation with exposure could not be evaluated, due to too few symptom reports. The result of the study does not support the hypothesis of an effect of mobile phone-like RF exposure on serum levels of SP, TNF R1, and BDNF in persons with AD.

Johansson A, Nordin S, Heiden M, Sandström M. Symptoms, personality traits, and stress in people with mobile phone-related symptoms and electromagnetic hypersensitivity. J Psychosom Res. 68(1):37-45, 2010.

OBJECTIVE: Some people report symptoms that they associate with electromagnetic field (EMF) exposure. These symptoms may be related to specific EMF sources or to electrical equipment in general (perceived electromagnetic hypersensitivity, EHS). Research and clinical observations suggest a difference between mobile phone (MP)-related symptoms and EHS with respect to symptom prevalence, psychological factors, and health prognosis. This study assessed prevalence of EMF-related and EMF-nonrelated symptoms, anxiety, depression, somatization, exhaustion, and stress in people with MP-related symptoms or EHS versus a population-based sample and a control sample without EMF-related symptoms. METHODS: Forty-five participants with MP-related symptoms and 71 with EHS were compared with a population-based sample (n=106) and a control group (n=63) using self-report questionnaires. RESULTS: The EHS group reported more symptoms than the MP group, both EMF-related and EMF-nonrelated. The MP group reported a high prevalence of somatosensory symptoms, whereas the EHS group reported more neurasthenic symptoms. As to self-reported personality traits and stress, the case groups differed only on somatization and listlessness in a direct comparison. In comparison with the reference groups, the MP group showed increased levels of exhaustion and depression but not of anxiety, somatization, and stress; the EHS

group showed increased levels for all of the conditions except for stress. CONCLUSION: The findings support the idea of a difference between people with symptoms related to specific EMF sources and people with general EHS with respect to symptoms and anxiety, depression, somatization, exhaustion, and stress. The differences are likely to be important in the management of patients.

Johnson EH, Chima SC, Muirhead DE, A cerebral primitive neuroectodermal tumor in a squirrel monkey (Saimiri sciureus). J Med Primatol 28(2):91-96, 1999.

An adult squirrel monkey with a history of long-term exposure to microwave radiation was found at necropsy to have a malignant tumor of the right cerebral cortex. Gross examination revealed a mass with expanding borders in the right frontoparietal cortex with compression of the adjacent lateral ventricle. Microscopy revealed a tumor composed of sheets of moderate-sized cells, resembling an oligodendroglioma, with clear cytoplasm and central nuclei interrupted by delicate vasculature. Malignant features were present in the form of marked nuclear pleomorphism, frequent mitotic figures, and focal necrosis. A neuronal cell origin for this tumor was supported by immunohistochemical analysis, which revealed immunopositivity for neurofilament proteins and neuron-specific enolase. Staining for vimentin and glial fibrillary acid protein was negative, except in reactive astrocytes at the tumor margins and adjacent to intra-tumoral blood vessels. Antibody activity against Ki-67 antigen, a marker of rapidly proliferating tumor cells, and p53 oncoprotein was strongly positive, indicative of the aggressive and malignant nature of this tumor. The tumor was diagnosed as a cerebral primitive neuroectodermal tumor.

Johnson Liakouris AG, Radiofrequency (RF) sickness in the Lilienfeld Study: an effect of modulated microwaves? Arch Environ Health 53(3):236-238, 1998.

There is a controversy among professionals regarding whether radiofrequency radiation sickness syndrome is a medical entity. In this study, this controversy was evaluated with a methodology adapted from case studies. The author reviewed U.S. literature, which revealed that research results are sufficiently consistent to warrant further inquiry. A review of statistically significant health effects noted in the Lilienfeld Study provided evidence that the disregarded health conditions match the cluster attributed to the radiofrequency sickness syndrome, thus establishing a possible correlation between health effects and chronic exposure to low-intensity, modulated microwave radiation. The author discusses these health effects relative to (a) exposure parameters recorded at the U.S. Embassy in Moscow and (b) the Soviet 10-microwatt safety standard for the public. Given the evidence, new research-with current knowledge and technology-is proposed.

Jokela K, Puranen L, Sihvonen AP. Assessment of the magnetic field exposure due to the battery current of digital mobile phones. Health Phys. 86(1):56-66, 2004.

Hand-held digital mobile phones generate pulsed magnetic fields associated with the battery current. The peak value and the waveform of the battery current were measured for seven different models of digital mobile phones, and the results were applied to compute approximately the magnetic flux density and induced currents in the phone-user's head. A simple circular loop model was used for the magnetic field source and a homogeneous sphere consisting of average brain tissue equivalent material simulated the head. The broadband magnetic flux density and the maximal induced current density

were compared with the guidelines of ICNIRP using two various approaches. In the first approach the relative exposure was determined separately at each frequency and the exposure ratios were summed to obtain the total exposure (multiple-frequency rule). In the second approach the waveform was weighted in the time domain with a simple low-pass RC filter and the peak value was divided by a peak limit, both derived from the guidelines (weighted peak approach). With the maximum transmitting power (2 W) the measured peak current varied from 1 to 2.7 A. The ICNIRP exposure ratio based on the current density varied from 0.04 to 0.14 for the weighted peak approach and from 0.08 to 0.27 for the multiple-frequency rule. The latter values are considerably greater than the corresponding exposure ratios 0.005 (min) to 0.013 (max) obtained by applying the evaluation based on frequency components presented by the new IEEE standard. Hence, the exposure does not seem to exceed the guidelines. The computed peak magnetic flux density exceeded substantially the derived peak reference level of ICNIRP, but it should be noted that in a near-field exposure the external field strengths are not valid indicators of exposure. Currently, no biological data exist to give a reason for concern about the health effects of magnetic field pulses from mobile phones.

Jones RP, Conway DH. The effect of electromagnetic interference from mobile communication on the performance of intensive care ventilators. Eur J Anaesthesiol. 22(8):578-583, 2005.

Electromagnetic interference produced by wireless communication can affect medical devices and hospital policies exist to address this risk. During the transfer of ventilated patients, these policies may be compromised by essential communication between base and receiving hospitals. Local wireless networks (e.g. Bluetooth) may reduce the 'spaghetti syndrome' of wires and cables seen on intensive care units, but also generate electromagnetic interference. The aim of this study was to investigate these effects on displayed and actual ventilator performance. METHODS: Five ventilators were tested: Drager Oxylog 2000, BREAS LTV-1000, Respironics BiPAP VISION, Puritan Bennett 7200 and 840. Electromagnetic interference was generated by three devices: Simoco 8020 radio handset, Nokia 7210 and Nokia 6230 mobile phone, Nokia 6230 communicating via Bluetooth with a Palm Tungsten T Personal Digital Assistant. We followed the American National Standard Recommended Practice for On-Site, Ad Hoc Testing (ANSI C63) for electromagnetic interference. We used a ventilator tester, to simulate healthy adult lungs and measure ventilator performance. The communication device under test was moved in towards each ventilator from a distance of 1 m in six axes. Alarms or error codes on the ventilator were recorded, as was ventilator performance. RESULTS: All ventilators tested, except for the Respironics VISION, showed a display error when subjected to electromagnetic interference from the Nokia phones and Simoco radio. Ventilator performance was only affected by the radio which caused the Puritan Bennett 840 to stop functioning completely. The transfer ventilators' performance were not affected by radio or mobile phone, although the mobile phone did trigger a low-power alarm. Effects on intensive care ventilators included display reset, with the ventilator restoring normal display function within 2 s, and low-power/low-pressure alarms. Bluetooth transmission had no effect on the function of all the ventilators tested. CONCLUSION: In a clinical setting, high-power-output devices such as a two-way radio may cause significant interference in ventilator function. Medium-power-output devices

such as mobile phones may cause minor alarm triggers. Low-power-output devices such as Bluetooth appear to cause no interference with ventilator function.

Jorge-Mora T, Folgueiras MA, Leiro-Vidal JM, Jorge-Barreiro FJ, Ares-Pena FJ, López-Martin E. Exposure to 2.45 GHz Microwave Radiation Provokes Cerebral Changes in Induction of Hsp-90 α/β Heat Shock Protein in Rat. **Prog Electromagn Res, 100:351-379, 2010.**

Physical agents such as non-ionizing continuous-wave 2.45 GHz radiation may cause damage that alters cellular homeostasis and may trigger activation of the genes that encode heat shock proteins (HSP). We used Enzyme-Linked ImmunoSorbent Assay (ELISA) and immunohistochemistry to analyze the changes in levels of HSP-90 and its distribution in the brain of Sprague-Dawley rats, ninety minutes and twenty-four hours after acute (30min) continuous exposure to 2.45 GHz radiation in a the Gigahertz Transverse Electromagnetic (GTEM cell). In addition, we studied further indicators of neuronal insult: dark neurons, chromatin condensation and nucleus fragmentation, which were observed under optical conventional or fluorescence microscopy after DAPI staining. The cellular distribution of protein HSP-90 in the brain increased with each corresponding SAR (0.034 ± 3.10^{-3}, 0.069 ± 5.10^{-3}, 0.27 ± 21.10^{-3} W/kg), in hypothalamic nuclei, limbic cortex and somatosensorial cortex after exposure to the radiation. At twenty-four hours post-irradiation, levels of HSP-90 protein remained high in all hypothalamic nuclei for all SARs, and in the parietal cortex, except the limbic system, HSP-90 levels were lower than in non-irradiated rats, almost half the levels in rats exposed to the highest power radiation. Non-apoptotic cellular nuclei and a some dark neurons were found ninety minutes and twenty-four hours after maximal SAR exposure. The results suggest that acute exposure to electromagnetic fields triggered an imbalance in anatomical HSP- 90 levels but the anti-apoptotic mechanism is probably sufficient to compensate the non-ionizing stimulus. Further studies are required to determine the regional effects of chronic electromagnetic pollution on heat shock proteins and their involvement in neurological processes and neuronal damage.

Jorge-Mora T, Misa-Agustiño MJ, Rodríguez-González JA, Jorge-Barreiro FJ, Ares-Pena FJ, López-Martín E. The effects of single and repeated exposure to 2.45 GHz radiofrequency fields on c-Fos protein expression in the paraventricular nucleus of rat hypothalamus. Neurochem Res. 36(12):2322-2332, 2011.

This study investigated the effects of microwave radiation on the PVN of the hypothalamus, extracted from rat brains. Expression of c-Fos was used to study the pattern of cellular activation in rats exposed once or repeatedly (ten times in 2 weeks) to 2.45 GHz radiation in a GTEM cell. The power intensities used were 3 and 12 W and the Finite Difference Time Domain calculation was used to determine the specific absorption rate (SAR). High SAR triggered an increase of the c-Fos marker 90 min or 24 h after radiation, and low SAR resulted in c-Fos counts higher than in control rats after 24 h. Repeated irradiation at 3 W increased cellular activation of PVN by more than 100% compared to animals subjected to acute irradiation and to repeated non-radiated repeated session control animals. The results suggest that PVN is sensitive to 2.45 GHz microwave radiation at non-thermal SAR levels.

Joseph W, Vermeeren G, Verloock L, Heredia MM, Martens LCharacterization of personal RF electromagnetic field exposure and actual absorption for the general public.Health Phys. 95(3):317-330, 2008.

In this paper, personal electromagnetic field exposure of the general public due to 12 different radiofrequency sources is characterized. Twenty-eight different realistic exposure scenarios based upon time, environment, activity, and location have been defined and a relevant number of measurements were performed with a personal exposure meter. Indoor exposure in office environments can be higher than outdoor exposure: 95th percentiles of field values due to WiFi ranged from 0.36 to 0.58 V m(-1), and for DECT values of 0.33 V m(-1) were measured. The downlink signals of GSM and DCS caused the highest outdoor exposures up to 0.52 V m(-1). The highest total field exposure occurred for mobile scenarios (inside a train or bus) from uplink signals of GSM and DCS (e.g., mobile phones) due to changing environmental conditions, handovers, and higher required transmitted signals from mobile phones due to penetration through windows while moving. A method to relate the exposure to the actual whole-body absorption in the human body is proposed. An application is shown where the actual absorption in a human body model due to a GSM downlink signal is determined. Fiftieth, 95th, and 99 th percentiles of the whole-body specific absorption rate (SAR) due to this GSM signal of 0.58 microW kg(-1), 2.08 microW kg(-1), and 5.01 microW kg(-1) are obtained for a 95th percentile of 0.26 V m(-1). A practical usable function is proposed for the relation between the whole-body SAR and the electric fields. The methodology of this paper enables epidemiological studies to make an analysis in combination with both electric field and actual whole-body SAR values and to compare exposure with basic restrictions.

Joseph W, Verloock L, Tanghe E, Martens L. In-situ measurement procedures for temporal RF electromagnetic field exposure of the general public.Health Phys. 96(5):529-542, 2009.

In this paper, the general public's exposure to FM, GSM, and UMTS over 7 day's time is investigated. The purpose of this paper is to investigate how short-period measurements can be representative for the actual maximal and average exposure during longer periods such as 1 week. Locations of public RF exposure have been categorized according to the type of environment, population density, and the amount of mobile phone traffic. Five different sites have been selected to perform measurements of the electric fields over time. In total 352,800 time samples of the electric field were obtained from the measurement campaign. A factor X is defined as the ratio between the actual maximal value of the temporal measurements and the estimated maximal value from short-period data. Three different methods to assess X are compared and an optimal method is proposed for an in-situ measurement procedure. Median values of X according to the proposed method are 1.05, 0.47, and 0.96, for FM, GSM, and UMTS, respectively. Moreover a factor R is defined as the ratio between the median and maximal value of the momentary temporal field measurements, indicating the level of variation of a certain signal over time. R enables to calculate maximal values from median values and vice versa. Median values of R are 0.92, 0.66, and 0.71 for FM, GSM, and UMTS,

respectively. By combining X and R one can estimate the actual maximal and median exposure during longer periods from short-period measurements

Joseph W, Frei P, Roösli M, Thuróczy G, Gajsek P, Trcek T, Bolte J, Vermeeren G, Mohler E, Juhász P, Finta V, Martens L. Comparison of personal radio frequency electromagnetic field exposure in different urban areas across Europe. Environ Res.110(7):658-663,2010.

BACKGROUND: Only limited data are available on personal radio frequency electromagnetic field (RF-EMF) exposure in everyday life. Several European countries performed measurement studies in this area of research. However, a comparison between countries regarding typical exposure levels is lacking. OBJECTIVES: To compare for the first time mean exposure levels and contributions of different sources in specific environments between different European countries. METHODS: In five countries (Belgium, Switzerland, Slovenia, Hungary, and the Netherlands), measurement studies were performed using the same personal exposure meters. The pooled data were analyzed using the robust regression on order statistics (ROS) method in order to allow for data below the detection limit. Mean exposure levels were compared between different microenvironments such as homes, public transports, or outdoor. RESULTS: Exposure levels were of the same order of magnitude in all countries and well below the international exposure limits. In all countries except for the Netherlands, the highest total exposure was measured in transport vehicles (trains, car, and busses), mainly due to radiation from mobile phone handsets (up to 97%). Exposure levels were in general lower in private houses or flats than in offices and outdoors. At home, contributions from various sources were quite different between countries. CONCLUSIONS: Highest total personal RF-EMF exposure was measured inside transport vehicles and was well below international exposure limits. This is mainly due to mobile phone handsets. Mobile telecommunication can be considered to be the main contribution to total RF-EMF exposure in all microenvironments.

Joseph W, Verloock L. Influence of mobile phone traffic on base station exposure of the general public.Health Phys. 99(5):631-638, 2010.

The influence of mobile phone traffic on temporal radiofrequency exposure due to base stations during 7 d is compared for five different sites with Erlang data (representing average mobile phone traffic intensity during a period of time). The time periods of high exposure and high traffic during a day are compared and good agreement is obtained. The minimal required measurement periods to obtain accurate estimates for maximal and average long-period exposure (7 d) are determined. It is shown that these periods may be very long, indicating the necessity of new methodologies to estimate maximal and average exposure from short-period measurement data. Therefore, a new method to calculate the fields at a time instant from fields at another time instant using normalized Erlang values is proposed. This enables the estimation of maximal and average exposure during a week from short-period measurements using only Erlang data and avoids the necessity of long measurement times.

Joseph W, Verloock L, Goeminne F, Vermeeren G, Martens L. Assessment of general public exposure to LTE and RF sources present in an urban environment.Bioelectromagnetics. 31(7):576-579, 2010.

For the first time, in situ electromagnetic field exposure of the general public to fields from long term evolution (LTE) cellular base stations is assessed. Exposure contributions due to different radiofrequency (RF) sources are compared with LTE exposure at 30 locations in Stockholm, Sweden. Total exposures (0.2-2.6 V/m) satisfy the International Commission on Non-Ionizing Radiation Protection (ICNIRP) reference levels (from 28 V/m for frequency modulation (FM), up to 61 V/m for LTE) at all locations. LTE exposure levels up to 0.8 V/m were measured, and the average contribution of the LTE signal to the total RF exposure equals 4%.

Joseph W, Vermeeren G, Verloock L, Martens L. Estimation of whole-body SAR from electromagnetic fields using personal exposure meters. Bioelectromagnetics. 31(4):286-295, 2010.

In this article, personal electromagnetic field measurements are converted into whole-body specific absorption rates for exposure of the general public. Whole-body SAR values calculated from personal exposure meter data are compared for different human spheroid phantoms: the highest SAR values (at 950 MHz) are obtained for the 1-year-old child (99th percentile of 17.9 microW/kg for electric field strength of 0.36 V/m), followed by the 5-year-old child, 10-year-old child, average woman, and average man. For the 1-year-old child, whole-body SAR values due to 9 different radiofrequency sources (FM, DAB, TETRA, TV, GSM900 DL, GSM1800 DL, DECT, UMTS DL, WiFi) are determined for 15 different scenarios. An SAR matrix for 15 different exposure scenarios and 9 sources is provided with the personal field exposure matrix. Highest 95th percentiles of the whole-body SAR are equal to 7.9 microW/kg (0.36 V/m, GSM900 DL), 5.8 microW/kg (0.26 V/m, DAB/TV), and 7.1 microW/kg (0.41 V/m, DECT) for the 1-year-old child, with a maximal total whole-body SAR of 11.5 microW/kg (0.48 V/m) due to all 9 sources. All values are below the basic restriction of 0.08 W/kg for the general public. 95th percentiles of whole-body SAR per V/m are equal to 60.1, 87.9, and 42.7 microW/kg for GSM900, DAB/TV, and DECT sources, respectively. Functions of the SAR versus measured electric fields are provided for the different phantoms and frequencies, enabling epidemiological and dosimetric studies to make an analysis in combination with both electric field and actual whole-body SAR.

Joseph W, Frei P, Röösli M, Vermeeren G, Bolte J, Thuróczy G, Gajšek P, Trček T, Mohler E, Juhász P, Finta V, Martens L. Between-country comparison of whole-body SAR from personal exposure data in urban areas.Bioelectromagnetics. 33(8):682-694, 2012.

In five countries (Belgium, Switzerland, Slovenia, Hungary, and the Netherlands), personal radio frequency electromagnetic field measurements were performed in different microenvironments such as homes, public transports, or outdoors using the same exposure meters. From the mean personal field exposure levels (excluding mobile phone

exposure), whole-body absorption values in a 1-year-old child and adult male model were calculated using a statistical multipath exposure method and compared for the five countries. All mean absorptions (maximal total absorption of 3.4 μW/kg for the child and 1.8 μW/kg for the adult) were well below the International Commission on Non-Ionizing Radiation Protection (ICNIRP) basic restriction of 0.08 W/kg for the general public. Generally, incident field exposure levels were well correlated with whole-body absorptions (SAR(wb)), although the type of microenvironment, frequency of the signals, and dimensions of the considered phantom modify the relationship between these exposure measures. Exposure to the television and Digital Audio Broadcasting band caused relatively higher SAR(wb) values (up to 65%) for the 1-year-old child than signals at higher frequencies due to the body size-dependent absorption rates. Frequency Modulation (FM) caused relatively higher absorptions (up to 80%) in the adult male.

Joseph W, Goeminne F, Verloock L, Vermeeren G, Martens L. In situ occupational and general public exposure to VHF/UHF transmission for air traffic communication.Radiat Prot Dosimetry.151(3):411-419, 2012.

Occupational and general public exposure due to very high frequency (VHF)/ultra high frequency (UHF) transmission centres for verbal communication for air traffic control is investigated in situ for the first time. These systems are used for communication with aircraft, resulting in different human exposure from that of classical broadcasting. Measurement methods are proposed for the exposure assessment, and a measurement campaign is executed in three transmission centres. By investigating the temporal behaviour of the VHF signals for 6 d, a realistic worst-case duty cycle of 29 % is determined. Periods of high exposures corresponding with high aircraft traffic are from 7 a.m. to 1 p.m. and in the evening. All measured electric-field values satisfy the International Commission on Non-ionizing Radiation Protection guidelines. Fields vary from 0.2 to 21.1 V m(-1) for occupational exposure and from 0.007 to 8.0 V m(-1) for general public exposure. The average fields equal 5.2 V m(-1) for workers, and 0.7 V m(-1) for general public.

Joseph W, Verloock L, Goeminne F, Vermeeren G, Martens L.In situ LTE exposure of the general public: Characterization and extrapolation.Bioelectromagnetics.33(6):466-475, 2012.

In situ radiofrequency (RF) exposure of the different RF sources is characterized in Reading, United Kingdom, and an extrapolation method to estimate worst-case long-term evolution (LTE) exposure is proposed. All electric field levels satisfy the International Commission on Non-Ionizing Radiation Protection (ICNIRP) reference levels with a maximal total electric field value of 4.5 V/m. The total values are dominated by frequency modulation (FM). Exposure levels for LTE of 0.2 V/m on average and 0.5 V/m maximally are obtained. Contributions of LTE to the total exposure are limited to 0.4% on average. Exposure ratios from 0.8% (LTE) to 12.5% (FM) are obtained. An extrapolation method is proposed and validated to assess the worst-case LTE exposure. For this method, the reference signal (RS) and secondary synchronization signal (S-SYNC) are measured and extrapolated to the worst-case value using an extrapolation factor. The influence of the

traffic load and output power of the base station on in situ RS and S-SYNC signals are lower than 1 dB for all power and traffic load settings, showing that these signals can be used for the extrapolation method. The maximal extrapolated field value for LTE exposure equals 1.9 V/m, which is 32 times below the ICNIRP reference levels for electric fields.

Joseph W, Goeminne F, Vermeeren G, Verloock L, Martens L. In situ exposure to non-directional beacons for air traffic control.Bioelectromagnetics. 33(3):274-277, 2012.

In situ electromagnetic field exposure of workers and the general public due to non-directional beacons (NDB) for air traffic control is assessed and characterized. For occupational exposure, the maximal measured electric field value is 881.6 V/m and the maximal magnetic field value is 9.1 A/m. The maximum electric fields exceed the International Commission on Non-Ionizing Radiation Protection (ICNIRP) reference levels at all seven NDB sites, and the magnetic fields at two of the seven NDB sites (occupational exposure). Recommendations and compliance distances for workers and the general public are provided.

Joseph W, Verloock L, Goeminne F, Vermeeren G, Martens L. Assessment of RF exposures from emerging wireless communication technologies in different environments.Health Phys. 102(2):161-172, 2012.

In situ electromagnetic (EM) radio frequency (RF) exposure to base stations of emerging wireless technologies is assessed at 311 locations, 68 indoor and 243 outdoor, spread over 35 areas in three European countries (Belgium, The Netherlands, and Sweden) by performing narrowband spectrum analyzer measurements. The locations are selected to characterize six different environmental categories (rural, residential, urban, suburban, office, and industrial). The maximal total field value was measured in a residential environment and equal to 3.9 V m(-1), mainly due to GSM900 signals. Exposure ratios for maximal electric field values, with respect to ICNIRP reference levels, range from 0.5% (WiMAX) to 9.3% (GSM900) for the 311 measurement locations. Exposure ratios for total field values vary from 3.1% for rural environments to 9.4% for residential environments. Exposures are lognormally distributed and are the lowest in rural environments and the highest in urban environments. Highest median exposures were obtained in urban environments (0.74 V m(-1)), followed by office (0.51 V m(-1)), industrial (0.49 V m(-1)), suburban (0.46 V m(-1)), residential (0.40 V m(-1)), and rural (0.09 V m(-1)) environments. The average contribution to the total electric field is more than 60% for GSM. Except for the rural environment, average contributions of UMTS-HSPA are more than 3%. Contributions of the emerging technologies LTE and WiMAX are on average less than 1%. The dominating outdoor source is GSM900 (95 percentile of 1.9 V m(-1)), indoor DECT dominates (95 percentile of 1.5 V m(-1)).

Joseph W, Goeminne F, Vermeeren G, Verloock L, Martens L.Occupational and public field exposure from communication, navigation, and radar systems used for air traffic control.Health Phys. 103(6):750-762, 2012.

ABSTRACT: Electromagnetic exposure (occupational and general public) to 14 types of air traffic control (ATC) systems is assessed. Measurement methods are proposed for in situ exposure assessment of these ATC systems. In total, 50 sites are investigated at 1,073 locations in the frequency range of 255 kHz to 24 GHz. For all installations, typical and maximal exposure values for workers and the general public are provided. Two of the 14 types of systems, Non-Directional Beacons (NDB) (up to 881.6 V m) and Doppler Very High Frequency (VHF) Omni-directional Range (DVOR) (up to 92.3 V m), exhibited levels requiring recommended minimum distances such that the ICNIRP reference levels are not exceeded. Cumulative exposure of all present radiofrequency (RF) sources is investigated, and it is concluded that the ATC source dominates the total exposure in its neighborhood.

Joubert V, Leveque P, Rametti A, Collin A, Bourthoumieu S, Yardin C. Microwave exposure of neuronal cells in vitro: Study of apoptosis. Int J Radiat Biol. 82(4):267-275, 2006.

Purpose:The aim of this study was to investigate microwave (MW) effects on neuronal apoptosis in vitro.Materials and methods:Human neuroblastoma cells SH-SY5Y were exposed to a 900 MHz global system for mobile communication (GSM) or continuous-wave (CW) radiofrequency fields for 24 h in a wire-patch cell. The specific absorption rates (SAR) used were 2 W/kg for CW and 0.25 W/kg average for GSM. During CW exposure, an increase of 2 degrees C was measured, and controls with cells exposed to 39 degrees C were then performed. Apoptosis rate was assessed immediately or 24 h after exposure using three methods: (i) 4',6-diamino-2-phenylindole (DAPI) staining; (ii) flow cytometry using double staining with TdT-mediated dUTP nick-end labeling (TUNEL) and propidium iodide (PI); and (iii) measurement of caspase-3 activity by fluorimetry.Results:No statistically significant difference in the apoptosis rate was observed between sham and 24 h MW-exposed cells, either GSM-900 at an average SAR of 0.25 W/kg, or CW 900 MHz at a SAR of 2 W/kg, either 0 h or 24 h post-exposure. Furthermore, for CW-exposure, apoptosis rates were comparable between sham-, CW-, 37 degrees C- and 39 degrees C-exposed cells. All three methods used to assess apoptosis were concordant.Conclusion:These results showed that, under the conditions of the present experiment, MW-exposure (either CW or GSM-900) does not significantly increase the apoptosis rate in the human neuroblastoma cell line SH-SY5Y.

Joubert V, Leveque P, Cueille M, Bourthoumieu S, Yardin C. No apoptosis is induced in rat cortical neurons exposed to GSM phone fields. Bioelectromagnetics.38(2) 115-121, 2007.

The aim of this study was to investigate the radiofrequency (RF) electromagnetic fields (EMF) effects on neuronal apoptosis in vitro. Primary cultured neurons from cortices of embryonic Wistar rats were exposed to a 900-MHz global system for mobile communication (GSM) RF field for 24 h in a wire-patch cell. The average-specific absorption rate (SAR) used was 0.25 W/kg. Apoptosis rate was assessed immediately or 24 h after exposure using three methods: (i) DAPI staining; (ii) flow cytometry using double staining with TdT-mediated dUTP nick-end labeling (TUNEL) and propidium

iodide (PI); and (iii) measurement of caspase-3 activity by fluorimetry. No statistically significant difference in the apoptosis rate was observed between controls and 24 h GSM-exposed neurons, either 0 h or 24 h post-exposure. All three methods used to assess apoptosis were concordant. These results showed that, under the conditions of experiment used, GSM-exposure does not significantly increase the apoptosis rate in rat primary neuronal cultures. This work is in accordance with other studies performed on cell lines and, to our knowledge, is the first one performed on cultured cortical neurons.

Joubert V, Bourthoumieu S, Leveque P, Yardin C. Apoptosis is Induced by Radiofrequency Fields through the Caspase-Independent Mitochondrial Pathway in Cortical Neurons. Radiat Res. 169(1):38-45, 2008.

In the present study, we investigated whether continuous-wave (CW) radiofrequency (RF) fields induce neuron apoptosis in vitro. Rat primary neuronal cultures were exposed to a CW 900 MHz RF field with a specific absorption rate (SAR) of 2 W/kg for 24 h. During exposure, an increase of 2 degrees C was measured in the medium; control experiments with neurons exposed to 39 degrees C were then performed. Apoptosis was assessed by condensation of nuclei with 4',6-diamino-2-phenylindole (DAPI) staining observed with an epifluorescence microscope and fragmentation of DNA with TdT-mediated dUTP nick-end labeling (TUNEL) analyzed by flow cytometry. A statistically significant difference in the rate of apoptosis was found in the RF-field-exposed neurons compared to the sham-, 37 degrees C- and 39 degrees C-exposed neurons either 0 or 24 h after exposure using both methods. To assess whether the observed apoptosis was caspase-dependent or -independent, assays measuring caspase 3 activity and apoptosis-inducing factor (AIF) labeling were performed. No increase in the caspase 3 activity was found, whereas the percentage of AIF-positive nuclei in RF-field-exposed neurons was increased by three- to sevenfold compared to other conditions. Our results show that, under the experimental conditions used, exposure of primary rat neurons to CW RF fields may induce a caspase-independent pathway to apoptosis that involves AIF.

Jovanovic D, Bragard G, Picard D, Chauvin S. Mobile telephones: A comparison of radiated power between 3G VoIP calls and 3G VoCS calls. J Expo Sci Environ Epidemiol. 2014 Nov 5. doi: 10.1038/jes.2014.74. [Epub ahead of print]

The purpose of this study is to assess the mean RF power radiated by mobile telephones during voice calls in 3G VoIP (Voice over Internet Protocol) using an application well known to mobile Internet users, and to compare it with the mean power radiated during voice calls in 3G VoCS (Voice over Circuit Switch) on a traditional network. Knowing that the specific absorption rate (SAR) is proportional to the mean radiated power, the user's exposure could be clearly identified at the same time. Three 3G (High Speed Packet Access) smartphones from three different manufacturers, all dual-band for GSM (900 MHz, 1800 MHz) and dual-band for UMTS (900 MHz, 1950 MHz), were used between 28 July and 04 August 2011 in Paris (France) to make 220 two-minute calls on a mobile telephone network with national coverage. The places where the calls were made were selected in such a way as to describe the whole range of usage situations of the mobile telephone. The measuring equipment, called "SYRPOM", recorded the radiation

power levels and the frequency bands used during the calls with a sampling rate of 20,000 per second. In the framework of this study, the mean normalised power radiated by a telephone in 3G VoIP calls was evaluated at 0.75% maximum power of the smartphone, compared with 0.22% in 3G VoCS calls. The very low average power levels associated with use of 3G devices with VoIP or VoCS support the view that RF exposure resulting from their use is far from exceeding the basic restrictions of current exposure limits in terms of SAR.

Júnior LC, Guimarães ED, Musso CM, Stabler CT, Garcia RM, Mourão-Júnior CA, Andreazzi AE. Behavior and memory evaluation of Wistar rats exposed to 1·8 GHz radiofrequency electromagnetic radiation. Neurol Res. 36(9):800-803, 2014.

Background: The development of communication systems has brought great social and economic benefits to society. As mobile phone use has become widespread, concerns have emerged regarding the potential adverse effects of radiofrequency electromagnetic radiation (RF-EMR) used by these devices. Objective: To verify potential effects of mobile phone radiation on the central nervous system (CNS) in an animal model. Methods: Male Wistar rats (60 days old) were exposed to RF-EMR from a Global System for Mobile (GSM) cell phone (1·8 GHz) for 3 days. At the end of the exposure, the following behavioral tests were performed: open field and object recognition. Results: Our results showed that exposed animals did not present anxiety patterns or working memory impairment, but stress behavior actions were observe. Conclusion: Given the results of the present study, we speculate that RF-EMR does not promote CNS impairment, but suggest that it may lead to stressful behavioral patterns.

Juutilainen J, Heikkinen P, Soikkeli H, Mäki-Paakkanen J. Micronucleus frequency in erythrocytes of mice after long-term exposure to radiofrequency radiation. Int J Radiat Biol. 83(4):213-220, 2007.

PURPOSE: The aim of the study was to investigate genotoxicity of long-term exposure to radiofrequency (RF) electromagnetic fields by measuring micronuclei in erythrocytes. The blood samples were collected in two animal studies evaluating possible cocarcinogenic effects of RF fields. METHODS: In study A, female CBA/S mice were exposed for 78 weeks (1.5 h/d, 5 d/week) to either a continuous 902.5 MHz signal similar to that emitted by analog NMT (Nordic Mobile Telephone) phones at a whole-body specific absorption rate (SAR) of 1.5 W/kg, or to a pulsed 902.4 MHz signal similar to that of digital GSM (Global System for Mobile Communications) phones at 0.35 W/kg. A third group was sham-exposed, and a fourth group served as cage controls. All but the cage control animals were exposed to 4 Gy of x-rays during three first weeks of the experiment. In study B, female transgenic mice (line K2) and their nontransgenic littermates were exposed for 52 weeks (1.5 h/d, 5 d/week). Two digital mobile phone signals, GSM and DAMPS (Digital Advanced Mobile Phone System), were used at 0.5 W/kg. All but the cage-control animals were exposed 3 times per week to an ultraviolet radiation dose of 1.2 MED (minimum erythema dose). RESULTS AND CONCLUSIONS: The results did not show any effects of RF fields on micronucleus frequency in polychromatic or normochromatic erythrocytes. The

results were consistent in two mouse strains (and in a transgenic variant of the second strain), after 52 or 78 weeks of exposure, at three SAR levels relevant to human exposure from mobile phones, and for three different mobile signals.

Kahn AA, O'Brien DF, Kelly P, Phillips JP, Rawluk D, Bolger C, Pidgeon CN. The anatomical distribution of cerebral gliomas in mobile phone users. Ir Med J. 96(8):240-242, 2003.

We analysed the association between mobile phone use and the anatomical distribution of glial brain tumours in Irish neurosurgical patients. All patients with unilateral histologically proven glioma were enrolled over a 12 month period. We hypothesised that were a cellular phone to cause a glioma then it would do so on the dominant hand side. Fifty mobile phone users and twenty three non-users were identified. The vast majority of patients (69/73) were right handed and the right side of the brain was more common as the tumour site (48/73). Fisher's exact test revealed no statistical significance for glioma location based on the handedness of the patient in the mobile phone user group and location of the tumour in both user and non-user groups. We discuss our findings and the stable trend in the incidence of reported glioma cases.

Kahya MC, Nazıroğlu M, Ciğ B. Selenium Reduces Mobile Phone (900 MHz)-Induced Oxidative Stress, Mitochondrial Function, and Apoptosis in Breast Cancer Cells. Biol Trace Elem Res. 2014 Jun 27. [Epub ahead of print]

Exposure to mobile phone-induced electromagnetic radiation (EMR) may affect biological systems by increasing free oxygen radicals, apoptosis, and mitochondrial depolarization levels although selenium may modulate the values in cancer. The present study was designed to investigate the effects of 900 MHz radiation on the antioxidant redox system, apoptosis, and mitochondrial depolarization levels in MDA-MB-231 breast cancer cell line. Cultures of the cancer cells were divided into four main groups as controls, selenium, EMR, and EMR + selenium. In EMR groups, the cells were exposed to 900 MHz EMR for 1 h (SAR value of the EMR was 0.36 ± 0.02 W/kg). In selenium groups, the cells were also incubated with sodium selenite for 1 h before EMR exposure. Then, the following values were analyzed: (a) cell viability, (b) intracellular ROS production, (c) mitochondrial membrane depolarization, (d) cell apoptosis, and (e) caspase-3 and caspase-9 values. Selenium suppressed EMR-induced oxidative cell damage and cell viability (MTT) through a reduction of oxidative stress and restoring mitochondrial membrane potential. Additionally, selenium indicated anti-apoptotic effects, as demonstrated by plate reader analyses of apoptosis levels and caspase-3 and caspase-9 values. In conclusion, 900 MHz EMR appears to induce apoptosis effects through oxidative stress and mitochondrial depolarization although incubation of selenium seems to counteract the effects on apoptosis and oxidative stress.

Kainz W, Neubauer G, Alesch F, Schmid G, Jahn O. Electromagnetic compatibility of electronic implants--review of the literature. Wien Klin Wochenschr 113(23-24):903-914, 2001.

The aim of the article was to provide an overview of published studies regarding the electromagnetic compatibility (EMC) of electronic implants. The available literature was

sorted according to combinations of implant types and sources of interference. Several experiments concerning the susceptibility of pacemakers to mobile phones have been performed. The results of these experiments suggest measures that may be used to prevent the disturbance of pacemakers. For instance, instead of carrying the activated mobile phone in the breast pocket it is recommended that a distance of 30 cm be maintained between the pacemaker and the mobile phone, and that the mobile phone be used on the contralateral side of the pacemaker's location. Similar measures may be recommended for patients with implantable cardioverter defibrillators when using mobile phones. Patients with electronic implants should walk rapidly through anti theft-devices because some of these devices are liable to disturb implants. Patients with cardiac pacemakers should not be subjected to magnetic resonance imaging as far as possible. For a variety of combinations of implants and interference sources, e.g. cardiac pacemakers and base station antennas, no studies were found in the literature. It is strongly recommended that trials be carried out to evaluate the potential risk for patients in these settings.

Kainz W, Alesch F, Chan DD. Electromagnetic interference of GSM mobile phones with the implantable deep brain stimulator, ITREL-III. Biomed Eng Online 2(1):11, 2003.

BACKGROUND: The purpose was to investigate mobile phone interference with implantable deep brain stimulators by means of 10 different 900 Mega Hertz (MHz) and 10 different 1800 MHz GSM (Global System for Mobile Communications) mobile phones. METHODS: All tests were performed in vitro using a phantom especially developed for testing with deep brain stimulators. The phantom was filled with liquid phantom materials simulating brain and muscle tissue. All examinations were carried out inside an anechoic chamber on two implants of the same type of deep brain stimulator: ITREL-III from Medtronic Inc., USA. RESULTS: Despite a maximum transmitted peak power of mobile phones of 1 Watt (W) at 1800 MHz and 2 W at 900 MHz respectively, no influence on the ITREL-III was found. Neither the shape of the pulse form changed nor did single pulses fail. Tests with increased transmitted power using CW signals and broadband dipoles have shown that inhibition of the ITREL-III occurs at frequency dependent power levels which are below the emissions of GSM mobile phones. The ITREL-III is essentially more sensitive at 1800 MHz than at 900 MHz. Particularly the frequency range around 1500 MHz shows a very low interference threshold. CONCLUSION: These investigations do not indicate a direct risk for ITREL-III patients using the tested GSM phones. Based on the interference levels found with CW signals, which are below the mobile phone emissions, we recommend similar precautions as for patients with cardiac pacemakers: 1. The phone should be used at the ear at the opposite side of the implant and 2. The patient should avoid carrying the phone close to the implant.

Kakita Y, Kashige N, Murata K, Kuroiwa A, Funatsu M, Watanabe K, Inactivation of Lactobacillus bacteriophage PL-1 by microwave irradiation. Microbiol Immunol39(8):571-576, 1995.

The effect of microwave irradiation on the survival of bacteriophage PL-1, which is specific for Lactobacillus casei, was studied using a commercial 2,450 MHz microwave oven. The phages were inactivated by microwave irradiation according to almost first-

order reaction kinetics. The rate of phage inactivation was not affected by the difference in the continuous or intermittent irradiation, nor by the concentrations of phages used, but was affected by the volume of phage suspensions, which prevented the loss of generated heat. Microwave irradiation of phage suspensions produced a number of ghost phages with empty heads, but fragmentation of the tail was hardly noticed. The breakage of phage genome DNA was primarily caused by the heat generated by microwave irradiation, whereas the phage DNA was not affected by the same temperature achieved by heat from outside. Thus we concluded that the phage-inactivating effect of microwave irradiation was mainly attributed to a thermal microwave effect, which was much stronger than a simple thermal exposure.

Kaliada TV, Nikitina VN, Liashko GG, Masterova Ilu, Shaposhnikova ES. [Experimental research on the biological action of the pulse-modulated microwave radiation created by shipboard radar stations]. Med Tr Prom Ekol (11):15-17, 1995. [Article in Russian]

The article represents experimental data on influence of impulse modulated microwave irradiation with discontinuous effects varying in intensity and exposure. Becavior, peripheral blood, biochemical and morphologic parameters were assessed in the laboratory animals exposed. The response appeared to correlate with individual and typologic features of the examinees.

Kalns J, Ryan KL, Mason PA, Bruno JG, Gooden R, Kiel JL. Oxidative stress precedes circulatory failure induced by 35-GHz microwave heating. Shock 13(1):52-59, 2000.

Sustained whole-body exposure of anesthetized rats to 35-GHz radio frequency radiation produces localized hyperthermia and hypotension, leading to circulatory failure and death. The physiological mechanism underlying the induction of circulatory failure by 35-GHz microwave (MW) heating is currently unknown. We hypothesized that oxidative stress may play a role in the pathophysiology of MW-induced circulatory failure and examined this question by probing organs for 3-nitrotyrosine (3-NT), a marker of oxidative stress. Animals exposed to low durations of MW that increased colonic temperature but were insufficient to produce hypotension showed a 5- to 12-fold increase in 3-NT accumulation in lung, liver, and plasma proteins relative to the levels observed in control rats that were not exposed to MW. 3-NT accumulation in rats exposed to MW of sufficient duration to induce circulatory shock returned to low, baseline levels. Leukocytes obtained from peripheral blood showed significant accumulation of 3-NT only at exposure levels associated with circulatory shock. 3-NT was also found in the villus tips and vasculature of intestine and within the distal tubule of the kidney but not in the irradiated skin of rats with MW-induced circulatory failure. The relationship between accumulation in liver, lung, and plasma proteins and exposure duration suggests either that nitro adducts are formed in the first 20 min of exposure and are then cleared or that synthesis of nitro adducts decreases after the first 20 min of exposure. Taken together, these findings suggest that oxidative stress occurs in many organs during MW heating. Because nitration occurs after microwave exposures that are not associated with circulatory collapse, systemic oxidative stress, as evidenced by tissue accumulation of 3-NT, is not correlated with circulatory failure in this model of shock.

Kamali K, Atarod M, Sarhadi S, Nikbakht J, Emami M, Maghsoudi R, Salimi H, Fallahpour B, Kamali N, Momtazan A, Ameli M. Effects of electromagnetic waves emitted from 3G+wi-fi modems on human semen analysis. Urologia. 84(4):209-214, 2017.

OBJECTIVE: The purpose of this study was to evaluate the effects of 3G+wifi modems on human sperm quality. A total of 40 semen specimens were gathered between March and September 2015, from healthy adult men. METHODS: The sperm samples were divided into two groups - 3G+wi-fi exposed and unexposed groups. In the unexposed group, the specimens were shielded by aluminum foil in three layers and put into an incubator at a temperature of 37°C for 50 minutes. The exposed group was positioned in another room in an incubator at a temperature of 37°C for 50 minutes. A 3G+wi-fi modem was put into the same incubator and a laptop computer was connected to the modem and was downloading for the entire 50 minutes. Semen analysis was done for each specimen and comparisons between parameters of the two groups were done by using Kolmogorov-Smirnov study and a paired t-test. RESULTS: Mean percentage of sperm with class A and B motility were not significantly different in two groups ($p = 0.22$ and 0.54, respectively). In class C, it was significantly lower in the exposed group ($p = 0.046$), while in class D it was significantly higher ($p = 0.022$). Velocity curvilinear, velocity straight line, velocity average path, mean angular displacement, lateral displacement and beat cross frequency were significantly higher in the unexposed group. The limitation was the in vitro design. CONCLUSIONS: Electromagnetic waves (EMWs) emitted from 3G+wi-fi modems cause a significant decrease in sperm motility and velocity, especially in non-progressive motile sperms. Other parameters of semen analysis did not change significantly.EMWs, which are used in communications worldwide, are a suspected cause of male infertility. Many studies evaluated the effects of **cell phones** and wi-fi on fertility. To our knowledge, no study has yet been done to show the effects of EMWs emitted from 3G+wi-fi modems on fertility.Our study revealed a significant decrease in the quality of human semen after exposure to EMWs emitted from 3G+wi-fi modems.

Kamibeppu K, Sugiura H. Impact of the mobile phone on junior high-school students' friendships in the Tokyo metropolitan area. Cyberpsychol Behav. 8(2):121-130, 2005.

The proportion of having keitai (Japanese mobile phone) has increased rapidly in young children. To research how junior high school students use their own keitai and to examine the impact of using it on their psychology, especially on their friendship, we recruited 651 students, grade 8, from five public junior high schools in the Tokyo metropolitan area. Each student participant completed a questionnaire that we had created. The response rates were 88.8% (n = 578) for participants. The proportion of having their own keitai was 49.3% (n = 285) and that of not having it was 50.7% (n = 293). We found that they used it much more frequently for e-mail than as a phone. Most of them exchanged e-mails between schoolmates, and more than a half of them exchanged e-mails more than 10 times a day. Sociable students estimated that their own keitai was useful for their friendship. But they experienced some insecurity or started staying up late at night engaged in e-mail exchanges, and they thought that they could not live without their own

keitai. Our findings suggest that keitai having an e-mail function play a big part in the junior high-school students' daily life, and its impact on students' friendships, psychology, or health should be discussed among students to prevent keitai addiction.

Kan P, Simonsen SE, Lyon JL, Kestle JR. Cellular phone use and brain tumor: a meta-analysis. J Neurooncol.86(1):71-78, 2007.

BACKGROUND: The dramatic increase in the use of cellular phones has generated concerns about potential adverse effects, especially the development of brain tumors. We conducted a meta-analysis to examine the effect of cellular phone use on the risk of brain tumor development. METHODS: We searched the literature using MEDLINE to locate case-control studies on cellular phone use and brain tumors. Odds ratios (ORs) for overall effect and stratified ORs associated with specific brain tumors, long-term use, and analog/digital phones were calculated for each study using its original data. A pooled estimator of each OR was then calculated using a random-effects model. RESULTS: Nine case-control studies containing 5,259 cases of primary brain tumors and 12,074 controls were included. All studies reported ORs according to brain tumor subtypes, and five provided ORs on patients with >/=10 years of follow up. Pooled analysis showed an overall OR of 0.90 (95% confidence interval [CI] 0.81-0.99) for cellular phone use and brain tumor development. The pooled OR for long-term users of >/=10 years (5 studies) was 1.25 (95% CI 1.01-1.54). No increased risk was observed in analog or digital cellular phone users. CONCLUSIONS: We found no overall increased risk of brain tumors among cellular phone users. The potential elevated risk of brain tumors after long-term cellular phone use awaits confirmation by future studies.

Kang KA, Lee HC, Lee JJ, Hong MN, Park MJ, Lee YS, Choi HD, Kim N, Ko YK, Lee JS. Effects of combined radiofrequency radiation exposure on levels of reactive oxygen species in neuronal cells.J Radiat Res. 2013 Oct 8. [Epub ahead of print]

The objective of this study was to investigate the effects of the combined RF radiation (837 MHz CDMA plus 1950 MHz WCDMA) signal on levels of intracellular reactive oxygen species (ROS) in neuronal cells. Exposure of the combined RF signal was conducted at specific absorption rate values of 2 W/kg of CDMA plus 2 W/kg of WCDMA for 2 h. Co-exposure to combined RF radiation with either H2O2 or menadione was also performed. The experimental exposure groups were incubator control, sham-exposed, combined RF radiation-exposed with or without either H2O2 or menadione groups. The intracellular ROS level was measured by flow cytometry using the fluorescent probe dichlorofluorescein diacetate. Intracellular ROS levels were not consistently affected by combined RF radiation exposure alone in a time-dependent manner in U87, PC12 or SH-SY5Y cells. In neuronal cells exposed to combined RF radiation with either H2O2 or menadione, intracellular ROS levels showed no statically significant alteration compared with exposure to menadione or H2O2 alone. These findings indicate that neither combined RF radiation alone nor combined RF radiation with menadione or H2O2 influences the intracellular ROS level in neuronal cells such as U87, PC12 or SH-SY5Y.

Kao HK, Li Q, Flynn B, Qiao X, Ruberti JW, Murphy GF, Guo L. Collagen synthesis modulated in wounds treated by pulsed radiofrequency energy. Plast Reconstr Surg. 131(4):490e-498e, 2013.

BACKGROUND: Chronic wounds are biochemically complex and are associated with insufficient cell proliferation, angiogenesis, and extracellular matrix remodeling. The mechanisms by which pulsed radiofrequency energy modulates wound healing are still unclear. METHODS: Db/db mice were wounded and exposed to pulsed radiofrequency energy. Gross closure, cell proliferation, and morphometric analysis of CD31-stained wound cross-sections were assessed. The mRNA expression of profibrotic factors (transforming growth factor-β and platelet-derived growth factor-A), angiogenetic factors (vascular endothelial growth factor and basic fibroblast growth factor), and extracellular matrix components (collagen I and α-smooth muscle actin) were evaluated by quantitative reverse-transcriptase polymerase chain reaction. Collagen protein level of the wound was determined by Western blot analysis. To test the effect of pulsed radiofrequency energy on cell movement in wound healing, cell migration was monitored in monolayer dermal fibroblast cultures. The degree of collagen alignment and gelation time was quantitatively assessed using image analysis techniques. RESULTS: Pulsed radiofrequency energy-treated wounds were characterized by dermal cell proliferation and increased collagen synthesis. By contrast, the CD31 density and the mRNA expression of vascular endothelial growth factor and basic fibroblast growth factor showed no significant difference between the pulsed radiofrequency energy-treated wounds and the sham group. The pulsed radiofrequency energy-treated dermal fibroblast cultures expressed a significantly longer gelation time compared with the sham-exposed cultures. CONCLUSIONS: Exposing wounds to pulsed radiofrequency accelerated wound healing in this diabetic mouse model by means of significantly increasing dermal cell proliferation and collagen synthesis. A cellular mechanism behind these observations has been proposed.

Kaprana AE, Chimona TS, Papadakis CE, Velegrakis SG, Vardiambasis IO, Adamidis G, Velegrakis GA. Auditory brainstem response changes during exposure to GSM-900 radiation: An experimental study. Audiol Neurootol. 16(4):270-276, 2011.

Abstract. The objective of the present study was to investigate the possible electrophysiological time-related changes in auditory pathway during mobile phone electromagnetic field exposure. Thirty healthy rabbits were enrolled in an experimental study of exposure to GSM-900 radiation for 60 min and auditory brainstem responses (ABRs) were recorded at regular time-intervals during exposure. The study subjects were radiated via an adjustable power and frequency radio transmitter for GSM-900 mobile phone emission simulation, designed and manufactured according to the needs of the experiment. The mean absolute latency of waves III-V showed a statistically significant delay ($p < 0.05$) after 60, 45 and 15 min of exposure to electromagnetic radiation of 900 MHz, respectively. Interwave latency I-III was found to be prolonged after 60 min of radiation exposure in correspondence to wave III absolute latency delay. Interwave latencies I-V and III-V were found with a statistically significant delay ($p < 0.05$) after 30 min of radiation. No

statistically significant delay was found for the same ABR parameters in recordings from the ear contralateral to the radiation source at 60 min radiation exposure compared with baseline ABR. The ABR measurements returned to baseline recordings 24 h after the exposure to electromagnetic radiation of 900 MHz. The prolongation of interval latencies I-V and III-V indicates that exposure to electromagnetic fields emitted by mobile phone can affect the normal electrophysiological activity of the auditory system, and these findings fit the pattern of general responses to a stressor.

Karaca E, Durmaz B, Aktug H, Yildiz T, Guducu C, Irgi M, Koksal MG, Ozkinay F, Gunduz C, Cogulu O.The genotoxic effect of radiofrequency waves on mouse brain. J Neurooncol. 106(1):53-58, 2012.

Concerns about the health effects of radiofrequency (RF) waves have been raised because of the gradual increase in usage of cell phones, and there are scientific questions and debates about the safety of those instruments in daily life. The aim of this study is to evaluate the genotoxic effects of RF waves in an experimental brain cell culture model. Brain cell cultures of the mice were exposed to 10.715 GHz with specific absorbtion rate (SAR) 0.725 W/kG signals for 6 h in 3 days at 25°C to check for the changes in the micronucleus (MNi) assay and in the expression of 11 proapoptotic and antiapoptotic genes. It was found that MNi rate increased 11-fold and STAT3 expression decreased 7-fold in the cell cultures which were exposed to RF. Cell phones which spread RF may damage DNA and change gene expression in brain cells.

Karaman MI, Gökçe AM, Koca O, Karaman B, Öztürk MI, Yurdakul N, Ercan F. The effects of electromagnetic waves emitted by the cell phones **on the testicular tissue. Arch Ital Urol Androl. 86(4):274-277, 2014.**

OBJECTIVES: Various risks have emerged in parallel to the rapidly increasing use of **cell phones**. Herein we studied the effects of **cell phone** emitted electromagnetic waves (EMW) on rat testes. MATERIAL AND METHODS: Twenty one adult male Albino rats were grouped into 3 groups each consisting of 7 rats. The first group was exposed to EMW on talk mode for 8 hours per day for 20 days and then their testes were extracted. The testes of the second group were extracted after 20 days of whole day EMW exposure. The third group was the control group. For the statistical analysis Mann-Whitney U analysis was performed. RESULTS: At light microscopic examination of the testicular tissue, the existence of a high number of immature cells in the lumen of the seminiferous tubule in addition to the normal seminiferous tubules, besides irregular tubules with a reduction in the spermatogenic **cell** lines and tubules without lumen were observed in groups 1 and 2. Histopathological alterations were scored as 0 = none, 1 = low, 2 = medium, 3 = serious. The average scores of the three groups were found to be 4.25 ± 1.5 for the group 1, 4.33 ± 3.9 for the group 2 and 0.37 ± 1.1 for the group 3 respectively. As a result of the statistical evaluation, group 1 and group 2 had significantly higher scores than the control group (p = 0.001). CONCLUSION: Infertility is one of the current problems of today due to a rapid increase in its incidence and cost. The negative effects of the EMWs on the testis should be taken into account and the necessary measures should be taken for prevention.

Karinen A, Heinavaara S, Nylund R, Leszczynski D. Mobile phone radiation might alter protein expression in human skin. BMC Genomics. 9(1):77, 2008.

ABSTRACT: BACKGROUND: Earlier we have shown that the mobile phone radiation (radiofrequency modulated electromagnetic fields; RF-EMF) alters protein expression in human endothelial cell line. This does not mean that similar response will take place in human body exposed to this radiation. Therefore, in this pilot human volunteer study, using proteomics approach, we have examined whether a local exposure of human skin to RF-EMF will cause changes in protein expression in living people. RESULTS: Small area of forearm's skin in 10 female volunteers was exposed to RF-EMF (specific absorption rate SAR=1.3W/kg) and punch biopsies were collected from exposed and non exposed areas of skin. Proteins extracted from biopsies were separated using 2-DE and protein expression changes were analyzed using PDQuest software. Analysis has identified 8 proteins that were statistically significantly affected (Anova and Wilcoxon tests). Two of the proteins were present in all 10 volunteers. This suggests that protein expression in human skin might be affected by the exposure to RF-EMF. The number of affected proteins was similar to the number of affected proteins observed in our earlier in vitro studies. CONCLUSIONS: This is the first study showing that molecular level changes might take place in human volunteers in response to exposure to RF-EMF. Our study confirms that proteomics screening approach can identify protein targets of RF-EMF in human volunteers.

Kato Y, Johansson O. Reported functional impairments of electrohypersensitive Japanese: A questionnaire survey. Pathophysiology.19(2) 95-100, 2012.

An increasing number of people worldwide complain that they have become

electromagnetic hypersensitive (EHS). We conducted a questionnaire survey of EHS persons in Japan. The aim was to identify electromagnetic fields (EMF) and plausible EMF sources that caused their symptoms. Postal questionnaires were distributed via a self-help group, and 75 participants (95% women) responded. Reported major complaints were "fatigue/tiredness" (85%), "headache", "concentration, memory, and thinking" difficulty (81%, respectively). Seventy-two per cent used some form of complementary/alternative therapy. The most plausible trigger of EHS onset was a mobile phone base station or personal handy-phone system (37%). Sixty-five percent experienced health problems to be due to the radiation from other passengers' mobile phones in trains or buses, and 12% reported that they could not use public transportation at all. Fifty-three percent had a job before the onset, but most had lost their work and/or experienced a decrease in income. Moreover, 85.3% had to take measures to protect themselves from EMF, such as moving to low EMF areas, or buying low EMF electric appliances. EHS persons were suffering not only from their symptoms, but also from economical and social problems.

Kawai H, Nagaoka T, Watanabe S, Saito K, Takahashi M, Ito K. Computational dosimetry in embryos exposed to electromagnetic plane waves over the frequency range of 10 MHz-1.5 GHz.Phys Med Biol. 55(1):N1-11, 2010.

This paper presents calculated specific absorption rate (SAR) dosimetry in 4 and 8 week Japanese pregnant-woman models exposed to plane waves over the frequency range of 10 MHz-1.5 GHz. Two types of 2 mm spatial-resolution pregnant-woman models comprised a woman model, which is similar to the average-sized Japanese adult female in height and weight, with a cubic (4 week) embryo or spheroidal (8 week) one. The averaged SAR in the embryos exposed to vertically and horizontally polarized plane waves at four kinds of propagation directions are calculated from 10 MHz to 1.5 GHz. The results indicate that the maximum average SAR in the embryos exposed to plane waves is lower than 0.08 W kg(-1) when the incident power density is at the reference level of ICNIRP guideline for general public environment.

Kayabasoglu G, Sezen OS, Eraslan G, Aydin E, Coskuner T, Unver S. Effect of chronic exposure to cellular telephone electromagnetic fields on hearing in rats. J Laryngol Otol. 125(4):348-353, 2011.

OBJECTIVE: To study the effects of the electromagnetic field emitted by cellular telephones upon the inner ear of rats, using distortion product otoacoustic emissions.METHODS: Forty Wistar Albino rats were used. Twenty newborn and 20 adult rats were divided into two groups of 10, one to participate in the study and one as a control. The rats were exposed to the electromagnetic field for 6 hours per day, for 30 consecutive days. Before and after the 30 day exposure period, distortion product otoacoustic emissions were measured in each group and a signal-to-noise ratio calculated, which was later used in statistical analysis.RESULTS: For both the newborn and adult rat groups, there was no significant difference in distortion product otoacoustic emissions recorded before and after exposure to the cellular telephone electromagnetic field ($p>0.05$).CONCLUSION: Exposure to the electromagnetic field emitted by cellular telephones, for 6 hours a day for 30 consecutive days, had no effect on the hearing of

newborn or adult rats, at the outer ear, middle ear or cochlear level.

Keetley V, Wood AW, Spong J, Stough C. Neuropsychological sequelae of digital mobile phone exposure in humans. Neuropsychologia. 44(10):1843-1848,2006.

The effect of electromagnetic fields from digital mobile phones (DMP) on cognitive functioning is an area receiving increased attention. This study compares the performance of 120 volunteers on 8 neuropsychological tests during real or sham exposure to a DMP set to maximum permissible radiofrequency power output. When results were adjusted for known covariates (gender, age, or education), several alterations at significance levels of $p<0.05$ were obtained. Of these, simple and choice reaction times (CRT) showed strong evidence of impairment. Further, performance on the Trail Making Task (TMT) improved, supporting the hypothesis that DMP radiofrequency emissions improve the speed of processing of information held in working memory.

Kellenyi, L, Thuroczy, G, Faludy, B, Lenard, L, Effects of mobile GSM radiotelephone exposure on the auditory brainstem response (ABR). Neurobiology 7:79-81, 1999.

A 15-min exposure to GSM phone radiation caused an increase in auditory brainstem response in the exposed side of human subjects. Subjects also showed a hearing deficiency in the high frequency range (20 dB hearing deficiency from 2 KHz to 10 KHz).

Kelsh MA, Shum M, Sheppard AR, McNeely M, Kuster N, Lau E, Weidling R, Fordyce T, Kühn S, Sulser C. Measured radiofrequency exposure during various mobile-phone use scenarios. J Expo Sci Environ Epidemiol.21(4):343-54, 2010.

Epidemiologic studies of mobile phone users have relied on self reporting or billing records to assess exposure. Herein, we report quantitative measurements of mobile-phone power output as a function of phone technology, environmental terrain, and handset design. Radiofrequency (RF) output data were collected using software-modified phones that recorded power control settings, coupled with a mobile system that recorded and analyzed RF fields measured in a phantom head placed in a vehicle. Data collected from three distinct routes (urban, suburban, and rural) were summarized as averages of peak levels and overall averages of RF power output, and were analyzed using analysis of variance methods. Technology was the strongest predictor of RF power output. The older analog technology produced the highest RF levels, whereas CDMA had the lowest, with GSM and TDMA showing similar intermediate levels. We observed generally higher RF power output in rural areas. There was good correlation between average power control settings in the software-modified phones and power measurements in the phantoms. Our findings suggest that phone technology, and to a lesser extent, degree of urbanization, are the two stronger influences on RF power output. Software-modified phones should be useful for improving epidemiologic exposure assessment.

Kemerov, S, Marinkev, M, Getova, D, Effects of low-intensity electromagnetic fields on behavioral activity of rats. Folia Med (Plovdiv) 41(3):75-80, 1999.

The present study aimed at comparative assessment of the changes in behavioral activity of rats after exposing them to low intensity electromagnetic fields (EMFs) in the meter, decimeter and centimeter ranges. The experiments were carried out on 24 Wistar rats divided into 4 groups (1 control and 3 experimental), treated with different EMFs. The rats were irradiated on the head area at power density of 10 mW/cm2. Using a conventional shuttle box, the conditioned and non-conditioned responses and spontaneous motor activity of the rats were studied. The results suggest that exposure to EMFs in the three ranges can slow down the formation of conditioned responses--this was clearly marked in the rats exposed to meter EMFs, whereas the effects of centimeter EMFs were delayed in time. The behavioral effects were mild at athermal dosages and the animals adapted easily to exposure conditions. This study shows that determination of the effects of different EMFs should be done for each of the ranges separately; determination of the exact dosage of the electromagnetic fields can help to avoid their negative biological effects.

Keow MA, Radiman S. Assessment of radiofrequency/microwave radiation emitted by the antennas of rooftop-mounted mobile phone base stations. Radiat Prot Dosimetry.121(2):122-127, 2006.

Radiofrequency (RF) and microwave (MW) radiation exposures from the antennas of rooftop-mounted mobile telephone base stations have become a serious issue in recent years due to the rapidly evolving technologies in wireless telecommunication systems. In Malaysia, thousands of mobile telephone base stations have been erected all over the country, most of which are mounted on the rooftops. In view of public concerns, measurements of the RF/MW levels emitted by the base stations were carried out in this study. The values were compared with the exposure limits set by several organisations and countries. Measurements were performed at 200 sites around 47 mobile phone base stations. It was found that the RF/MW radiation from these base stations were well below the maximum exposure limits set by various agencies.

Kerbacher JJ, Meltz ML, Erwin DN, Influence of radiofrequency radiation on chromosome aberrations in CHO cells and its interaction with DNA-damaging agents. Radiat Res 123(3):311-319, 1990.

A limited number of contradictory reports have appeared in the literature about the ability of radiofrequency (rf) radiation to induce chromosome aberrations in different biological systems. The technical documentation associated with such reports is often absent or deficient. In addition, no information is available as to whether any additional genotoxic hazard would result from a simultaneous exposure of mammalian cells to rf radiation and a chemical which (by itself) induces chromosome aberrations. In the work described, we have therefore tested two hypotheses. The first is that rf radiation by itself, at power densities and exposure conditions which are higher than is consistent with accepted safety guidelines, can induce chromosome aberrations in mammalian cells. The second is that, during a simultaneous exposure to a chemical known to be genotoxic, rf radiation can affect molecules, biochemical processes, or cellular organelles, and thus result in an increase or decrease in

chromosome aberrations. Mitomycin C (MMC) and Adriamycin (ADR) were selected because they act by different mechanisms, and because they might put normal cells at risk during combined-modality rf radiation (hyperthermia)-chemotherapy treatment of cancer. The studies were performed with suitable 37 degrees C and equivalent convection heating-temperature controls in a manner designed to discriminate between any thermal and possible nonthermal action. Radiofrequency exposures were conducted for 2 h under conditions resulting in measurable heating (a maximum increase of 3.2 degrees C), with pulsed-wave rf radiation at a frequency of 2450 MHz and an average net forward power of 600 W, resulting in an SAR of 33.8 W/kg. Treatments with MMC or ADR were for a total of 2.5 h and encompassed the 2-h rf radiation exposure period. The CHO cells from each of the conditions were subsequently analyzed for chromosome aberrations. In cells exposed to rf radiation alone, and where a maximum temperature of approximately 40 degrees C was achieved in the tissue culture medium, no alteration in the frequency from 37 degrees C control levels was observed. Relative to the chemical treatment with MMC alone at 37 degrees C, for two different concentrations, no alteration was observed in the extent of chromosome aberrations induced by either simultaneous rf radiation exposure or convection heating to equivalent temperatures. At the ADR concentration that was used, most of the indices of chromosome aberrations which were scored indicated a similar result.

Kerekhanjanarong V, Supiyaphun P, Naratricoon J, Laungpitackchumpon P. The effect of mobile phone to audiologic system. J Med Assoc Thai.88 Suppl 4:S231-234, 2005.

Mobile phones have come into widespread use. There are a lot of possible adverse effect to health. Use of mobile phone generate potentially harmful radiofrequency electromagnetic field (EMF) particularly for the hearing aspect. 98 subjects underwent hearing evaluations at Department of Otolaryngology, Faculty of Medicine, King Chulalongkorn Memorial Hospital, Chulalongkorn University. 31 males and 67females, mean age was 30.48 +/- 9.51 years old, all subjects were investigated the hearing level by audiometry, tympanometry, otoacoustic emission (OAE) and auditory brain stem evoked response (ABR). The average of using time were 32.54 +/- 27.64 months, 57 subjects usually used the right side and 41 the left side. Average time of use per day was 26.31 +/- 30.91 minutes (range from 3 to 180 mins). When the authors compared the audiogram, both pure tone and speech audiometry, between the dominant and nondominant side, it indicated that there is no significant different. When the authors focused on the 8 subjects that used the mobile phone more than 60 mins per day. It indicated that the hearing threshold of the dominant ears was worse than the nondominant ears.

Kerimoğlu G, Mercantepe T, Erol HS, Turgut A, Kaya H, Çolakoğlu S, Odacı E. Effects of long-term exposure to 900 megahertz electromagnetic field on heart morphology and biochemistry of male adolescent rats. Biotech Histochem. 2016 Aug 11:1-10. [Epub ahead of print]

The pathological effects of exposure to an electromagnetic field (EMF) during adolescence may be greater than those in adulthood. We investigated the effects of

exposure to 900 MHz EMF during adolescence on male adult rats. Twenty-four 21-day-old male rats were divided into three equal groups: control (Cont-Gr), sham (Shm-Gr) and EMF-exposed (EMF-Gr). EMF-Gr rats were placed in an EMF exposure cage (Plexiglas cage) for 1 h/day between postnatal days 21 and 59 and exposed to 900 MHz EMF. Shm-Gr rats were placed inside the Plexiglas cage under the same conditions and for the same duration, but were not exposed to EMF. All animals were sacrificed on postnatal day 60 and the hearts were extracted for microscopic and biochemical analyses. Biochemical analysis showed increased levels of malondialdehyde and superoxide dismutase, and reduced glutathione and catalase levels in EMF-Gr compared to Cont-Gr animals. Hematoxylin and eosin stained sections from EMF-Gr animals exhibited structural changes and capillary congestion in the myocardium. The percentage of apoptotic myocardial cells in EMF-Gr was higher than in either Shm-Gr or Cont-Gr animals. Transmission electron microscopy of myocardial cells of EMF-Gr animals showed altered structure of Z bands, decreased myofilaments and pronounced vacuolization. We found that exposure of male rats to 900 MHz EMF for 1 h/day during adolescence caused oxidative stress, which caused structural alteration of male adolescent rat heart tissue.

Kerimoğlu G, Aslan A, Baş O, Çolakoğlu S, Odacı E. Adverse effects in lumbar spinal cord morphology and tissue biochemistry in Sprague Dawley male rats following exposure to a continuous 1-h a day 900-MHz electromagnetic field throughout adolescence. J Chem Neuroanat. 78:125-130, 2016.

Cell phones, an indispensable element of daily life, are today used at almost addictive levels by adolescents. Adolescents are therefore becoming increasingly exposed to the effect of the electromagnetic field (EMF) emitted by cell phones. The purpose of this study was to investigate the effect of exposure to a 900-MHz EMF throughout adolescence on the lumbar spinal cord using histopathological, immunohistochemical and biochemical techniques. Twenty-four Sprague Dawley (28.3-43.9g) aged 21days were included in the study. These were divided equally into three groups - control (CG), sham (SG) and electromagnetic (ELMAG). No procedure was performed on the CG rats until the end of the study. SG and ELMAG rats were kept inside an EMF cage (EMFC) for 1h a day every day at the same time between postnatal days 22 and 60. During this time, ELMAG rats were exposed to the effect of a 900-MHz EMF, while the SG rats were kept in the EMFC without being exposed to EMF. At the end of the study, the lumbar regions of the spinal cords of all rats in all groups were extracted. Half of each extracted tissue was stored at -80°C for biochemical analysis, while the other half was used for histopathological and immunohistochemical analyses. In terms of histopathology, a lumbar spinal cord with normal morphology was observed in the other groups, while morphological irregularity in gray matter, increased vacuolization and infiltration of white matter into gray matter were pronounced in the ELMAG rats. The cytoplasm of some neurons in the gray matter was shrunken and stained dark, and vacuoles were observed in the cytoplasms. The apoptotic index of glia cells and neurons were significantly higher in ELMAG compared to the other groups. Biochemical analysis revealed a significantly increased MDA value in ELMAG compared to CG, while SOD and GSH levels decreased significantly. In conclusion, our study results suggest that continuous exposure to a 900-MHz EMF for 1h

a day through all stages of adolescence can result in impairments at both morphological and biochemical levels in the lumbar region spinal cords of Sprague Dawley rats.

Kerimoğlu G, Hancı H, Baş O, Aslan A, Erol HS, Turgut A, Kaya H, Çankaya S, Sönmez OF, Odacı E. Pernicious effects of long-term, continuous 900-MHz electromagnetic field throughout adolescence on hippocampus morphology, biochemistry and pyramidal neuron numbers in 60-day-old Sprague Dawley male rats. J Chem Neuroanat. 77:169-175, 2016.

The central nervous system (CNS) begins developing in the intrauterine period, a process that continues until adulthood. Contact with chemical substances, drugs or environmental agents such as electromagnetic field (EMF) during adolescence therefore has the potential to disturb the development of the morphological architecture of components of the CNS (such as the hippocampus). The hippocampus is essential to such diverse functions as memory acquisition and integration and spatial maneuvering. EMF can result in severe damage to both the morphology of the hippocampus and its principal functions during adolescence. Although children and adolescents undergo greater exposure to EMF than adults, the information currently available regarding the effects of exposure to EMF during this period is as yet insufficient. This study investigated the 60-day-old male rat hippocampus following exposure to 900 megahertz (MHz) EMF throughout the adolescent period using stereological, histopathological and biochemical analysis techniques. Eighteen male Sprague Dawley rats aged 21days were assigned into control, sham and EMF groups on a random basis. No procedure was performed on the control group rats. The EMF group (EMFGr) was exposed to a 900-MHz EMF for 1h daily from beginning to end of adolescence. The sham group rats were held in the EMF cage but were not exposed to EMF. All rats were sacrificed at 60days of age. Their brains were extracted and halved. The left hemispheres were set aside for biochemical analyses and the right hemispheres were subjected to stereological and histopathological evaluation. Histopathological examination revealed increased numbers of pyknotic neurons with black or dark blue cytoplasm on EMFGr slides stained with cresyl violet. Stereological analyses revealed fewer pyramidal neurons in EMFGr than in the other two groups. Biochemical analyses showed an increase in malondialdehyde and glutathione levels, but a decrease in catalase levels in EMFGr. Our results indicate that oxidative stress-related morphological damage and pyramidal neuron loss may be observed in the rat hippocampus following exposure to 900-MHz EMF throughout the adolescent period.

Kesari KK, Behari J. Fifty-gigahertz Microwave exposure effect of radiations on rat brain. Appl Biochem Biotechnol. 158(1):126-139,2009.

The object of this study is to investigate the effects of 50-GHz microwave radiation on the brain of Wistar rats. Male rats of the Wistar strain were used in the study. Animals of 60-day age were divided into two groups-group 1, sham-exposed, and group 2, experimental (microwave-exposed). The rats were housed in a temperature-controlled room (25 degrees C) with constant humidity (40-50%) and received food and water ad libitum. During exposure, rats were placed in Plexiglas cages with drilled ventilation holes and

kept in an anechoic chamber. The animals were exposed for 2 h a day for 45 days continuously at a power level of 0.86 muW/cm(2) with nominal specific absorption rate 8.0 x 10(-4) w/kg. After the exposure period, the rats were killed and homogenized, and protein kinase C (PKC), DNA double-strand break, and antioxidant enzyme activity [superoxides dismutase (SOD), catalase, and glutathione peroxidase (GPx)] were estimated in the whole brain. Result shows that the chronic exposure to these radiations causes DNA double-strand break (head and tail length, intensity and tail migration) and a significant decrease in GPx and SOD activity (p = <0.05) in brain cells, whereas catalase activity shows significant increase in the exposed group of brain samples as compared with control (p = <0.001). In addition to these, PKC decreased significantly in whole brain and hippocampus (p < 0.05). All data are expressed as mean +/- standard deviation. We conclude that these radiations can have a significant effect on the whole brain.

Kesari KK, Behari J. Microwave exposure affecting reproductive system in male rats. Appl Biochem Biotechnol. Microwave exposure affecting reproductive system in male rats 31(6):495-498, 2010.

The object of present study is to investigate the effects of 50 GHz microwave frequency electromagnetic fields on reproductive system of male rats. Male rats of Wistar strain were used in the study. Animals 60 days old were divided into two groups-group I sham exposed and group II experimental (microwave exposed). During exposure, rats were confined in Plexiglas cages with drilled ventilation holes for 2 h a day for 45 days continuously at a specified specific absorption rate of 8.0 x 10(-4) W/kg. After the last exposure, the rats were sacrificed immediately and sperms were collected. Antioxidant enzyme (superoxide dismutase (SOD), glutathione peroxidase (GPx), and catalase), histone kinase, apoptosis, and cell cycle were analyzed in sperm cells. Result shows a significant decrease in the level of sperm GPx and SOD activity (p </= 0.05), whereas catalase shows significant increase in exposed group of sperm samples as compared with control (p < 0.02). We observed a statistically significant decrease in mean activity of histone kinase as compared to the control (p < 0.016). The percentage of cells dividing in a spermatogenesis was estimated by analyzing DNA per cell by flow cytometry. The percentage of apoptosis in electromagnetic field exposed group shows increased ratio as compared to sham exposed (p < 0.004). There were no significant differences in the G(0)/G(1) phase; however, a significant decrease (p < 0.026) in S phase was obtained. Results also indicate a decrease in percentage of G(2)/M transition phase of cell cycle in exposed group as compared to sham exposed (p < 0.019). We conclude that these radiations may have a significant effect on reproductive system of male rats, which may be an indication of male infertility.

Kesari KK, Behari J, Kumar S. Mutagenic response of 2.45 GHz radiation exposure on rat brain. Int J Radiat Biol. 86(4):334-343, 2010.

Purpose: To investigate the effect of 2.45 GHz microwave radiation on rat brain of male wistar strain. Material and methods: Male rats of wistar strain (35 days old with 130 +/- 10 g body weight) were selected for this study. Animals were divided into two groups: Sham exposed and experimental. Animals were exposed for 2 h a day for 35 days to 2.45 GHz frequency at 0.34 mW/cm(2) power density. The whole body

specific absorption rate (SAR) was estimated to be 0.11 W/Kg. Exposure took place in a ventilated Plexiglas cage and kept in anechoic chamber in a far field configuration from the horn antenna. After the completion of exposure period, rats were sacrificed and the whole brain tissue was dissected and used for study of double strand DNA (Deoxyribonucleic acid) breaks by micro gel electrophoresis and the statistical analysis was carried out using comet assay (IV-2 version software). Thereafter, antioxidant enzymes and histone kinase estimation was also performed. Results: A significant increase was observed in comet head ($P < 0.002$), tail length ($P < 0.0002$) and in tail movement ($P < 0.0001$) in exposed brain cells. An analysis of antioxidant enzymes glutathione peroxidase ($P < 0.005$), and superoxide dismutase ($P < 0.006$) showed a decrease while an increase in catalase ($P < 0.006$) was observed. A significant decrease ($P < 0.023$) in histone kinase was also recorded in the exposed group as compared to the control (sham-exposed) ones. One-way analysis of variance (ANOVA) method was adopted for statistical analysis. Conclusion: The study concludes that the chronic exposure to these radiations may cause significant damage to brain, which may be an indication of possible tumour promotion (Behari and Paulraj 2007).

Kesari KK, Kumar S, Behari J. Mobile phone usage and male infertility in Wistar rats. Indian J Exp Biol. 48(10):987-992, 2010.

A significant decrease in protein kinase C and total sperm count along with increased apoptosis were observed in male Wistar rats exposed to mobile phone frequencies (2 h/day x 35 days at 0.9 W/kg specific absorption rate). The results suggest that a reduction in protein kinase activity may be related to overproduction of reactive oxygen species (ROS) under microwave field exposure. Decrease in sperm count and an increase in apoptosis may be causative factor due to mobile radiation exposure leading to infertility.

Kesari KK, Kumar S, Behari J. Effects of Radiofrequency Electromagnetic Wave Exposure from Cellular Phones on the Reproductive Pattern in Male Wistar Rats. Appl Biochem Biotechnol. 164(4):546-559, 2011.

The present study investigates the effect of free radical formation due to mobile phone exposure and effect on fertility pattern in 70-day-old male Wistar rats (sham exposed and exposed). Exposure took place in Plexiglas cages for 2 h a day for 35 days to mobile phone frequency. The specific absorption rate was estimated to be 0.9 W/kg. An analysis of antioxidant enzymes glutathione peroxidase ($P < 0.001$) and superoxide dismutase ($P < 0.007$) showed a decrease, while an increase in catalase ($P < 0.005$) was observed. Malondialdehyde ($P < 0.003$) showed an increase and histone kinase ($P = 0.006$) showed a significant decrease in the exposed group. Micronuclei also show a significant decrease ($P < 0.002$) in the exposed group. A significant change in sperm cell cycle of G(0)-G(1) ($P = 0.042$) and G(2)/M ($P = 0.022$) were recorded. Generation of free radicals was recorded to be significantly increased ($P = 0.035$). Our findings on antioxidant, malondialdehyde, histone kinase, micronuclei, and sperm cell cycle are clear indications of an infertility pattern, initiated due to an overproduction of reactive oxygen species. It is concluded that

radiofrequency electromagnetic wave from commercially available cell phones might affect the fertilizing potential of spermatozoa.

Kesari KK, Kumar S, Behari J. 900-MHz microwave radiation promotes oxidation in rat brain. Electromagn Biol Med. 30(4):219-234, 2011.

Recently, there have been several reports referring to detrimental effects due to radio frequency electromagnetic fields (RF-EMF) exposure. Special attention was given to investigate the effect of mobile phone exposure on the rat brain. Since the integrative mechanism of the entire body lies in the brain, it is suggestive to analyze its biochemical aspects. For this, 35-day old Wistar rats were exposed to a mobile phone for 2 h per day for a duration of 45 days where specific absorption rate (SAR) was 0.9 W/Kg. Animals were divided in two groups: sham exposed (n = 6) and exposed group (n = 6). Our observations indicate a significant decrease ($P < 0.05$) in the level of glutathione peroxidase, superoxide dismutase, and an increase in catalase activity. Moreover, protein kinase shows a significant decrease in exposed group ($P < 0.05$) of hippocampus and whole brain. Also, a significant decrease ($P < 0.05$) in the level of pineal melatonin and a significant increase ($P < 0.05$) in creatine kinase and caspase 3 was observed in exposed group of whole brain as compared with sham exposed. Finally, a significant increase in the level of ROS (reactive oxygen species) ($P < 0.05$) was also recorded. The study concludes that a reduction or an increase in antioxidative enzyme activities, protein kinase C, melatonin, caspase 3, and creatine kinase are related to overproduction of reactive oxygen species (ROS) in animals under mobile phone radiation exposure. Our findings on these biomarkers are clear indications of possible health implications.

Kesari KK, Behari J. Evidence for mobile phone radiation exposure effects on reproductive pattern of male rats: Role of ROS. Electromagn Biol Med. 31(3):213-22, 2012.

The relationship between radiofrequency electromagnetic fields emitted from mobile phone and infertility is a matter of continuing debate. It is postulated that these radiations may affect the reproduction pattern spell by targeting biochemistry of sperm. In an attempt to expedite the issue, 70 days old Wistar rats (n = 6) were exposed to mobile phone radiofrequency (RF) radiation for 2 h per day for 45 days and data compared with sham exposed (n = 6) group. A significant decrease ($P < 0.05$) in the level of testosterone and an increase in caspase-3 activity were found in the RF-exposed animals. Distortions in sperm head and mid piece of sperm mitochondrial sheath were also observed as captured by Transmission Electron Microscope (TEM). In addition, progeny from RF-exposed rats showed significant decreases in number and weight as compared with that of sham-exposed animals. A reduction in testosterone, an increase in caspase-3, and distortion in spermatozoa could be caused by overproduction of reactive oxygen species (ROS) in animals under mobile phone radiation exposure. Our findings on these biomarkers are clear indications of possible health implications of repeated exposure to mobile phone radiation.

Kesari KK, Kumar S, Behari J. Pathophysiology of microwave radiation: effect on rat brain.Appl Biochem Biotechnol. 166(2):379-388, 2012.

The study aims to investigate the effect of 2.45 GHz microwave radiation on Wistar rats. Rats of 35 days old with 130 ± 10 g body weight were selected for this study. Animals were divided into two groups: sham exposed and experimental (six animals each). Animals were exposed for 2 h a day for 45 days at 2.45 GHz frequency (power density, 0.21 mW/cm(2)). The whole body specific absorption rate was estimated to be 0.14 W/kg. Exposure took place in a ventilated plexiglas cage and kept in an anechoic chamber under a horn antenna. After completion of the exposure period, rats were killed, and pineal gland and whole brain tissues were isolated for the estimation of melatonin, creatine kinase, caspase 3, and calcium ion concentration. Experiments were performed in a blind manner and repeated. A significant decrease ($P < 0.05$) was recorded in the level of pineal melatonin of exposed group as compared with sham exposed. A significant increase ($P < 0.05$) in creatine kinase, caspase 3, and calcium ion concentration was observed in whole brain of exposed group of animals as compared to sham exposed. One-way analysis of variance method was adopted for statistical analysis. The study concludes that a reduction in melatonin or an increase in caspase-3, creatine kinase, and calcium ion may cause significant damage in brain due to chronic exposure of these radiations. These biomarkers clearly indicate possible health implications of such exposures.

Kesari KK, Kumar S, Nirala J, Siddiqui MH, Behari J. Biophysical Evaluation of Radiofrequency Electromagnetic Field Effects on Male Reproductive Pattern. Cell Biochem Biophys. 65(2): 85-96, 2013 .

There are possible hazardous health effects of exposure to radiofrequency electromagnetic radiations emitted from mobile phone on the human reproductive pattern. It is more effective while keeping mobile phones in pocket or near testicular organs. Present review examines the possible concern on radio frequency radiation interaction and biological effects such as enzyme induction, and toxicological effects, including genotoxicity and carcinogenicity, testicular cancer, and reproductive outcomes. Testicular infertility or testicular cancer due to mobile phone or microwave radiations suggests an increased level of reactive oxygen species (ROS). Though generation of ROS in testis has been responsible for possible toxic effects on physiology of reproduction, the reviews of last few decades have well established that these radiations are very harmful and cause mutagenic changes in reproductive pattern and leads to infertility. The debate will be focused on bio-interaction mechanism between mobile phone and testicular cancer due to ROS formation. This causes the biological damage and leads to several changes like decreased sperm count, enzymatic and hormonal changes, DNA damage, and apoptosis formation. In the present review, physics of mobile phone including future research on various aspects has been discussed.

Kesari KK, Meena R, Nirala J, Kumar J, Verma HN. Effect of 3G cell phone exposure with computer controlled 2-D stepper motor on non-thermal activation of

the hsp27/p38MAPK stress pathway in rat brain. Cell Biochem Biophys. 68(2):347-358, 2014.

Cell phone radiation exposure and its biological interaction is the present concern of debate. Present study aimed to investigate the effect of 3G cell phone exposure with computer controlled 2-D stepper motor on 45-day-old male Wistar rat brain. Animals were exposed for 2 h a day for 60 days by using mobile phone with angular movement up to zero to 30°. The variation of the motor is restricted to 90° with respect to the horizontal plane, moving at a pre-determined rate of 2° per minute. Immediately after 60 days of exposure, animals were scarified and numbers of parameters (DNA double-strand break, micronuclei, caspase 3, apoptosis, DNA fragmentation, expression of stress-responsive genes) were performed. Result shows that microwave radiation emitted from 3G mobile phone significantly induced DNA strand breaks in brain. Meanwhile a significant increase in micronuclei, caspase 3 and apoptosis were also observed in exposed group ($P < 0.05$). Western blotting result shows that 3G mobile phone exposure causes a transient increase in phosphorylation of hsp27, hsp70, and p38 mitogen-activated protein kinase (p38MAPK), which leads to mitochondrial dysfunction-mediated cytochrome c release and subsequent activation of caspases, involved in the process of radiation-induced apoptotic cell death. Study shows that the oxidative stress is the main factor which activates a variety of cellular signal transduction pathways, among them the hsp27/p38MAPK is the pathway of principle stress response. Results conclude that 3G mobile phone radiations affect the brain function and cause several neurological disorders.

Keshvari J, Lang S. Comparison of radio frequency energy absorption in ear and eye region of children and adults at 900, 1800 and 2450 MHz. Phys Med Biol. 50(18):4355-4369, 2005.

The increasing use of mobile communication devices, especially mobile phones by children, has triggered discussions on whether there is a larger radio frequency (RF) energy absorption in the heads of children compared to that of adults. The objective of this study was to clarify possible differences in RF energy absorption in the head region of children and adults using computational techniques. Using the finite-difference time-domain (FDTD) computational method, a set of specific absorption rate (SAR) calculations were performed for anatomically correct adult and child head models. A half-wave dipole was used as an exposure source at 900, 1800 and 2450 MHz frequencies. The ear and eye regions were studied representing realistic exposure scenarios to current and upcoming mobile wireless communication devices. The differences in absorption were compared with the maximum energy absorption of the head model. Four magnetic resonance imaging (MRI) based head models, one female, one adult, two child head models, aged 3 and 7 years, were used. The head models greatly differ from each other in terms of size, external shape and the internal anatomy. The same tissue dielectric parameters were applied for all models. The analyses suggest that the SAR difference between adults and children is more likely caused by the general differences in the head anatomy and geometry of the individuals rather than age. It seems that the external shape of the head and the distribution of different tissues within the head play a significant role in the RF energy absorption.

Keshvari J, Heikkilä T. Volume-averaged SAR in adult and child head models when using mobile phones: a computational study with detailed CAD-based models of commercial mobile phones. Prog Biophys Mol Biol. 107(3):439-442, 2011.

Previous studies comparing SAR difference in the head of children and adults used highly simplified generic models or half-wave dipole antennas. The objective of this study was to investigate the SAR difference in the head of children and adults using realistic EMF sources based on CAD models of commercial mobile phones. Four MRI-based head phantoms were used in the study. CAD models of Nokia 8310 and 6630 mobile phones were used as exposure sources. Commercially available FDTD software was used for the SAR calculations. SAR values were simulated at frequencies 900 MHz and 1747 MHz for Nokia 8310, and 900 MHz, 1747 MHz and 1950 MHz for Nokia 6630. The main finding of this study was that the SAR distribution/variation in the head models highly depends on the structure of the antenna and phone model, which suggests that the type of the exposure source is the main parameter in EMF exposure studies to be focused on. Although the previous findings regarding significant role of the anatomy of the head, phone position, frequency, local tissue inhomogeneity and tissue composition specifically in the exposed area on SAR difference were confirmed, the SAR values and SAR distributions caused by generic source models cannot be extrapolated to the real device exposures. The general conclusion is that from a volume averaged SAR point of view, no systematic differences between child and adult heads were found.

Keshvari J, Keshvari R, Lang S. The effect of increase in dielectric values on specific absorption rate (SAR) in eye and head tissues following 900, 1800 and 2450 MHz radio frequency (RF) exposure. Phys Med Biol. 51(6):1463-1477, 2006.

Numerous studies have attempted to address the question of the RF energy absorption difference between children and adults using computational methods. They have assumed the same dielectric parameters for child and adult head models in SAR calculations. This has been criticized by many researchers who have stated that child organs are not fully developed, their anatomy is different and also their tissue composition is slightly different with higher water content. Higher water content would affect dielectric values, which in turn would have an effect on RF energy absorption. The objective of this study was to investigate possible variation in specific absorption rate (SAR) in the head region of children and adults by applying the finite-difference time-domain (FDTD) method and using anatomically correct child and adult head models. In the calculations, the conductivity and permittivity of all tissues were increased from 5 to 20% but using otherwise the same exposure conditions. A half-wave dipole antenna was used as an exposure source to minimize the uncertainties of the positioning of a real mobile device and making the simulations easily replicable. Common mobile telephony frequencies of 900, 1800 and 2450 MHz were used in this study. The exposures of ear and eye regions were investigated. The SARs of models with increased dielectric values were compared to the SARs of the models where dielectric values were unchanged. The analyses suggest that increasing the value of dielectric parameters does not necessarily mean that volume-averaged SAR would increase. Under many exposure conditions, specifically at

higher frequencies in eye exposure, volume-averaged SAR decreases. An increase of up to 20% in dielectric conductivity or both conductivity and permittivity always caused a SAR variation of less than 20%, usually about 5%, when it was averaged over 1, 5 or 10 g of cubic mass for all models. The thickness and composition of different tissue layers in the exposed regions within the human head play a more significant role in SAR variation compared to the variations (5-20%) of the tissue dielectric parameters.

Ketabi N, Mobasheri H, Faraji-Dana R. Electromagnetic fields (UHF) increase voltage sensitivity of membrane ion channels; possible indication of cell phone effect on living cells. Electromagn Biol Med. 2013 Nov 15. [Epub ahead of print]

The effects of ultra high frequency (UHF) nonionizing electromagnetic fields (EMF) on the channel activities of nanopore forming protein, OmpF porin, were investigated. The voltage clamp technique was used to study the single channel activity of the pore in an artificial bilayer in the presence and absence of the electromagnetic fields at 910 to 990 MHz in real time. Channel activity patterns were used to address the effect of EMF on the dynamic, arrangement and dielectric properties of water molecules, as well as on the hydration state and arrangements of side chains lining the channel barrel. Based on the varied voltage sensitivity of the channel at different temperatures in the presence and absence of EMF, the amount of energy transferred to nano-environments of accessible groups was estimated to address the possible thermal effects of EMF. Our results show that the effects of EMF on channel activities are frequency dependent, with a maximum effect at 930 MHz. The frequency of channel gating and the voltage sensitivity is increased when the channel is exposed to EMF, while its conductance remains unchanged at all frequencies applied. We have not identified any changes in the capacitance and permeability of membrane in the presence of EMF. The effect of the EMF irradiated by cell phones is measured by Specific Absorption Rate (SAR) in artificial model of human head, Phantom. Thus, current approach applied to biological molecules and electrolytes might be considered as complement to evaluate safety of irradiating sources on biological matter at molecular level.

Khalil AM, Gagaa M, Alshamali A. 8-Oxo-7, 8-dihydro-2'-deoxyguanosine as a biomarker of DNA damage by mobile phone radiation. Hum Exp Toxicol.31(7):734-740, 2012.

We examined the effect of exposure to mobile phone 1800 MHz radio frequency radiation (RFR) upon the urinary excretion of 8-oxo-7, 8-dihydro-2'-deoxyguanosine (8-oxodG), one major form of oxidative DNA damage, in adult male Sprague-Dawley rats. Twenty-four rats were used in three independent experiments (RFR exposed and control, 12 rats, each). The animals were exposed to RFR for 2 h from Global System for Mobile Communications (GSM) signal generator with whole-body-specific absorption rate of 1.0 W/kg. Urine samples were collected from the rat while housed in a metabolic cage during the exposure period over a 4-h period at 0.5, 1.0, 2.0 and 4.0 h from the beginning of exposure. In the control group, the signal generator was left in the turn-off position. The creatinine-standardized concentrations of 8-oxodG

were measured. With the exception of the urine collected in the last half an hour of exposure, significant elevations were noticed in the levels of 8-oxodG in urine samples from rats exposed to RFR when compared to control animals. Significant differences were seen overall across time points of urine collection with a maximum at 1 h after exposure, suggesting repair of the DNA lesions leading to 8-oxodG formation.

Khalil AM, Abu Khadra KM, Aljaberi AM, Gagaa MH, Issa HS. Assessment of oxidant/antioxidant status in saliva of cell phone users. Electromagn Biol Med. 2013 Jun 19. [Epub ahead of print]

Hazardous health effects resulting from exposure to radiofrequency electromagnetic radiation (RF-EMR) emitted from cell phones have been reported in the literature. However, the cellular and molecular targets of RF-EMR are still controversial. The aim of this study was to examine the oxidant/antioxidant status in saliva of cell phone users. Saliva samples collected before using a cell phone as well as at the end of 15 and 30 min calls were tested for two commonly used oxidative stress biomarkers: malondialdehyde (MDA) and 8-oxo-7,8-dihydro-2'-deoxyguanosine (8-Oxo-dG). The 8-oxo-dG levels were determined by enzyme-linked immunosorbent (ELISA) competitive assay, while the MDA levels were measured using the OxiSelect MDA adduct ELISA Kit. The antioxidant capacity of the saliva was evaluated using the oxygen radical absorption capacity (ORAC) and the hydroxyl radical averting capacity (HORAC) assays according to the manufacture instructions. The mean 8-oxo-dG and the Bradford protein concentrations (ng/ml and mg/ml, respectively) peaked at 15 min. The levels of HORAC, ORAC and MDA progressively increased with time and reached maximum at 30 min. However, there was no significant effect of talking time on the levels of 8-OxodG and MDA. Similarly, there was no statistically significant effect of talking time on the oxygen and hydroxyl radicals averting capacities, (ORAC) and (HORAC), respectively. These findings suggest that there is no relationship between exposure to radio frequency radiation (RFR) and changes in the salivary oxidant/antioxidant profile.

Khan MM. Adverse effects of excessive mobile phone use.Int J Occup Med Environ Health. 21(4):289-293, 2008.

Introduction: Research findings indicate that the use of mobile phones may lead to a number of symptoms such as headache, impaired concentration and memory, and also fatigue. Materials and Methods: The present study was designed to investigate whether the symptoms of ill health reported by young people may be associated with the use of mobile phone (MP) and to analyze its influence on health and development of medical students. The questionnaire was designed specifically for this study and contained items regarding health condition and health complaints as well as the frequency of MP use. The response rate was 86.6% (286 of 330 forms, completed by 73.77% males and 26.22% females). Results: Most of the subjects (83.57%) had some knowledge about the adverse effects of MP use. 76.92% of the students carried one mobile, and 23.08% more than one. 55.94%, of the subjects reported the average daily MP use of less than 30 min, 27.97%, of 30-60 min, 11.53%, of 60-90

min and 4.54% of more than 90 min. 16.08% of the subjects complained of headache and 24.48% of fatigue. Impaired concentration was reported by 34.27% of respondents, memory disturbances by 40.56%, sleeplessness by 38.8%, hearing problems by 23.07%, and facial dermatitis by 16.78%. The sensation of warmth within the auricle and behind/around the ear was reported by 28.32%. Out of 286 subjects who participated in this study, 44.4% related their symptoms to mobile phone use. Conclusions: The findings of the present study indicate that mobile phones play a large part in the daily life of medical students. Therefore, its impact on psychology and health should be discussed among the students to prevent the harmful effects of mobile phone use.

Khramov RN, Sosunov EA, Koltun SV, Ilyasova EN, Lednev VV, Millimeter-wave effects on electric activity of crayfish stretch receptors. Bioelectromagnetics 12(4):203-214, 1991.

The effects of super high frequency (SHF) microwaves (34-78 GHz) on rates of spontaneous firing of the slowly adapting, stretch-receptor neurons of crayfish were studied. Initially, irradiation of continuously perfused, fluid-cooled preparations at power densities to 250 mW/cm2 caused a transient decrease in the rate of spontaneous firing (the dynamic response). Subsequently, with extinction of the SHF field, the rate of firing increased, finally stabilizing at pre-exposure levels (stationary phase). Rates of firing also increased when the receptor muscle was stretched, and they were inversely correlated with small, field-induced increases of temperature (approximately 1.5 degrees C). The response to SHF radiation did not depend on frequency if temperature of the medium was constant. No resonant peaks were found when the millimeter range of frequencies was scanned.

Khudnitskii, SS, Moshkarev, EA, Fomenko, TV, [On the evaluation of the influence of cellular phones on their users]. [Article in Russian] Med Tr Prom Ekol (9):20-24, 1999.

The authors studied influence of ultrahigh frequency radiation caused by cellular phones on functional state of central nervous, cardiovascular systems and local temperature changes in cellular phones users. The head area near the phone antenna appeared to be under the most intensive heating. Ultrahigh frequency radiation induces significant changes in local temperature and in physiologic parameters of central nervous and cardiovascular systems.

Khullar S1, Sood A2, Sood S3. Auditory Brainstem Responses and EMFs Generated by Mobile Phones. Indian J Otolaryngol Head Neck Surg. 65(Suppl 3):645-649, 2013.

There has been a manifold increase in the number of mobile phone users throughout the world with the current number of users exceeding 2 billion. However this advancement in technology like many others is accompanied by a progressive increase in the frequency and intensity of electromagnetic waves without consideration of the health consequences. The aim of our study was to advance our understanding of the potential adverse effects of GSM mobile phones on auditory

brainstem responses (ABRs). 60 subjects were selected for the study and divided into three groups of 20 each based on their usage of mobile phones. Their ABRs were recorded and analysed for latency of waves I-V as well as interpeak latencies I-III, I-V and III-V (in ms). Results revealed no significant difference in the ABR parameters between group A (control group) and group B (subjects using mobile phones for maximum 30 min/day for 5 years). However the latency of waves was significantly prolonged in group C (subjects using mobile phones for 10 years for a maximum of 30 min/day) as compared to the control group. Based on our findings we concluded that long term exposure to mobile phones may affect conduction in the peripheral portion of the auditory pathway. However more research needs to be done to study the long term effects of mobile phones particularly of newer technologies like smart phones and 3G.

Khurana VG, Hardell L, Everaert J, Bortkiewicz A, Carlberg M, Ahonen M. Epidemiological evidence for a health risk from mobile phone base stations.Int J Occup Environ Health. 16(3):263-267, 2010.

Human populations are increasingly exposed to microwave/radiofrequency (RF) emissions from wireless communication technology, including mobile phones and their base stations. By searching PubMed, we identified a total of 10 epidemiological studies that assessed for putative health effects of mobile phone base stations. Seven of these studies explored the association between base station proximity and neurobehavioral effects and three investigated cancer. We found that eight of the 10 studies reported increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations. None of the studies reported exposure above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting the health of human populations. We believe that comprehensive epidemiological studies of long-term mobile phone base station exposure are urgently required to more definitively understand its health impact.

Kilgallon SJ, Simmons LW. Image content influences men's semen quality. Biol Lett 1:252-255, 2005.

There is increasing evidence from non-human animals that males adjust their ejaculation expenditure according to the risk of sperm competition. In this study we show that, after controlling for lifestyle factors known to influence semen quality, human males viewing images depicting sperm competition had a higher percentage of motile sperm in their ejaculates. Many lifestyle variables were confirmed to influence semen quality, including the recent suggestion that storage of mobile phones close to the testes can decrease semen quality.

Kim BC, Park SO. Evaluation of RF electromagnetic field exposure levels from cellular base stations in Korea. Bioelectromagnetics. 31(6):495-498, 2010.

This article presents the measurement results of human exposure to CDMA800 and CDMA1800 signals at locations in Korea where the general public has expressed concern. Measurements were performed at 50 locations across the country to compare the electromagnetic field levels with the general public exposure compliance

limits. At each site, the distances between the nearest single or co-located base station and measurement positions were within a range of approximately 32-422 m. The measured exposure levels were very low compared with the international standard and the Korean human protection notice. The highest field level was 1.5 V/m, which corresponds to 0.15% of the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines for human exposure.

Kim BC, Kim W-K, Lee G-T, Choi H-D, Kim N, Pack J-K. Evaluation of radiofrequency exposure levels from multiple wireless installations in population dense areas in Korea. Bioelectromagnetics. Published online: 4 SEP 2014 | DOI: 10.1002/bem.21874.

This paper presents the results of measurements from simultaneous human exposure to various radiofrequency (RF) signals at densely populated areas. Measurements were performed at 1260 positions across Korea to determine exposure compliance to electromagnetic fields for the general public. The measured exposure levels were very low compared with the international exposure guidelines and Korean human protection notice. The highest total exposure ratio was 5.1×10^{-3} (approximately 7.1% of guideline limits).

Kim DW, Lee JH, Ji HC, Kim SC, Nam KC, Cha EJ. Physiological effects of RF exposure on hypersensitive people by a cell phone. Conf Proc IEEE Eng Med Biol Soc. 2008:2322-2325, 2008.

Persons with electromagnetic hypersensitivity (EHS) complain of subjective symptoms such as headaches, insomnia, memory loss etc. resulting from radio frequency (RF) radiation by cellular phones. There have been various EHS provocation studies on heart rate, blood pressure, and subjective symptoms using GSM phones. However, there are few provocation studies on case-control study investigating simultaneously physiological parameters from CDMA phones. In this study, two volunteer groups of 18 self-declared EHS and 19 controls were exposed to both sham and real RF exposures by a CDMA cellular phone for half an hour each. We investigated the physiological parameters such as heart rates, respiration rates, and hear rate variability (HRV). In conclusion, the RF exposure by a CDMA cellular phone did not have any effects on the physiological parameters for both groups.

Kim HS, An YS, Paik MJ, Lee YS, Choi HD, Kim BC, Pack JK, Kim N, Ahn YH. The effects of exposure to 915 MHz radiofrequency identification on cerebral glucose metabolism in rat: A [F-18] FDG micro-PET study. Int J Radiat Biol. 2013 May 7. [Epub ahead of print]

Purpose: We investigated the effect of whole-body exposure to 915-MHz radiofrequency identification (RFID) on rat cortical glucose metabolism by using ^{18}F-deoxyglucose positron emission tomography (FDG-PET). Materials and methods: Male Sprague-Dawley rats were divided into three groups: Cage-control, sham-exposed and RFID-exposed groups. Rats were exposed to the 915-MHz RFID for 8 h daily, 5 days per week, for 2 or 16 weeks. The whole-body average specific

absorption rate (SAR) was 4 W/kg for the field of the 915 MHz RFID signal. FDG-PET images were obtained the day after RFID exposure, using micro-PET with a FDG tracer. With a Xeleris functional imaging workstation, absolute values in regions of interest (ROI) in the frontal, temporal and parietal cortexes and cerebellum were measured. Cortical ROI values were normalized to the cerebellar value and compared. Results: The data showed that the relative cerebral glucose metabolic rate was unchanged in the frontal, temporal and parietal cortexes of the 915 MHz RFID-exposed rats, compared with rats in cage-control and sham-exposed groups. Conclusion: Our results suggest that 915_MHz_RFID radiation exposure did not cause a significant long lasting effect on glucose metabolism in the rat brain.

Kim HS, Kim YJ, Lee YH, Lee YS, Choi HD, Pack JK, Kim N, Ahn YH. Effect of whole-body exposure to the 848.5-MHz code division multiple access (CDMA) electromagnetic field on adult neurogenesis in the young, healthy rat brain. Int J Radiat Biol. 2014 Dec 15:1-15. [Epub ahead of print]

Introduction: Whether exposure to the 848.5-MHz code division multiple access (CDMA) signal affects adult neurogenesis is unclear. Materials and methods: An animal experiment was performed with a reverberation chamber designed as a whole-body CDMA exposure system. Male Sprague-Dawley rats were assigned to three groups (n = 6 per group): cage-control, sham-exposed, and CDMA-exposed groups. Rats in the CDMA-exposed group were exposed to the CDMA signal at a 2 W/kg whole-body specific absorption rate (SAR) for 1 or 8 h daily, 5 days per week, for 2 weeks. Rats received a single intraperitoneal injection of Bromodeoxyuridine (BrdU) to label proliferative cells daily for the last five consecutive days of CDMA signal exposure. An unbiased stereological method was used to estimate the number of $BrdU^+$ cells in the subventricular zone (SVZ) and dentate gyrus (DG). Results: We found no significant changes in the number of $BrdU^+$ cells in the SVZ or DG in the CDMA-exposed rats, compared with rats in the cage-control and sham-exposed groups ($p > 0.05$). Conclusion: Our results suggest that exposure to the CDMA signal does not affect neurogenesis in the adult rat brain, at least under our experimental conditions.

Kim HS, Park JS, Jin YB, Do Choi H, Kwon JH, Pack JK, Kim N, Ahn YH. Effects of exposure to electromagnetic field from 915 MHz radiofrequency identification system on circulating blood cells in the healthy adult rat. Bioelectromagnetics. 2017 Nov 24. doi: 10.1002/bem.22093.

We investigated whether exposure to the 915 MHz radiofrequency identification (RFID) signal affected circulating blood cells in rats. Sprague-Dawley rats were exposed to RFID at a whole-body specific absorption rate of 2 W/kg for 8 h per day, 5 days per week, for 2 weeks. Complete blood counts were performed after RFID exposure, and the CD4+ /CD8+ ratio was determined by flow cytometry. The number of red blood cells (RBCs) and the values of hemoglobin, hematocrit, and RBC indices were increased in the RFID-exposed group compared with those in the cage-control and sham-exposed groups ($P < 0.05$). However, the RBCs and platelet numbers were within normal physiologic response ranges. The number of white blood cells, including lymphocytes, was

decreased in RFID-exposed rats. However, there was no statistically significant difference between the sham-exposed and RFID-exposed groups in terms of T-cell counts or CD4+ /CD8+.

Kim JH, Kim HJ, Yu DH, Kweon HS, Huh YH, Kim HR. Changes in numbers and size of synaptic vesicles of cortical neurons induced by exposure to 835 MHz radiofrequency-electromagnetic field. PLoS One. 2017 Oct 18;12(10):e0186416.

We studied the effects of radiofrequency electromagnetic fields (RF-EMFs) exposure on neuronal functions of mice. Particularly, we focused on RF-EMF effects on synaptic vesicles (SVs), which store neurotransmitters at axon terminals or synaptic boutons. C57 BL/6 mice were exposed to 835 MHz RF-EMF (4.0 W/kg SAR, for 5 h daily) and alterations in SVs at presynaptic terminals in the cerebral cortex were determined. Ultrastructure of randomly selected cortical neurons was observed using typical electron microscopy and bio-high voltage electron microscopy (Bio-HVEM) methods, which enable the estimation of the numbers and size of SVs. The density of the SVs (number /10 μm2 or 40 μm3) was significantly decreased in the presynaptic boutons of cortical neurons after RF-EMF exposure. Furthermore, qPCR and immunoblotting analyses revealed that the expression of synapsins I/II (Syns I/II) genes and proteins were significantly decreased in the cortical neurons of RF-EMF exposed mice. The present study suggested that alteration of SVs and Syn levels may result in alterations of neurotransmitters in the cerebral cortex following RF-EMF exposure.

Kim JY, Hong SY, Lee YM, Yu SA, Koh WS, Hong JR, Son T, Chang SK, Lee M. In vitro assessment of clastogenicity of mobile-phone radiation (835 MHz) using the alkaline comet assay and chromosomal aberration test. Environ Toxicol. 23(3):319-327, 2008.

Recently we demonstrated that 835-MHz radiofrequency radiation electromagnetic fields (RF-EMF) neither affected the reverse mutation frequency nor accelerated DNA degradation in vitro. Here, two kinds of cytogenetic endpoints were further investigated on mammalian cells exposed to 835-MHz RF-EMF (the most widely used communication frequency band in Korean CDMA mobile phone networks) alone and in combination with model clastogens: in vitro alkaline comet assay and in vitro chromosome aberration (CA) test. No direct cytogenetic effect of 835-MHz RF-EMF was found in the in vitro CA test. The combined exposure of the cells to RF-EMF in the presence of ethylmethanesulfonate (EMS) revealed a weak and insignificant cytogenetic effect when compared to cells exposed to EMS alone in CA test. Also, the comet assay results to evaluate the ability of RF-EMF alone to damage DNA were nearly negative, although showing a small increase in tail moment. However, the applied RF-EMF had potentiation effect in comet assay when administered in combination with model clastogens (cyclophosphamide or 4-nitroquinoline 1-oxide). Thus, our results imply that we cannot confidently exclude any possibility of an increased risk of genetic damage, with important implications for the possible health effects of exposure to 835-MHz electromagnetic fields.

Kim JY, Kim HJ, Kim N, Kwon JH, Park MJ. Effects of radiofrequency field exposure on glutamate-induced oxidative stress in mouse hippocampal HT22 cells. Int J Radiat Biol. 2016 Sep 20:1-22. [Epub ahead of print]

PURPOSE: To define the impact of radiofrequency (RF) under in vitro experimental Alzheimer's disease conditions, we investigated the effect of RF radiation on glutamate-induced oxidative stress in mouse hippocampal neuronal HT22 cells. MATERIALS AND METHODS: Cell survival rate was measured by MTT and trypan blue exclusion assays. Cell cycle distribution, cell death, and ROS production were analyzed using flow cytometry. Expression of proteins was analyzed by Western blot. RESULTS: RF exposure alone had a marginal impact on cell proliferation, however significantly enhanced glutamate-induced cytotoxicity in HT22 cells. Glutamate augmented the subG1 fraction of cell cycle, annexin/propidium iodide positive cell population, and expression of cleaved poly (ADP ribose) polymerase, which were further increased by RF exposure. Glutamate induced reactive oxygen species (ROS) generation and RF exposure further upregulated it. N-acetylcysteine (NAC) treatment completely abrogated glutamate- and RF-induced ROS production followed by cell death and restored cell proliferation in HT22 cells. Finally, glutamate phosphorylated c-Jun N-terminal kinase (JNK) and RF increased this event further. Treatment with NAC and inhibitor of JNK decreased JNK phosphorylation and restored cell proliferation, respectively. CONCLUSIONS: Our results demonstrate that RF exposure enhanced glutamate-induced cytotoxicity by further increase of ROS production in HT22 cells.

Kim K, Kim HJ, Song DJ, Cho YM, Choi JW. Risk perception and public concerns of electromagnetic waves from cellular phones in Korea. Bioelectromagnetics. 35(4):235-344, 2014.

In this study, the difference between the risk perception of electromagnetic waves from cellular phones and the risk perception of other factors such as environment and food was analyzed. The cause of the difference in the psychological and social factors that affect the group with high risk perception of electromagnetic waves was also analyzed. A questionnaire survey on the risk perception of electromagnetic waves from cellular phones was carried out on 1001 subjects (men and women) over the age of 20. In the group with high risk perception of electromagnetic waves from cellular phones, women had higher risk perception than men. Logistic regression analysis, where the group with high risk perception of electromagnetic waves and the group with low risk perception were used as dependent variables, indicated that the risk perception of electromagnetic waves in women was 1.815 times statistically significantly higher than the risk perception of men (95% CI: 1.340-2.457). Also, high risk perception of electromagnetic waves from cellular phones was observed when the subjects considered that they had more personal knowledge (OR: 1.416, 95% CI: 1.216-1.648), that the seriousness of the risk to future generations was high (OR: 1.410, 95% CI: 1.234-1.611), and their outrage for the occurrence of accidents related to electromagnetic waves was high (OR: 1.460, 95% CI: 1.264-1.686). The results of this study need to be sufficiently considered and reflected in designing the risk communication strategies and communication methods for the preventive measures and advice on electromagnetic waves from cellular phones.

Kim KB, Byun HO, Han NK, Ko YG, Choi HD, Kim N, Pack JK, Lee JS. Two-dimensional electrophoretic analysis of radio-frequency radiation-exposed MCF7 breast cancer cells. J Radiat Res. 51(2):205-213, 2010.

Although many in vitro studies have previously been conducted to elucidate the biological effects of radio frequency (RF) radiation over the past decades, the existence and nature of any effects is still inconclusive. In an effort to further elucidate this question, we have monitored changes in protein expression profiles in RF-exposed MCF7 human breast cancer cells using two-dimensional gel electrophoresis. MCF7 cells were exposed to 849 MHz RF radiation for 1 h per day for three consecutive days at specific absorption rates (SARs) of either 2 W/Kg or 10 W/kg. During exposure, the temperature in the exposure chamber was kept in an isothermal condition. Twenty-four hours after the final RF exposure, the protein lysates from MCF cells were prepared and two-dimensional electrophoretic analyses were conducted. The protein expression profiles of the MCF cells were not significantly altered as the result of RF exposure. None of the protein spots on the two-dimensional electrophoretic gels showed reproducible changes in three independent experiments. To determine effect of RF radiation on protein expression profiles more clearly, three spots showing altered expression without reproducibility were identified using electrospray ionization tandem mass spectrometry analysis and their expressions were examined with RT-PCR and Western blot assays. There was no alteration in their mRNA and protein levels. As we were unable to observe any significant and reproducible changes in the protein expression profiles of the RF radiation-exposed MCF7 cells using high throughput and non-high throughput techniques, it seems unlikely that RF exposure modulates the protein expression profile.

Kim JH, Yu DH, Kim HJ, Huh YH, Cho SW, Lee JK, Kim HG, Kim HR. Exposure to 835 MHz radiofrequency electromagnetic field induces autophagy in hippocampus but not in brain stem of mice. Toxicol Ind Health. 2017 Jan 1:748233717740066. doi: 10.1177/0748233717740066.

The exploding popularity of mobile phones and their close proximity to the brain when in use has raised public concern regarding possible adverse effects from exposure to radiofrequency electromagnetic fields (RF-EMF) on the central nervous system. Numerous studies have suggested that RF-EMF emitted by mobile phones can influence neuronal functions in the brain. Currently, there is still very limited information on what biological mechanisms influence neuronal cells of the brain. In the present study, we explored whether autophagy is triggered in the hippocampus or brain stem after RF-EMF exposure. C57BL/6 mice were exposed to 835 MHz RF-EMF with specific absorption rates (SAR) of 4.0 W/kg for 12 weeks; afterward, the hippocampus and brain stem of mice were dissected and analyzed. Quantitative real-time polymerase chain reaction (qRT-PCR) analysis demonstrated that several autophagic genes, which play key roles in autophagy regulation, were significantly upregulated only in the hippocampus and not in the brain stem. Expression levels of LC3B-II protein and p62, crucial autophagic regulatory proteins, were significantly changed only in the hippocampus. In parallel, transmission electron microscopy (TEM) revealed an increase in the number of autophagosomes and autolysosomes in the hippocampal neurons of RF-EMF-exposed

mice. The present study revealed that autophagy was induced in the hippocampus, not in the brain stem, in 835 MHz RF-EMF with an SAR of 4.0 W/kg for 12 weeks. These results could suggest that among the various adaptation processes to the RF-EMF exposure environment, autophagic degradation is one possible mechanism in specific brain regions.

Kim MJ, Rhee SJ. Green tea catechins protect rats from microwave-induced oxidative damage to heart tissue. J Med Food. 7(3):299-304, 2004.

We investigated the effects of **greentea** catechin on oxidative damage in microwave-exposed rats. The microwave-exposed rats received one of three diets: catechin-free (MW-0C), 0.25% catechin (MW-0.25C), or 0.5% catechin (MW-0.5C). Rats were sacrificed 6 days after microwave irradiation (2.45 GHz, 15 minutes). Cytochrome P(450) levels in the MW-0C group was increased by 85% compared with normal, but was 11% and 14% lower in the MW-0.25C and MW-0.5C groups than in the MW-0C group. NADPH-cytochrome P(450) reductase activity in the MW-0C group was increased by 29%, compared with the normal group, but was significantly less in the MW-0.25C and MW-0.5C groups. Superoxide dismutase activity in the MW-0C group was decreased by 34%, compared with the normal group, but in the MW-0.25C and MW-0.5C groups was 19% and 25% higher. The activity of glutathione peroxidase in the MW-0C group was decreased by 28% but remained near normal with catechin supplements. Superoxide radical concentrations in the MW-0C group were increased by 35%, compared with the normal group. However, superoxide radicals in the MW-0.25C and MW-0.5C groups were 11% and 12% lower, respectively, compared with the MW-0C group. Microwave irradiation significantly increased levels of thiobarbituric acid-reactive substances, carbonyl values, and lipofuscin contents, but **greentea** catechin partially overcame the effects of the microwave irradiation. In conclusion, the mixed function oxidase system was activated, the formation of superoxide radical, lipid peroxide, oxidized protein, and lipofuscin was increased, and the antioxidative defense system was weakened in heart tissue of microwave-exposed rats, but the oxidative damage was significantly reduced by catechin supplementation.

Kim SC, Nam KC, Kim DW. Estimation of relative exposure levels for cellular phone users using a neural network. Bioelectromagnetics. 27(6):440-444, 2006.

The wide and growing use of cellular phones has raised questions about the possible health risks associated with radio frequency (RF) electromagnetic fields. It would be helpful for epidemiologists as well as cellular phone users to obtain the relative exposure levels, because the RF exposure level is very difficult to accurately measure and quantify for all individuals. In this study, a neural network model was developed to estimate relative exposure levels on a scale of 0-10 and thus rank the individual risk of exposure using available information. We used parameters such as usage time per day, total usage period, hands-free usage, extension of antenna, specific absorption rate (SAR) of the cellular phone, and flip or folder type, which are related to RF exposure. Using the relative exposure levels obtained from this model, epidemiologists can divide the subjects into exposed and nonexposed groups in a study investigating the relationship between exposure level and brain cancer in the future, provided that more knowledge between the cellular phone usage pattern and the exposure is available.

Kim TH, Huang TQ, Jang JJ, Kim MH, Kim HJ, Lee JS, Pack JK, Seo JS, Park WY. Local exposure of 849 MHz and 1763 MHz radiofrequency radiation to mouse heads does not induce cell death or cell proliferation in brain.Exp Mol Med. 40(3):294-303, 2008.

Erratum in Exp Mol Med. 2008 Aug 31;40(4):477. Kim, Tae-Hyoung [corrected to Kim, Tae-Hyung].

Even though there is no direct evidence to prove the cellular and molecular changes induced by radiofrequency (RF) radiation itself, we cannot completely exclude the possibility of any biological effect of mobile phone frequency radiation. We established a carousel-type exposure chamber for 849 MHz or 1763 MHz of mobile phone RF radiation to expose RF to the heads of C57BL mice. In this chamber, animals were irradiated intermittently at 7.8 W/kg for a maximum of 12 months. During this period, the body weights of 3 groups-sham, 849 MHz RF, and 1763 MHz RF-did not show any differences between groups. The brain tissues were obtained from 3 groups at 6 months and 12 months to examine the differences in histology and cell proliferation between control and RF exposure groups, but we could not find any change upon RF radiation. Likewise, we could not find changes in the expression and distribution of NeuN and GFAP in hippocampus and cerebellum, or in cell death by TUNEL assay in RF exposure groups. From these data, we conclude that the chronic exposure to 849 MHz and 1763 MHz RF radiation at a 7.8 W/kg specific absorption rate (SAR) could not induce cellular alterations such as proliferation, death, and reactive gliosis.

Kimata H. Enhancement of allergic skin wheal responses by microwave radiation from mobile phones in patients with atopic eczema/dermatitis syndrome. Int Arch Allergy Immunol 129(4):348-350, 2002.

Microwave radiation from mobile phones enhanced skin wheal responses induced by house dust mite and Japanese cedar pollen while it had no effect on wheal responses induced by histamine in patients with atopic eczema/dermatitis syndrome (AEDS). Microwave radiation also increased plasma levels of substance P (SP) and vasoactive intestinal peptide (VIP) in patients with AEDS. These results indicate that microwave radiation from mobile phones may enhance allergen-induced wheal responses in association with the release of SP and VIP. This finding may be useful in elucidating the pathophysiology and treatment of AEDS.

Kimata H. Enhancement of allergic skin wheal responses in patients with atopic eczema/dermatitis syndrome by playing video games or by a frequently ringing mobile phone. Eur J Clin Invest. 33(6):513-517, 2003.

BACKGROUND: Playing video games causes physical and psychological stress, including increased heart rate and blood pressure and aggression-related feelings. Use of mobile phones is very popular in Japan, and frequent ringing is a common and intrusive part of Japanese life. Atopic eczema/dermatitis syndrome is often exacerbated by stress. Stress increases serum IgE levels, skews cytokine pattern towards Th2 type, enhances

allergen-induced skin wheal responses, and triggers mast cell degranulation via substance P, vasoactive intestinal peptide and nerve growth factor. MATERIALS AND METHODS: (1) In the video game study, normal subjects (n = 25), patients with allergic rhinitis (n = 25) or atopic eczema/dermatitis syndrome (n = 25) played a video game (STREET FIGHTER II) for 2 h. Before and after the study, allergen-induced wheal responses, plasma levels of substance P, vasoactive intestinal peptide and nerve growth factor, and in vitro production of total IgE, antihouse dust mite IgE and cytokines were measured. (2) In the mobile phone study, normal subjects (n = 27), patients with allergic rhinitis (n = 27) or atopic eczema/dermatitis syndrome (n = 27) were exposed to 30 incidences of ringing mobile phones during 30 min. Before and after the study, allergen-induced wheal responses, plasma levels of substance P, vasoactive intestinal peptide and nerve growth factor were measured. RESULTS: Playing video games had no effect on the normal subjects or the patients with allergic rhinitis. In contrast, playing video games significantly enhanced allergen-induced skin wheal responses and increased plasma levels of substance P, vasoactive intestinal peptide and nerve growth factors in the patients with atopic eczema/dermatitis syndrome. Moreover, playing video games enhanced in vitro production of total IgE and anti-house dust mite IgE with concomitant increased production of IL-4, IL-10 and IL-13 and decreased production of IFN-gamma and IL-12 in the patients with atopic eczema/dermatitis syndrome. However, exposure to frequently ringing mobile phones significantly enhanced allergen-induced skin wheal responses, plasma levels of substance P, vasoactive intestinal peptide and nerve growth factors in the patients with atopic eczema/dermatitis syndrome, but not in the normal subjects or the patients with allergic rhinitis. CONCLUSION: Playing video games enhanced allergic responses with a concomitant increased release of substance P, vasoactive intestinal peptide and nerve growth factor, and skewing of the cytokine pattern toward Th2 type in the patients with atopic eczema/dermatitis syndrome. In addition, exposure to frequently ringing mobile phones also enhanced allergic responses with a concomitant increased release of substance P, vasoactive intestinal peptide and nerve growth factor Collectively, high technology causes stress, which in turn may aggravate symptoms of atopic eczema/dermatitis syndrome.

Kimata H. Laughter counteracts enhancement of plasma neurotrophin levels and allergic skin wheal responses by mobile phone-mediated stress. Behav Med. 29(4):149-152, 2004.

Laughter caused by viewing a comic video (Rowan Atkinson's The Best Bits of Mr. Bean) reduced the plasma nerve growth factor, neurotrophin-3 levels, and allergic skin wheal responses in patients with atopic dermatitis, whereas viewing a nonhumorous video (weather information) failed to do so. In contrast, stress induced by writing mail on a mobile phone enhanced the plasma nerve growth factor, neurotrophin-3 levels, and allergic skin wheal responses. However, previewing the comic video counteracted mobile phone-mediated enhancement of plasma neurotrophins or allergic skin wheal responses, whereas previewing the weather information failed to do so. Taken together, these results suggest that, in patients with atopic dermatitis, writing mail on a mobile phone causes stress and enhances allergic responses with a concomitant increase in plasma neurotrophins that are counteracted by laughter. These results may be useful in the study

of pathophysiology and treatment of atopic dermatitis.

Kimata H. Microwave radiation from cellular phones increases allergen-specific IgE production. Allergy 60(6):838-839, 2005. (no abstract available).

Kirschvink JL, Microwave absorption by magnetite: a possible mechanism for coupling nonthermal levels of radiation to biological systems. Bioelectromagnetics 17(3):187-194, 1996.

The presence of trace amounts of biogenic magnetite (Fe3O4) in animal and human tissues and the observation that ferromagnetic particles are ubiquitous in laboratory materials (including tissue culture media) provide a physical mechanism through which microwave radiation might produce or appear to produce biological effects. Magnetite is an excellent absorber of microwave radiation at frequencies between 0.5 and 10.0 GHz through the process of ferromagnetic resonance, where the magnetic vector of the incident field causes precession of Bohr magnetons around the internal demagnetizing field of the crystal. Energy absorbed by this process is first transduced into acoustic vibrations at the microwave carrier frequency within the crystal lattice via the magnetoacoustic effect; then, the energy should be dissipated in cellular structures in close proximity to the magnetite crystals. Several possible methods for testing this hypothesis experimentally are discussed. Studies of microwave dosimetry at the cellular level should consider effects of biogenic magnetite.

Kismali G, Ozgur E, Guler G, Akcay A, Sel T, Seyhan N. The influence of 1800 MHz GSM-like signals on blood chemistry and oxidative stress in non-pregnant and pregnant rabbits. Int J Radiat Biol. 88(5):414-419, 2012.

PURPOSE: Environmental electromagnetic fields originate from man-made sources, such as mobile phones and base stations, and have led to increasing publicconcern about their possible adverse health effects. We aimed to investigate the possible effects of radiofrequency radiation (RFR) generated from these devices on oversensitive animals, such as pregnant rabbits. MATERIALS AND METHODS: In the present study, the effects of whole body 1800 MHz Global System for Mobile Communications (GSM)-like RFR exposure for 15 min/day for seven days on blood chemistry and lipid peroxidation levels in both non-pregnant and pregnant New Zealand White rabbits were investigated. Thirteen-month-old rabbits were studied in the following four groups: Non-pregnant control, non-pregnant RFR-exposed, pregnant control and pregnant RFR-exposed. RESULTS: Lipid peroxidation, namely malondialdehyde (MDA) levels, did not change after RFR exposure. However, blood chemistry parameters, such as cholesterol (CHO), total protein (TP), albumin (ALB), uric acid, creatinin and creatine kinase (CK) and creatine kinase-myocardial band isoenzyme (CK-MB) changed due to both pregnancy and RFR exposure. CONCLUSION: Our investigations have been shown that no indication for oxidative stress was detected in the blood of pregnant rabbits upon RF exposure at specific conditions employed in the present study. Minor changes in some blood chemistry parameters were detected but CK-MB and CK increases were found remarkable. Studies on RFR exposure during pregnancy will help establish international standards for the protection of pregnant women from environmental RFR.

Kittel A, Siklos L, Thuroczy G, Somosy Z, Qualitative enzyme histochemistry and microanalysis reveals changes in ultrastructural distribution of calcium and calcium-activated ATPases after microwave irradiation of the medial habenula. Acta Neuropathol (Berl) 92(4):362-368, 1996.

The localization of calcium and calcium-activated ATPases was investigated electron microscopically in the medial habenula of mice after whole body irradiation with modulated microwaves. In non-irradiated animals calcium-containing precipitates were seen in different subcellular compartments and were often localized on the luminal side of membranes of synaptic vesicles in nerve terminals. At 1 h after 16-Hz modulated microwave irradiation, the number of synaptic vesicles containing calcium precipitates decreased, and reaction products appeared at new locations: in the synaptic clefts and on non-synaptic surfaces of the neuronal plasma membrane. This modified calcium distribution remained unchanged for 24 h following irradiation. Calcium-activated "ecto"-localized ATPase was detected as a punctuated-linear distribution of the reaction product outlining whole areas of glial and neuronal plasma membrane in the habenula of control animals. This pattern did not change on microwave irradiation. However, a quercetin-sensitive "endo"-localized Ca(2+)-ATPase activity appeared in some nerve terminals 24 h after irradiation. Thus, microwave irradiation can influence neuronal calcium homeostasis by inducing Ca2+ redistribution across the plasma membrane and by modifying Ca(2+)-ATPase activity. However, no direct correlation between these effects could be demonstrated by the present study.

Kiyohara K, Wake K, Watanabe S, Arima T, Sato Y, Kojimahara N, Taki M, Yamaguchi N. Recall accuracy of mobile phone calls among Japanese young people. J Expo Sci Environ Epidemiol. 2015 Mar 18. doi: 10.1038/jes.2015.13. [Epub ahead of print]

This study aimed to elucidate the recall accuracy of mobile phone calls among young people using new software-modified phone (SMP) technology. A total of 198 Japanese students aged between 10 and 24 years were instructed to use a SMP for 1 month to record their actual call statuses. Ten to 12 months after this period, face-to-face interviews were conducted to obtain the self-reported call statuses during the monitoring period. Using the SMP record as the gold standard of validation, the recall accuracy of phone calls was evaluated. A total of 19% of the participants (34/177) misclassified their laterality (i.e., the dominant side of ear used while making calls), with the level of agreement being moderate (κ-statistics, 0.449). The level of agreement between the self-reports and SMP records was relatively good for the duration of calls (Pearson's r, 0.620), as compared with the number of calls (Pearson's r, 0.561). The recall was prone to small systematic and large random errors for both the number and duration of calls. Such a large random recall error for the amount of calls and misclassification of laterality suggest that the results of epidemiological studies of mobile phone use based on self-assessment should be interpreted cautiously.

Kizilay A, Ozturan O, Erdem T, Tayyar Kalcioglu M, Cem Miman M. Effects of chronic exposure of electromagnetic fields from mobile phones on hearing in rats.

Auris Nasus Larynx. 30(3):239-245, 2003.

OBJECTIVE: Little attention has been paid to the effects of electromagnetic field (EMF) of mobile phones on hearing. The aim of this study is to investigate the effects of chronic exposure to EMF emitting from mobile phones on the inner ear of adult and developing rats using distortion product otoacoustic emissions (DPOAEs). METHODS: EMF of mobile phones exposure was scheduled according to a sham-exposure controlled experimental design. Every day seven of 14 adult and four newborn rats were exposed to 1-h mobile phone EMF for 30 days, while the other seven adult rats were assigned to control group. DPOAEs were measured in both groups before and after the chronic exposure to EMF. The newborn rats were tested following similar exposure beginning on the 2nd day after birth. RESULTS: No measurable EMF associated changes in DPOAEs either in adult or developing rat inner ears were determined (P>0.05). CONCLUSION: It was concluded that chronic exposure of EMF, as long as 30 days 1 h per day, emitting from a mobile phone did not cause any hearing deterioration in adult and developing rats, at least at outer and middle ear and cochlear levels.

Klaeboe L, Blaasaas KG, Tynes T.Use of mobile phones in Norway and risk of intracranial tumours. Eur J Cancer Prev. 16(2):158-164, 2007.

To test the hypothesis that exposure to radio-frequency electromagnetic fields from mobile phones increases the incidence of gliomas, meningiomas and acoustic neuromas in adults. The incident cases were of patients aged 19-69 years who were diagnosed during 2001-2002 in Southern Norway. Population controls were selected and frequency-matched for age, sex, and residential area. Detailed information about mobile phone use was collected from 289 glioma (response rate 77%), 207 meningioma patients (71%), and 45 acoustic neuroma patients (68%) and from 358 (69%) controls. For regular mobile phone use, defined as use on average at least once a week or more for at least 6 months, the odds ratio was 0.6 (95% confidence interval 0.4-0.9) for gliomas, 0.8 (95% confidence interval 0.5-1.1) for meningiomas and 0.5 (95% confidence interval 0.2-1.0) for acoustic neuromas. Similar results were found with mobile phone use for 6 years or more for gliomas and acoustic neuromas. An exception was meningiomas, where the odds ratio was 1.2 (95% confidence interval 0.6-2.2). Furthermore, no increasing trend was observed for gliomas or acoustic neuromas by increasing duration of regular use, the time since first regular use or cumulative use of mobile phones. The results from the present study indicate that use of mobile phones is not associated with an increased risk of gliomas, meningiomas or acoustic neuromas.

Klaps A, Ponocny I, Winker R, Kundi M, Auersperg F, Barth A. Mobile phone base stations and well-being - A meta-analysis. Sci Total Environ. 544:24-30, 2015. doi: 10.1016/j.scitotenv.2015.11.009. [Epub ahead of print]

It is unclear whether electromagnetic fields emitted by mobile phone base stations affect well-being in adults. The existing studies on this topic are highly inconsistent. In the current paper we attempt to clarify this question by carrying out a meta-analysis which is based on the results of 17 studies. Double-blind studies found no effects on human well-being. By contrast, field or unblinded studies clearly showed

that there were indeed effects.
This provides evidence that at least some effects are based on a nocebo effect. Whether there is an influence of electromagnetic fields emitted by mobile phone base stations thus depends on a person's knowledge about the presence of the presumed cause. Taken together, the results of the meta-analysis show that the effects of mobile phone base stations seem to be rather unlikely. However, nocebo effects occur.

Kleinlogel H, Dierks T, Koenig T, Lehmann H, Minder A, Berz R Effects of weak mobile Phone-Electromagnetic fields (GSM, UMTS) on well-being and resting EEG. Bioelectromagnetics. 29(6):479-487, 2008.

Modern mobile phones emit electromagnetic fields (EMFs) ranging from 900 to 2000 MHz which are suggested to have an influence on well-being, attention and neurological parameters in mobile phone users. To date most studies have investigated Global System for Mobile Communications (GSM)-EMF and only very few studies were concerned with Universal Mobile Telecommunications System (UMTS)-EMF. Consequently, we tested the effects of both types of EMF, 1950 MHz UMTS (SAR 0.1 and 1 W/kg) and pulsed 900 MHz GSM (1 W/kg), on well-being and vigilance-controlled resting electroencephalogram (eyes closed) in 15 healthy, right-handed subjects. A double-blind, randomised, crossover application of the test procedure was used. Neither the UMTS- nor the GSM-EMF produced any significant changes in the measured parameters compared to sham exposure. The results do not give any evidence for a deleterious effect of the EMF on normal healthy mobile phone users.

Kleinlogel H, Dierks T, Koenig T, Lehmann H, Minder A, Berz R. Effects of weak mobile phone - electromagnetic fields (GSM, UMTS) on event related potentials and cognitive functions. Bioelectromagnetics. 29(6):488-497, 2008.

Modern mobile phones emit electromagnetic fields (EMF) ranging from 900 to 2000 MHz which are suggested to have an influence on well-being, attention and neurological parameters in mobile phone users. Until now most studies have investigated Global System for Mobile Communications (GSM)-EMF and only very few studies have focused on Universal Mobile Telecommunications System (UMTS)-EMF. Therefore, we tested the effects of both types of unilaterally presented EMF, 1950 UMTS (0.1 and 1 W/kg) and pulsed 900 MHz GSM (1 W/kg), on visually evoked occipital P100, the P300 of a continuous performance test, auditory evoked central N100 and the P300 during an oddball task as well as on the respective behavioral parameters, reaction time and false reactions, in 15 healthy, right handed subjects. A double-blind, randomized, crossover application of the test procedure was used. Neither the UMTS- nor the GSM-EMF produced any significant changes in the measured parameters compared to sham exposure. The results do not give any evidence for a deleterious effect of the EMF on normal healthy mobile phone users.

Klug S, Hetscher M, Giles S, Kohlsmann S, Kramer K, The lack of effects of nonthermal RF electromagnetic fields on the development of rat embryos grown in culture. Life Sci 61(18):1789-1802, 1997.

Rat embryos (9.5 days old) were exposed for up to 36 h to various radio frequency (RF) electric and magnetic fields (modulation frequency: 16, 60, 120 Hz; electric field strength: 60, 600 V/m; magnetic induction: 0.2, 2.0 microT). A resonator technique was used to generate standing waves thus fulfilling three conditions: The site of maximum electric and magnetic oscillations could be separated, the field strengths were known exactly and a high homogeneity over the sample volume was achieved. In each frequency region the transmitter power levels were set to give specific absorption rate (SAR) values spreading from far below to far above the values met in the field of telecommunication (0.2, 1.0 and 5.0 W/kg). The criteria used to examine the embryos on day 11.5 for possible structural effects consisted of a scoring system, photographs, histology using both light and electron microscopy and determination of the protein content. All these data have been taken as sets of different intermediate frequency (IF) amplitude modulation of the RF carriers. Neither the electric nor the magnetic fields tested interfered significantly with the normal growth and differentiation of the embryos in vitro.

Koca O, Gökçe AM, Oztürk MI, Ercan F, Yurdakul N, Karaman MI. Effects of intensive cell phone (philips genic 900) use on the rat kidney tissue. Urol J. 10(2):886-891. 2013.

PURPOSE: To investigate effects of electromagnetic radiation (EMR) emitted by cell phones on the rat kidney tissue. MATERIALS AND METHODS: Twenty-one male Albino rats were divided into 3 groups, each comprising 7 rats. Group 1 was exposed to a cell phone in speech mode for 8 hours/day for 20 days and their kidneys were removed. Group 2 was exposed to EMR for 20 days and then their kidneys were removed after an interval of 20 days. Cell phone used in the present study was Philips Genie 900, which has the highest specific absorption rate on the market. RESULTS: Light microscopic examination of the kidney tissues obtained from the first group of rats revealed glomerular damage, dilatation of Bowman's capsule, formation of large spaces between the tubules, tubular damage, perivascular edema, and inflammatory cell infiltration. The mean severity score was 4.64 ± 1.7 in group 1, 4.50 ± 0.8 in group 2, and 0 in group 3. While there was no significant difference between group 1 and group 2 ($P > .05$), the mean severity scores of groups 1 and 2 were significantly higher than that of the control group ($P = .001$ for each). CONCLUSION: Considering the damage in rat kidney tissue caused by EMR-emitting cell phones, high-risk individuals should take protective measures.

Koca O, Gokce AM, Akyuz M, Ercan F, Yurdakul N, Karaman MI. A new problem in inflammatory bladder diseases: Use of mobile phones! Int Braz J Urol. 40(4):520-525, 2014.

PURPOSE: Technological developments provide a lot of conveniences to our lives. This issue is one of the risks that arise along with these conveniences. In our study we tried to understand the impact of electromagnetic waves from mobile phones on bladder tissue. MATERIALS AND METHODS: Twenty-one adult male albino rats were divided into three equal groups. Group 1 was exposed to electromagnetic wave for 8 hours per day for 20 days and then their bladders were taken off immediately. Group 2 was firstly exposed to electromagnetic wave for 8 hours per day for 20 days then secondly another for 20 days

without exposition to electromagnetic wave and then their bladders were taken off. Group 3 was the control group and they were not exposed to electromagnetic wave. RESULTS: Under microscopic examination of bladder tissue, in the first group severe inflammatory cell infiltration was seen in lamina propria and muscle layer in contrast to intact urothelium. In the second group mild inflammatory cell infiltration was seen in lamina propria and muscle layer. The mean scores for the three groups were 5.5 ± 2.5, 0.8 ± 1.3 and 1.2 ± 1.5 respectively. Mean score of group 1 was statistically higher than others (p = 0.001). CONCLUSION: Intensive use of mobile phones has negative impact on bladder tissue as well as the other organs. Keeping a minimum level of mobile phone use makes it easy to be kept under control of diseases in which inflammation is an etiologic factor.

Kolosova LI, Akoev GN, Avelev VD, Riabchikova OV, Babu KS, Effect of low-intensity millimeter wave electromagnetic radiation on regeneration of the sciatic nerve in rats. Bioelectromagnetics 17(1):44-47, 1996.

The effect of low-intensity millimeter wave electromagnetic radiation (MWR) on regeneration of the rat sciatic nerve after transection and microsurgical reapproximation was examined. Rats were exposed to 54 GHz MWR at a power density of 4 mW/cm2. It was found that MWR treatment of the femoral skin in the area of suture accelerated the regeneration of nerve fibers. At the twentieth postoperative day, the MWR-treated animals had a 32% increase in the regeneration distance compared to the control animals. The conduction velocity showed a 26% increase in the MWR-treated animals.

Koivisto, M, Revonsuo, A, Krause, C, Haarala, C, Sillanmaki, L, Laine, M, Hamalainen, H, Effects of 902 MHz electromagnetic field emitted by cellular telephones on response times in humans. Neuroreport 11(2):413-415, 2000.

The present study examined possible influences of a 902 MHz electromagnetic field emitted by cellular telephones on cognitive functioning in 48 healthy humans. A battery of 12 reaction time tasks was performed twice by each participant in a counterbalanced order: once with and once without the exposure to the field. The results showed that the exposure to the electromagnetic field speeded up response times in simple reaction time and vigilance tasks and that the cognitive time needed in a mental arithmetics task was decreased. The results suggest that exposure to the electromagnetic field emitted by cellular telephones may have a facilitatory effect on brain functioning, especially in tasks requiring attention and manipulation of information in working memory.

Koivisto M, Krause CM, Revonsuo A, Laine M, Hamalainen H, The effects of electromagnetic field emitted by GSM phones on working memory. Neuroreport 11(8):1641-1643, 2000.

The influence of pulsed radiofrequency (RF) electromagnetic fields of digital GSM mobile phones on working memory in healthy subjects were studied. Memory load was varied from 0 to 3 items in an n-back task. Each subject was tested twice within a single session, with and without the RF exposure (902MHz, 217Hz). The RF field speeded up response times when the memory load was three items but no effects of RF were observed with lower loads. The results suggest that RF fields have a measurable effect on human

cognitive performance and encourage further studies on the interactions of RF fields with brain function.

Koivisto M, Haarala C, Krause CM, Revonsuo A, Laine M, Hamalainen H, GSM phone signal does not produce subjective symptoms. Bioelectromagnetics 22(3):212-215, 2001.

The influence of pulsed radiofrequency (RF) electromagnetic fields of digital GSM mobile phones (902 MHz, 217 Hz pulse modulation) on subjective symptoms or sensations in healthy subjects were studied in two single-blind experiments. The duration of the RF exposure was about 60 min in Experiment 1 and 30 min in Experiment 2. Each subject rated symptoms or sensations in the beginning of the experimental session and at the end of both the exposure and the nonexposure conditions. The symptoms rated were headache, dizziness, fatigue, itching or tingling of the skin, redness on the skin, and sensations of warmth on the skin. The results did not reveal any differences between exposure and non-exposure conditions, suggesting that a 30-60 min exposure to this RF field does not produce subjective symptoms in humans.

Kojima M, Hata I, Wake K, Watanabe S, Yamanaka Y, Kamimura Y, Taki M, Sasaki K. Influence of anesthesia on ocular effects and temperature in rabbit eyes exposed to microwaves. Bioelectromagnetics 25(3):228-233, 2004.

To investigate the effect of systemic anesthesia on ocular effects and temperature in rabbit eyes exposed to microwaves, one eye each of 43 male pigmented rabbits (Dutch, 1.8-2.2 kg) was exposed at 2.45 GHz for 60-20 min (300 mW/cm2; 108 W/kg), either under anesthesia (ketamine hydrochloride (5 mg/kg) + xylazine (0.23 mg/kg)) or without anesthesia. Changes in the anterior segment were evaluated by image analysis utilizing a Scheimpflug camera, specular microscopy, and a laser flare cell meter. Temperatures within the eye were measured during microwave exposure by a Fluoroptic thermometer. The exposed eyes showed miosis, conjunctival congestion, corneal edema, and an increase in the light scattering of the anterior shallow cortex in the pupillary area of the lens. The group under systemic anesthesia showed much stronger symptoms than those treated without anesthesia. All of the anterior ocular changes disappeared within a week. The highest temperature during exposure was in the vitreous, followed by the anterior chamber, and the retrobulbar cavity of the orbit. The ocular temperatures of the rabbits under systemic anesthesia were 2-9 degrees C higher than those without anesthesia. Body temperature showed an increase of 1 degrees C during the exposure. Acute high intensity microwave exposure temporarily induced anterior segments inflammation and lens changes. The more pronounced ocular effects in the anesthetized rabbits were associated with the significantly higher ocular temperatures in the anesthetized animals. The influence of systemic anesthesia on ocular changes should be considered.

Köktürk S, Yardimoglu M, Celikozlu SD, Dolanbay EG, Cimbiz A. Effect of Lycopersicon esculentum extract on apoptosis in the rat cerebellum, following prenatal and postnatal exposure to an electromagnetic field. Exp Ther Med. 6(1):52-56, 2013.

The expansion of mobile phone technology has raised concerns regarding the effect of 900-MHz electromagnetic field (EMF) exposure on the central nervous system. At

present, the developing human brain is regularly exposed to mobile telephones, pre- and postnatally. Several studies have demonstrated the acute effects of EMF exposure during pre- or postnatal periods; however, the chronic effects of EMF exposure are less understood. Thus, the aim of the present study was to determine the chronic effects of EMF on the pre- and postnatal rat cerebellum. The control group was maintained in the same conditions as the experimental groups, without the exposure to EMF. In the EMF1 group, the rats were exposed to EMF during pre- and postnatal periods (until postnatal day 80). In the EMF2 group, the rats were also exposed to EMF pre- and postnatally; in addition, however, they were provided with a daily oral supplementation of *Lycopersicon esculentum* extract (~2 g/kg). The number of caspase-3-labeled Purkinje neurons and granule cells present in the rats in the control and experimental groups were then counted. The neurodegenerative changes were studied using cresyl violet staining, and these changes were evaluated. In comparison with the control animals, the EMF1 group demonstrated a significant increase in the number of caspase-3-labeled Purkinje neurons and granule cells present in the cerebellum ($P<0.001$). However, in comparison with the EMF1 group, the EMF2 group exhibited significantly fewer caspase-3-labeled Purkinje neurons and granule cells in the cerebellum. In the EMF1 group, the Purkinje neurons were revealed to have undergone dark neuron degenerative changes. However, the presence of dark Purkinje neurons was reduced in the EMF2 group, compared with the EMF1 group. The results indicated that apoptosis and neurodegeneration in rats exposed to EMF during pre- and postnatal periods may be reduced with *Lycopersicon esculentum* extract therapy.

Koldayev VM, Shchepin YV, Effects of electromagnetic radiation on embryos of sea-urchins. Bioelectrochem Bioenerg 43:161-164, 1997.

Electromagnetic radiation (EMR) causes a decrease in the number of fertilized eggs and an increase in the number of zygotes with abnormal fertilization envelopes in sea-urchins. The microstructural impairments of the cellular surface, the increase of lipid peroxidation and the changes of amino acid metabolism show that the impairments of the development of embryos exposed to EMR are caused by the damages of the membrane structures.

Kolodynski AA, Kolodynska VV, Motor and psychological functions of school children living in the area of the Skrunda Radio Location Station in Latvia. Sci Total Environ 180(1):87-93, 1996.

This paper presents the results of experiments on school children living in the area of the Skrunda Radio Location Station (RLS) in Latvia. Motor function, memory and attention significantly differed between the exposed and control groups. Children living in front of the RLS had less developed memory and attention, their reaction time was slower and their neuromuscular apparatus endurance was decreased.

Kolomytseva MP, Gapeev AB, Sadovnikov VB, Chemeris NK. [Suppression of nonspecific resistance of the body under the effect of extremely high frequency electromagnetic radiation of low intensity] Biofizika. 47(1):71-77, 2002. [Article in Russian] **(I-M)**

The dynamics of leukocyte number and functional activity of peripheral blood neutrophils under whole-body exposure of healthy mice to low-intensity extremely-high-frequency electromagnetic radiation (EHF EMR, 42.0 GHz, 0.15 mW/cm2, 20 min daily) was studied. It was shown that the phagocytic activity of peripheral blood neutrophils was suppressed by about 50% ($p < 0.01$ as compared with the sham-exposed control) in 2-3 h after the single exposure to EHF EMR. The effect persisted for 1 day after the exposure, and then the phagocytic activity of neutrophils returned to the norm within 3 days. A significant modification of the leukocyte blood profile in mice exposed to EHF EMR for 5 days was observed after the cessation of exposures: the number of leukocytes increased by 44% ($p < 0.05$ as compared with sham-exposed animals), mostly due to an increase in the lymphocyte content. The supposition was made that EHF EMR effects can be mediated via the metabolic systems of arachidonic acid and the stimulation of adenylate cyclase activity, with subsequent increase in the intracellular cAMP level. The results indicated that the whole-body exposure of healthy mice to low-intensity EHF EMR has a profound effect on the indices of nonspecific immunity.

Kol'tsov IuV, Korolev VN, Kusakin SA, [Two-step exposure of biological objects to infrared laser and microwave radiation]. Biofizika 44(2):378-381, 1999. [Article in Russian]

The effect of two-step exposure of bacterial objects to infrared laser and microwave pulse radiations was studied. The effect is determined by the time interval between two excitation steps and pulse duration. It was shown that the biologically active dose of microwave radiation is much lower than that of infrared laser radiation; however, laser radiation induces a stronger cellular response. It was found that microwaves enhance the efficiency of infrared laser radiation.

Komatsubara Y, Hirose H, Sakurai T, Koyama S, Suzuki Y, Taki M, Miyakoshi J. Effect of high-frequency electromagnetic fields with a wide range of SARs on chromosomal aberrations in murine m5S cells. Mutat Res. 587(1-2):114-119, 2005.

To investigate the induction of chromosomal aberrations in mouse m5S cells after exposure to high-frequency electromagnetic fields (HFEMFs) at 2.45GHz, cells were exposed for 2h at average specific absorption rates (SARs) of 5, 10, 20, 50 and 100W/kg with continuous wave-form (CW), or at a mean SAR of 100W/kg (with a maximum of 900W/kg) with pulse wave-form (PW). The effects of HFEMF exposure were compared with those in sham-exposed controls and with mitomycin C (MMC) or X-ray treatment as positive controls. We examined all structural, chromatid-type and chromosome-type changes after HFEMF exposures and treatments with MMC and X-rays. No significant differences were observed following exposure to HFEMFs at SARs from 5 to 100W/kg CW and at a mean SAR of 100W/kg PW (a maximum SAR of 900W/kg) compared with sham-exposed controls, whereas treatments with MMC and X-rays increased the frequency of chromatid-type and chromosome-type aberrations. In summary, HFEMF exposures at 2.45GHz for 2h with up to 100W/kg SAR CW and an average 100W/kg PW (a maximum SAR of 900W/kg) do not induce chromosomal aberrations in m5S cells. Furthermore, there was no difference between exposures to CW and PW HFEMFs.

Kompis M, Negri S, Hausler R. Electromagnetic interference of bone-anchored hearing aids by cellular phones. Acta Otolaryngol 120(7):855-859, 2000.

We report a case of electromagnetic interference between a bone-anchored hearing aid (BAHA) and a cellular phone. A 54-year-old women was successfully treated for severe mixed conductive and sensorineural hearing loss with a BAHA. Five years after implantation, the patient experienced a sudden feeling of dizziness, accompanied by a loud buzzing sound and by a sensation of head pressure while examining a digital mobile phone. During a subsequent experiment, the buzzing sound could be reproduced and was identified as electromagnetic interference between the BAHA and digital cellular phones. Seventeen adult BAHA users from our clinic participated in a subsequent survey. Of the 13 patients with some experience of digital cellular phones, 11 reported hearing annoying noises elicited by these devices. However, no other sensation, such as dizziness, was described. Owing to the increasing number of users of both hearing aids and cellular phones, the incidence of electromagnetic interference must be expected to increase as well. Although to date there is no evidence that such interference may be harmful or dangerous to users of conventional or bone-anchored hearing aids, unexpected interference can be a frightening experience.

Kompis M, Hausler R. Electromagnetic interference of bone-anchored hearing aids by cellular phones revisited. Acta Otolaryngol 122(5):510-512, 2002.

The electromagnetic interference of the recently introduced bone-anchored hearing aid (BAHA) model "BAHA Compact" by digital cellular phones is investigated and compared with that of the older "BAHA Classic 300" model. Measurements with two different digital cellular phones in a laboratory setting indicated that the noise level due to electromagnetic interference was at least 10 dB lower for the BAHA Compact device than for the BAHA Classic 300. To compare the experience of patients using the BAHA Compact with those using a BAHA Classic 300 in an earlier study, a survey was performed. Six users of a BAHA Compact who used digital cellular phones participated in the survey. Four patients did not hear any noise associated with the use of a digital cellular phone. Two patients reported hearing quiet sounds when they were on the telephone, but not when somebody else in the vicinity used a digital cellular phone. These findings confirm that the susceptibility to electromagnetic interference of the BAHA Compact device is low.

Kopecky R, Hamnerius Y, Persson M. Study of subgridding in SAR computation for the cochlea. Bioelectromagnetics. 26(6):520-522, 2005.

A 3D subgridding technique is used to model the specific absorption rate (SAR) distribution in the isolated cochlea exposed to mobile phone radiation at 1750 MHz using the FDTD method. The cochlea is modeled using an increasing spatial resolutions of 1, 1/3, 1/5, and 1/7 mm. First simulations were performed at 1 mm spatial resolution. The numerical resolution was then increased to 1/3, 1/5, and 1/7 using subgridding without changing the spatial resolution. A second set of simulations was then performed when both the spatial and numerical resolution were increased together. From the obtained results, we conclude that subgridding is important only when both the numerical resolution of the computational grid and the spatial resolution of the model are increased together.

Korpinen L, Pääkkönen R. Accidents and close call situations connected to the use of mobile phones. Accid Anal Prev. 45(2):75-82, 2012.

Abstract. The aim of our work was to study the accidents and close call situations connected to the use of mobile phones. We have analyzed how the accidents/close call situations are connected to background information, in particular age, gender and self-reported symptoms. The study was carried out as a cross-sectional study by posting the questionnaire to 15,000 working-age Finns. The responses (6121) were analyzed using the logistic regression models. Altogether 13.7% of respondents had close call situations and 2.4% had accidents at leisure, in which the mobile phone had a partial effect, and at work the amounts were 4.5% and 0.4% respectively, during the last 12 months. Essentially, we found that: (1) men tend to have more close calls and accidents while on a mobile phone, (2) younger people tend to have more accidents and close calls while on a mobile phone, but it does not appear to be large enough to warrant intervention, (3) employed people tend to have more problems with mobile phone usage and accidents/close calls, and (4) there was a slight increase in mobile-phone-related accidents/close calls if the respondent also reported sleep disturbances and minor aches and pains. In the future, it is important to take into account and study how symptoms can increase the risk of accidents or close call situations in which a mobile phone has a partial effect.

Koprivica M, Neskovic N, Neskovic A, Paunovic G. Statistical analysis of electromagnetic radiation measurements in the vicinity of GSM/UMTS base station antenna masts. Radiat Prot Dosimetry. 158(3):263-275, 2014.

As a result of dense installations of public mobile base station, additional electromagnetic radiation occurs in the living environment. In order to determine the level of radio-frequency radiation generated by base stations, extensive electromagnetic field strength measurements were carried out for 664 base station locations. Base station locations were classified into three categories: indoor, masts and locations with installations on buildings. Having in mind the large percentage (47 %) of sites with antenna masts, a detailed analysis of this location category was performed, and the measurement results were presented. It was concluded that the total electric field strength in the vicinity of base station antenna masts in no case exceeded 10 V m(-1), which is quite below the International Commission on Non-Ionizing Radiation Protection reference levels. At horizontal distances >50 m from the mast bottom, the median and maximum values were <1 and 2 V m(-1), respectively.

Kos B, Valič B, Kotnik T, Gajšek P. Exposure assessment in front of a multi-band base station antenna. Bioelectromagnetics. 32(3):234-242, 2011.

This study investigates occupational exposure to electromagnetic fields in front of a multi-band base station antenna for mobile communications at 900, 1800, and 2100 MHz. Finite-difference time-domain method was used to first validate the antenna model against measurement results published in the literature and then investigate the specific absorption rate (SAR) in two heterogeneous, anatomically correct human models (Virtual Family male and female) at distances from 10 to 1000 mm. Special attention was given to simultaneous exposure to fields of three different frequencies, their interaction and the additivity of SAR resulting from each

frequency. The results show that the highest frequency--2100 MHz--results in the highest spatial-peak SAR averaged over 10 g of tissue, while the whole-body SAR is similar at all three frequencies. At distances > 200 mm from the antenna, the whole-body SAR is a more limiting factor for compliance to exposure guidelines, while at shorter distances the spatial-peak SAR may be more limiting. For the evaluation of combined exposure, a simple summation of spatial-peak SAR maxima at each frequency gives a good estimation for combined exposure, which was also found to depend on the distribution of transmitting power between the different frequency bands.

Kottou S, Nikolopoulos D, Yannakopoulos PH, Vogiannis E, Petraki E, Panagiotaras D, Koulougliotis D. Preliminary background indoor EMF measurements in Greece. Phys Med. 2015 May 21. pii: S1120-1797(15)00112-X. doi: 10.1016/j.ejmp.2015.05.002. [Epub ahead of print]

The main purpose of this work was to investigate the fluctuation of Greek indoor electromagnetic field (EMF) intensity values and identify peaks that might occur. The scientific interest is mainly focused on the bands of extremely low-frequency (ELF) magnetic fields and radiofrequency (RF) electric fields which have been suggested to be possibly carcinogenic to humans by the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR). Electromagnetic radiation (EMR) measurements were performed in a variety of indoor dwellings, in Attica and in the islands of Zakynthos and Lesvos. A total number of 4540 measurements were taken in a wide frequency range (50 Hz-2100 MHz) of which 3301 in Attica, 963 in Lesvos and 276 in Zakynthos. Statistical analysis of the data revealed specific statistically significant differences between the mean values of the electric (ELF and RF) but not the magnetic (ELF) field strengths measured at different distances from the EMF source, as well as between some of the mean values of the RF electric field at different bands. Some statistically significant differences between mean electric field values at different geographic locations were also identified. As far as the RF electric field is concerned, the maximum values, in most cases, were below 0.5 V/m, however increased values above 1 V/m and up to 5.6 V/m were occasionally observed. The ELF magnetic field values were lower than 1 μT. It may be concluded that overall, the observed indoor EMF intensity values remained well below domestic and European established limits.

Koveshnikova IV, Antipenko EN, [The participation of thyroid hormones in modifying the mutagenic effect of microwaves]. Radiobiologiia 31(1):147-149, 1991. [Article in Russian]

The mutagenic effect of microwaves (2,450 or 2,750 MHz, 500 microW/cm2, 30 days, 7 h a day) increases with both low and high thyroid hormone content in rats. This indicates that normal functioning of the thyroid gland is an important condition for the stabilization of chromosome integrity under the effect of nonionizing radiation of microwaves.

Koveshnikov IV, Antipenko EN, [Quantitative patterns in the cytogenetic action of microwaves]. Radiobiologiia 31(1):149-151, 1991. [Article in Russian]

It was shown on hepatocytes of albino mongrel rats that the energy flow density (EFD) of 100 muW/cm2 approximated the level at which the mutagenic effects of microwaves started developing (3,000 MHz, pulse frequency 400 Hz, 60 days, 12 h a day). The severity of the mutagenic effects of radiation with EFD of 100, 500 and 2,500 muW/cm2 depended on the type of the microwave generation that was responsible for the energy loading variations. The increase in the total radiation energy levelled the mutagenic effects of microwaves of all three intensities.

Kowall B, Breckenkamp J, Heyer K, Berg-Beckhoff G. German wide cross sectional survey on health impacts of electromagnetic fields in the view of general practitioners. Int J Public Health.55(5):507-512, 2010.

OBJECTIVES: The proportion of general practitioners (GPs) in Germany who assume health impacts of electromagnetic fields (EMF) is assessed. Moreover, factors associated with this risk perception are examined. METHODS: A 7% random sample was drawn from online lists of all the GPs working in Germany. 1,867 doctors received a long version of a self-administered postal questionnaire about EMF and health (response rate 23.3%), 928 doctors received a short version (response rate 49.1%). RESULTS: 37.3% of responders to the short and 57.5% of responders to the long questionnaire agreed "that there are persons whose health complaints are caused by EMF when legal limit values are met". A late responder analysis for the survey with the short questionnaire led to a still lower estimate of 29% for GPs believing in health-relevant effects of EMF. CONCLUSION: About a third of German GPs associate EMF with health complaints and thus deviate considerably from current scientific knowledge. To avoid a strong selection bias in the surveys of the perception of EMF risks, use of short questionnaires and late responder analysis are recommended.

Kowalczuk C, Yarwood G, Blackwell R, Priestner M, Sienkiewicz Z, Bouffler S, Ahmed I, Abd-Alhameed R, Excell P, Hodzic V, Davis C, Gammon R, Balzano Q. Absence of nonlinear responses in cells and tissues exposed to RF energy at mobile phone frequencies using a doubly resonant cavity. Bioelectromagnetics.31(7):556-565,2010.

A doubly resonant cavity was used to search for nonlinear radiofrequency (RF) energy conversion in a range of biological preparations, thereby testing the hypothesis that living tissue can demodulate RF carriers and generate baseband signals. The samples comprised high-density cell suspensions (human lymphocytes and mouse bone marrow cells); adherent cells (IMR-32 human neuroblastoma, G361 human melanoma, HF-19 human fibroblasts, N2a murine neuroblastoma (differentiated and non-differentiated) and Chinese hamster ovary (CHO) cells) and thin sections or slices of mouse tissues (brain, kidney, muscle, liver, spleen, testis, heart and diaphragm). Viable and non-viable (heat killed or metabolically impaired) samples were tested. Over 500 cell and tissue samples were placed within the cavity, exposed to continuous wave (CW) fields at the resonant frequency (f) of the loaded cavity (near 883 MHz) using input powers of 0.1 or 1 mW, and monitored for second harmonic generation by inspection of the output at 2f. Unwanted signals were minimised using low pass filters (</=1 GHz) at the input to, and high pass filters (>/=1

GHz) at the output from, the cavity. A tuned low noise amplifier allowed detection of second harmonic signals above a noise floor as low as -169 dBm. No consistent second harmonic of the incident CW signals was detected. Therefore, these results do not support the hypothesis that living cells can demodulate RF energy, since second harmonic generation is the necessary and sufficient condition for demodulation.

Koyama S, Isozumi Y, Suzuki Y, Taki M, Miyakoshi J. Effects of 2.45-GHz electromagnetic fields with a wide range of SARs on micronucleus formation in CHO-K1 cells. ScientificWorldJournal 4 Suppl 2:29-40, 2004.

There has been considerable discussion about the influence of high-frequency electromagnetic fields (HFEMF) on the human body. In particular, HFEMF used for mobile phones may be of great concern for human health. In order to investigate the properties of HFEMF, we have examined the effects of 2.45-GHz EMF on micronucleus (MN) formation in Chinese hamster ovary (CHO)-K1 cells. MN formation is induced by chromosomal breakage or inhibition of spindles during cell division and leads to cell damage. We also examined the influence of heat on MN formation, since HFEMF exposure causes a rise in temperature. CHO-K1 cells were exposed to HFEMF for 2 h at average specific absorption rates (SARs) of 5, 10, 20, 50, 100, and 200 W/kg, and the effects on these cells were compared with those in sham-exposed control cells. The cells were also treated with bleomycin alone as a positive control or with combined treatment of HFEMF exposure and bleomycin. Heat treatment was performed at temperatures of 37, 38, 39, 40, 41, and 42 degrees C. The MN frequency in cells exposed to HFEMF at a SAR of lower than 50 W/kg did not differ from the sham-exposed controls, while those at SARs of 100 and 200 W/kg were significantly higher when compared with the sham-exposed controls. There was no apparent combined effect of HFEMF exposure and bleomycin treatment. On heat treatment at temperatures from 38-42 degrees C, the MN frequency increased in a temperature-dependent manner. We also showed that an increase in SAR causes a rise in temperature and this may be connected to the increase in MN formation generated by exposure to HFEMF.

Koyama S, Narita E, Suzuki Y, Taki M, Shinohara N, Miyakoshi J. Effect of a 2.45-GHz radiofrequency electromagnetic field on neutrophil chemotaxis and phagocytosis in differentiated human HL-60 cells.J Radiat Res. 2014 Sep 5. pii: rru075. [Epub ahead of print]

The potential public health risks of radiofrequency (RF) fields have been discussed at length, especially with the use of mobile phones spreading extensively throughout the world. In order to investigate the properties of RF fields, we examined the effect of 2.45-GHz RF fields at the specific absorption rate (SAR) of 2 and 10 W/kg for 4 and 24 h on neutrophil chemotaxis and phagocytosis in differentiated human HL-60 cells. Neutrophil chemotaxis was not affected by RF-field exposure, and subsequent phagocytosis was not affected either compared with that under sham exposure conditions. These studies demonstrated an initial immune response in the human body exposed to 2.45-GHz RF fields at the SAR of 2 W/kg, which is the maximum value recommended by the International Commission for Non-Ionizing Radiation Protection (ICNIRP) guidelines. The results of our experiments for RF-field exposure at an SAR under 10 W/kg showed very

little or no effects on either chemotaxis or phagocytosis in neutrophil-like human HL-60 cells.

Koylu H, Mollaoglu H, Ozguner F, Nazyroglu M, Delibab N. Melatonin modulates 900 Mhz microwave-induced lipid peroxidation changes in rat brain. Toxicol Ind Health. 22(5):211-216, 2006.

Microwaves (MW) from cellular phones may affect biological systems by increasing free radicals, which may enhance lipid peroxidation levels of the brain, thus leading to oxidative damage. Melatonin is synthesized in and secreted by the pineal gland at night and exhibits anti-oxidant properties. Several studies suggest that supplementation with anti-oxidant can influence MW-induced brain damage. The present study was designed to determine the effects of MW on the brain lipid peroxidation system, and the possible protective effects of melatonin on brain degeneration induced by MW. Twenty-eight Sprague-Dawley male rats were randomly divided into three groups as follows: (1) sham-operated control group (N = 8); (2) study 900-MHz MW-exposed group (N = 8); and (3) 900-MHz MW-exposed+melatonin (100 microg/kg sc before daily MW exposure treated group) (N = 10). Cortex brain and hippocampus tissues were removed to study the levels of lipid peroxidation as malonyl dialdehyde. The levels of lipid peroxidation in the brain cortex and hippocampus increased in the MW group compared with the control group, although the levels in the hippocampus were decreased by MW+melatonin administration. The brain cortex lipid peroxidation levels were unaffected by melatonin treatment. We conclude that melatonin may prevent MW-induced oxidative changes in the hippocampus by strengthening the anti-oxidant defense system, by reducing oxidative stress products.

Koyu A, Ozguner F, Cesur G, Gokalp O, Mollaoglu H, Caliskan S, Delibas N. No effects of 900 MHz and 1800 MHz electromagnetic field emitted from cellular phone on nocturnal serum melatonin levels in rats. Toxicol Ind Health. 21(1-2):27-31, 2005.

In this study, the effects of exposure to a 900 MHz and 1800 MHz electromagnetic field (EMF) on serum nocturnal melatonin levels of adult male Sprague-Dawley rats were studied. Thirty rats were used in three independent groups, 10 of which were exposed to 900 MHz, 10 of which were exposed to 1800 MHz and 10 of which were sham-exposed (control). The exposures were performed 30 min/day, for five days/week for four weeks to 900 MHz or 1800 MHz EMF Control animals were kept under the same environmental conditions as the study groups except with no EMF exposure. The concentration of nocturnal melatonin in the rat serum was measured by using a radioimmunoassay method. There were no statistically significant differences in serum melatonin concentrations between the 900 MHz EMF group and the sham-exposed group (P > 0.05). The values at 12:00 pm were 39.11 +/- 6.5 pg/mL in the sham-exposed group and 34.97 +/- 5.1 pg/mL in the 900 MHz EMF-exposed group. Also, there were no statistically significant differences in serum melatonin concentrations between the sham-exposed group and the 1800 MHz EMF-exposed group (P > 0.05). The values at 12:00 pm were 39.11 +/- 6.5 pg/mL in the sham-exposed group and 37.96 +/- 7.4 pg/mL in the exposed group. These results indicate that mobile phones, emitting 900 and 1800 MHz EMF, have no effect on nocturnal serum melatonin levels in rats.

Koyu A, Cesur G, Ozguner F, Akdogan M, Mollaoglu H, Ozen S. Effects of 900MHz electromagnetic field on TSH and thyroid hormones in rats. Toxicol Lett. 157(3):257-262, 2005.

In this study, the effects of exposure to a 900megahertz (MHz) electromagnetic field (EMF) on serum thyroid stimulating hormone (TSH) and triiodothronine-thyroxin (T(3)-T(4)) hormones levels of adult male Sprague-Dawley rats were studied. Thirty rats were used in three independent groups, 10 of which were control (without stress and EMF), 10 of which were exposed to 900MHz EMF and 10 of which were sham-exposed. The exposures were performed 30min/day, for 5days/week for 4 weeks to 900MHz EMF. Sham-exposed animals were kept under the same environmental conditions as the study groups except with no EMF exposure. The concentration of TSH and T(3)-T(4) hormones in the rat serum was measured by using an immunoradiometric assay (IRMA) method for TSH and a radio-immunoassay (RIA) method for T(3) and T(4) hormones. TSH values and T(3)-T(4) at the 900MHz EMF group were significantly lower than the sham-exposed group ($p<0.01$). There were no statistically significant differences in serum TSH values and T(3)-T(4) hormone concentrations between the control and the sham-exposed group ($p>0.05$). These results indicate that 900MHz EMF emitted by cellular telephones decrease serum TSH and T(3)-T(4) levels.

Kramarenko AV, Tan U. Effects of high-frequency electromagnetic fields on human eeg: A brain mapping study. Int J Neurosci. 113(7):1007-1019, 2003.

Cell phones emitting pulsed high-frequency electromagnetic fields (EMF) may affect the human brain, but there are inconsistent results concerning their effects on electroencephalogram (EEG). We used a 16-channel telemetric electroencephalograph (ExpertTM), to record EEG changes during exposure of human skull to EMF emitted by a mobile phone. Spatial distribution of EMF was especially concentrated around the ipsilateral eye adjacent to the basal surface of the brain. Traditional EEG was full of noises during operation of a cellular phone. Using a telemetric electroencephalograph (ExpertTM) in awake subjects, all the noise was eliminated, and EEG showed interesting changes: after a period of 10-15 s there was no visible change, the spectrum median frequency increased in areas close to antenna; after 20-40 s, a slow-wave activity (2.5-6.0 Hz) appeared in the contralateral frontal and temporal areas. These slow waves lasting for about one second repeated every 15-20 s at the same recording electrodes. After turning off the mobile phone, slow-wave activity progressively disappeared; local changes such as increased median frequency decreased and disappeared after 15-20 min. We observed similar changes in children, but the slow-waves with higher amplitude appeared earlier in children (10-20 s) than adults, and their frequency was lower (1.0-2.5 Hz) with longer duration and shorter intervals. The results suggested that cellular phones may reversibly influence the human brain, inducing abnormal slow waves in EEG of awake persons.

Krasil'nikov PM, [Resonance interactions of surface charged lipid vesicles with the microwave electromagnetic field]. Biofizika 44(6):1078-1082, 1999. [Article in Russian]

The occurrence of collective excitations in an ionic medium on the surface of lipid membranes was shown. The excitations are due to a fast lateral mobility of ions and

the excitation of high-frequency displacement currents in the Stern's layer at the charged surface of the membrane. These effects determine the mechanism of induction of resonant dipole moments on lipid vesicles which can underlie the effect of "recognition" and the autooscillation mode of aggegation of vesicles in a colloidal solution.

Krause CM, Sillanmaki L, Koivisto M, Haggqvist A, Saarela C, Revonsuo A, Laine M, Hamalainen H, Effects of electromagnetic field emitted by cellular phones on the EEG during a memory task. Neuroreport 11(4):761-764, 2000.

The effects of electromagnetic fields (EMF) emitted by cellular phones on the ERD/ERS of the 4-6 Hz, 6-8 Hz, 8-10 Hz and 10-12 Hz EEG frequency bands were studied in 16 normal subjects performing an auditory memory task. All subjects performed the memory task both with and without exposure to a digital 902 MHz EMF in counterbalanced order. The exposure to EMF significantly increased EEG power in the 8-10 Hz frequency band only. Nonetheless, the presence of EMF altered the ERD/ERS responses in all studied frequency bands as a function of time and memory task (encoding vs retrieval). Our results suggest that the exposure to EMF does not alter the resting EEG per se but modifies the brain responses significantly during a memory task.

Krause CM, Sillanmaki L, Koivisto M, Haggqvist A, Saarela C, Revonsuo A, Laine M, Hamalainen H, Effects of electromagnetic fields emitted by cellular phones on the electroencephalogram during a visual working memory task. Int J Radiat Biol 76(12):1659-1667, 2000.

PURPOSE: To examine the effects of electromagnetic fields (EMF) emitted by cellular phones on the event-related desynchronization/synchronization (ERD/ERS) responses of the 4-6, 6-8, 8-10 and 10-12Hz EEG frequency bands during cognitive processing. MATERIALS AND METHODS: Twenty-four subjects performed a visual sequential letter task (n-back task) with three different working memory load conditions: zero, one and two items. All subjects performed the memory task both with and without exposure to a digital 902 MHz EMF in counterbalanced order. RESULTS: The presence of EMF altered the ERD/ERS responses in the 6-8 and 8-10 Hz frequency bands but only when examined as a function of memory load and depending also on whether the presented stimulus was a target or not. CONCLUSIONS: The results suggest that the exposure to EMF modulates the responses of EEG oscillatory activity approximately 8 Hz specifically during cognitive processes.

Krause CM, Haarala C, Sillanmaki L, Koivisto M, Alanko K, Revonsuo A, Laine M, Hamalainen H. Effects of electromagnetic field emitted by cellular phones on the EEG during an auditory memory task: a double blind replication study. Bioelectromagnetics. 25(1): 33-40, 2004.

The effects of electromagnetic fields (EMF) emitted by cellular phones on the event related desynchronization/synchronization (ERD/ERS) of the 4-6, 6-8, 8-10, and 10-12 Hz electroencephalogram (EEG) frequency bands were studied in 24 normal subjects performing an auditory memory task. This study was a systematic replication of our previous work. In the present double blind study, all subjects performed the memory task both with and without exposure to a digital 902 MHz field in a counterbalanced order. We

were not able to replicate the findings from our earlier study. All eight of the significant changes in our earlier study were not significant in the present double blind replication. Also, the effect of EMF on the number of incorrect answers in the memory task was inconsistent. We previously reported no significant effect of EMF exposure on the number of incorrect answers in the memory task, but a significant increase in errors was observed in the present study. We conclude that EMF effects on the EEG and on the performance on memory tasks may be variable and not easily replicable for unknown reasons.

Krause CM, Bjornberg CH, Pesonen M, Hulten A, Liesivuori T, Koivisto M, Revonsuo A, Laine M, Hamalainen H. Mobile phone effects on children's event-related oscillatory EEG during an auditory memory task. Int J Radiat Biol. 82(6):443-450, 2006.

Purpose: To assess the effects of electromagnetic fields (EMF) emitted by mobile phones (MP) on the 1 - 20 Hz event-related brain oscillatory EEG (electroencephalogram) responses in children performing an auditory memory task (encoding and recognition).Materials and methods: EEG data were gathered while 15 subjects (age 10 - 14 years) performed an auditory memory task both with and without exposure to a digital 902 MHz MP in counterbalanced order.Results: During memory encoding, the active MP modulated the event-related desynchronization/synchronization (ERD/ERS) responses in the approximately 4 - 8 Hz EEG frequencies. During recognition, the active MP transformed these brain oscillatory responses in the approximately 4 - 8 Hz and approximately 15 Hz frequencies.Conclusions: The current findings suggest that EMF emitted by mobile phones has effects on brain oscillatory responses during cognitive processing in children.

Krause CM, Pesonen M, Haarala Bjornberg C, Hamalainen H. Effects of pulsed and continuous wave 902 MHz mobile phone exposure on brain oscillatory activity during cognitive processing. Bioelectromagnetics.28(4):296-308, 2007.

The aim of the current double-blind studies was to partially replicate the studies by Krause et al. [2000ab, 2004] and to further investigate the possible effects of electromagnetic fields (EMF) emitted by mobile phones (MP) on the event-related desynchronisation/synchronisation (ERD/ERS) EEG (electroencephalogram) responses during cognitive processing. Two groups, both consisting of 36 male participants, were recruited. One group performed an auditory memory task and the other performed a visual working memory task in six exposure conditions: SHAM (no EMF), CW (continuous wave EMF) and PM (pulse modulated EMF) during both left- and right-side exposure, while the EEG was recorded. In line with our previous studies, we observed that the exposure to EMF had modest effects on brain oscillatory responses in the alpha frequency range (approximately 8-12 Hz) and had no effects on the behavioural measures. The effects on the EEG were, however, varying, unsystematic and inconsistent with previous reports. We conclude that the effects of EMF on brain oscillatory responses may be subtle, variable and difficult to replicate for unknown reasons.

Krause D, Mullins JM, Penafiel LM, Meister R, Nardone RM, Microwave exposure alters the expression of 2-5A-dependent RNase. Radiat Res 127(2):164-170, 1991.

The effects of 2.45-GHz continuous-wave microwaves (SAR = 130 mW/g) on the expression of the interferon-regulated enzymes 2'-5'-oligoadenylate (2-5A) synthetase(s) and 2-5A-dependent endoribonuclease (RNase L) were studied in murine L929 cells. Cells growing as monolayers were removed from the substratum and placed in suspension culture for a 4-h sham or microwave exposure. The cells were returned to monolayer growth for 18 h, and then harvested and assayed to determine the amount of RNase L protein (via [32P]2-5A binding) and the specific activities of RNase L and 2-5A synthetase. Binding of radioactive 2-5A to RNase L for sham- and microwave-exposed samples was 14.5 and 36.4% above control, respectively (the microwave-exposed bound 19.0% more probe than the sham-exposed). The increases in 2-5A binding were accompanied by corresponding elevations of RNase L specific activity. In contrast, sham or microwave irradiation produced no alterations in 2-5A synthetase specific activity. No detectable differences were noted in the postexposure cell viability, plating efficiency, or proliferation rate. Also, there were no detectable differences in cell viability or plating efficiency between controls and cultures irradiated for 2 h when the temperature was simultaneously increased to above normal physiological limits (39 to 45 degrees C). The SAR (130 mW/g) and the power density (95 mW/cm2) used for the greater part of this study were nearly 20 times higher than the ANSI limit of 8 mW/g and 5 mW/cm2 for any 1 g of exposed human tissue.

Kristiansen IS, Elstein AS, Gyrd-Hansen D, Kildemoes HW, Nielsen JB. Radiation from mobile phone systems: Is it perceived as a threat to people's health? Bioelectromagnetics. 30(5):393-401, 2009.

The aim of this study was to explore the prevalence, nature and determinants of concerns about mobile phone radiation. We used data from a 2006 telephone survey of 1004 people aged 15+ years in Denmark. Twenty-eight percent of the respondents were concerned about exposure to mobile phone radiation; radiation from masts was of concern to about 15%. In contrast, 82% were concerned about pollution. Nearly half of the respondents considered the mortality risk of 3G phones and masts to be of the same order of magnitude as being struck by lightning (0.1 fatalities per million people per year) while 7% thought it was equivalent to tobacco-induced lung cancer (approximately 500 fatalities per million per year). Among women, concerns about mobile phone radiation were positively associated with educational attainment, perceived mobile phone mortality risk and concerns about unknown consequences of new technologies. More than two thirds of the respondents felt that they had received inadequate public information about the 3G system. The results of the study indicate that the majority of the population has little concern about mobile phone radiation while a small minority is very concerned.

Krylov IN, Iasnetsov VV, Dukhanin AS, Pal'tsev IuP, [Pharmacologic correction of learning and memory disorders induced by exposure to high-frequency electromagnetic radiation]. Biull Eksp Biol Med 115(3):260-262, 1993. [Article in Russian]

Acute exposure of rats to microwaves (12.6 chr, 2375 MHz, power density 1 mW/cm2) induced the retrograde amnesia. It was show the role of opioidergic, benzodiazepine, GABAergic and cholinergic components in the amnesic effects of microwaves. Piracetam

(100 mg/kg, i. p.) and oxiracetam (10 mg/kg, i. p.) prevented the negative effects of microwaves on memory processes.

Krylova IN, Dukhanin AS, Il'in AB, Kuznetsova Elu, Balaeva NV, Shimanovskii NL, Pal'tsev IuP, Iasnetsov VV, [The effect of ultrahigh-frequency electromagnetic radiation on learning and memory processes]. Biull Eksp Biol Med 114(11):483-484, 1994. [Article in Russian]

Low-intensity electromagnetic field (12.6 cm, 2375 MHz, power density 1 mW/cm2) produced retrograde amnesia in the rat passive avoidance test. No effect was registered of microwave irradiation on the open field behavior and the pain sensitivity. Functional activity of the m-cholinergic receptors decreased, but their number increased in the brain cortex. It is suggested that cholinergic system plays an important role in the effects of electromagnetic field on memory processes.

Kubinyi G, Thuroczy G, Bakos J, Boloni E, Sinay H, Szabo LD, Effect of continuous-wave and amplitude-modulated 2.45 GHz microwave radiation on the liver and brain aminoacyl-transfer RNA synthetases of in utero exposed mice. Bioelectromagnetics 17(6):497-503, 1996.

Investigations have been carried out concerning the effects of microwave (MW) exposure on the aminoacyl-transfer ribonucleic acid (tRNA) synthetase of the progeny of females that were exposed during their entire period of gestation (19 days). The changes caused by continuous-wave (CW) and amplitude-modulated (AM) MW radiation have been compared. CFLP mice were exposed to MW radiation for 100 min each day in an anechoic room. The MW frequency was 2.45 GHz, and the amplitude modulation had a 50 Hz rectangular waveform (on/off ratio, 50/50%). The average power density exposure was 3 mW/cm2, and the whole body specific absorption rate (SAR) was 4.23 +/- 0.63 W/kg. The weight and mortality of the progeny were followed until postnatal day 24. Aminoacyl-tRNA synthetase enzymes and tRNA from the brains and livers of the offspring (461 exposed, 487 control) were isolated. The aminoacyl-tRNA synthetase activities were determined. The postnatal increase of body weight and organ weight was not influenced by the prenatal MW radiation. The activity of enzyme isolated from the brain showed a significant decrease after CW MW exposure, but the changes were not significant after 50 Hz AM MW exposure. The activity of the enzyme isolated from liver increased under CW and 50 Hz modulated MW.

Kuehn S, Kelsh MA, Kuster N, Sheppard AR, Shum M. Analysis of mobile phone design features affecting radiofrequency power absorbed in a human head phantom. Bioelectromagnetics. 2013 Mar 26. doi: 10.1002/bem.21784. [Epub ahead of print]

The US FCC mandates the testing of all mobile phones to demonstrate compliance with the rule requiring that the peak spatial SAR does not exceed the limit of 1.6 W/kg averaged over any 1 g of tissue. These test data, measured in phantoms with mobile phones operating at maximum antenna input power, permitted us to evaluate the variation in SARs across mobile phone design factors such as shape and antenna design, communication technology, and test date (over a 7-year period). Descriptive statistical summaries calculated for 850 MHz and 1900 MHz phones and ANOVA were

used to evaluate the influence of the foregoing factors on SARs. Service technology accounted for the greatest variability in compliance test SARs that ranged from AMPS (highest) to CDMA, iDEN, TDMA, and GSM (lowest). However, the dominant factor for SARs during use is the time-averaged antenna input power, which may be much less than the maximum power used in testing. This factor is largely defined by the communication system; e.g., the GSM phone average output can be higher than CDMA by a factor of 100. Phone shape, antenna type, and orientation of a phone were found to be significant but only on the order of up to a factor of 2 (3 dB). The SAR in the tilt position was significantly smaller than for touch. The side of the head did not affect SAR levels significantly. Among the remaining factors, external antennae produced greater SARs than internal ones, and brick and clamshell phones produced greater SARs than slide phones. Assuming phone design and usage patterns do not change significantly over time, we have developed a normalization procedure and formula that permits reliable prediction of the relative SAR between various communication systems. This approach can be applied to improve exposure assessment in epidemiological research.

Kues HA, Monahan JC, D'Anna SA, McLeod DS, Lutty GA, Koslov S, Increased sensitivity of the non-human primate eye to microwave radiation following ophthalmic drug pretreatment. Bioelectromagnetics 13(5):379-393, 1992.

Previous studies in our laboratory have established that pulsed microwaves at 2.45 GHz and 10 mW/cm2 are associated with production of corneal endothelial lesions and with disruption of the blood-aqueous barrier in the non-human primate eye. In the study reported here we examined ocular damage in monkeys (M. mulatta and M. fascicularis) following topical treatment with one of two ophthalmic drugs (timolol maleate and pilocarpine) that preceded exposure to pulsed microwaves. Anesthetized monkeys were sham exposed or exposed to pulsed, 2.45 GHz microwaves (10 microseconds, 100 pps) at average power densities of 0.2, 1, 5, 10, or 15 mW/cm2 4 h a day for 3 consecutive days (respective SARs were 0.052, 0.26, 1.3, 2.6, and 3.9 W/kg). Immediately before microwave exposure, one or both eyes were treated topically with one drop of 0.5% timolol maleate or of 2% pilocarpine. Following administration of a drug, we observed a significant reduction in the power-density threshold (from 10 to 1 mW/cm2) for induction of corneal endothelial lesions and for increased vascular permeability of the iris. Diagnostic procedures (in vivo specular microscopy and fluorescein iris angiography) were performed following each exposure protocol. In addition, increased vascular permeability was confirmed with horseradish peroxidase tracer techniques. Although we did not measure intraocular temperatures in experimental animals, the results suggest that a mechanism other than significant heating of the eye is involved. Our data indicate that pulsed microwaves at an average SAR of 0.26 W/kg, if administered after pretreatment with ophthalmic drugs, can produce significant ocular effects in the anesthetized primate.

Kues HA, D'Anna SA, Osiander R, Green WR, Monahan JC, Absence of ocular effects after either single or repeated exposure to 10 mW/cm(2) from a 60 GHz CW source. Bioelectromagnetics 20(8):463-473, 1999.

This study was designed to examine ocular effects associated with exposure to millimeter waves (60 GHz). Rabbits served as the primary experimental subjects. To confirm the

results of the rabbit experiments in a higher species, the second phase of the study used nonhuman primates (Macaca mulatta). First, this study used time-resolved infrared radiometry to assess the field distribution patterns produced by different antennas operating at 60 GHz. These results allowed us to select an antenna that produced a uniform energy distribution and the best distance at which to expose our experimental subjects. The study then examined ocular changes after exposure at an incident power density of 10 mW/cm(2). Acute exposure of both rabbits and nonhuman primates consisted of a single 8 h exposure, and the repeated exposure protocol consisted of five separate 4 h exposures on consecutive days. One eye in each animal was exposed and the contralateral eye served as the sham-exposed control. After postexposure diagnostic examinations, animals were euthanized and the eyes were removed. Ocular tissue was examined by both light and transmission electron microscopy. Neither microscopic examinations nor the diagnostic procedures performed on the eyes of acute and repeatedly exposed rabbits found any ocular changes that could be attributed to millimeter-wave exposure at 10 mW/cm(2). Examination of the primates after comparable exposures also failed to detect any ocular changes due to exposure. On the basis of our results, we conclude that single or repeated exposure to 60 GHz CW radiation at 10 mW/cm(2) does not result in any detectable ocular damage.

Kühn S, Jennings W, Christ A, Kuster N. Assessment of induced radio-frequency electromagnetic fields in various anatomical human body models. Phys Med Biol. 54(4):875-890, 2009.

The reference levels for testing compliance of human exposure with radio-frequency (RF) safety limits have been derived from very simplified models of the human. In order to validate these findings for anatomical models, we investigated the absorption characteristics for various anatomies ranging from 6 year old child to large adult male by numerical modeling. We address the exposure to plane-waves incident from all major six sides of the humans with two orthogonal polarizations each. Worst-case scattered field exposure scenarios have been constructed in order to test the implemented procedures of current in situ compliance measurement standards (spatial averaging versus peak search). Our findings suggest that the reference levels of current electromagnetic (EM) safety guidelines for demonstrating compliance as well as some of the current measurement standards are not consistent with the basic restrictions and need to be revised.

Kulaber A, Kerimoğlu G, Ersöz Ş, Çolakoğlu S, Odacı E. Alterations of thymic morphology and antioxidant biomarkers in 60-day-old male rats following exposure to a continuous 900 MHz electromagnetic field during adolescence. Biotech Histochem. 92(5):331-337, 2017.

We investigated changes in thymic tissue of male rats exposed to a 900 megahertz (MHz) electromagnetic field (EMF) on postnatal days 22-59. Three groups of six 21-day-old male Sprague-Dawley rats were allocated as: control (CG), sham (SG) and EMF (EMFG) groups. No procedure was performed on the CG rats. SG rats were placed in a Plexiglas cage for 1 h every day between postnatal days 22 and 59 without exposure to EMF. EMFG rats were placed in the same cage for the same periods as the SG rats and were exposed to 900 MHz EMF. Rats were sacrificed on postnatal day 60. Sections of

thymus were stained for histological assessment. Oxidant/antioxidant parameters were investigated biochemically. Malondialdehyde (MDA) levels in EMFG increased compared to the other groups. Extravascular erythrocytes were observed in the medullary/corticomedullary regions in EMFG sections. We found that 900 MHz EMF applied for 1 h/day on postnatal days 22-59 can increase tissue MDA and histopathological changes in male rat thymic tissue.

Kulkybaev GA, Pospelov NI, [Changes in gastric electric activity and serum catecholamine level under the influence of electromagnetic microwaves]. Med Tr Prom Ekol (5):8-11, 2000. (Article in Russian)

Chronic experiments on 17 dogs revealed that ultrahigh-frequency electromagnetic waves applied on epigastric area and head induce a double-phase response: depressed electric activity of gaster and increased total catecholamines level during exposure, but higher gastric activity and lower levels of epinephrine and norepinephrine in 24 hours after each of 10 procedures and during 7 days after 10 procedures. Double-phase changes in electric activity of gaster could be explained by double-phase fluctuations of humoral division in chromaffin system.

Kumar A, Singh HP, Batish DR, Kaur S, Kohli RK. EMF radiations (1800 MHz)-inhibited early seedling growth of maize (Zea mays) involves alterations in starch and sucrose metabolism. Protoplasma. 2015 Aug 16. [Epub ahead of print]

The present study investigated the impact of 1800-MHz electromagnetic field radiations (EMF-r), widely used in mobile communication, on the growth and activity of starch-, sucrose-, and phosphate-hydrolyzing enzymes in Zea mays seedlings. We exposed Z. mays to modulated continuous wave homogenous EMF-r at specific absorption rate (SAR) of 0.169 watts per kilogram for ½, 1, 2, and 4 hours. The analysis of seedlings after 7 days revealed that short-term exposure did not induce any significant change, while longer exposure of 4 h caused significant growth and biochemical alterations. There was a reduction in the root and coleoptile length with more pronounced effect on coleoptile growth (23% reduction on 4-h exposure). The contents of photosynthetic pigments and total carbohydrates declined by 13 and 18%, respectively, in 4-h exposure treatments compared to unexposed control. The activity of starch-hydrolyzing enzymes-α- and β-amylases-increased by ~92 and 94%, respectively, at an exposure duration of 4 h, over that in the control. In response to 4-h exposure treatment, the activity of sucrolytic enzymes-acid invertases and alkaline invertases-was increased by 88 and 266%, whereas the specific activities of phosphohydrolytic enzymes (acid phosphatases and alkaline phosphatases) showed initial increase up to ≤2 h duration and then declined at >2 h exposure duration. The study concludes that EMF-r-inhibited seedling growth of Z. mays involves interference with starch and sucrose metabolism.

Kumar G, McIntosh RL, Anderson V, McKenzie RJ, Wood AW. A Genotoxic Analysis on Hematopoietic system after Mobile Phone Type Radiation Exposure in Rats. Int J Radiat Biol. 91(8):664-672, 2015.

PURPOSE: In our earlier study we reported that 900 MHz continuous wave (CW) radiofrequency radiation (RFR) exposure (2 W/kg specific absorption rate (SAR)) had no significant effect on the hematopoietic system of rats. In this paper we extend the scope of the previous study by testing for possible effects at: i) different SAR levels; ii) both 900 and 1800 MHz, and; iii) both CW and pulse modulated (PM) RFR. MATERIALS AND METHODS: Excised long bones from rats were placed in medium and RFR exposed in i) a Transverse Electromagnetic (TEM) cell or ii) a waveguide. Finite-difference time-domain (FDTD) numerical analyses were used to estimate forward power needed to produce nominal SAR levels of 2/10 and 2.5/12.4 W/kg in the bone marrow. After exposure, the lymphoblasts were extracted and assayed for proliferation rate, and genotoxicity. RESULTS: Our data did not indicate any significant change in these end points for any combination of CW/PM exposure at 900/1800 MHz at SAR levels of nominally 2/10 W/kg or 2.5/12.4 W/kg. CONCLUSIONS: No significant changes were observed in the hematopoietic system of rats after the exposure of CW/PM wave 900 MHz/1800 MHz RF radiations at different SAR values.

Kumar NR, Sangwan S, Badotra P. Exposure to cell phone radiations produces biochemical changes in worker honey bees. Toxicol Int. 18(1):70-72, 2011.

The present study was carried out to find the effect of cell phone radiations on various biomolecules in the adult workers of Apis mellifera L. The results of the treated adults were analyzed and compared with the control. Radiation from the cell phone influences honey bees' behavior and physiology. There was reduced motor activity of the worker bees on the comb initially, followed by en masse migration and movement toward "talk mode" cell phone. The initial quiet period was characterized by rise in concentration of biomolecules including proteins, carbohydrates and lipids, perhaps due to stimulation of body mechanism to fight the stressful condition created by the radiations. At later stages of exposure, there was a slight decline in the concentration of biomolecules probably because the body had adapted to the stimulus.

Kumar RS, Sareesh NN, Nayak S, Mailankot M. Hypoactivity of Wistar rats exposed to mobile phone on elevated plus maze. Indian J Physiol Pharmacol. 53(3):283-286, 2009.

No abstract available. From discussion section: “In conclusion, our preliminary results indicate mobile phone exposure induced behavioral changes in rats, expressed as deficit in open arm exploration on elevated plus-maze.”

Kumar S, Kesari KK, Behari J. Influence of microwave exposure on fertility of male rats. Fertil Steril.95(4):1500-1502, 2011.

The present study investigates the effect of 10-GHz microwave radiation on the fertility pattern of 70-day-old male rats (sham exposed and exposed), which were exposed for 2 h/d for 45 days continuously at a specific absorption rate of 0.014 W/kg and a power density of 0.21 mW/cm(2). Results show a significant change in the level of reactive oxygen species, histone kinase, apoptotic cells, and percentage of G(2)/M transition phase of cell cycle in the exposed group compared with the sham-exposed

group. The study concludes that there is a significant effect of microwave radiations on the reproductive pattern in male rats, which is a causative factor of male infertility.

Kumar S, Kesari KK, Behari J. Evaluation of genotoxic effects in male Wistar rats following microwave exposure. Indian J Exp Biol. 48(6):586-592, 2010.

Wistar rats (70 days old) were exposed for 2 h a day for 45 days continuously at 10 GHz [power density 0.214 mW/cm2, specific absorption rate (SAR) 0.014 W/kg] and 50 GHz (power density 0.86 microW/cm2, SAR 8.0 x10(-4) W/kg). Micronuclei (MN), reactive oxygen species (ROS), and antioxidant enzymes activity were estimated in the blood cells and serum. These radiations induce micronuclei formation and significant increase in ROS production. Significant changes in the level of serum glutathione peroxidase, superoxide dismutase and catalase were observed in exposed group as compared with control group. It is concluded that microwave exposure can be affective at genetic level. This may be an indication of tumor promotion, which comes through the overproduction of reactive oxygen species.

Kumar S, Kesari KK, Behari J. The therapeutic effect of a pulsed electromagnetic field on the reproductive patterns of male Wistar rats exposed to a 2.45-GHz microwave field. Clinics (Sao Paulo). 66(7):1237-1245, 2011.

INTRODUCTION: Environmental exposure to man-made electromagnetic fields has been steadily increasing with the growing demand for electronic items that are operational at various frequencies. Testicular function is particularly susceptible to radiation emitted by electromagnetic fields. OBJECTIVES: This study aimed to examine the therapeutic effects of a pulsed electromagnetic field (100 Hz) on the reproductive systems of male Wistar rats (70 days old). METHODS: The experiments were divided into five groups: microwave sham, microwave exposure (2.45 GHz), pulsed electromagnetic field sham, pulsed electromagnetic field (100 Hz) exposure, and microwave/pulsed electromagnetic field exposure. The animals were exposed for 2 hours/day for 60 days. After exposure, the animals were sacrificed, their sperm was used for creatine and caspase assays, and their serum was used for melatonin and testosterone assays. RESULTS: The results showed significant increases in caspase and creatine kinase and significant decreases in testosterone and melatonin in the exposed groups. This finding emphasizes that reactive oxygen species (a potential inducer of cancer) are the primary cause of DNA damage. However, pulsed electromagnetic field exposure relieves the effect of microwave exposure by inducing Faraday currents. CONCLUSIONS: Electromagnetic fields are recognized as hazards that affect testicular function by generating reactive oxygen species and reduce the bioavailability of androgen to maturing spermatozoa. Thus, microwave exposure adversely affects male fertility, whereas pulsed electromagnetic field therapy is a non-invasive, simple technique that can be used as a scavenger agent to combat oxidative stress.

Kumar S, Behari J, Sisodia R. Impact of microwave at X-band in the aetiology of male infertility. Electromagn Biol Med. 31(3):223-232, 2012.

Reports of declining male fertility have renewed interest in assessing the role of environmental and occupational exposures to electromagnetic fields (EMFs) in the

aetiology of human infertility. Testicular functions are particularly susceptible to electromagnetic fields. The aim of the present work was to investigate the effect of 10-GHz EMF on male albino rat's reproductive system and to investigate the possible causative factor for such effect of exposure. The study was carried out in two groups of 70-day old adult male albino rats: a sham-exposed and a 10-GHz-exposed group (2 h a day for 45 days). Immediately after completion of the exposure, animals were sacrificed and sperms were extracted from the cauda and caput part of testis for the analysis of MDA, melatonin, and creatine kinase. Creatine kinase results revealed an increased level of phosphorylation that converts creatine to creatine phosphate in sperms after EMF exposure. EMF exposure also reduced the level of melatonin and MDA. It is concluded that microwaveexposure could adversely affect male fertility by reducing availability of the above parameters. These results are indications of deleterious effects of these radiations on reproductive pattern of male rats.

Kumar S, Behari J, Sisodia R. Influence of electromagnetic Fields on reproductive system of male rats.Int J Radiat Biol. 2012 Oct 19. [Epub ahead of print]

Purpose: Reports of declining male fertility have renewed interest in the role of environmental and occupational exposures in the etiology of human infertility. The aim of the present work is to investigate the effect of 10 GHz exposure on male Wistar rat's reproductive system and to find out the possible causative factors. Materials and methods: The study was divided into sham exposed and exposed groups. Seventy days old rats were exposed to 10 GHz microwave radiation for two hours per day for 45 days at power density 0.21mW/cm(2) and specific absorption rate (SAR) of 0.014W/kg. After the end of the experiment, blood samples were collected for the estimation of in vivo chromosomal aberration damage and micronucleus test. Spermatozoa were taken out for estimation of caspase3, comet assay, testosterone and electron microscopy and compared with sham exposed. Results: The study of scanning electron microscopic revealed shrinkage of the lumen of the seminiferous tubules. Apoptotic bodies were found in exposed group. A flow cytometry examination showed formation of micronuclei body in lymphocytes of exposed group. Comet assay confirmed DNA (deoxyribonucleic acid) strand break. Testosterone level was found significantly decreased with the shrinkage of testicular size. Conclusions: 10 GHz field has an injurious effect on fertility potential of male exposed animals.

Kumar V, Vats RP, Pathak PP. Harmful effects of 41 and 202 MHz radiations on some body parts and tissues. Indian J Biochem Biophys. 45(4):269-274, 2008.

Many types of invisible electromagnetic waves are produced in our atmosphere. When these radiations penetrate our body, electric fields are induced inside the body, resulting in the absorption of power, which is different for different body parts and also depends on the frequency of radiations. Higher power absorption may result into health problems. In this communication, effects of electromagnetic waves (EMW) of 41 and 202 MHz frequencies transmitted by the TV tower have been studied on skin, muscles, bone and fat of human. Using international standards for safe exposure limits of specific absorption rate (SAR), we have found the safe distance from TV transmission towers for two frequencies. It is suggested that transmission towers should be located away from the

thickly populated areas and people should keep away from the transmission towers, as they radiate electromagnetic radiations that are harmful to some parts/tissues of body.

Kumari K, Koivisto H, Viluksela M, Paldanius KMA, Marttinen M, Hiltunen M, Naarala J, Tanila H, Juutilainen J. Behavioral testing of mice exposed to intermediate frequency magnetic fields indicates mild memory impairment. PLoS One. 2017 Dec 4;12(12):e0188880.

Human exposure to intermediate frequency magnetic fields (MF) is increasing due to applications like electronic article surveillance systems and induction heating cooking hobs. However, limited data is available on their possible health effects. The present study assessed behavioral and histopathological consequences of exposing mice to 7.5 kHz MF at 12 or 120 μT for 5 weeks. No effects were observed on body weight, spontaneous activity, motor coordination, level of anxiety or aggression. In the Morris swim task, mice in the 120 μT group showed less steep learning curve than the other groups, but did not differ from controls in their search bias in the probe test. The passive avoidance task indicated a clear impairment of memory over 48 h in the 120 μT group. No effects on astroglial activation or neurogenesis were observed in the hippocampus. The mRNA expression of brain-derived neurotrophic factor did not change but expression of the proinflammatory cytokine tumor necrosis factor alpha mRNA was significantly increased in the 120 μT group. These findings suggest that 7.5 kHz MF exposure may lead to mild learning and memory impairment, possibly through an inflammatory reaction in the hippocampus.

Kumlin T, Iivonen H, Miettinen P, Juvonen A, van Groen T, Puranen L, Pitkäaho R, Juutilainen J, Tanila H. Mobile phone radiation and the developing brain: behavioral and morphological effects in juvenile rats. Radiat Res. 168(4):471-479, 2007.

The increasing use of mobile phones by children and teenagers has raised concerns about their safety. Addressing such concerns is difficult, because no data are available on possible effects from long-term exposure to radiofrequency (RF) fields during the development of the nervous system. Possible morphological and functional changes were evaluated in the central nervous system of young male Wistar rats exposed to 900 MHz mobile phone signal for 2 h/day on 5 days/week. After 5 weeks of exposure at whole-body average specific energy absorption rates of 0.3 or 3.0 W/kg or sham exposure, six rats per group were examined histologically, and the remaining 18 rats per group were subjected to behavioral tests. No degenerative changes, dying neurons, or effects on the leakage of the blood-brain barrier were detected. No group differences were observed in the open-field test, plus maze test or acoustic startle response tests. In the water maze test, however, significantly improved learning ($P = 0.012$) and memory ($P = 0.01$) were detected in rats exposed to RF fields. The results do not indicate a serious threat to the developing brain from mobile phone radiation at intensities relevant to human exposure. However, the interesting finding of improved learning and memory warrants further studies.

Kundi M. The controversy about a possible relationship between mobile phone use

and cancer. Cien Saude Colet. 15(5):2415-2430, 2010.

Over the last decade, mobile phone use increased to almost 100% prevalence in many countries. Evidence for potential health hazards accumulated in parallel by epidemiologic investigations has raised controversies about the appropriate interpretation and the degree of bias and confounding responsible for reduced or increased risk estimates. Overall, 33 epidemiologic studies were identified in the peer-reviewed literature, mostly (25) about brain tumors. Methodologic considerations revealed that three important conditions for epidemiologic studies to detect an increased risk are not met:no evidence-based exposure metric is available; the observed duration of mobile phone use is generally still too low; no evidence-based selection of end points among the grossly different types of neoplasias is possible because of lack of etiologic hypotheses. The overall evidence speaks in favor of an increased risk, but its magnitude cannot be assessed at present because of insufficient information on long-term use.

Kundi M, Hutter HP.Mobile phone base stations-Effects on wellbeing and health.Pathophysiology. 16(2-3):123-135, 2009.

Studying effects of mobile phone base station signals on health have been discouraged by authoritative bodies like WHO International EMF Project and COST 281. WHO recommended studies around base stations in 2003 but again stated in 2006 that studies on cancer in relation to base station exposure are of low priority. As a result only few investigations of effects of base station exposure on health and wellbeing exist. Cross-sectional investigations of subjective health as a function of distance or measured field strength, despite differences in methods and robustness of study design, found indications for an effect of exposure that is likely independent of concerns and attributions. Experimental studies applying short-term exposure to base station signals gave various results, but there is weak evidence that UMTS and to a lesser degree GSM signals reduce wellbeing in persons that report to be sensitive to such exposures. Two ecological studies of cancer in the vicinity of base stations report both a strong increase of incidence within a radius of 350 and 400m respectively. Due to the limitations inherent in this design no firm conclusions can be drawn, but the results underline the urgent need for a comprehensive investigation of this issue. Animal and in vitro studies are inconclusive to date. An increased incidence of DMBA induced mammary tumors in rats at a SAR of 1.4W/kg in one experiment could not be replicated in a second trial. Indications of oxidative stress after low-level in vivo exposure of rats could not be supported by in vitro studies of human fibroblasts and glioblastoma cells. From available evidence it is impossible to delineate a threshold below which no effect occurs, however, given the fact that studies reporting low exposure were invariably negative it is suggested that power densities around 0.5-1mW/m(2) must be exceeded in order to observe an effect. The meager data base must be extended in the coming years. The difficulties of investigating long-term effects of base station exposure have been exaggerated, considering that base station and handset exposure have almost nothing in common both needs to be studied independently. It cannot be accepted that studying base stations is postponed until there is firm evidence for mobile phones.

Kunjilwar KK, Behari J Effect of amplitude-modulated radio frequency radiation on cholinergic system of developing rats. Brain Res 601(1-2):321-324, 1993.

We examined the effect of long-term exposure to radio frequency radiation 147 MHz and its sub-harmonics 73.5 and 36.75 MHz amplitude modulated at 16 and 76 Hz (30-35 days, 3 h per day) on cholinergic systems in developing rat brain. A significant decrease in acetylcholine esterase activity was found in exposed rats as compared to the control. Decrease in acetylcholine esterase (AChE) activity was independent of carrier wave frequencies. A short-term exposure did not have any significant effect on AChE activity.

Kuribayashi M, Wang J, Fujiwara O, Doi Y, Nabae K, Tamano S, Ogiso T, Asamoto M, Shirai T. Lack of effects of 1439 MHz electromagnetic near field exposure on the blood-brain barrier in immature and young rats. Bioelectromagnetics. 26(7):578-88, 2005.

Possible effects of 1439 MHz electromagnetic near field (EMF) exposure on the blood-brain barrier (BBB) were investigated using immature (4 weeks old) and young (10 weeks old) rats, equivalent in age to the time when the BBB development is completed and the young adult, respectively. Alteration of BBB related genes, such as those encoding p-glycoprotein, aquaporin-4, and claudin-5, was assessed at the protein and mRNA levels in the brain after local exposure of the head to EMF at 0, 2, and 6 W/kg specific energy absorption rates (SARs) for 90 min/day for 1 or 2 weeks. Although expression of the 3 genes was clearly decreased after administration of 1,3-dinitrobenzene (DNB) as a positive control, when compared with the control values, there were no pathologically relevant differences with the EMF at any exposure levels at either age. Vascular permeability, monitored with reference to transfer of FITC-dextran, FD20, was not affected by EMF exposure. Thus, these findings suggest that local exposure of the head to 1439 MHz EMF exerts no adverse effects on the BBB in immature and young rats.

Kuybulu AE, Öktem F, Çiriş İM, Sutcu R, Örmeci AR, Çömlekçi S, Uz E. Effects of long-term pre- and post-natal exposure to 2.45 GHz wireless devices on developing male rat kidney. Ren Fail. 2016 Feb 24:1-10. [Epub ahead of print]

Purpose The aim of the present study was to investigate oxidative stress and apoptosis in kidney tissues of male Wistar rats that pre- and postnatally exposed to wireless electromagnetic field (EMF) with an internet frequency of 2.45 GHz for a long time. Methods The study was conducted in three groups of rats which were pre-natal, post-natal. and sham exposed groups. Oxidative stress markers and histological evaluation of kidney tissues were studied. Results Renal tissue malondialdehyde (MDA) and total oxidant (TOS) levels of pre-natal group were high and total antioxidant (TAS) and superoxide dismutase (SOD) levels were low. Spot urine NAG/creatinine ratio was significantly higher in pre- and post-natal groups ($p < 0.001$). Tubular injury was detected in most of the specimens in post-natal groups. Immunohistochemical analysis showed low-intensity staining with Bax in cortex, high-intensity staining with Bcl-2 in cortical and medullar areas of pre-natal group (p values, 0.000, 0.002, 0.000, respectively) when compared with sham group. Bcl2/Bax staining intensity ratios of medullar and cortical

area was higher in pre-natal group than sham group (p = 0.018, p = 0.011). Conclusion Based on this study, it is thought that chronic pre- and post-natal period exposure to wireless internet frequency of EMF may cause chronic kidney damages; staying away from EMF source in especially pregnancy and early childhood period may reduce negative effects of exposure on kidney.

Kwee S, Raskmark P, Changes in cell proliferation due to environmental non-ionizing radiation 2. Microwave radiation. Bioelectrochem Bioenerg 44(2) 251-255, 1998.

Due to the use of mobile telephones, there is an increased exposure of the environment to weak radiofrequency (RF) electromagnetic fields, emitted by these devices. This study was undertaken to investigate if the microwave radiation from these fields will have a similar effect on cell proliferation as weak electromagnetic (ELF) fields. 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) values for each cell well were calculated for this exposure system. Experiments were performed on cell cultures of transformed human epithelial amnion cells (AMA), which were exposed to 960 MHz microwave fields at three different power levels and three different exposure times, respectively. It was found that cell growth in the exposed cells was decreased in comparison to that in the control and sham exposed cells. Cell proliferation during the period following exposure varied not only with the various SAR levels, but also with the length of exposure time. On the other hand, repeated periods of exposure did not seem to change the effects. There was a general linear correlation between power level and growth change. However, the exposure time required to obtain the maximum effect was not the same for the various power levels. It turned out that at low power level, a maximum effect was first reached after a longer exposure time than at higher power level. A similar phenomenon was registered in the studies on ELF electromagnetic fields. Here, it was found that there was a linear correlation between the length of exposure time to obtain maximum effect and field strength.

Kwee S, Raskmark P, Velizarov P. Changes in cellular proteins due to environmental non-ionizing radiation. i. Heat-shock proteins. Electro- and Magnetobiology 20: 141-152, 2001.

This paper describes the effect of weak microwave fields on the amounts of heat-shock proteins in cell cultures at various temperatures. The field was generated by signal simulation of the Global System for Mobile communications (GSM) of 960 Mhz, used in portable phones. Transformed human epithelial amnion (AMA) cells, growing on glass coverslips, were exposed in a transverse electromagnetic (TEM) cell to a microwave field, generating a specific absorption rate (SAR) of 2.1 $mW.kg^{-1}$ in the cells. Exposure temperatures were 35, 37, and 40 ± 0.1°C, respectively, and the exposure time was 20 min. The heat-shock proteins Hsp-70 and Hsp-27 were detected by immuno-

fluorescence. Higher amounts of Hsp-70 were present in the cells exposed at 35 and 37°C than in the sham-exposed cells. These effects can be considered to be athermal, since the field strength was much lower than the safety standard for absence of heat generation by microwave fields. There was no significant response in the case of Hsp-27.

Kwon MK, Nam KC, Lee da S, Jang KH, Kim DW. Effects of RF fields emitted from smart phones on cardio-respiratory parameters: a preliminary provocation study. Conf Proc IEEE Eng Med Biol Soc. 2011:1961-1964, 2011.

This paper describes an experimental setup for evaluating the physiological effects of radiofrequency (RF) emitted from a Wideband Code Division Multiple Access (WCDMA) module with a 24 dBm at 1950 MHz for specific absorption rate (SAR(1g)) of 1.57 W/kg. This provocation study was executed in a double-blind study of two volunteer groups of 10 self-reported electromagnetic hypersensitivity (EHS) and 10 non-EHS subjects under both sham and real exposures in a randomly assigned and counter-balanced order. In the preliminary results, WCDMA RF exposure of 30 min did not have any effects on physiological changes in either group.

Kwon MK, Choi JY, Kim SK, Yoo TK, Kim DW. Effects of radiation emitted by WCDMA mobile phones on electromagnetic hypersensitive subjects. Environ Health. 11(1):69, 2012.

BACKGROUND: With the use of the third generation (3 G) mobile phones on the rise, social concerns have arisen concerning the possible health effects of radio frequency-electromagnetic fields (RF-EMFs) emitted by wideband code division multiple access (WCDMA) mobile phones in humans. The number of people with self-reported electromagnetic hypersensitivity (EHS), who complain of various subjective symptoms such as headache, dizziness and fatigue, has also increased. However, the origins of EHS remain unclear. METHODS: In this double-blind study, two volunteer groups of 17 EHS and 20 non-EHS subjects were simultaneously investigated for physiological changes (heart rate, heart rate variability, and respiration rate), eight subjective symptoms, and perception of RF-EMFs during real and sham exposure sessions. Experiments were conducted using a dummy phone containing a WCDMA module (average power, 24 dBm at 1950 MHz; specific absorption rate, 1.57 W/kg) within a headset placed on the head for 32 min. RESULTS: WCDMA RF-EMFs generated no physiological changes or subjective symptoms in either group. There was no evidence that EHS subjects perceived RF-EMFs better than non-EHS subjects. CONCLUSIONS: Considering the analyzed physiological data, the subjective symptoms surveyed, and the percentages of those who believed they were being exposed, 32 min of RF radiation emitted by WCDMA mobile phones demonstrated no effects in either EHS or non-EHS subjects.

Kwon MK, Kim SK, Koo JM, Choi JY, Kim DW. EHS subjects do not perceive RF EMF emitted from smart phones better than non-EHS subjects. Conf Proc IEEE Eng Med Biol Soc. 2012:2190-193, 2012.

As the use of smart phones increases, social concerns have arisen concerning the possible effects of radio frequency-electromagnetic fields (RF-EMFs) emitted from wideband code division multiple access (WCDMA) mobile phones on human health. The number of people with self-reported electromagnetic hypersensitivity (EHS) who complain of various subjective symptoms, such as headache, insomnia, etc., has also recently increased. However, it is unclear whether EHS subjects can detect RF-EMFs exposure or not. In this double-blind study, two volunteer groups of 17 EHS and 20 non-EHS subjects were investigated in regards to their perception of RF-EMFs with real and sham exposure sessions. Experiments were conducted using a WCDMA module inside a dummy phone with an average power of 24 dBm at 1950 MHz and a specific absorption rate of 1.57 W/kg using a dummy headphone for 32 min. In conclusion, there was no indication that EHS subjects perceive RF-EMFs better than non-EHS subjects.

Kwon MS, Kujala T, Huotilainen M, Shestakova A, Näätänen R, Hämäläinen H. Preattentive auditory information processing under exposure to the 902 MHz GSM mobile phone electromagnetic field: A mismatch negativity (MMN) study. Bioelectromagnetics.30(3):241-248, 2009.

Previous studies on the effects of the mobile phone electromagnetic field (EMF) on various event-related potential (ERP) components have yielded inconsistent and even contradictory results, and often failed in replication. The mismatch negativity (MMN) is an auditory ERP component elicited by infrequent (deviant) stimuli differing in some physical features from the repetitive frequent (standard) stimuli in a sound sequence. The MMN provides a sensitive measure for cortical auditory stimulus feature discrimination, regardless of attention and other contaminating factors. In this study, MMN responses to duration, intensity, frequency, and gap changes were recorded in healthy young adults (n = 17), using a multifeature paradigm including several types of auditory change in the same stimulus sequence, while a GSM mobile phone was placed on either ear with the EMF (902 MHz pulsed at 217 Hz; SAR(1g) = 1.14 W/kg, SAR(10g) = 0.82 W/kg, peak value = 1.21 W/kg, measured with an SAM phantom) on or off. An MMN was elicited by all deviant types, while its amplitude and latency showed no significant differences due to EMF exposure for any deviant types. In the present study, we found no conclusive evidence that acute exposure to GSM mobile phone EMF affects cortical auditory change detection processing reflected by the MMN.

Kwon MS, Jääskeläinen SK, Toivo T, Hämäläinen H. No effects of mobile phone electromagnetic field on auditory brainstem response. Bioelectromagnetics. 31(1):48-55, 2010.

The present study investigated the possible effects of the electromagnetic field (EMF) emitted by an ordinary GSM mobile phone (902.4 MHz pulsed at 217 Hz) on brainstem auditory processing. Auditory brainstem responses (ABR) were recorded in 17 healthy young adults, without a mobile phone at baseline, and then with a mobile phone on the ear under EMF-off and EMF-on conditions. The amplitudes, latencies, and interwave intervals of the main ABR components (waves I, III, V) were compared among the three conditions. ABR waveforms showed no significant differences due to exposure, suggesting that short-term exposure to mobile phone EMF did not affect the transmission of sensory stimuli from the cochlea up to the midbrain along the auditory nerve and

brainstem auditory pathways.

Kwon MS, **Huotilainen M**, **Shestakova A**, **Kujala T**, **Näätänen R**, **Hämäläinen H**. **No effects of mobile phone use on cortical auditory change-detection in children: An ERP study. Bioelectromagnetics.31(3):191-199, 2010.**

We investigated the effect of mobile phone use on the auditory sensory memory in children. Auditory event-related potentials (ERPs), P1, N2, mismatch negativity (MMN), and P3a, were recorded from 17 children, aged 11-12 years, in the recently developed multi-feature paradigm. This paradigm allows one to determine the neural change-detection profile consisting of several different types of acoustic changes. During the recording, an ordinary GSM (Global System for Mobile Communications) mobile phone emitting 902 MHz (pulsed at 217 Hz) electromagnetic field (EMF) was placed on the ear, over the left or right temporal area (SAR(1g) = 1.14 W/kg, SAR(10g) = 0.82 W/kg, peak value = 1.21 W/kg). The EMF was either on or off in a single-blind manner. We found that a short exposure (two 6 min blocks for each side) to mobile phone EMF has no statistically significant effects on the neural change-detection profile measured with the MMN. Furthermore, the multi-feature paradigm was shown to be well suited for studies of perception accuracy and sensory memory in children. However, it should be noted that the present study only had sufficient statistical power to detect a large effect size.

Kwon MS, Vorobyev V, Kännälä S, Laine M, Rinne JO, Toivonen T, Johansson J, Teräs M, Lindholm H, Alanko T, Hämäläinen H. GSM mobile phone radiation suppresses brain glucosemetabolism. J Cereb Blood Flow Metab. 31(12):2293-2301, 2011.

We investigated the effects of mobile phone radiation on cerebral glucosemetabolism using high-resolution positron emission tomography (PET) with the (18)F-deoxyglucose (FDG) tracer. A long half-life (109 minutes) of the (18)F isotope allowed a long, natural exposure condition outside the PET scanner. Thirteen young right-handed male subjects were exposed to a pulse-modulated 902.4 MHz Global System for Mobile Communications signal for 33 minutes, while performing a simple visual vigilance task. Temperature was also measured in the head region (forehead, eyes, cheeks, ear canals) during exposure. (18)F-deoxyglucose PET images acquired after the exposure showed that relative cerebral metabolic rate of glucose was significantly reduced in the temporoparietal junction and anterior temporal lobe of the right hemisphere ipsilateral to the exposure. Temperature rise was also observed on the exposed side of the head, but the magnitude was very small. The exposure did not affect task performance (reaction time, error rate). Our results show that short-term mobile phone exposure can locally suppress brain energy metabolism in humans.

Kwon MS, Vorobyev V, Kännälä S, Laine M, Rinne JO, Toivonen T, Johansson J, Teräs M, Joutsa J, Tuominen L, Lindholm H, Alanko T, Hämäläinen H. No effects of short-term GSM mobile phone radiation on cerebral blood flow measured using positron emission tomography. Bioelectromagnetics. 33(3):247-256, 2012.

The present study investigated the effects of 902.4 MHz global system for mobile communications (GSM) mobile phone radiation on cerebral blood flow using positron

emission tomography (PET) with the (15) O-water tracer. Fifteen young, healthy, right-handed male subjects were exposed to phone radiation from three different locations (left ear, right ear, forehead) and to sham exposure to test for possible exposure effects on brain regions close to the exposure source. Whole-brain [^{15}O]H_2O-PET images were acquired 12 times, 3 for each condition, in a counterbalanced order. Subjects were exposed for 5 min in each scan while performing a simple visual vigilance task. Temperature was also measured in the head region (forehead, eyes, cheeks, ear canals) during exposure. The exposure induced a slight temperature rise in the ear canals but did not affect brain hemodynamics and task performance.The results provided no evidence for acute effects of short-term mobile phone radiation on cerebral blood flow.

L'Abbate N, Pranzo S, Martucci V, Rella C, Vitucci L, Salamanna S. [Evaluation of the levels of radiofrequency electromagnetic fields in the territory of the city of Bari in outside and inside environments] G Ital Med Lav Ergon. 26(1):19-27, 2004. [Article in Italian]

In this study we measured the levels of the high frequency field in the proximity of non-ionizing radiation sources (wireless transmitting stations for mobile telephones and radio and television transmitters) in nine districts of the city of Bari. The measurements were taken both inside and outside closed environments. For the indoor measurements we took into account electromagnetic field generating equipment (VDT, electric domestic appliances, mobile telephones) in working and non-working order and with the windows open and shut respectively. We carried out these measurements according to the methods laid down in the Italian regulation CEI ENV 50166-2 of May 1995, as shown in the enclosure to the Ministerial Decree of 10.9.98 n.381. The electromagnetic field levels near wireless transmitting stations for mobile telephones are certainly modest when we consider that they never exceeded the limits established by the aforesaid Ministerial Decree. On the contrary radio and television equipment creates a much greater source of exposure. The electromagnetic field levels are certainly superior to those of the wireless transmitting stations although they never exceed, except in one isolated case, the values established by the Ministerial Decree 381/98.

La Regina M, Moros EG, Pickard WF, Straube WL, Baty J, Roti Roti JL. The effect of chronic exposure to 835.62 MHz FDMA or 847.74 MHz CDMA radiofrequency radiation on the incidence of spontaneous tumors in rats. Radiat Res. 160(2):143-151, 2003.

This study was designed to determine whether chronic exposure to radiofrequency (RF) radiation from cellular phones increased the incidence of spontaneous tumors in F344 rats. Eighty male and 80 female rats were randomly placed in each of three irradiation groups. The sham group received no irradiation; the Frequency Division Multiple Access (FDMA) group was exposed to 835.62 MHz FDMA RF radiation; and the Code Division Multiple Access (CDMA) group was exposed to 847.74 MHz CDMA RF radiation. Rats were irradiated 4 h per day, 5 days per week over 2 years. The nominal time-averaged specific absorption rate (SAR) in the brain for the

irradiated animals was 0.85 +/- 0.34 W/kg (mean +/- SD) per time-averaged watt of antenna power. Antennas were driven with a time-averaged power of 1.50 +/- 0.25 W (range). That is, the nominal time-averaged brain SAR was 1.3 +/- 0.5 W/kg (mean +/- SD). This number was an average from several measurement locations inside the brain, and it takes into account changes in animal weight and head position during irradiation. All major organs were evaluated grossly and histologically. The number of tumors, tumor types and incidence of hyperplasia for each organ were recorded. There were no significant differences among final body weights or survival days for either males or females in any group. No significant differences were found between treated and sham-exposed animals for any tumor in any organ. We conclude that chronic exposure to 835.62 MHz FDMA or 847.74 MHz CDMA RF radiation had no significant effect on the incidence of spontaneous tumors in F344 rats.

Laberge-Nadeau C, Maag U, Bellavance F, Lapierre SD, Desjardins D, Messier S, Sai;di A. Wireless telephones and the risk of road crashes. Accid Anal Prev. 35(5):649-660, 2003.

In light of the rapidly increasing development of the cell phone market, the use of such equipment while driving raises the question of whether it is associated with an increased accident risk; and if so, what is its magnitude. This research is an epidemiological study on two large cohorts, namely users and non-users of cell phones, with the objective of verifying whether an association exists between cell phone use and road crashes, separating those with injuries.The Societe de l'Assurance Automobile du Quebec (SAAQ) mailed a questionnaire and letter of consent to 175000 licence holders for passenger vehicles. The questionnaire asked about exposure to risk, driving habits, opinions about activities likely to be detrimental to driving and accidents within the last 24 months. For cell phone users, questions pertaining to the use of the telephone were added. We received 36078 completed questionnaires, with a signed letter of consent. Four wireless phone companies provided the files on cell phone activity, and the SAAQ the files for 4 years of drivers' records and police reports. The three data sources were merged using an anonymized identification number. The statistical methods include logistic-normal regression models to estimate the strength of the links between the explanatory variables and crashes.The relative risk of all accidents and of accidents with injuries is higher for users of cell phones than for non-users. The relative risks (RR) for injury collisions and also for all collisions is 38% higher for men and women cell phone users. These risks diminish to 1.1 for men and 1.2 for women if other variables, such as the kilometres driven and driving habits are incorporated into the models. Similar results hold for several sub-groups. The most significant finding is a dose-response relationship between the frequency of cell phone use, and crash risks. The adjusted relative risks for heavy users are at least two compared to those making minimal use of cell phones; the latter show similar collision rates as do the non-users.

Lagorio S, Rossi S, Vecchia P, De Santis M, Bastianini L, Fusilli M, Ferrucci A, Desideri E, Comba P, Mortality of plastic-ware workers exposed to radiofrequencies. Bioelectromagnetics 18(6):418-421, 1997.

The mortality experience of a cohort of Italian plastic-ware workers exposed to radiofrequency (RF)-electromagnetic fields generated by dielectric heat sealers was investigated. Follow-up extended from 1962 to 1992. The standardised mortality ratio (SMR) analysis was restricted to 481 women workers, representing 78% of the total person-years at risk. Mortality from malignant neoplasms was slightly elevated, and increased risks of leukemia and accidents were detected. The all-cancer SMR was higher among women employed in the sealing department, where exposure to RF occurred, than in the whole cohort. This study raises interest in a possible association between exposure to RF radiation and cancer risk. However, the study power was very small, and the possible confounding effects of exposure to solvents and vinyl chloride monomer (VCM) could not be ruled out. The hypothesis of an increased risk of cancer after radiofrequency exposure should be further explored by means of analytical studies characterised by adequate power and more accurate exposure assessment.

Lagroye I, Anane R, Wettring BA, Moros EG, Straube WL, Laregina M, Niehoff M, Pickard WF, Baty J, Roti JL. Measurement of DNA damage after acute exposure to pulsed-wave 2450 MHz microwaves in rat brain cells by two alkaline comet assay methods. Int J Radiat Biol. 80(1):11-20, 2004.

Purpose: To investigate the effect of 2450 MHz pulsed-wave microwaves on the induction of DNA damage in brain cells of exposed rats and to discover whether proteinase K is needed to detect DNA damage in the brain cells of rats exposed to 2450 MHz microwaves. Materials and methods: Sprague-Dawley rats were exposed to 2450 MHz pulsed-wave microwaves and sacrificed 4 h after a 2-h exposure. Rats irradiated whole-body with 1 Gy (137)Cs were included as positive controls. DNA damage was assayed by two variants of the alkaline comet assay on separate aliquots of the same cell preparation. Results: Significant DNA damage was observed in the rat brain cells of rats exposed to gamma-rays using both versions of the alkaline comet assay independent of the presence or absence of proteinase K. However, neither version of the assay could detect any difference in comet length and/or normalized comet moment between sham- and 2450 MHz pulsed-wave microwave-exposed rats, regardless of the inclusion or omission of proteinase K in the comet assay. Conclusions: No DNA damage in brain cells was detected following exposure of rats to 2450 MHz microwaves pulsed-wave at a specific absorption rate of 1.2 W kg(-1) regardless of whether or not proteinase K was included in the assay. Thus, the results support the conclusion that low-level 2450 MHz pulsed-wave microwave exposures do not induce DNA damage detectable by the alkaline comet assay.

Lagroye I, Hook GJ, Wettring BA, Baty JD, Moros EG, Straube WL, Roti Roti JL. Measurements of alkali-labile DNA damage and protein-DNA crosslinks after 2450 MHz microwave and low-dose gamma irradiation In vitro. Radiat Res. 161(2): 201-214, 2004.

In vitro experiments were performed to determine whether 2450 MHz microwave radiation induces alkali-labile DNA damage and/or DNA-protein or DNA-DNA crosslinks in C3H 10T(1/2) cells. After a 2-h exposure to either 2450 MHz continuous-wave (CW) microwaves at an SAR of 1.9 W/kg or 1 mM cisplatinum (CDDP, a positive control for DNA crosslinks), C3H 10T(1/2) cells were irradiated with 4 Gy of gamma rays ((137)Cs).

Immediately after gamma irradiation, the single-cell gel electrophoresis assay was performed to detect DNA damage. For each exposure condition, one set of samples was treated with proteinase K (1 mg/ml) to remove any possible DNA-protein crosslinks. To measure DNA-protein crosslinks independent of DNA-DNA crosslinks, we quantified the proteins that were recovered with DNA after microwave exposure, using CDDP and gamma irradiation, positive controls for DNA-protein crosslinks. Ionizing radiation (4 Gy) induced significant DNA damage. However, no DNA damage could be detected after exposure to 2450 MHz CW microwaves alone. The crosslinking agent CDDP significantly reduced both the comet length and the normalized comet moment in C3H 10T(1/2) cells irradiated with 4 Gy gamma rays. In contrast, 2450 MHz microwaves did not impede the DNA migration induced by gamma rays. When control cells were treated with proteinase K, both parameters increased in the absence of any DNA damage. However, no additional effect of proteinase K was seen in samples exposed to 2450 MHz microwaves or in samples treated with the combination of microwaves and radiation. On the other hand, proteinase K treatment was ineffective in restoring any migration of the DNA in cells pretreated with CDDP and irradiated with gamma rays. When DNA-protein crosslinks were specifically measured, we found no evidence for the induction of DNA-protein crosslinks or changes in amount of the protein associated with DNA by 2450 MHz CW microwave exposure. Thus 2-h exposures to 1.9 W/ kg of 2450 MHz CW microwaves did not induce measurable alkali-labile DNA damage or DNA-DNA or DNA-protein crosslinks.

Lahham A, Hammash A. Outdoor radiofrequency radiation levels in the West Bank-Palestine. Radiat Prot Dosimetry. 149(4):399-402, 2012.

This work presents the results of exposure levels to radio frequency (RF) emission from different sources in the environment of the West Bank-Palestine. These RF emitters include FM and TV broadcasting stations and mobile phone base stations. Power densities were measured at 65 locations distributed over the West Bank area. These locations include mainly centres of the major cities. Also a 24 h activity level was investigated for a mobile phone base station to determine the maximum activity level for this kind of RF emitters. All measurements were conducted at a height of 1.7 m above ground level using hand held Narda SRM 3000 spectrum analyzer with isotropic antenna capable of collecting RF signals in the frequency band from 75 MHz to 3 GHz. The average value of power density resulted from FM radio broadcasting in all investigated locations was 0.148 μW cm(-2), from TV broadcasting was 0.007 μW cm(-2) and from mobile phone base station was 0.089 μW cm(-2). The maximum total exposure evaluated at any location was 3.86 μW cm(-2). The corresponding exposure quotient calculated for this site was 0.02. This value is well below unity indicating compliance with the International Commission on non-ionising Radiation protection guidelines. Contributions from all relevant RF sources to the total exposure were evaluated and found to be ~62 % from FM radio, 3 % for TV broadcasting and 35 % from mobile phone base stations. The average total exposure from all investigated RF sources was 0.37 μW cm(-2).

Lahham A, Sharabati A, ALMasri H. Assessment of Public Exposure From WLANs in the West Bank-Palestine. Radiat Prot Dosimetry. 2017 Mar 3:1-5. doi: 10.1093/rpd/ncx028.

A total of 271 measurements were conducted at 69 different sites including homes, hospitals, educational institutions and other public places to assess the exposure to radiofrequency emission from wireless local area networks (WLANs). Measurements were conducted at different distances from 40 to 10 m from the access points (APs) in real life conditions using Narda SRM-3000 selective radiation meter. Three measurements modes were considered at 1 m distance from the AP which are transmit mode, idle mode, and from the client card (laptop computer). All measurements were conducted indoor in the West Bank environment. Power density levels from WLAN systems were found to vary from 0.001 to ~1.9 μW cm-2 with an average of 0.12 μW cm-2. Maximum value found was in university environment, while the minimum was found in schools. For one measurement case where the AP was 20 cm far while transmitting large files, the measured power density reached a value of ~4.5 μW cm-2. This value is however 221 times below the general public exposure limit recommended by the International Commission on Non-Ionizing Radiation Protection, which was not exceeded in any case. Measurements of power density at 1 m around the laptop resulted in less exposure than the AP in both transmit and idle modes as well. Specific absorption rate for the head of the laptop user was estimated and found to vary from 0.1 to 2 mW/kg. The frequency distribution of measured power densities follows a log-normal distribution which is generally typical in the assessment of exposure resulting from sources of radiofrequency emissions.

Lahkola A, Salminen T, Auvinen A. Selection bias due to differential participation in a case-control study of mobile phone use and brain tumors. Ann Epidemiol. 15(5):321-325, 2005.

PURPOSE: To evaluate the possible selection bias related to the differential participation of mobile phone users and non-users in a Finnish case-control study on mobile phone use and brain tumors. METHODS: Mobile phone use was investigated among 777 controls and 726 cases participating in the full personal interview (full participants), and 321 controls and 103 cases giving only a brief phone interview (incomplete participants). To assess selection bias, the Mantel-Haenszel estimate of odds ratio was calculated for three different groups: full study participants, incomplete participants, and a combined group consisting of both full and incomplete participants. RESULTS: Among controls, 83% of the full participants and 73% of the incomplete participants had regularly used a mobile phone. Among cases, the figures were 76% and 64%, respectively. The odds ratio for brain tumor based on the combined group of full and incomplete participants was slightly closer to unity than that based only on the full participants. CONCLUSIONS: Selection bias tends to distort the effect estimates below unity, while analyses based on more comprehensive material gave results close to unity.

Lahkola A, Tokola K, Auvinen A. Meta-analysis of mobile phone use and intracranial tumors. Scand J Work Environ Health. 32(3):171-177, 2006.

OBJECTIVES: A summary of epidemiologic evidence regarding the effect of mobile phone use on intracranial tumor risk was obtained by means of a meta-analysis. METHODS: Reports of published studies on mobile phone use and intracranial tumors were sought. Altogether 12 relevant publications were identified from the PubMed

database and reference lists of articles. Fixed or random effects analysis was carried out depending on the presence of heterogeneity between studies. Risk estimates were obtained for people who had used mobile phones for the longest periods of time (>5 years in most reports). A pooled estimate was calculated for all intracranial tumors combined and also separately for different histological tumor types. Separate analyses were conducted also based on the tumor location and type of mobile telephone network (NMT or GSM). Results Twelve studies with 2780 cases gave a pooled odds ratio (OR) of 0.98 [95% confidence interval (95% CI) 0.83-1.16] for all intracranial tumors related to mobile phone use. For gliomas, the pooled OR was 0.96 (95% CI 0.78-1.18), for meningiomas it was 0.87 (95% CI 0.72-1.05), and for acoustic neuromas it was 1.07 (95% CI 0.89-1.30). Little indication was found for increased risks of analogue or digital phone use or temporal or occipital tumors. Conclusions The totality of evidence does not indicate a substantially increased risk of intracranial tumors from mobile phone use for a period of at least 5 years.

Lahkola A, Auvinen A, Raitanen J, Schoemaker MJ, Christensen HC, Feychting M, Johansen C, Klaeboe L, Lonn S, Swerdlow AJ, Tynes T, Salminen T. Mobile phone use and risk of glioma in 5 North European countries. Int J Cancer. 120(8):1769-1775, 2007.

Public concern has been expressed about the possible adverse health effects of mobile telephones, mainly related to intracranial tumors. We conducted a population-based case-control study to investigate the relationship between mobile phone use and risk of glioma among 1,522 glioma patients and 3,301 controls. We found no evidence of increased risk of glioma related to regular mobile phone use (odds ratio, OR = 0.78, 95% confidence interval, CI: 0.68, 0.91). No significant association was found across categories with duration of use, years since first use, cumulative number of calls or cumulative hours of use. When the linear trend was examined, the OR for cumulative hours of mobile phone use was 1.006 (1.002, 1.010) per 100 hr, but no such relationship was found for the years of use or the number of calls. We found no increased risks when analogue and digital phones were analyzed separately. For more than 10 years of mobile phone use reported on the side of the head where the tumor was located, an increased OR of borderline statistical significance (OR = 1.39, 95% CI 1.01, 1.92, p trend 0.04) was found, whereas similar use on the opposite side of the head resulted in an OR of 0.98 (95% CI 0.71, 1.37). Although our results overall do not indicate an increased risk of glioma in relation to mobile phone use, the possible risk in the most heavily exposed part of the brain with long-term use needs to be explored further before firm conclusions can be drawn.

Lahkola A, Salminen T, Raitanen J, Heinävaara S, Schoemaker M, Christensen HC, Feychting M, Johansen C, Klæboe L, Lönn S, Swerdlow A, Tynes T, Auvinen A. Meningioma and mobile phone use--a collaborative case-control study in five North European countries. Int J Epidemiol.37(6):1304-1313, 2008.

BACKGROUND: Use of mobile telephones has been suggested as a possible risk factor for intracranial tumours. To evaluate the effect of mobile phones on risk of meningioma, we carried out an international, collaborative case-control study of 1209 meningioma cases and 3299 population-based controls. METHODS: Population-

based cases were identified, mostly from hospitals, and controls from national population registers and general practitioners' patient lists. Detailed history of mobile phone use was obtained by personal interview. Regular mobile phone use (at least once a week for at least 6 months), duration of use, cumulative number and hours of use, and several other indicators of mobile phone use were assessed in relation to meningioma risk using conditional logistic regression with strata defined by age, sex, country and region. RESULTS: Risk of meningioma among regular users of mobile phones was apparently lower than among never or non-regular users (odds ratio, OR = 0.76, 95% confidence interval, CI 0.65, 0.89). The risk was not increased in relation to years since first use, lifetime years of use, cumulative hours of use or cumulative number of calls. The findings were similar regardless of telephone network type (analogue/digital), age or sex. CONCLUSIONS: Our results do not provide support for an association between mobile phone use and risk of meningioma.

Lai H. Interaction of microwaves and a temporally incoherent magnetic field on spatial learning in the rat. Physiol Behav. 82(5):785-789, 2004.

The effect of a temporally incoherent magnetic field ('noise') on microwave-induced spatial learning deficit in the rat was investigated. Rats were trained in six sessions to locate a submerged platform in a circular water maze. Four treatment groups of rats were studied: microwave-exposure (2450-MHz continuous-wave microwaves, power density 2 mW/cm(2), average whole-body specific absorption rate 1.2 W/kg), 'noise' exposure (60 mG), 'microwave+noise' exposure, and sham exposure. Animals were exposed to these conditions for 1 h immediately before each training session. One hour after the last training session, animals were tested in a 2-min probe trial in the maze during which the platform was removed. The time spent during the 2 min in the quadrant of the maze in which the platform had been located was scored. Results show that microwave-exposed rats had significant deficit in learning to locate the submerged platform when compared with the performance of the sham-exposed animals. Exposure to 'noise' alone did not significantly affect the performance of the animals (i.e., it was similar to that of the sham-exposed rats). However, simultaneous exposure to 'noise' significantly attenuated the microwave-induced spatial learning deficit (i.e. 'microwave+noise'-exposed rats learned significantly better than the microwave-exposed rats). During the probe trial, microwave-exposed animals spent significantly less time in the quadrant where the platform was located. However, response of the 'microwave+noise'-exposed animals was similar to that of the sham-exposed animals during the probe trial. Thus, simultaneous exposure to a temporally incoherent magnetic field blocks microwave-induced spatial learning and memory deficits in the rat.

Lai H, Singh NP, Acute low-intensity microwave exposure increases DNA single-strand breaks in rat brain cells. Bioelectromagnetics 16(3):207-210, 1995.

Levels of DNA single-strand break were assayed in brain cells from rats acutely exposed to low-intensity 2450 MHz microwaves using an alkaline microgel electrophoresis method. Immediately after 2 h of exposure to pulsed (2 microseconds width, 500 pulses/s) microwaves, no significant effect was observed, whereas a dose rate-dependent [0.6 and 1.2 W/kg whole body specific absorption rate (SAR)] increase in DNA single-strand breaks was found in brain cells of rats at 4 h postexposure. Furthermore, in

rats exposed for 2 h to continuous-wave 2450 MHz microwaves (SAR 1.2 W/kg), increases in brain cell DNA single-strand breaks were observed immediately as well as at 4 h postexposure.

Lai H, Singh NP, Single- and double-strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromagnetic radiation. Int J Radiat Biol 69(4):513-521, 1996.

We investigated the effects of acute (2-h) exposure to pulsed (2-micros pulse width, 500 pulses s(-1)) and continuous wave 2450-MHz radiofrequency electromagnetic radiation on DNA strand breaks in brain cells of rat. The spatial averaged power density of the radiation was 2mW/cm2, which produced a whole-body average-specific absorption rate of 1.2W/kg. Single- and double-strand DNA breaks in individual brain cells were measured at 4h post-exposure using a microgel electrophoresis assay. An increase in both types of DNA strand breaks was observed after exposure to either the pulsed or continuous-wave radiation, No significant difference was observed between the effects of the two forms of radiation. We speculate that these effects could result from a direct effect of radiofrequency electromagnetic energy on DNA molecules and/or impairment of DNA-damage repair mechanisms in brain cells. Our data further support the results of earlier in vitro and in vivo studies showing effects of radiofrequency electromagnetic radiation on DNA.

Lai, H, Singh, NP, Melatonin and a spin-trap compound block radiofrequency electromagnetic radiation-induced DNA strand breaks in rat brain cells. Bioelectromagnetics 18(6):446-454, 1997.

Effects of in vivo microwave exposure on DNA strand breaks, a form of DNA damage, were investigated in rat brain cells. In previous research, we have found that acute (2 hours) exposure to pulsed (2 microseconds pulses, 500 pps) 2450-MHz radiofrequency electromagnetic radiation (RFR) (power density 2 mW/cm2, average whole body specific absorption rate 1.2 W/kg) caused an increase in DNA single- and double-strand breaks in brain cells of the rat when assayed 4 hours post exposure using a microgel electrophoresis assay. In the present study, we found that treatment of rats immediately before and after RFR exposure with either melatonin (1 mg/kg/injection, SC) or the spin-trap compound N-tert-butyl-alpha-phenylnitrone (PBN) (100 mg/kg/injection, i.p.) blocks this effects of RFR. Since both melatonin and PBN are efficient free radical scavengers it is hypothesized that free radicals are involved in RFR-induced DNA damage in the brain cells of rats. Since cumulated DNA strand breaks in brain cells can lead to neurodegenerative diseases and cancer and an excess of free radicals in cells has been suggested to be the cause of various human diseases, data from this study could have important implications for the health effects of RFR exposure.

Lai H, Singh NP, Interaction of Microwaves and a Temporally Incoherent Magnetic Field on Single and Double DNA Strand Breaks in Rat Brain Cells. Electromag Biol Med 24:23-29, 2005.

The effect of a temporally incoherent magnetic field ('noise') on microwave-induced DNA single and double strand breaks in rat brain cells was investigated. Four treatment groups of rats were studied: microwave-exposure (continuous-wave 2450-MHz

microwaves, power density 1 mW/cm^2, average whole body specific absorption rate of 0.6 W/kg), 'noise'-exposure (45 mG), 'microwave + noise'-exposure, and sham-exposure. Animals were exposed to these conditions for 2 hrs. DNA single and double strand breaks in brain cells of these animals were assayed 4 hrs later using a microgel electrophoresis assay. Results show that brain cells of microwave-exposed rats had significantly higher levels of DNA single and double strand breaks when compared with sham-exposed animals. Exposure to 'noise' alone did not significantly affect the levels (i.e., they were similar to those of the sham-exposed rats). However, simultaneous 'noise' exposure blocked microwave-induced increases in DNA strand breaks. These data indicate that simultaneous exposure to a temporally incoherent magnetic field could block microwave-induced DNA damage in brain cells of the rat.

Lai, H, Carino, MA, Singh, NP, Naltrexone blocks RFR-induced DNA double strand breaks in rat brain cells. Wireless Networks 3:471-476, 1997.

Previous research in our laboratory has shown that various effects of radiofrequency electromagnetic radiation (RFR) exposure on the nervous system are mediated by endogenous opioids in the brain. We have also found that acute exposure to RFR induced DNA strand breaks in brain cells of the rat. The present experiment was carried out to investigate whether endogenous opioids are also involved in RFR-induced DNA strand breaks. Rats were treated with the opioid antagonist naltrexone (1 mg/kg, IP) immediately before and after exposure to 2450-MHz pulsed (2 μs pulses, 500 pps) RFR at a power density of 2 mW/cm2 (average whole body specific absorption rate of 1.2 W/kg) for 2 hours. DNA double strand breaks were assayed in brain cells at 4 hours after exposure using a microgel electrophoresis assay. Results showed that the RFR exposure significantly increased DNA double strand breaks in brain cells of the rat, and the effect was partially blocked by treatment with naltrexone. Thus, these data indicate that endogenous opioids play a mediating role in RFR-induced DNA strand breaks in brain cells of the rat.

Lai H, Horita A, Guy AW, Microwave irradiation affects radial-arm maze performance in the rat. Bioelectromagnetics 15(2):95-104, 1994.

After 45 min of exposure to pulsed 2450 MHz microwaves (2 microseconds pulses, 500 pps, 1 mW/cm2, average whole body SAR 0.6 W/kg), rats showed retarded learning while performing in the radial-arm maze to obtain food rewards, indicating a deficit in spatial "working memory" function. This behavioral deficit was reversed by pretreatment before exposure with the cholinergic agonist physostigmine or the opiate antagonist naltrexone, whereas pretreatment with the peripheral opiate antagonist naloxone methiodide showed no reversal of effect. These data indicate that both cholinergic and endogenous opioid neurotransmitter systems in the brain are involved in the microwave-induced spatial memory deficit.

Lai H, Carino MA, Wen YF, Horita A, Guy AW, Naltrexone pretreatment blocks microwave-induced changes in central cholinergic receptors. Bioelectromagnetics 12(1):27-33, 1991.

Repeated exposure of rats to pulsed, circularly polarized microwaves (2,450-MHz, 2-microseconds pulses at 500 pps, power density 1 mW/cm2, at an averaged, whole-body

SAR of 0.6 W/kg) induced biphasic changes in the concentration of muscarinic cholinergic receptors in the central nervous system. An increase in receptor concentration occurred in the hippocampus of rats subjected to ten 45-min sessions of microwave exposure, whereas a decrease in concentration was observed in the frontal cortex and hippocampus of rats exposed to ten 20-min sessions. These findings, which confirm earlier work in the authors' laboratory, were extended to include pretreatment of rats with the narcotic antagonist naltrexone (1 mg/kg, IP) before each session of exposure. The drug treatment blocked the microwave-induced changes in cholinergic receptors in the brain. These data further support the authors' hypothesis that endogenous opioids play a role in the effects of microwaves on central cholinergic systems.

Lai H, Carino MA, Horita A, Guy AW, Opioid receptor subtypes that mediate a microwave-induced decrease in central cholinergic activity in the rat. Bioelectromagnetics 13(3):237-246, 1992.

We performed experiments to investigate subtypes of opioid receptors in the brain involved in the effect of acute (45 min) pulsed microwave exposure (2,450-MHz, 2-microseconds pulses, 500 pps, average power density 1 mW/cm2, peak-power density, 1 W/cm2, average whole body SAR 0.6 W/kg) on cholinergic activity in the rat brain. Rats were pretreated by microinjection of specific antagonists of mu, delta, and kappa opioid-receptors into the lateral cerebroventricle before exposure to microwaves. The data showed that all three subtypes of opioid receptors are involved in the microwave-induced decrease in cholinergic activity in the hippocampus. However, the microwave-induced decrease in cholinergic activity in the frontal cortex was not significantly affected by any of the drug treatments, confirming our previous conclusion that the effect of microwaves on the frontal cortex is not mediated by endogenous opioids.

Lai H, Carino MA, Horita A, Guy AW, Single vs. repeated microwave exposure: effects on benzodiazepine receptors in the brain of the rat. Bioelectromagnetics 13(1):57-66, 1992.

We studied the effects of single (45 min) and repeated (ten daily 45-min sessions) microwave exposures (2450-MHz, 1 mW/cm2, average whole-body SAR of 0.6 W/kg, pulsed at 500 pps with pulse width of 2 microseconds) on the concentration and affinity of benzodiazepine receptors in the cerebral cortex, hippocampus, and cerebellum of the rat. We used a receptor-binding assay with 3H-flunitrazepam as ligand. Immediately after a single exposure, an increase in the concentration of receptor was observed in the cerebral cortex, but no significant effect was observed in the hippocampus or cerebellum. No significant change in binding affinity of the receptors was observed in any of the brain-regions studied. In rats subjected to repeated exposures, no significant change in receptor concentration was found in the cerebral cortex immediately after the last exposure, which may indicate an adaptation to repeated exposures. Our data also show that handling and exposure procedures in our experiments did not significantly affect benzodiazepine receptors in the brain. Because benzodiazepine receptors in the brain are responsive to anxiety and stress, our data support the hypothesis that low-intensity microwave irradiation can be a source of stress.

Lai H, Carino MA, Horita A, Guy AW, Intraseptal microinjection of beta-funaltrexamine blocked a microwave-induced decrease of hippocampal

cholinergic activity in the rat. Pharmacol Biochem Behav 53(3):613-616, 1994.

Acute (45 min) exposure to pulsed (2 microseconds pulse width, 500 pulses per second) 2450-MHz microwaves at a power density of 1 mW/cm2 (whole body specific absorption rate 0.6 W/kg) microwaves caused a decrease in cholinergic activity in the hippocampus of the rat as measured by the sodium-dependent high-affinity choline uptake. Microinjection of beta-funaltrexamine (1 microgram) into the septum before microwave exposure blocked this effect. These data indicate that mu-opioid receptors in the septum mediate a microwave-induced decrease in cholinergic activity in the hippocampus and support our hypothesis that microwaves at a whole body SAR of 0.6 W/kg can activate endogenous opioids in the brain.

Lakshmi NK, Tiwari R, BhargavaSC, Ahuja YRInvestigations on DNA damage and frequency of micronuclei in occupational exposure to electromagnetic fields (EMFs) emitted from video display terminals (VDTs). Gen Mol Biol 33(1): 154-158, 2010.

The potential effect of electromagnetic fields (EMFs) emitted from video display terminals (VDTs) to elicit biological response is a major concern for the public. The software professionals are subjected to cumulative EMFs in their occupational environments. This study was undertaken to evaluate DNA damage and incidences of micronuclei in such professionals. To the best of our knowledge, the present study is the first attempt to carry out cytogenetic investigations on assessing bioeffects in personal computer users. The study subjects (n = 138) included software professionals using VDTs for more than 2 years with age, gender, socioeconomic status matched controls (n = 151). DNA damage and frequency of micronuclei were evaluated using alkaline comet assay and cytochalasin blocked micronucleus assay respectively. Overall DNA damage and incidence of micronuclei showed no significant differences between the exposed and control subjects. With exposure characteristics, such as total duration (years) and frequency of use (minutes/day) sub-groups were assessed for such parameters. Although cumulative frequency of use showed no significant changes in the DNA integrity of the classified sub-groups, the long-term users (> 10 years) showed higher induction of DNA damage and increased frequency of micronuclei and micro nucleated cells.

Lalic H, Lekic A, Radosevic-Stasic B. Comparison of chromosome aberrations in peripheral blood lymphocytes from people occupationally exposed to ionizing and radiofrequency radiation. Acta Med Okayama 55(2):117-127, 2001.

The genotoxic effects of occupational exposure to ionizing and non-ionizing radiation were investigated in 25 physicians and nurses working in hospitals and in 20 individuals working at radio-relay stations. Examination was conducted by chromosome aberration analysis of peripheral blood lymphocytes. The data showed that total number of chromosome aberrations in people exposed to ionizing and radio-frequency radiation (4.08 +/- 0.37 and 4.35 +/- 0.5 on 200 scored metaphases, respectively) were almost equally higher than those of non-irradiated subjects. The increase was in proportion to the number of individuals having more that 5-aberration/200 metaphases. Acentric fragments comprised the most frequently seen type of aberration. The average numbers in examined groups (11.8 x 10(-3) and 14.8 x 10(-3) per cell, respectively), were significantly

higher than 4.2 x 10(-3), which was observed in controls, unexposed individuals. Dicentric fragments were also frequent (4.8 x 10(-3) and 6.25 x 10(-3), respectively, vs. 0.52 x 10(-3) in control). In contrast, the frequency of chromatid breaks increased only after ionizing radiation (3.8 x 10(-3) vs. 0.26 x 10(-3) in control). A positive correlation between the total number of chromosome aberrations and cumulative 6-years dosage was also found. The data emphasized the dangerous effects of prolonged exposure to both types of radiation and indicated that chromosomal aberration analysis should be obligatory for individuals working at radio-relay stations.

Lam LT. Distractions and the risk of car crash injury: the effect of drivers' age. J Safety Res 33(3):411-419, 2002.

PROBLEM: Motor-vehicle accidents are one of the major causes of injury in most motorized countries. Driver distractions have been suggested as a contributor to traffic accidents. Moreover, age of the driver seems to have a role in the relationship between distractions and car crashes. But very few studies have investigated the effect of driver's age on this relationship. This exploratory study investigated the association between distractions, both inside and outside the vehicle, and the increased risk of car crash injury among drivers across different ages. METHOD: This study used a case series design to analyze data routinely collected by the NSW police in Australia. A special focus of this study was on how drivers' age affects the risk of car crash injury, which was determined by using a well-documented risk estimation methodology. RESULTS: The results obtained indicated that drivers of all ages, on the whole, are more susceptible to distractions inside the vehicle than distractions coming from outside. Age was shown to affect the relationship between in-vehicle distraction and the risk of car crash injury. A separate analysis was also conducted on hand-held phone usage while driving with results supplementing previous findings reported in the literature. IMPACT TO INDUSTRY: Safety strategies to countermeasure in-vehicle distractions have been suggested and discussed.

Lamble D, Kauranen T, Laakso M, Summala H, Cognitive load and detection thresholds in car following situations: safety implications for using mobile (cellular) telephones while driving. Accid Anal Pre 31(6):617-623, 1999.

This study was aimed at investigating drivers' ability to detect a car ahead decelerating, while doing mobile phone related tasks. Nineteen participants aged between 20 and 29 years, (2000-125000 km driving experience) drove at 80 km/h, 50 m behind a lead car, on a 30 km section of motorway in normal traffic. During each trial the lead car started to decelerate at an average of 0.47 m/s2 while the participant either looked at the car in front (control), continuously dialed series of three random integers on a numeric keypad (divided visual attention), or performed a memory and addition task (non-visual attention). The results indicated that drivers' detection ability was impaired by about 0.5 s in terms of brake reaction time and almost 1 s in terms of time-to-collision, when they were doing the non-visual task whilst driving. This impairment was similar to when the drivers were dividing their visual attention between the road ahead and dialing numbers on the keypad. It was concluded that neither a hands-free option nor a voice controlled interface removes the safety problems associated with the use of mobile phones in a car.

Lameth J, Gervais A, Colin C, Lévêque P, Jay TM, Edeline JM, Mallat M. Acute Neuroinflammation Promotes Cell Responses to 1800 MHz GSM Electromagnetic Fields in the Rat Cerebral Cortex. Neurotox Res. 2017 Jun 3. doi: 10.1007/s12640-017-9756-3. [Epub ahead of print]

Erratum in Erratum to: Acute Neuroinflammation Promotes Cell Responses to 1800 MHz GSM Electromagnetic Fields in the rat Cerebral Cortex. [Neurotox Res. 2017]

Mobile phone communications are conveyed by radiofrequency (RF) electromagnetic fields, including pulse-modulated global system for mobile communications (GSM)-1800 MHz, whose effects on the CNS affected by pathological states remain to be specified. Here, we investigated whether a 2-h head-only exposure to GSM-1800 MHz could impact on a neuroinflammatory reaction triggered by lipopolysaccharide (LPS) in 2-week-old or adult rats. We focused on the cerebral cortex in which the specific absorption rate (SAR) of RF averaged 2.9 W/kg. In developing rats, 24 h after GSM exposure, the levels of cortical interleukin-1ß (IL1ß) or NOX2 NADPH oxidase transcripts were reduced by 50 to 60%, in comparison with sham-exposed animals (SAR = 0), as assessed by RT-qPCR. Adult rats exposed to GSM also showed a 50% reduction in the level of IL1ß mRNA, but they differed from developing rats by the lack of NOX2 gene suppression and by displaying a significant growth response of microglial cell processes imaged in anti-Iba1-stained cortical sections. As neuroinflammation is often associated with changes in excitatory neurotransmission, we evaluated changes in expression and phosphorylation of α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid (AMPA) receptors in the adult cerebral cortex by Western blot analyses. We found that GSM exposure decreased phosphorylation at two residues on the GluA1 AMPAR subunit (serine 831 and 845). The GSM-induced changes in gene expressions, microglia, and GluA1 phosphorylation did not persist 72 h after RF exposure and were not observed in the absence of LPS pretreatment. Together, our data provide evidence that GSM-1800 MHz can modulate CNS cell responses triggered by an acute neuroinflammatory state.

Landgrebe M, Hauser S, Langguth B, Frick U, Hajak G, Eichhammer P. Altered cortical excitability in subjectively electrosensitive patients: results of a pilot study. J Psychosom Res. 62(3):283-288, 2007.

OBJECTIVE: Hypersensitivity to electromagnetic fields is frequently claimed to be linked to a variety of unspecific somatic and/or neuropsychological complaints. Whereas provocation studies often failed to demonstrate a causal relationship between electromagnetic field exposure and symptom formation, neurophysiological examinations highlight baseline deviations in people claiming to be electrosensitive. METHODS: To elucidate a potential role of dysfunctional cortical regulations in mediating hypersensitivity to electromagnetic fields, cortical excitability parameters were measured by transcranial magnetic stimulation in subjectively electrosensitive patients (n=23) and two control groups (n=49) differing in their level of unspecific health complaints. RESULTS: Electrosensitive patients showed reduced intracortical facilitation as compared to both control groups, while motor thresholds and intracortical inhibition were unaffected.

CONCLUSIONS: This pilot study gives additional evidence that altered central nervous system function may account for symptom manifestation in subjectively electrosensitive patients as has been postulated for several chronic multisymptom illnesses sharing a similar clustering of symptoms.

Landgrebe M, Frick U, Hauser S, Langguth B, Rosner R, Hajak G, Eichhammer P. Cognitive and neurobiological alterations in electromagnetic hypersensitive patients: results of a case-control study. Psychol Med. 38(12):1781-1791, 2008.

BACKGROUND: Hypersensitivity to electromagnetic fields (EMF) is frequently claimed to be linked to a variety of non-specific somatic and neuropsychological complaints. Whereas provocation studies often failed to demonstrate a causal relationship between EMF exposure and symptom formation, recent studies point to a complex interplay of neurophysiological and cognitive alterations contributing to symptom manifestation in electromagnetic hypersensitive patients (EHS). However, these studies have examined only small sample sizes or have focused on selected aspects. Therefore this study examined in the largest sample of EHS EMF-specific cognitive correlates, discrimination ability and neurobiological parameters in order to get further insight into the pathophysiology of electromagnetic hypersensitivity. METHOD: In a case-control design 89 EHS and 107 age- and gender-matched controls were included in the study. Health status and EMF-specific cognitions were evaluated using standardized questionnaires. Perception thresholds following single transcranial magnetic stimulation (TMS) pulses to the dorsolateral prefrontal cortex were determined using a standardized blinded measurement protocol. Cortical excitability parameters were measured by TMS. RESULTS: Discrimination ability was significantly reduced in EHS (only 40% of the EHS but 60% of the controls felt no sensation under sham stimulation during the complete series), whereas the perception thresholds for real magnetic pulses were comparable in both groups (median 21% versus 24% of maximum pulse intensity). Intra-cortical facilitation was decreased in younger and increased in older EHS. In addition, typical EMF-related cognitions (aspects of rumination, symptom intolerance, vulnerability and stabilizing self-esteem) specifically differentiated EHS from their controls. CONCLUSIONS: These results demonstrate significant cognitive and neurobiological alterations pointing to a higher genuine individual vulnerability of electromagnetic hypersensitive patients.

Landgrebe M, Frick U, Hauser S, Hajak G, Langguth B. Association of tinnitus and electromagnetic hypersensitivity: hints for a shared pathophysiology? PLoS One.4(3):e5026, 2009.

BACKGROUND: Tinnitus is a frequent condition with high morbidity and impairment in quality of life. The pathophysiology is still incompletely understood. Electromagnetic fields are discussed to be involved in the multi-factorial pathogenesis of tinnitus, but data proofing this relationship are very limited. Potential health hazards of electromagnetic fields (EMF) have been under discussion for long. Especially, individuals claiming themselves to be electromagnetic hypersensitive suffer from a variety of unspecific symptoms, which they attribute to EMF-exposure. The aim of the study was to elucidate the relationship between EMF-exposure, electromagnetic hypersensitivity and tinnitus using a case-control design. METHODOLOGY: Tinnitus occurrence and tinnitus severity

were assessed by questionnaires in 89 electromagnetic hypersensitive patients and 107 controls matched for age-, gender, living surroundings and workplace. Using a logistic regression approach, potential risk factors for the development of tinnitus were evaluated. FINDINGS: Tinnitus was significantly more frequent in the electromagnetic hypersensitive group (50.72% vs. 17.5%) whereas tinnitus duration and severity did not differ between groups. Electromagnetic hypersensitivity and tinnitus were independent risk factors for sleep disturbances. However, measures of individual EMF-exposure like e.g. cell phone use did not show any association with tinnitus. CONCLUSIONS: Our data indicate that tinnitus is associated with subjective electromagnetic hypersensitivity. An individual vulnerability probably due to an over activated cortical distress network seems to be responsible for, both, electromagnetic hypersensitivity and tinnitus. Hence, therapeutic efforts should focus on treatment strategies (e.g. cognitive behavioral therapy) aiming at normalizing this dysfunctional distress network.

Landler L, Painter MS, Youmans PW, Hopkins WA, Phillips JB. Spontaneous magnetic alignment by yearling snapping turtles: rapid association of radio frequency dependent pattern of magnetic input with novel surroundings. PLoS One. 10(5):e0124728, 2015.

We investigated spontaneous magnetic alignment (SMA) by juvenile snapping turtles using exposure to low-level radio frequency (RF) fields at the Larmor frequency to help characterize the underlying sensory mechanism. Turtles, first introduced to the testing environment without the presence of RF aligned consistently towards magnetic north when subsequent magnetic testing conditions were also free of RF ('RF off → RF off'), but were disoriented when subsequently exposed to RF ('RF off → RF on'). In contrast, animals initially introduced to the testing environment with RF present were disoriented when tested without RF ('RF on → RF off'), but aligned towards magnetic south when tested with RF ('RF on → RF on'). Sensitivity of the SMA response of yearling turtles to RF is consistent with the involvement of a radical pair mechanism. Furthermore, the effect of RF appears to result from a change in the pattern of magnetic input, rather than elimination of magnetic input altogether, as proposed to explain similar effects in other systems/organisms. The findings show that turtles first exposed to a novel environment form a lasting association between the pattern of magnetic input and their surroundings. However, under natural conditions turtles would never experience a change in the pattern of magnetic input. Therefore, if turtles form a similar association of magnetic cues with the surroundings each time they encounter unfamiliar habitat, as seems likely, the same pattern of magnetic input would be associated with multiple sites/localities. This would be expected from a sensory input that functions as a global reference frame, helping to place multiple locales (i.e., multiple local landmark arrays) into register to form a global map of familiar space.

Lange DG, Sedmak J, Japanese encephalitis virus (JEV): potentiation of lethality in mice by microwave radiation. Bioelectromagnetics 12(6):335-348, 1991.

The expression of Japanese Encephalitis Virus (JEV) lethality in mice requires entry of

the virus into the central nervous system. This entry is presumably through the capillary endothelial cells (CEC), because entry between CECs is inhibited by bands of circumferential tight-junctions. A viremic stage occurs during the first 4 to 5 days after JEV administration in mice, and both microwave radiation (2.45-GHz, continuous wave, 10-min exposure) and hypercarbia were employed to increase CEC permeability to JEV. Exposure to microwaves at power densities of 10-50 mW/cm2 resulted in a dose-dependent increase in JEV-induced lethality. Mice did not become tolerant or sensitized to microwave potentiation of JEV-induced mortality because 4 daily exposures at 10 or 50 mW/cm2 (SARS, approximately 24-98 W/kg) did not alter the lethality pattern to subsequent microwave radiation of JEV-exposed animals. Similarly, hypercarbia (5, 10, and 20% CO2) was observed to produce a dose-dependent increase in JEV-induced lethality. Both microwave radiation and hypercarbia are thought to promote pinocytosis in CNS capillary endothelial cells. This may be one mechanism by which they enhance JEV-induced lethality in adult Swiss-Cox mice.

Lange DG, D'Antuono ME, Timm RR, Ishii TK, Fujimoto JM. Differential response of the permeability of the rat liver canalicular membrane to sucrose and mannitol following in vivo acute single and multiple exposures to microwave radiation (2.45 GHz) and radiant-energy thermal stress. Radiat Res 134(1):54-62, 1993.

Both acute and chronic exposures to microwave radiation altered the function of the rat canalicular membrane. A single acute exposure to microwave radiation [80 mW/cm2, 2.45 GHz, continuous wave, 30 min exposure (SAR approximately equal to 72 W/kg)] or a matched radiant-energy thermal load, both designed to raise core body temperature approximately 3 degrees C, decreased the permeability of the canalicular membrane of male Sprague-Dawley rats to sucrose. The change in canalicular membrane permeability was demonstrated by a significant increase in the percentage of [3H]sucrose recovered in bile following its administration by a segmented retrograde intrabiliary injection. Similar acute exposures to microwave and radiant-energy thermal sources produced no significant alterations in canalicular membrane permeability to [14C]mannitol. In both acute exposure protocols, a rapidly reversible increase in bile flow rate was observed. Four exposures (30 min/day x 4 days) to either microwave radiation (80 mW/cm2) or a matched radiant-energy thermal load resulted in a significant depression in bile flow rate at normothermic temperatures. Animals receiving multiple exposures to microwave radiation had significant decreases in canalicular membrane permeability to both [3H]sucrose and [14C]mannitol, while similar exposure to radiant-energy thermal load alone altered canalicular membrane permeability to [3H]sucrose. An examination of the hepatic clearance of sucrose and mannitol following acute microwave exposure demonstrated no significant differences. Thus acute single exposure to microwave and radiant-energy thermal loads produced similar alterations in canalicular membrane permeability. Conversely, multiple exposures produced nonreversible changes in bile flow rate and canalicular membrane permeability, with microwave exposure producing greater alterations in the function of the canalicular membrane than an equivalent radiant-energy thermal load.

Langer P, Holzner B, Magnet W, Kopp M. Hands-free mobile phone conversation impairs the peripheral visual system to an extent comparable to an alcohol level of

4-5 g 100 ml. Hum Psychopharmacol. 20(1):65-66, 2005. Letter.

Lantow M, Schuderer J, Hartwig C, Simko M. Free radical release and HSP70 expression in two human immune-relevant cell lines after exposure to 1800 MHz Radiofrequency Radiation. Radiat Res. 165(1):88-94, 2006.

The goal of this study was to investigate whether radiofrequency (RF) electromagnetic-field (EMF) exposure at 1800 MHz causes production of free radicals and/or expression of heat-shock proteins (HSP70) in human immune-relevant cell systems. Human Mono Mac 6 and K562 cells were used to examine free radical release after exposure to incubator control, sham, RF EMFs, PMA, LPS, heat (40 degrees C) or co-exposure conditions. Several signals were used: continuous-wave, several typical modulations of the Global System for Mobile Communications (GSM): GSM-non DTX (speaking only), GSM-DTX (hearing only), GSM-Talk (34% speaking and 66% hearing) at specific absorption rates (SARs) of 0.5, 1.0, 1.5 and 2.0 W/kg. Heat and PMA treatment induced a significant increase in superoxide radical anions and in ROS production in the Mono Mac 6 cells when compared to sham and/ or incubator conditions. No significant differences in free radical production were detected after RF EMF exposure or in the respective controls, and no additional effects on superoxide radical anion production were detected after co-exposure to RF EMFs+PMA or RF EMFs+LPS. The GSM-DTX signal at 2 W/kg produced a significant difference in free radical production when the data were compared to sham because of the decreasing sham value. This difference disappeared when data were compared to the incubator controls. To determine the involvement of heat-shock proteins as a possible inhibitor of free radical production, we investigated the HSP70 expression level after different RF EMF exposures; no significant effects were detected.

Lantow M, Lupke M, Frahm J, Mattsson MO, Kuster N, Simko M. ROS release and Hsp70 expression after exposure to 1,800 MHz radiofrequency electromagnetic fields in primary human monocytes and lymphocytes. Radiat Environ Biophys.45(1):55-62, 2006.

The aim of this study is to investigate if 1,800 MHz radiofrequency electromagnetic fields (RF-EMF) can induce reactive oxygen species (ROS) release and/or changes in heat shock protein 70 (Hsp70) expression in human blood cells, using different exposure and co-exposure conditions. Human umbilical cord blood-derived monocytes and lymphocytes were used to examine ROS release after exposure to continuous wave or different GSM signals (GSM-DTX and GSM-Talk) at 2 W/kg for 30 or 45 min of continuous or intermittent (5 min ON/5 min OFF) exposure. The cells were exposed to incubator conditions, to sham, to RF-EMF, or to chemicals in parallel. Cell stimulation with the phorbol ester phorbol-12-myristate-13-acetate (PMA; 1 muM) was used as positive control for ROS release. To investigate the effects on Hsp70 expression, the human monocytes were exposed to the GSM-DTX signal at 2 W/kg for 45 min, or to heat treatment (42 degrees C) as positive control. ROS production and Hsp70 expression were determined by flow cytometric analysis. The data were compared to sham and/or to control values and the statistical analysis was performed by the Student's t-test ($P<0.05$). The PMA treatment induced a significant increase in ROS production in human monocytes and lymphocytes when the data were compared to sham or to incubator

controls. After continuous or intermittent GSM-DTX signal exposure (2 W/kg), a significantly different ROS production was detected in human monocytes if the data were compared to sham. However, this significant difference appeared due to the lowered value of ROS release during sham exposure. In human lymphocytes, no differences could be detected if data were compared either to sham or to incubator control. The Hsp70 expression level after 0, 1, and 2 h post-exposure to GSM-DTX signal at 2 W/kg for 1 h did not show any differences compared to the incubator or to sham control.

Lantow M, Viergutz T, Weiss DG, Simko M. Comparative study of cell cycle kinetics and induction of apoptosis or necrosis after exposure of human mono mac 6 cells to radiofrequency radiation. Radiat Res. 166(3):539-543, 2006.

The possible harmful effects of radiofrequency electromagnetic fields (RF EMFs) are controversial. We have used human Mono Mac 6 cells to investigate the influence of RF EMFs in vitro on cell cycle alterations and BrdU uptake, as well as the induction of apoptosis and necrosis in human Mono Mac 6 cells, using flow cytometry after exposure to a 1800 MHz, 2 W/kg specific absorption rate (SAR), GSM-DTX signal for 12 h. No statistically significant differences in the induction of apoptosis or necrosis, cell cycle kinetics, or BrdU uptake were detected after RF EMF exposure compared to sham or incubator controls. However, in the positive control cells treated with gliotoxin and PMA (phorbol 12 myristate-13 acetate), a significant increase in apoptotic and necrotic cells was seen. Cell cycle analysis or BrdU incorporation for 72 h showed no differences between RF EMF- or sham-exposed cells, whereas PMA treatment induced a significant accumulation of cells in G(0)/G(1)-phase and a reduction in S-phase cells. RF EMF radiation did not induce cell cycle alterations or changes in BrdU incorporation or induce apoptosis and necrosis in Mono Mac 6 cells under the exposure conditions used.

Larsen AI, Olsen J, Svane O, Gender-specific reproductive outcome and exposure to high-frequency electromagnetic radiation among physiotherapists. Scand J Work Environ Health 17(5):324-329, 1991.

The aim of this case-referent study was to investigate reproductive hazards other than congenital malformations after exposure to high-frequency electromagnetic radiation. Cases and referents were sampled from a cohort of pregnancies of members of the Union of Danish Physiotherapists through linkage of the union file with national medical registers. Case groups were spontaneous abortions and children with low birth-weight prematurity, and stillbirth/death within one year. Exposure to high-frequency electromagnetic radiation before and during pregnancy was assessed through telephone interviews. As referents to the 270 cases, 316 pregnancies were randomly sampled. A total of 8.4% did not participate. Only 23.5% of the children born by the highly exposed mothers were boys. This value is a statistically significantly altered gender ratio showing a dose-response pattern. High-frequency electromagnetic radiation was furthermore associated with low birthweight, but only for male newborns. The other outcomes were not statistically significantly associated with exposure to high-frequency electromagnetic radiation.

Larsen AI, Congenital malformations and exposure to high-frequency electromagnetic radiation among Danish physiotherapists. Scand J Work Environ

Health 17(5):318-323, 1991.

A cluster initiated the present case-referent study to assess the relation between exposure to high-frequency electromagnetic radiation and congenital malformations. Through the linkage of a cohort formed from a union file of Danish physiotherapists with complete national registers of pregnancy outcome, cases (pregnancies terminated by the birth of a malformed child) and referents were identified. From responses in a blinded telephone interview without knowledge of case status, exposure to high-frequency electromagnetic radiation in the first month of pregnancy was assessed. Indices reflecting duration of exposure ("time") and maximum level of exposure ("peak") were composed. After a 7% dropout 54 cases and 247 referents were interviewed. No statistically significant associations between pregnancy outcome and high-frequency electromagnetic radiation were found (odds ratio 1.7, 95% confidence interval 0.6-4.3).

Lass L, Tuulik V, Ferenets CR, Riisalo R, Hinrikus H. Effects of 7 Hz-modulated 450 MHz electromagnetic radiation on human performance in visual memory tasks. Int. J. Rad. Biol. 78: 937-944, 2002.

Abstract: Purpose: The aim was to examine low-level 7 Hz-modulated 450 MHz radiation effects on human performance in visually presented neuropsychological tasks associated with attention and short-term memory. Materials and methods: A homogeneous group of 100 subjects (37 female, 63 male) were randomly assigned to either the exposed (10-20 min, 0.158mW cm^{-2}) or the sham-exposed group. A battery of three different tests measured attention and shortterm memory. Task 1 involved alternately selecting black digits from 1 to 25 in ascending order and white digits from 24 to 1 in descending order. The time spent on the task and the number of errors were recorded and analysed. Task 2 involved viewing a picture of 12 objects during 3 s, followed by a list of 24 words. The subject was required to select words representing previously presented objects. In task 3, an array of letters in 10 rows (60 in each row) was presented, and the subject was required to identify all examples of a particular two-letter combination. Results: The results of tasks 1 and 3 showed a significant increase in variances of errors ($p < 0.05$) in the exposed versus the shamexposed group. The results of task 2 indicated a significant decrease in errors ($p < 0.05$) in the exposed group. Conclusions: The data provide additional evidence that acute lowlevel exposure to microwaves modulated at 7 Hz can affect cognitive processes such as attention and short-term memory.

Laszlo, A., Moros, E. G., Davidson, T., Bradbury, M., Straube, W. and Roti Roti, J. The Heat-Shock Factor is not Activated in Mammalian Cells Exposed to Cellular Phone Frequency Microwaves. Radiat. Res. 164, 163-172, 2005.

There has been considerable interest in the biological effects of exposure to radiofrequency electromagnetic radiation, given the explosive growth of cellular telephone use, with the possible induction of malignancy being a significant concern. Thus the determination of whether nonthermal effects of radiofrequency electromagnetic radiation contribute to the process leading to malignancy is an important task. One proposed pathway to malignancy involves the induction of the stress response by exposures to cell phone frequency microwaves. The first step in the induction of the stress response is the activation of the DNA-binding activity of the specific transcription factor involved in this

response, the heat-shock factor (HSF). The DNA-binding activity of HSF in hamster, mouse and human cells was determined after acute and continuous exposures to frequency domain multiple access (FDMA)- or code domain multiple access (CDMA)-modulated microwaves at low (0.6 W/kg) or high (approximately 5 W/kg) SARs at frequencies used for mobile communication. The DNA-binding activity of HSF was monitored using a gel shift assay; the calibration of this assay indicated that an increase of approximately 10% in the activation of the DNA-binding activity of HSF after a 1 degrees C increase in temperature could be detected. We failed to detect any increase in the DNA-binding ability of HSF in cultured mammalian cells as a consequence of any exposure tested, within the sensitivity of our assay. Our results do not support the notion that the stress response is activated as a consequence of exposure to microwaves of frequencies associated with mobile communication devices.

Laudisi F, Sambucci M, Nasta F, Pinto R, Lodato R, Altavista P, Lovisolo GA, Marino C, Pioli C. Prenatal exposure to radiofrequencies: Effects of WiFi signals on thymocyte development and peripheral T cell compartment in an animal model.Bioelectromagnetics. 33(8):652-661, 2012.

Wireless local area networks are an increasing alternative to wired data networks in workplaces, homes, and public areas. Concerns about possible health effects of this type of signal, especially when exposure occurs early in life, have been raised. We examined the effects of prenatal (in utero) exposure to wireless fidelity (WiFi) signal-associated electromagnetic fields (2450 MHz center-frequency band) on T cell development and function. Pregnant mice were exposed whole body to a specific absorption rate of 4 W/kg, 2 h per day, starting 5 days after mating and ending 1 day before the expected delivery. Sham-exposed and cage control groups were used as controls. No effects on cell count, phenotype, and proliferation of thymocytes were observed. Also, spleen cell count, CD4/CD8 cell frequencies, T cell proliferation, and cytokine production were not affected by the exposure. These findings were consistently observed in the male and female offspring at early (5 weeks of age) and late (26 weeks of age) time points. Nevertheless, the expected differences associated with aging and/or gender were confirmed. In conclusion, our results do not support the hypothesis that the exposure to WiFi signals during prenatal life results in detrimental effects on the immune T cell compartment.

Lauer O, Frei P, Gosselin MC, Joseph W, Röösli M, Fröhlich J. Combining near- and far-field exposure for an organ-specific and whole-body RF-EMF proxy for epidemiological research: A reference case. Bioelectromagnetics. 2013 Feb 15. doi: 10.1002/bem.21782. [Epub ahead of print]

A framework for the combination of near-field (NF) and far-field (FF) radio frequency electromagnetic exposure sources to the average organ and whole-body specific absorption rates (SARs) is presented. As a reference case, values based on numerically derived SARs for whole-body and individual organs and tissues are combined with realistic exposure data, which have been collected using personal exposure meters during the Swiss Qualifex study. The framework presented can be applied to any study region where exposure data is collected by appropriate measurement equipment. Based on results derived from the data for the region of Basel, Switzerland, the relative

importance of NF and FF sources to the personal exposure is examined for three different study groups. The results show that a 24-h whole-body averaged exposure of a typical mobile phone user is dominated by the use of his or her own mobile phone when a Global System for Mobile Communications (GSM) 900 or GSM 1800 phone is used. If only Universal Mobile Telecommunications System (UMTS) phones are used, the user would experience a lower exposure level on average caused by the lower average output power of UMTS phones. Data presented clearly indicate the necessity of collecting band-selective exposure data in epidemiological studies related to electromagnetic fields.

Laurence JA, French PW, Lindner RA, Mckenzie DR, Biological Effects of Electromagnetic Fields-Mechanisms for the Effects of Pulsed Microwave Radiation on Protein Conformation. J Theor Biol 206(2):291-298, 2000.

Microwave exposure under "athermal" conditions occurs when no temperature rise can be measured by conventional thermometry. The existence of biological effects arising from the athermal exposure is still controversial, partly because of a lack of the linear dose response relation. We propose a model in which pulsed microwave radiation causes a triggering of the heat shock or stress response by altering the conformation of proteins through a transient heating of the protein and its close environment. We support this by modelling using the heat diffusion equation and show that pulsed exposure even when athermal can lead to transient temperature excursions outside the normal range. We propose that the power window phenomenon in which biological effects are observed at low power levels may be caused by an incomplete triggering of the heat shock response.

Le Quément C, Nicolaz CN, Habauzit D, Zhadobov M, Sauleau R, Le Dréan Y. Impact of 60-GHz millimeter waves and corresponding heat effect on endoplasmic reticulum stress sensor gene expression. Bioelectromagnetics. 35(6):444-451, 2014.

Emerging high data rate wireless communication systems, currently under development, will operate at millimeter waves (MMW) and specifically in the 60 GHz band for broadband short-range communications. The aim of this study was to investigate potential effects of MMW radiation on the cellular endoplasmic reticulum (ER) stress. Human skin cell lines were exposed at 60.4 GHz, with incident power densities (IPD) ranging between 1 and 20 mW/cm(2) . The upper IPD limits correspond to the ICNIRP local exposure limit for the general public. The expression of ER-stress sensors, namely BIP and ORP150, was then examined by real-time RT-PCR. Our experimental data demonstrated that MMW radiations do not change BIP or ORP150 mRNA basal levels, whatever the cell line, the exposure duration or the IPD level. Co-exposure to the well-known ER-stress inducer thapsigargin (TG) and MMW were then assessed. Our results show that MMW exposure at 20 mW/cm(2) inhibits TG-induced BIP and ORP150 over expression. Experimental controls showed that this inhibition is linked to the thermal effect resulting from the MMW exposure.

Lebedeva NN, Sulimov AV, Sulimova OP, Kotrovskaya TI, Gailus T. Cellular phone electromagnetic field effects on bioelectric activity of human brain. Crit Rev Biomed Eng 28(1-2):323-337, 2000.

24 volunteers participated in the experiments. The investigation of EEG reactions to cellular phone (EMF frequency 902.4 MHz and intensity 0.06 mW/cm2) was conducted. Two experiments were performed with each subject--cellular phone exposure and Placebo Duration of the experiment was 60 min: 15 min--background; 15 min--EMF exposure or Placebo; 30 min--afterexposure. EEG was recorded in 16 standard leads with "eyes open" and "eyes closed". Special software with non-linear dynamics was developed for EEG analyses. One parameter, multichannel (global) correlation dimension, was calculated. The changes of these parameters can be evidence of brain functional state changes. As a result of EEG record processing, a significant increase of global correlation dimension during the exposure and afterexposure period was discovered, more pronounced in the case of "eyes closed". That can be viewed as the manifestation of cortex activation under phone EMF exposure.

Lebedeva NN, Sulimov AV, Sulimova OP, Korotkovskaya TI, Gailus T, Investigation of brain potentials in sleeping humans exposed to the electromagnetic field of mobile phones. Crit Rev Biomed Eng 29(1):125-133, 2001.

An investigation was made of 8-hour EEG tracings of sleeping humans exposed to the electromagnetic field of a GSM-standard mobile phone. To analyze the EEG-patterns, manual scoring, nonlinear dynamics, and spectral analysis were employed. It was found that, when human beings were exposed to the electromagnetic field of a cellular phone, their cerebral cortex biopotentials revealed an increase in the alpha-range power density as compared to the placebo experiment. It was also found that the dimension of EEG correlation dynamics and the relation of sleep stages changed under the influence of the electromagnetic field of a mobile phone.

Lee AK, Hong SE, Kwon JH, Choi HD, Cardis E. Mobile phone types and SAR characteristics of the human brain. Phys Med Biol. 62(7):2741-2761, 2017.

Mobile phones differ in terms of their operating frequency, outer shape, and form and location of the antennae, all of which affect the spatial distributions of their electromagnetic field and the level of electromagnetic absorption in the human head or brain. For this paper, the specific absorption rate (SAR) was calculated for four anatomical head models at different ages using 11 numerical phone models of different shapes and antenna configurations. The 11 models represent phone types accounting for around 86% of the approximately 1400 commercial phone models released into the Korean market since 2002. Seven of the phone models selected have an internal dual-band antenna, and the remaining four possess an external antenna. Each model was intended to generate an average absorption level equivalent to that of the same type of commercial phone model operating at the maximum available output power. The 1 g peak spatial SAR and ipsilateral and contralateral brain-averaged SARs were reported for all 11 phone models. The effects of the phone type, phone position, operating frequency, and age of head models on the brain SAR were comprehensively determined.

Lee D, Lee J, Lee I. Cell Phone Generated Radio Frequency Electromagnetic Field Effects on the Locomotor Behaviors of the Fishes Poecilia reticulata **and Danio rerio. Int J Radiat Biol. 2015 Jun 15:1-20. [Epub ahead of print]**

PURPOSE: The locomotor behavior of small fish was characterized under a cell phone generated radio frequency electromagnetic field (RF EMF). MATERIALS AND METHODS: The trajectory of movement of 10 pairs of poecilia reticulata and 15 pairs of danio rerio in a fish tank was recorded and tracked under the presence of a cell phone generated RF EMF. The measures were based on spatial and temporal distributions. A time-series trajectory was utilized to emphasis the dynamic nature of locomotor behavior. Fish movement was recorded in real-time. Their spatial, velocity, turning angle and sinuosity distribution were analyzed in terms of F(v,x), P[n(x,t)], P(v), F (Θ) and F(s), respectively. In addition, potential temperature elevation caused by a cellular phone was also examined. RESULTS: We demonstrated that a cellular phone induced temperature elevation was not relevant, and that our measurements reflected RF EMF-induced effects on the locomotor behavior of poecilia reticulata and danio rerio. Fish locomotion was observed under normal conditions, in the visual presence of a cell phone, after feeding, and under starvation. Fish locomotor behavior was random both in normal conditions and in the presence of an off-signaled cell phone. However, there were significant changes in the locomotion of the fish after feeding under the RF EMF. CONCLUSIONS: The locomotion of the fed fish was affected in terms of changes in population and velocity distributions under the presence of the RF EMF emitted by the cell phone. There was, however, no significant difference in angular distribution.

Lee HJ, Lee JS, Pack JK, Choi HD, Kim N, Kim SH, Lee YS. Lack of teratogenicity after combined exposure of pregnant mice to CDMA and WCDMA radiofrequency electromagnetic fields. Radiat Res. 172(5):648-652, 2009.

Concern about the possible adverse effects of radiofrequency (RF)-field exposure on public health has increased because of the extensive use of wireless mobile phones and other telecommunication devices in daily life. The murine fetus is a very sensitive indicator of the effects of stress or stimuli in the environment. Therefore, we investigated the teratogenic effects of multi-signal radiofrequency electromagnetic fields (RF EMFs) on mouse fetuses. Pregnant mice were simultaneously exposed to two types of RF signals, single code division multiple access (CDMA) and wideband code division multiple access (WCDMA). Mice received two 45-min RF-field exposures, separated by a 15-min interval, daily throughout the entire gestation period. The whole-body average specific absorption rate (SAR) of CDMA or WCDMA was 2.0 W/kg. The animals were killed humanely on the 18th day of gestation and fetuses were examined for mortality, growth retardation, changes in head size and other morphological abnormalities. From the results, we report for the first time that simultaneous experimental exposure to CDMA and WCDMA RF EMFs did not cause any observable adverse effects on mouse fetuses.

Lee HJ, Pack JK, Kim TH, Kim N, Choi SY, Lee JS, Kim SH, Lee YS. The lack of histological changes of CDMA cellular phone-based radio frequency on rat testis. Bioelectromagnetics.31(7):528-534, 2010.

We examined the histological changes by radiofrequency (RF) fields on rat testis, specifically with respect to sensitive processes such as spermatogenesis. Male rats were exposed to 848.5 MHz RF for 12 weeks. The RF exposure schedule consisted

of two 45-min RF exposure periods, separated by a 15-min interval. The whole-body average specific absorption rate (SAR) of RF was 2.0 W/kg. We then investigated correlates of testicular function such as sperm counts in the cauda epididymis, malondialdehyde concentrations in the testes and epididymis, frequency of spermatogenesis stages, germ cell counts, and appearance of apoptotic cells in the testes. We also performed p53, bcl-2, caspase 3, p21, and PARP immunoblotting of the testes in sham- and RF-exposed animals. Based on these results, we concluded that subchronic exposure to 848.5 MHz with 2.0 W/kg SAR RF did not have any observable adverse effects on rat spermatogenesis.

Lee HJ, Jin YB, Lee JS, Choi SY, Kim TH, Pack JK, Choi HD, Kim N, Lee YS. Lymphoma development of simultaneously combined exposure to two radiofrequency signals in AKR/J mice.Bioelectromagnetics. 32(6):485-492, 2011.

There are public concerns regarding possible carcinogenic or cancer-promoting effects of radiofrequency electromagnetic fields (RF-EMFs) because of the extensive use of wireless mobile phones and other telecommunication devices in daily life. However, so far it is unclear if non-thermal exposure of single EMF exposure in animal studies has a direct influence on carcinogenesis. Here, carcinogenic effects of combined signal RF-EMFs on AKR/J mice, which were used for the lymphoma animal model, were investigated. Six-week-old AKR/J mice were simultaneously exposed to two types of RF signals: single code division multiple access (CDMA) and wideband code division multiple access (WCDMA). AKR/J mice were exposed to combined RF-EMFs for 45 min/day, 5 days/week, for a total of 42 weeks. The whole-body average specific absorption rate (SAR) of CDMA and WCDMA fields was 2.0 W/kg each, 4.0 W/kg in total. When we examined final survival, lymphoma incidence, and splenomegaly incidence, no differences were found between sham- and RF-exposed mice. However, occurrence of metastasis infiltration to the brain in lymphoma-bearing mice was significantly different in RF-exposed mice when compared to sham-exposed mice, even though no consistent correlation (increase or decrease) was observed between male and female mice. However, infiltration occurrence to liver, lung, and spleen was not different between the groups. From the results, we suggested that simultaneous exposure to CDMA and WCDMA RF-EMFs did not affect lymphoma development in AKR/J mice.

Lee HJ, Jin YB, Kim TH, Pack JK, Kim N, Choi HD, Lee JS, Lee YS. The effects of simultaneous combined exposure to CDMA and WCDMA electromagnetic fields on rat testicular function.Bioelectromagnetics. 2011 Oct 19. doi: 10.1002/bem.20715. [Epub ahead of print]

Wireless mobile phones and other telecommunication devices are used extensively in daily life. We therefore examined the effects of combined exposure to radiofrequency electromagnetic fields (RF-EMF) on rat testicular function, specifically with respect to sensitive processes such as spermatogenesis. Male rats were exposed to single code division multiple access (CDMA) and wideband code division multiple access (WCDMA) RF signals for 12 weeks. The RF exposure schedule comprised 45 min/day, 5 days/week for a total of 12 weeks. The whole-body average specific absorption rate (SAR) of CDMA and WCDMA was 2.0 W/kg each or 4.0 W/kg in total. We then investigated the correlates

of testicular function such as sperm count in the cauda epididymis, testosterone concentration in the blood serum, malondialdehyde concentrations in the testes and epididymis, frequency of spermatogenesis stages, and appearance of apoptotic cells in the testes. We also immunoblotted for p53, bcl2, GADD45, cyclin G, and HSP70 in the testes of sham- and combined RF-exposed animals. Based on the results, we concluded that simultaneous exposure to CDMA and WCDMA RF-EMFs at 4.0 W/kg SAR did not have any observable adverse effects on rat spermatogenesis.

Lee JJ, Kwak HJ, Lee YM, Lee JW, Park MJ, Ko YG, Choi HD, Kim N, Pack JK, Hong SI, Lee JS. Acute radio frequency irradiation does not affect cell cycle, cellular migration, and invasion. Bioelectromagnetics. 29(8):615-625, 2008.

Although in vitro studies have been previously conducted to determine the biological effects of radio frequency (RF) radiation, it has not yet been determined whether or not RF radiation poses a potential hazard. This study was conducted to determine whether RF radiation exposure exerts detectable effects on cell cycle distribution, cellular invasion, and migration. NIH3T3 mouse fibroblasts were exposed to 849 MHz of RF radiation at average SAR values of 2 or 10 W/kg for either 1 h, or for 1 h per day for 3 days. During the exposure period, the temperature in the exposure chamber was maintained isothermally by circulating water throughout the cavity. Cell cycle distribution was analyzed at 24 and 48 h after exposure, by flow cytometry. We detected no statistically significant differences between the sham-exposed and RF radiation-exposed cells. Cellular invasion and migration were assessed by in vitro Matrigel invasion and Transwell migration assays. The RF radiation-exposed groups evidenced no significant changes in motility and invasiveness compared to the sham-exposed group. However, the ionizing radiation-exposed cells, used as a positive control group, manifested dramatic alterations in their cell cycle distribution, cellular invasiveness, and migration characteristics. Our results show that 849 MHz RF radiation exposure exerts no detectable effects on cell cycle distribution, cellular migration, or invasion at average SAR values of 2 or 10 W/kg.

Lee JS, Huang TQ, Lee JJ, Pack JK, Jang JJ, Seo JS. Subchronic exposure of hsp70.1-deficient mice to radiofrequency radiation. Int J Radiat Biol. 81(10):781-792, 2005.

Purpose: Heat shock protein 70 (HSP70) is one of the most inducible proteins to play a cytoprotective role under stressful conditions. Previously we generated hsp70.1-deficient mice to elucidate the in vivo function of HSP70 in detail. The renal tissues and embryonic fibroblasts of these mice were shown to be more vulnerable to hyperosmotic stress. Since RF (radiofrequency) energy has been suggested to be an environmental stressor, we carried out a study to determine whether sub-chronic RF exposure can cause constitutive induction of a stress response at a cellular and/or molecular level in hsp70.1-deficient mice due to repeated stimulation.Materials and methods: Eight-week-old hsp70.1-deficient mice were exposed twice daily for 45 min, with a 15 min interval, 5 days a week for 10 weeks. Whole-body average specific absorption rate was 0.4 W/Kg for fields of both 849 MHz and 1763 MHz. Major tissues were histopathologically analysed, and immunocytochemically evaluated for cell proliferative activity. Apoptosis was investigated

by TdT-mediated dUTP nick-end labeling (TUNEL) assay. To determine whether RF radiation elicits a stress response, the expression level of heat shock proteins (HSP) and phosphorylation of the stress-activated kinases were also observed by western blots.Results: No difference was observed in the histopathological analysis between sham- and RF-exposed mice. There was no evidence of increased proliferative and apoptotic activities. The levels of HSP90, HSP70, and HSP25 showed no obvious changes. RF exposure did not affect the phosphorylation status of the major stress-activated kinase (MAPK); extracellular signal-regulated kinase 1/2 (ERK1/2), C-Jun N-terminal kinase 1/2 (JNK1/2) or p38 MAPK.Conclusion: The hsp70.1-deficient mice did not show any significant changes in terms of cell proliferation, apoptosis, or stress response due to exposure of 849 or 1,763 MHz RF fields.

Lee JS, Huang TQ, Kim TH, Kim JY, Kim HJ, Pack JK, Seo JS. Radiofrequency radiation does not induce stress response in human T-lymphocytes and rat primary astrocytes. Bioelectromagnetics. 27(7):578-588, 2006.

Heat shock proteins (HSPs) are rapidly induced by a variety of stressors, including heat shock, ethanol, heavy metals, UV, and gamma-radiation. Mitogen-activated protein kinases (MAPKs) are also involved in the stress transduction pathways in all eukaryotes. In this study, we attempted to determine whether radiofrequency (RF) radiation is able to induce a non-thermal stress response. Human T-lymphocyte Jurkat cells and rat primary astrocytes were exposed to 1763 MHz of RF radiation at an average specific absorption rate (SAR) of either 2 W/kg or 20 W/kg, for 30 min or 1 h. Temperature was completely controlled at 37 +/- 0.2 degrees C throughout the exposure period. The sham exposures were performed under exactly identical experimental conditions without exposure to RF radiation. We assessed alterations in the expression of HSPs and the activation of MAPKs in the RF-exposed cells. No detectable difference was observed in the expression levels of HSP90, HSP70, and HSP27. The phosphorylation status of MAPKs, extracellular signal-regulated kinases (ERK1/2), c-Jun N-terminal protein kinases (JNK1/2), or p38, did not change significantly. In order to determine whether RF radiation can promote the effects of 12-O-tetradecanoylphorbol 13-acetate (TPA) on stress response, cells were exposed to RF radiation coupled with TPA treatment. When TPA alone was applied, the MAPKs were found to be phosphorylated in a dose-dependent manner. However, RF radiation did not result in any enhancement of TPA-induced MAPK phosphorylation. Neither TPA nor RF radiation exerted any detectable effect on the induction of HSPs. These results indicate that 1763 MHz RF radiation alone did not elicit any stress response, nor did it have any effect on TPA-induced MAPK phosphorylation, under our experimental conditions.

Lee JW, Kim MS, Kim YJ, Choi YJ, Lee Y, Chung HW. Genotoxic effects of 3 T magnetic resonance imaging in cultured human lymphocytes.Bioelectromagnetics. 32(7):535-542, 2011.

The clinical and preclinical use of high-field intensity (HF, 3 T and above) magnetic resonance imaging (MRI) scanners have significantly increased in the past few years. However, potential health risks are implied in the MRI and especially HF MRI environment due to high-static magnetic fields, fast gradient magnetic fields, and strong

radiofrequency electromagnetic fields. In this study, the genotoxic potential of 3 T clinical MRI scans in cultured human lymphocytes in vitro was investigated by analyzing chromosome aberrations (CA), micronuclei (MN), and single-cell gel electrophoresis. Human lymphocytes were exposed to electromagnetic fields generated during MRI scanning (clinical routine brain examination protocols: three-channel head coil) for 22, 45, 67, and 89 min. We observed a significant increase in the frequency of single-strand DNA breaks following exposure to a 3 T MRI. In addition, the frequency of both CAs and MN in exposed cells increased in a time-dependent manner. The frequencies of MN in lymphocytes exposed to complex electromagnetic fields for 0, 22, 45, 67, and 89 min were 9.67, 11.67, 14.67, 18.00, and 20.33 per 1000 cells, respectively. Similarly, the frequencies of CAs in lymphocytes exposed for 0, 45, 67, and 89 min were 1.33, 2.33, 3.67, and 4.67 per 200 cells, respectively. These results suggest that exposure to 3 T MRI induces genotoxic effects in human lymphocytes.

Lee KS, Choi JS, Hong SY, Son TH, Yu K. Mobile phone electromagnetic radiation activates MAPK signaling and regulates viability in Drosophila. Bioelectromagnetics.29(5):371-379, 2008.

Mobile phones are widely used in the modern world. However, biological effects of electromagnetic radiation produced by mobile phones are largely unknown. In this report, we show biological effects of the mobile phone 835 MHz electromagnetic field (EMF) in the Drosophila model system. When flies were exposed to the specific absorption rate (SAR) 1.6 W/kg, which is the proposed exposure limit by the American National Standards Institute (ANSI), more than 90% of the flies were viable even after the 30 h exposure. However, in the SAR 4.0 W/kg strong EMF exposure, viability dropped from the 12 h exposure. These EMF exposures triggered stress response and increased the production of reactive oxygen species. The EMF exposures also activated extracellular signal regulated kinase (ERK) and c-Jun N-terminal kinase (JNK) signaling, but not p38 kinase signaling. Interestingly, SAR 1.6 W/kg activated mainly ERK signaling and expression of an anti-apoptotic gene, whereas SAR 4.0 W/kg strongly activated JNK signaling and expression of apoptotic genes. In addition, SAR 4.0 W/kg amplified the number of apoptotic cells in the fly brain. These findings demonstrate that the exposure limit on electromagnetic radiation proposed by ANSI triggered ERK-survival signaling but the strong electromagnetic radiation activated JNK-apoptotic signaling in Drosophila.

Lee S, Johnson D, Dunbar K, Dong H, Ge X, Kim YC, Wing C, Jayathilaka N, Emmanuel N, Zhou CQ, Gerber HL, Tseng CC, Wang SM2.45GHz radiofrequency fields alter gene expression in cultured human cells. FEBS Lett. 579(21):4829-4836, 2005.

The biological effect of radiofrequency (RF) fields remains controversial. We address this issue by examining whether RF fields can cause changes in gene expression. We used the pulsed RF fields at a frequency of 2.45GHz that is commonly used in telecommunication to expose cultured human HL-60 cells. We used the serial analysis of gene expression (SAGE) method to measure the RF effect on gene expression at the genome level. We observed that 221 genes altered their expression after a 2-h exposure.

The number of affected genes increased to 759 after a 6-h exposure. Functional classification of the affected genes reveals that apoptosis-related genes were among the upregulated ones and the cell cycle genes among the downregulated ones. We observed no significant increase in the expression of heat shock genes. These results indicate that the RF fields at 2.45GHz can alter gene expression in cultured human cells through non-thermal mechanism.

Lee SS, Kim HR, Kim MS, Park S, Yoon ES, Park SH, Kim DW. Influence of Smartphone Wi-Fi Signals on Adipose-Derived Stem Cells. J Craniofac Surg. 2014 Aug 5. [Epub ahead of print].

The use of smartphones is expanding rapidly around the world, thus raising the concern of possible harmful effects of radiofrequency generated by smartphones. We hypothesized that Wi-Fi signals from smartphones may have harmful influence on adipose-derived stem cells (ASCs). An in vitro study was performed to assess the influence of Wi-Fi signals from smartphones. The ASCs were incubated under a smartphone connected to a Wi-Fi network, which was uploading files at a speed of 4.8 Mbps for 10 hours a day, for a total of 5 days. We constructed 2 kinds of control cells, one grown in 37°C and the other grown in 39°C. After 5 days of Wi-Fi exposure from the smartphone, the cells underwent cell proliferation assay, apoptosis assay, and flow cytometry analysis. Three growth factors, vascular endothelial growth factor, hepatocyte growth factor, and transforming growth factor-β, were measured from ASC-conditioned media. Cell proliferation rate was higher in Wi-Fi-exposed cells and 39°C control cells compared with 37°C control cells. Apoptosis assay, flow cytometry analysis, and growth factor concentrations showed no remarkable differences among the 3 groups. We could not find any harmful effects of Wi-Fi electromagnetic signals from smartphones. The increased proliferation of ASCs under the smartphone, however, might be attributable to the thermal effect.

LeeTMC, HoSMY, Tsang LYH, Yang SYC, LiLSW, ChanCCH, Effect on human attention of exposure to the electromagnetic field emitted by mobile phones. NeuroReport 12:729-731, 2001.

This study examined the effect of exposure to the electromagnetic field emitted by mobile phones on human attention. Three measures of attention were administered to 72 teenagers, 37 of whom were mobile phone users. The results showed that the mobile phone users performed better on one of the three measures of attention than did the non-mobile phone users. The results suggest that exposure to the electro- magnetic field emitted by mobile phones may have a mild facilitating effect on attention functions, which is consistent with previous observations that exposure to the electromagnetic field has a facilitating effect on cognitive processing. The possibility that mobile phone users may be naturally better at multiple tasking tasks was discussed.

Lee TM, Lam PK, Yee LT, Chan CC. The effect of the duration of exposure to the electromagnetic field emitted by mobile phones on human attention. Neuroreport. 14(10):1361-1364, 2003.

Previous findings suggested the facilitating effect of the electromagnetic field emitted by mobile phones on human attention. This study aimed to examine the relationship between the facilitating effect and the duration of exposure to the electromagnetic field emitted by mobile phones on human attention. Seventy-eight university students were randomly assigned to either an experimental or a control group. Their performance in the administered attention tasks was compared. Participants in the experimental group performed better on one of the two measures of attention only after they had been exposed to the electromagnetic field emitted by the mobile phone for some time. The results seem to suggest that attention functions may be differentially enhanced after exposing to the electromagnetic field emitted by mobile phones. Furthermore, this transient facilitation effect might be dose dependent.

Lee W, Yang KL. Using medaka embryos as a model system to study biological effects of the electromagnetic fields on development and behavior. Ecotoxicol Environ Saf. 2014 Jul 29;108C:187-194. doi: 10.1016/j.ecoenv.2014.06.035. [Epub ahead of print].

The electromagnetic fields (EMFs) of anthropogenic origin are ubiquitous in our environments. The health hazard of extremely low frequency and radiofrequency EMFs has been investigated for decades, but evidence remains inconclusive, and animal studies are urgently needed to resolve the controversies regarding developmental toxicity of EMFs. Furthermore, as undersea cables and technological devices are increasingly used, the lack of information regarding the health risk of EMFs to aquatic organisms needs to be addressed. Medaka embryos (Oryzias latipes) have been a useful tool to study developmental toxicity in vivo due to their optical transparency. Here we explored the feasibility of using medaka embryos as a model system to study biological effects of EMFs on development. We also used a white preference test to investigate behavioral consequences of the EMF developmental toxicity. Newly fertilized embryos were randomly assigned to four groups that were exposed to an EMF with 3.2 kHz at the intensity of 0.12, 15, 25, or 60μT. The group exposed to the background 0.12μT served as the control. The embryos were exposed continually until hatch. They were observed daily, and the images were recorded for analysis of several developmental endpoints. Four days after hatching, the hatchlings were tested with the white preference test for their anxiety-like behavior. The results showed that embryos exposed to all three levels of the EMF developed significantly faster. The endpoints affected included the number of somites, eye width and length, eye pigmentation density, midbrain width, head growth, and the day to hatch. In addition, the group exposed to the EMF at 60μT exhibited significantly higher levels of anxiety-like behavior than the other groups did. In conclusion, the EMF tested in this study accelerated embryonic development and heightened anxiety-like behavior. Our results also demonstrate that the medaka embryo is a sensitive and cost-efficient in vivo model system to study developmental toxicity of EMFs.

Leena K, Tomi L, Arja RR. Intensity of mobile phone use and health compromising behaviours-how is information and communication technology connected to health-related lifestyle in adolescence? J Adolesc. 28(1):35-47, 2005.

The association of mobile phone use with health compromising behaviours (smoking,

snuffing, alcohol) was studied in a survey comprising a representative sample of 14-16-year-olds ([Formula: see text]) in 2001. Mobile phone was used by 89% of respondents and by 13% for at least 1h daily. The intensity of use was positively associated with health compromising behaviours. The associations remained, although somewhat reduced, after including weekly spending money in the models. This study concludes that, at least in the present developmental level of communication technologies, intensive mobile phone use seems to be part of the same health-related lifestyle as health compromising behaviours.

Leitgeb N, Tropper K, [Eye heating caused by microwave ovens]. Biomed Tech (Berl) 38(1-2):17-20, 1993. [Article in German].

To clarify the question as to whether microwave ovens represent a risk for the eyes, a worst-case situation was investigated in which it was assumed that a child observes the internal heating process with its eyes as close to the door of a microwave oven as it is possible to get. As expected, heating of the eyes was observed, which, however, was caused mainly by the conventional heating process rather than by microwave radiation. Significant microwave heating was observed only when increased scattered radiation was simulated by inactivating the safety contacts and opening the door of the microwave oven. When the door is opened to a clearly visible gap width (2.3 cm), the contribution of the microwave component to the overall temperature increase of 5 degrees C after one hour of continuous exposure did not exceed 16%. Even at the maximum possible door gap width which just did not cause the oven to switch off automatically (2.6 cm), 15 minutes of continuous exposure contributed only 50% to the 2 degrees C temperature increase. On the basis of these results, damage to the eye through the use of microwave ovens can be excluded.

Leng L, Zhang Y. Etiology of Pituitary Tumors: A Case Control Study. Turk Neurosurg. 2016;26(2):195-9. doi: 10.5137/1019-5149.JTN.5985-12.1.

AIM: Pituitary tumors are generally benign, but may be associated with some morbidities. The aim of this study was to identify the risk factors for pituitary tumors. MATERIAL AND METHODS: A population-based case-control study on the potential risk factors of pituitary tumors was conducted in China. The personal interview technique was used to gather information on medical and reproductive history, taste, and cigarette smoking from 204 pituitary tumor cases and 246 controls aged between 6 and 82 years. RESULTS: The risk of tumor was reduced when the interviewee was a worker. The risk was raised with spicy taste, mobile phone use, duration of use, characteristics, and taking vitamins. No significant association was observed with gender, age, education, marriage, speed of eating, fat intake, other tastes (salt, sour, sweet), medical and reproductive history, female sex hormones, cigarette smoking, tea drinking, wine drinking, menses, and oral contraceptive use, whether the interviewee was a farmer. CONCLUSION: Increased risk for pituitary tumors is related with spicy taste, mobile phone use, duration of use, characteristics, taking vitamins and possibly a reduced risk is related with the interviewee being a worker. Further investigations are needed to clarify the causes of these associations.

Lepp A, Barkley JE, Sanders GJ, Rebold M, Gates P. The relationship between cell phone use, physical and sedentary activity, and cardiorespiratory fitness in a sample of U.S. college students. Int J Behav Nutr Phys Act. 2013 Jun 21;10:79. doi: 10.1186/1479-5868-10-79.

BACKGROUND: Today's cell phones increase opportunities for activities traditionally defined as sedentary behaviors (e.g., surfing the internet, playing video games). People who participate in large amounts of sedentary behaviors, relative to those who do not, tend to be less physically active, less physically fit, and at greater risk for health problems. However, cell phone use does not have to be a sedentary behavior as these devices are portable. It can occur while standing or during mild-to-moderate intensity physical activity. Thus, the relationship between cell phone use, physical and sedentary activity, and physical fitness is unclear. The purpose of this study was to investigate these relationships among a sample of healthy college students. METHODS: Participants were first interviewed about their physical activity behavior and cell phone use. Then body composition was assessed and the validated self-efficacy survey for exercise behaviors completed. This was followed by a progressive exercise test on a treadmill to exhaustion. Peak oxygen consumption (VO2 peak) during exercise was used to measure cardiorespiratory fitness. Hierarchical regression was used to assess the relationship between cell phone use and cardiorespiratory fitness after controlling for sex, self-efficacy, and percent body fat. Interview data was transcribed, coded, and Chi-square analysis was used to compare the responses of low and high frequency cell phone users. RESULTS: Cell phone use was significantly ($p = 0.047$) and negatively ($\beta = -0.25$) related to cardio respiratory fitness independent of sex, self-efficacy, and percent fat which were also significant predictors ($p < 0.05$). Interview data offered several possible explanations for this relationship. First, high frequency users were more likely than low frequency users to report forgoing opportunities for physical activity in order to use their cell phones for sedentary behaviors. Second, low frequency users were more likely to report being connected to active peer groups through their cell phones and to cite this as a motivation for physical activity. Third, high levels of cell phone use indicated a broader pattern of sedentary behaviors apart from cell phone use, such as watching television. CONCLUSION: Cell phone use, like traditional sedentary behaviors, may disrupt physical activity and reduce cardiorespiratory fitness.

Lerchl A, Krüger H, Niehaus M, Streckert JR, Bitz AK, Hansen V. Effects of mobile phone electromagnetic fields at nonthermal SAR values on melatonin and body weight of Djungarian hamsters (Phodopus sungorus). J Pineal Res. 44(3):267-272, 2008.

In three experiments, adult male Djungarian hamsters (Phodopus sungorus) were exposed 24 hr/day for 60 days to radio frequency electromagnetic fields (RF-EMF) at 383, 900, and 1800 MHz, modulated according to the TETRA (383 MHz) and GSM standards (900 and 1800 MHz), respectively. A radial waveguide system ensured a well defined and uniform exposure at whole-body averaged specific absorption rates of 80 mW/kg, which is equal to the upper limit of whole-body exposure of the general population in Germany and other countries. For each experiment, using two identical waveguides, hamsters were exposed (n = 120) and sham-exposed (n = 120) in a blind

fashion. In all experiments, pineal and serum melatonin levels as well as the weights of testes, brain, kidneys, and liver were not affected. At 383 MHz, exposure resulted in a significant transient increase in body weight up to 4%, while at 900 MHz this body weight increase was more pronounced (up to 6%) and not transient. At 1800 MHz, no effect on body weight was seen. The results corroborate earlier findings which have shown no effects of RF-EMF on melatonin levels in vivo and in vitro. The data are in accordance with the hypothesis that absorbed RF energy may result in metabolic changes which eventually cause body weight increases in exposed animals. The data support the notion that metabolic effects of RF-EMFs need to be investigated in more detail in future studies.

Lerchl A, Klose M, Grote K, Wilhelm AF, Spathmann O, Fiedler T, Streckert J, Hansen V, Clemens M. Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans. Biochem Biophys Res Commun. 2015 Mar 6. pii: S0006-291X(15)00398-8. doi: 10.1016/j.bbrc.2015.02.151. [Epub ahead of print]

The vast majority of in vitro and in vivo studies did not find cancerogenic effects of exposure to electromagnetic fields (RF-EMF), i.e. emitted by mobile phones and base stations. Previously published results from a pilot study with carcinogen-treated mice, however, suggested tumor-promoting effects of RF-EMF (Tillmann et al., 2010). We have performed a replication study using higher numbers of animals per group and including two additional exposure levels (0 (sham), 0.04, 0.4 and 2 W/kg SAR). We could confirm and extend the originally reported findings. Numbers of tumors of the lungs and livers in exposed animals were significantly higher than in sham-exposed controls. In addition, lymphomas were also found to be significantly elevated by exposure. A clear dose-response effect is absent. We hypothesize that these tumor-promoting effects may be caused by metabolic changes due to exposure. Since many of the tumor-promoting effects in our study were seen at low to moderate exposure levels (0.04 and 0.4 W/kg SAR), thus well below exposure limits for the users of mobile phones, further studies are warranted to investigate the underlying mechanisms. Our findings may help to understand the repeatedly reported increased incidences of brain tumors in heavy users of mobile phones.

Lesch MF, Hancock PA. Driving performance during concurrent cell-phone use: are drivers aware of their performance decrements? Accid Anal Prev. 36(3):471-480, 2004.

Prior research has documented the manner in which a variety of driving performance measures are impacted by concurrent cell-phone use as well as the influence of age and gender of the driver. This current study examined the extent to which different driver groups are aware of their associated performance decrements. Subjects' confidence in dealing with distractors while driving and their ratings of task performance and demand were compared with their actual driving performance in the presence of a cell-phone task. While high confidence ratings appeared to be predictive of better driving performance for male drivers (as confidence increased, the size of the distraction effects decreased), this relationship did not hold for females; in fact, for older females, as confidence increased, performance decreased. Additionally, when drivers were matched in terms of confidence

level, brake responses of older females were slowed to a much greater extent (0.38s) than were brake responses of any other group (0.10s for younger males and females and 0.07s for older males). Finally, females also rated the driving task as less demanding than males, even though their performance was more greatly affected by distraction. These results suggest that many drivers may not be aware of their decreased performance while using cell-phones and that it may be particularly important to target educational campaigns on driver distraction towards female drivers for whom there tended to be a greater discrepancy between driver perceptions and actual performance.

Leshin VV, [Changes of neurocytes in CNS under general exposure to UHF field with local protection applied]. Med Tr Prom Ekol (5):5-8, 2000. [Article in Russian]

Experiments on white rats were performed to study influence of UHF field on cortical sensomotor area under general exposure or with the head shielded. The changes in CNS caused by UHF field were not prevented completely by means of the shield. That is probably due to pathologic reflex impulses from the body receptors.

Leszczynski D, Joenväärä S, Reivinen J, Kuokka R, Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: Molecular mechanism for cancer- and blood-brain barrier-related effects. Differentiation 70:120–129, 2002.

Abstract We have examined whether non-thermal exposures of cultures of the human endothelial cell line EA.hy926 to 900 MHz GSM mobile phone microwave radiation could activate stress response. Results obtained demonstrate that 1-hour non-thermal exposure of EA.hy926 cells changes the phosphorylation status of numerous, yet largely unidentified, proteins. One of the affected proteins was identified as heat shock protein-27 (hsp27). Mobile phone exposure caused a transient increase in phosphorylation of hsp27, an effect which was prevented by SB203580, a specific inhibitor of p38 mitogen-activated protein kinase (p38MAPK). Also, mobile phone exposure caused transient changes in the protein expression levels of hsp27 and p38MAPK. All these changes were non-thermal effects because, as determined using temperature probes, irradiation did not alter the temperature of cell cultures, which remained throughout the irradiation period at 37±0.3 °C. Changes in the overall pattern of protein phosphorylation suggest that mobile phone radiation activates a variety of cellular signal transduction pathways, among them the hsp27/p38MAPK stress response pathway. Based on the known functions of hsp27, we put forward the hypothesis that mobile phone radiation-induced activation of hsp27 may (i) facilitate the development of brain cancer by inhibiting the cytochrome c/caspase-3 apoptotic pathway and (ii) cause an increase in blood-brain barrier permeability through stabilization of endothelial cell stress fibers. We postulate that these events, when occurring repeatedly over a long period of time, might become a health hazard because of the possible accumulation of brain tissue damage. Furthermore, our hypothesis suggests that other brain damaging factors may co-participate in mobile phone radiation-induced effects.

Leszczynski D, Nylund R, Joenvaara S, Reivinen J. Applicability of discovery science approach to determine biological effects of mobile phone radiation. Proteomics. 4(2):426-431, 2004.

We argue that the use of high-throughput screening techniques, although expensive and laborious, is justified and necessary in studies that examine biological effects of mobile phone radiation. The "case of hsp27 protein" presented here suggests that even proteins with only modestly altered (by exposure to mobile phone radiation) expression and activity might have an impact on cell physiology. However, this short communication does not attempt to present the full scientific evidence that is far too large to be presented in a single article and that is being prepared for publication in three separate research articles. Examples of the experimental evidence presented here were designed to show the flow of experimental process demonstrating that the use of high-throughput screening techniques might help in rapid identification of the responding proteins. This, in turn, can help in speeding up of the process of determining whether these changes might affect human health.

Leung S, Croft RJ, McKenzie RJ, Iskra S, Silber B, Cooper NR, O'Neill B, Cropley V, Diaz-Trujillo A, Hamblin D, Simpson D. Effects of 2G and 3G mobile phones on performance and electrophysiology in adolescents, young adults and older adults. Clin Neurophysiol. 122(11):2203-2216, 2011.

OBJECTIVE: This study examined sensory and cognitive processing in adolescents, young adults and older adults, when exposed to 2nd (2G) and 3rd (3G) generation mobile phone signals. **METHODS:** Tests employed were the auditory 3-stimulus oddball and the N-back. Forty-one 13-15 year olds, forty-two 19-40 year olds and twenty 55-70 year olds were tested using a double-blind cross-over design, where each participant received Sham, 2G and 3G exposures, separated by at least 4 days. **RESULTS:** 3-Stimulus oddball task: Behavioural: accuracy and reaction time of responses to targets were not affected by exposure. Electrophysiological: augmented N1 was found in the 2G condition (independent of age group). N-back task: Behavioural: the combined groups performed less accurately during the 3G exposure (compared to Sham), with post hoc tests finding this effect separately in the adolescents only. Electrophysiological: delayed ERD/ERS responses of the alpha power were found in both 3G and 2G conditions (compared to Sham; independent of age group). **CONCLUSION:** Employing tasks tailored to each individual's ability level, this study provides support for an effect of acute 2G and 3G exposure on human cognitive function. **SIGNIFICANCE:** The subtlety of mobile phone effect on cognition in our study suggests that it is important to account for individual differences in future mobile phone research.

Leung S, Diao Y, Chan K, Siu Y, Wu Y. Specific Absorption Rate Evaluation for Passengers Using Wireless Communication Devices inside Vehicles with Different Handedness, Passenger Counts, and Seating Locations. IEEE Trans Biomed Eng. 2012 Aug 8. [Epub ahead of print]

Radiation from mobile phones inside vehicles, which are semi open metallic enclosures with irregular shapes and apertures, has been a major concern and has warranted investigation in past years. In this paper, the specific absorption rate (SAR) induced in mobile phone users inside a vehicle was evaluated using different scenarios, including handedness, passenger counts, and seating locations. A computer simulation for SAR distributions in a human body was performed based on

the Finite-difference Time-domain method (FDTD). The SAR values in mobile phone users in free space were also compared to those inside a vehicle; results illustrated that the maximum SAR induced for mobile phone users in a vehicle is 5% higher than those in free space, but the SAR results showed no significant difference for the handedness. By comparing the SAR values between mobile phone users and non-users inside a vehicle with a passenger count and seating locations, it was observed that the SAR values around the non-users body varied much in different situations, and were higher than those in free space, in some circumstances.

Levis AG, Minicuci N, Ricci P, Gennaro V, Garbisa S. Mobile phones and head tumours. The discrepancies in cause-effect relationships in the epidemiological studies - how do they arise?Environ Health. 10:59, 2011.

BACKGROUND: Whether or not there is a relationship between use of mobile phones (analogue and digital cellulars, and cordless) and head tumour risk (brain tumours, acousticneuromas, and salivary gland tumours) is still a matter of debate; progress requires a critical analysis of the methodological elements necessary for an impartial evaluation of contradictory studies. **METHODS:** A close examination of the protocols and results from all case-control and cohort studies, pooled- and meta-analyses on head tumour risk for mobile phone users was carried out, and for each study the elements necessary for evaluating its reliability were identified. In addition, new meta-analyses of the literature data were undertaken. These were limited to subjects with mobile phone latency time compatible with the progression of the examined tumours, and with analysis of the laterality of head tumour localisation corresponding to the habitual laterality of mobile phone use. **RESULTS:** Blind protocols, free from errors, bias, and financial conditioning factors, give positive results that reveal a cause-effect relationship between long-term mobile phone use or latency and statistically significant increase of ipsilateral head tumour risk, with biological plausibility. Non-blind protocols, which instead are affected by errors, bias, and financial conditioning factors, give negative results with systematic underestimate of such risk. However, also in these studies a statistically significant increase in risk of ipsilateral head tumours is quite common after more than 10 years of mobile phone use or latency. The meta-analyses, our included, examining only data on ipsilateral tumours in subjects using mobile phones since or for at least 10 years, show large and statistically significant increases in risk of ipsilateral brain gliomas and acoustic neuromas. **CONCLUSIONS:** Our analysis of the literature studies and of the results from meta-analyses of the significant data alone shows an almost doubling of the risk of head tumours induced by long-term mobile phone use or latency.

Lewicka M, Henrykowska GA, Pacholski K, Szczęsny A, Dziedziczak-Buczyńska M, Buczyński A. The Impact of Electromagnetic Radiation of Different Parameters on Platelet Oxygen Metabolism - In Vitro Studies. Adv Clin Exp Med. 24(1):31-35, 2015.

BACKGROUND: Electromagnetic radiation emitted by a variety of devices, e.g. cell phones, computers and microwaves, interacts with the human body in many ways. Research studies carried out in the last few decades have not yet resolved the issue of the effect of this factor on the human body and many questions are left without an

unequivocal answer. Various biological and health-related effects have not been fully recognized. Thus further studies in this area are justified. OBJECTIVES: A comparison of changes within catalase enzymatic activity and malondialdehyde concentration arising under the influence of the electromagnetic radiation emitted by car electronics, equipment used in physiotherapy and LCD monitors. MATERIAL AND METHODS: The suspension of human blood platelets at a concentration of 1 × 109/0.001 dm 3, obtained from whole blood by manual apheresis, was the study material. Blood platelets were exposed to an electromagnetic field for 30 min in a laboratory stand designed for the reconstruction of the electromagnetic radiation generated by car electronics, physiotherapy equipment and LCD monitors. The changes in catalase activity and malondialdehyde concentration were investigated after the exposure and compared to the control values (unexposed material). RESULTS: An increase in catalase activity and malondialdehyde concentration was observed after 30 min exposure of platelets to EMF regardless of the radiation source. The most significant changes determining the degree of oxidative stress were observed after exposure to the EMF generated by car electronics. CONCLUSIONS: The low frequency electromagnetic fields generated by car electronics, physiotherapy equipment and LCD monitors may be a cause of oxidative stress in the human body and may lead to free radical diseases.

Lewis RC, Mínguez-Alarcón L, Meeker JD, Williams PL, Mezei G, Ford JB, Hauser R; EARTH Study Team. Self-reported mobile phone use and semen parameters among men from a fertility clinic. Reprod Toxicol. 2016 Nov 9. pii: S0890-6238(16)30408-7. doi: 10.1016/j.reprotox.2016.11.008. [Epub ahead of print]

There is increasing concern that use of mobile phones, a source of low-level radio-frequency electromagnetic fields, may be associated with poor semen quality, but the epidemiologic evidence is limited and conflicting. The relationship between mobile phone use patterns and markers of semen quality was explored in a longitudinal cohort study of 153 men that attended an academic fertility clinic in Boston, Massachusetts. Information on mobile phone use duration, headset or earpiece use, and the body location in which the mobile phone was carried was ascertained via nurse-administered questionnaire. Semen samples (n=350) were collected and analyzed onsite. To account for multiple semen samples per man, linear mixed models with random intercepts were used to investigate the association between mobile phone use and semen parameters. Overall, there was no evidence for a relationship between mobile phone use and semen quality.

Li BF, Guo GZ, Ren DQ, Zhang RB. Electromagnetic pulses induce fluctuations in blood pressure in rats. Int J Radiat Biol.83(6):421-429, 2007.

Purpose: To investigate the effects of exposure to electromagnetic pulses (EMP) on functional indices of the cardiovascular system in male Sprague-Dawley rats. Materials and methods: A tapered parallel plate Gigahertz Transverse Electromagnetic cell (GTEM cell) with a flared rectangular coaxial transmission line was used to expose the rats to EMP (0.5 pps, total 200 pulses and whole-body averaged specific absorption rate 50 mW/kg at 200 kV/m or 75 mW/kg at 400 kV/m). Concurrent sham-exposed animals were used as controls. Cardiovascular functions,

namely, heart rate, and systolic, mean and diastolic blood pressures were measured immediately and up to 4 weeks post-exposure using a non-invasive tail-cuff photoelectric sensor sphygmomanometer. Results: The heart rates in sham- and EMP-exposed rats were not significantly changed. In the exposed rats, increased systolic blood pressure (SBP) occurred at 0 h and decreased SBP occurred at 1 day and 3 days after exposure. Significantly higher diastolic blood pressure (DBP) was found at 0 h and significantly lower DBP was found at 12 h, 1 day, and 1 month after exposure. Significantly higher mean arterial pressure (MAP) was noted at 0 h and significantly lower MAP was noted at 1 day. Conclusions: Significant alterations in arterial blood pressure were observed in rats exposed to EMP exposure while heart rate was not altered.

Li C, Chen Z, Yang L, Lv B, Liu J, Varsier N, Hadjem A, Wiart J, Xie Y, Ma L, Wu T. Generation of infant anatomical models for evaluating electromagnetic field exposures. Bioelectromagnetics. 2015 Jan;36(1):10-26, 2015.

Realistic anatomical modeling is essential in analyzing human exposure to electromagnetic fields. Infants have significant physical and anatomical differences compared with other age groups. However, few realistic infant models are available. In this work, we developed one 12-month-old male whole body model and one 17-month-old male head model from magnetic resonance images. The whole body and head models contained 28 and 30 tissues, respectively, at spatial resolution of 1 mm × 1 mm × 1 mm. Fewer identified tissues in the whole body model were a result of the low original image quality induced by the fast imaging sequence. The anatomical and physical parameters of the models were validated against findings in published literature (e.g., a maximum deviation as 18% in tissue mass was observed compared with the data from International Commission on Radiological Protection). Several typical exposure scenarios were realized for numerical simulation. Dosimetric comparison with various adult and child anatomical models was conducted. Significant differences in the physical and anatomical features between adult and child models demonstrated the importance of creating realistic infant models. Current safety guidelines for infant exposure to radiofrequency electromagnetic fields may not be conservative.

Li C, Zhan C, Long Y, Gu H, Deng Y, Jiang Y, Tang M, Tang C, Luo S, [Some biochemical indexes in white rabbit's blood affected by acute high intensity microwave]. Hua Hsi I Ko Ta Hsueh Hsueh Pao ;26(2):206-209, 1995. [Article in Chinese]

Irradiation of white rabbits by 10, 50, 100 and 200 mW/cm2 microwave respectively can cause the disorder of protein metabolism, the abnormality of blood sugar, and the change of the activity of serum alpha-hydroxybutyrate dehydrogenase, lactate dehydrogenase, glutamic oxalacetic transaminase, glutamic pyruvic transaminase, acid phosphatase ect. These changes can be used as indexes in the evaluation of the effect of acute high intensity microwave exposure. The effect on the organism mainly depends on the intensity of exposure provided the dose of microwave remains the same.

Li C, Wu T. Dosimetry for infant exposures to electronic article surveillance system: Posture, physical dimension and anatomy. Bioelectromagnetics. 2015 Mar 10. doi: 10.1002/bem.21901. [Epub ahead of print]

The use of electronic article surveillance (EAS) systems has become popular in many public sites. As a consequence, concern has risen about infant exposure to magnetic fields (MFs) from this kind of device. To evaluate infant exposure to MFs of an EAS system (operating at 125 kHz and 13.56 MHz), we numerically compared dosimetric results among adult, child and infant models. Results revealed that postures insignificantly influenced dosimetric results if there was a similar cross-sectional area under exposure. Although safety limits are unlikely to be exceeded, the infant has higher SAR values for brain and central nervous system tissues compared with adult (1.5x at 125 kHz and 112x at 13.56 MHz), which deserve further investigation. Infant's specific anatomy (e.g., non-proportionally large head and high fat content) did not induce higher SAR values. The numerical models developed in the study (stroller and postured infant models) could be freely used for nonprofit academic research.

Li CY, Liu CC, Chang YH, Chou LP, Ko MC. A population-based case-control study of radiofrequency exposure in relation to childhood neoplasm. Sci Total Environ. 435-436:472-478, 2012.

This population-based case-control study in Taiwan considered incident cases aged 15 years or less and admitted in 2003 to 2007 for all neoplasm (ICD-9-CM: 140-239) (n=2606), including 939 leukemia and 394 brain neoplasm cases. Controls were randomly selected, with a case/control ratio of 1:30 and matched on year of birth, from all non-neoplasm children insured in the same year when the index case was admitted. Annual summarized power (ASP, watt-year) was calculated for each of the 71,185 mobile phone base stations (MPBS) in service between 1998 and 2007. Then, the annual power density (APD, watt-year/km(2)) of each township (n=367) was computed as a ratio of the total ASP of all MPBS in a township to the area of that particular township. Exposure of each study subject to radio frequency (RF) was indicated by the averaged APD within 5 years prior to the neoplasm diagnosis (cases) or July 1st of the year when the index case was admitted (controls) in the township where the subject lived. Unconditional logistic regression model with generalized estimation equation was employed to calculate the covariate-adjusted odds ratio [AOR] of childhood neoplasm in relation to RF exposure. A higher than median averaged APD (approximately 168 WYs/km(2)) was significantly associated with an increased AOR for all neoplasms (1.13; 1.01 to 1.28), but not for leukemia (1.23; 0.99 to 1.52) or brain neoplasm (1.14, 0.83 to 1.55). This study noted a significantly increased risk of all neoplasms in children with higher-than-median RF exposure to MPBS. The slightly elevated risk was seen for leukemia and brain neoplasm, but was not statistically significant. These results may occur due to several methodological limitations.

Li CY, Liao MH, Lin CW, Tsai WS, Huang CC, Tang TK. Inhibitory Effects of Microwave Radiation on LPS-Induced NFκB Expression in THP-1 Monocytes. Chin J Physiol. 55(6):421-427, 2012.

Microwave radiations can be encountered regularly in daily lives. When WHO announced that microwave radiations were a kind of environmental energy which interfere with the physiological functions of the human body, great concerns have been raised over the damages microwave frequencies can do to human physiology. The immunological performance and the activities of the cellular inflammatory factor NFκB have been closely related in monocyte. Due to the effect of phorbol 12-myristate 13-acetate (PMA) on THP-1 monocytes, THP-1 monocytes would differentiate into macrophages and would then react with lipopolysaccharides (LPS), and the amount of NFκB increased in the THP-1 monocytes. Expression of cytokine is affected when cells are exposed to a frequency of 2450 MHz and at 900 W. Thus, in our experiments, an observation was made when THP-1 monocytes were stimulated with PMA and LPS to differentiate into macrophage, the amount of NFκB in cells increased exponentially, and the levels of NFκB expression were decreased by the exposure of microwave radiation. In conclusion, microwave radiations were found to inhibit the activity functions of THP-1 monocytes stimulated with PMA and LPS.

Li H, Peng R, Wang C, Qiao S, Yong-Zou, Gao Y, Xu X, Wang S, Dong J, Zuo H, Li-Zhao, Zhou H, Wang L, Hu X. Alterations of cognitive function and 5-HT system in rats after long term microwave exposure. Physiol Behav. 2014 Dec 24. pii: S0031-9384(14)00663-5. doi: 10.1016/j.physbeh.2014.12.039. [Epub ahead of print]

The increased use of microwaves raises concerns about its impact on health including cognitive function in which neurotransmitter system plays an important role. In this study, we focused on the serotonergic system and evaluated the long term effects of chronic microwave radiation on cognition and correlated items. Wistar rats were exposed or sham exposed to 2.856GHz microwaves with the average power density of 5, 10, 20 or 30mW/cm^2 respectively for 6min three times a week up to 6weeks. At different time points after the last exposure, spatial learning and memory function, morphology structure of the hippocampus, electroencephalogram (EEG) and neurotransmitter content (amino acid and monoamine) of rats were tested. Above results raised our interest in serotonin system. Tryptophan hydroxylase 1 (TPH1) and monoamine oxidase (MAO), two important rate-limiting enzymes in serotonin synthesis and metabolic process respectively, were detected. Expressions of serotonin receptors including 5-HT$_{1A, 2A, 2C}$ receptors were measured. We demonstrated that chronic exposure to microwave (2.856GHz, with the average power density of 5, 10, 20 and 30mW/cm^2) could induce dose-dependent deficit of spatial learning and memory in rats accompanied with inhibition of brain electrical activity, the degeneration of hippocampus neurons, and the disturbance of neurotransmitters, among which the increase of 5-HT occurred as the main long-term change that the decrease of its metabolism partly contributed to. Besides, the variations of 5-HT$_{1A}$R and 5-HT$_{2C}$R expressions were also indicated. The results suggested that in the long-term way, chronic microwave exposure could induce cognitive deficit and 5-HT system may be involved in it.

Li, JR, Chou, CK, McDougall, JA, Dasgupta, G, Wu, HH, Ren, RL, Lee, A, Han, J, Momand J TP53 tumor suppressor protein in normal human fibroblasts does not

respond to 837 MHz microwave exposure. Radiat Res 151(6):710-716, 1999.

The TP53 tumor suppressor protein (formerly known as p53) responds to a wide variety of environmental insults. To evaluate the safety of cellular telephones, TP53 responses in human fibroblast cells were studied after exposure to 837 MHz microwaves. Cells were exposed in a temperature-controlled transverse electromagnetic (TEM) chamber to a specific absorption rate (SAR) of 0.9 or 9.0 W/kg at 837 MHz continuous-wave (CW) microwave irradiation for 2 h. The TP53 protein levels were measured by Western blot at 2, 8, 24 and 48 h after treatment. The TP53 protein levels in microwave-treated cells, sham-treated cells, and untreated cells remained unchanged relative to each other at all times tested (Fisher test and Student-Newman-Keuls test, P > 0.05). No morphological alterations were observed in microwave-treated cells compared to sham-treated cells. We conclude that TP53 protein expression levels in cultured human fibroblast cells do not change significantly during a 48-h period after exposure to 837 MHz continuous microwaves for 2 h at SAR levels of 0.9 or 9.0 W/kg.

Li L, Bisht KS, LaGroye I, Zhang P, Straube WL, Moros EG, Roti Roti JL.Measurement of DNA damage in mammalian cells exposed in vitro to radiofrequency fields at sars of 3-5 w/kg. Radiat Res 156:328-332, 2001.

In the present study, we determined whether exposure of mammalian cells to 3.2-5.1 W/kg specific absorption rate (SAR) radiofrequency fields could induce DNA damage in murine C3H 10T(1/2) fibroblasts. Cell cultures were exposed to 847.74 MHz code-division multiple access (CDMA) and 835.62 frequency-division multiple access (FDMA) modulated radiations in radial transmission line (RTL) irradiators in which the temperature was regulated to 37.0 +/- 0.3 degrees C. Using the alkaline comet assay to measure DNA damage, we found no statistically significant differences in either comet moment or comet length between sham-exposed cells and those exposed for 2, 4 or 24 h to CDMA or FDMA radiations in either exponentially growing or plateau-phase cells. Further, a 4-h incubation after the 2-h exposure resulted in no significant changes in comet moment or comet length. Our results show that exposure of cultured C3H 10T(1/2) cells at 37 degrees C CDMA or FDMA at SAR values of up to 5.1 W/kg did not induce measurable DNA damage.

Li WH, Li YZ, Song DD, Wang XR, Liu M, Wu XD, Liu XH. Calreticulin Protects Rat Microvascular Endothelial Cells against Microwave Radiation-induced Injury by Attenuating Endoplasmic Reticulum Stress. Microcirculation. 2014 Mar 3. doi: 10.1111/micc.12126. [Epub ahead of print]

OBJECTIVE: The present study was designed to evaluate whether exogenous calreticulin (CRT) was beneficial for alleviating microwave radiation (MR)-induced injury by suppressing endoplasmic reticulum (ER) stress in rat myocardial microvascular endothelial cells (MMECs). METHODS: MMECs were pretreated with CRT (25 pg/mL) for 12 h, followed by the exposure to 2.856 GHz radiation at a mean power density of 30 mW/cm^2 for 6 min. MR-induced injury in MMECs was evaluated by lactate dehydrogenase (LDH) leakage, apoptosis and cell viability analysis. The expression of glucose-regulating protein 78 (GRP78), CRT, C/EBP homologous protein (CHOP), Bcl-2 and Bax were examined by Western blot analysis to reflect ER-stress response and ER stress-related apoptosis. RESULTS: MR induced marked MMECs injury, as shown by

increased LDH leakage and apoptosis rate and decreased cell viability. MR also induced excessive ER stress, characterized by increased expression of GRP78 and CRT, and ER stress-related apoptotic signaling as well, as shown by the up-regulation of CHOP and Bax and the down-regulation of Bcl-2. Exogenous CRT pretreatment remarkably attenuated MR-induced cell apoptosis and LDH leakage, ER stress and activation of the ER stress-related apoptotic signaling. CONCLUSIONS: Exogenous CRT attenuates MR-induced ER stress-related apoptosis by suppressing CHOP-mediated apoptotic signaling pathways in MMECs.

Li X, Hu XJ, Peng RY, Gao YB, Wang SM, Wang LF, Xu XP, Su ZT, Yang GS. [A aquaporin 4 expression and effects in rat hippocampus after microwave radiation.] Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi. 27(9):534-538, 2009. [Article in Chinese]

OBJECTIVE: To investigate the expression of aquaporin 4 (AQP4) after microwave exposure and the correlation with the brain injury by radiation. METHODS: 70 male rats were exposed to microwave whose average power density was 0, 10, 30 and 100 mW/cm(2) respectively. Rats were sacrificed at 6 h, 1 d, 3 d and 7 d after exposure. Immunohistochemistry and Western blot were used to detect the expression of AQP4 in protein level in rat hippocampus, and the expression of AQP4 in gene level was measured by in situ hybridization and RT-PCR. RESULTS: The expression of AQP4 in rat hippocampus was abnormal after 10, 30, 100 mW/cm(2) microwave exposure. The protein level showed increased at first and then recovered at 10 and 30 mW/cm(2) groups, while increased progressively in 100 mW/cm(2) group within 14 d ($P < 0.01$). The gene expression of AQP4 was increased (0.51 +/- 0.02) at the beginning (6 h) and then regained after 10 mW/cm(2) microwave exposure, while in 30 and 100 mW/cm(2) groups, it rose to the peak at 7 d (0.46 +/- 0.02 and 0.43 +/- 0.08) and didn't get back ($P = 0.004$; $P = 0.012$). CONCLUSION: Microwave radiation can increase the expression of AQP4 in rat hippocampus. The change might participate in the process of increasing permeability of blood-brain barrier and lead to the brain edema after microwave radiation.

Lian HY, Lin KW, Yang C, Cai P. Generation and propagation of yeast prion [URE3] are elevated under electromagnetic field. Cell Stress Chaperones. 2017 Dec 6. doi: 10.1007/s12192-017-0867-9.

In this study, we studied the effect of 2.0 GHz radio frequency electromagnetic field (RF-EMF) and 50 Hz extremely low frequency electromagnetic field (ELF-EMF) exposure on prion generation and propagation using two budding yeast strains, NT64C and SB34, as model organisms. Under exposure to RF-EMF or ELF-EMF, the de novo generation and propagation of yeast prions [URE3] were elevated in both strains. The elevation increased over time, and the effects of ELF-EMF occurred in a dose-dependent manner. The transcription and expression levels of the molecular chaperones Hsp104, Hsp70-Ssa1/2, and Hsp40-Ydj1 were not statistically significantly changed after exposure. Furthermore, the levels of ROS, as well as the activities of superoxide dismutase (SOD) and catalase (CAT), were significantly elevated after short-term, but not long-term exposure. This work demonstrated for the

first time that EMF exposure could elevate the de novo generation and propagation of yeast prions and supports the hypothesis that ROS may play a role in the effects of EMF on protein misfolding. The effects of EMF on protein folding and ROS levels may mediate the broad effects of EMF on cell function.

Libertin CR, Panozzo J, Groh KR, Chang-Liu CM, Schreck S, Woloschak GE. Effects of gamma rays, ultraviolet radiation, sunlight, microwaves and electromagnetic fields on gene expression mediated by human immunodeficiency virus promoter. Radiat Res. 140(1):91-96, 1994.

Previous work by our group and others has shown the modulation of human immunodeficiency virus (HIV) promoter or long terminal repeat (LTR) after exposure to neutrons and ultraviolet radiations. Using HeLa cells stably transfected with a construct containing the chloramphenicol acetyl transferase (CAT) gene, the transcription of which is mediated by the HIV-LTR, we designed experiments to examine the effects of exposure to different types of radiation (such as gamma rays, ultraviolet and sunlight irradiations, electromagnetic fields and microwaves) on HIV-LTR-driven expression of CAT. These results demonstrated ultraviolet-light-induced transcription from the HIV promoter, as has been shown by others. Exposure to other DNA-damaging agents such as gamma rays and sunlight (with limited exposures) had no significant effect on transcription mediated by HIV-LTR, suggesting that induction of HIV is not mediated by just any type of DNA damage but rather may require specific types of DNA damage. Microwaves did not cause cell killing when cells in culture were exposed in high volumes of medium, and the same cells showed no changes in expression. When microwave exposure was carried out in low volumes of medium (so that excessive heat was generated) induction of HIV-LTR transcription (as assayed by CAT activity) was evident. Electromagnetic field exposures had no effect on expression of HIV-LTR. These results demonstrate that not all types of radiation and not all DNA-damaging agents are capable of inducing HIV. We hypothesize that induction of HIV transcription may be mediated by several different signals after exposure to radiation.

Liddle CG, Putnam JP, Huey OP, Alteration of life span of mice chronically exposed to 2.45 GHz CW microwaves. Bioelectromagnetics 15(3):177-181, 1994.

Female CD1 mice were exposed from the thirty-fifth day of age for the remainder of their lives to 2.45 GHz, CW-microwave radiation at a power density of 3 or 10 mW/cm2 (SAR = 2.0 or 6.8 W/kg). Exposures took place 1 h/day, 5 day/week in an anechoic chamber at an ambient temperature of 22 degrees C and a relative humidity of 50%. There were 25 animals in each exposure group, and an equal number of controls were concurrently sham exposed. The average life span of animals exposed at 10 mW/cm2 was significantly shorter than that of sham-exposed controls (572 days vs. 706 days; P = .049; truncation > 20%). In contrast, the average lifespan of the animals exposed at 3 mW/cm2 was slightly, but not significantly, longer (738 days) than that of controls (706 days).

Liljestrand B, Sandström M, Hansson Mild K. RF exposure during use of electrosurgical units Electromag. Biol. Med. 22:129-132, 2003.

Electrosurgical units (ESUs) commonly used in operating suites employ

radiofrequency (RF) energy for cutting and coagulation, and operate at different frequencies in the range 0.3–5 MHz. Around the electrode and cables, electric and magnetic fields at similar frequencies will be generated, and the surgeon using the ESU will therefore be exposed to these electromagnetic fields. In this study we have measured the levels of RF fields near the lead wires of two electrosurgical units, BARD 3000 operating at a fixed frequency of 0.5 MHz, and ERBE ICC 350 with a frequency range from 0.3 to 1 MHz. Electric fields were measured at distances from 5–30 cm from the lead wire. Measurements were done with the ESU both cutting and coagulating, and power levels ranging from 10–100 W. The magnetic field outside the lead wire was calculated from the measured current through the leads using standard theory. Using those measurements as a base, the calculated local exposure of the surgeon's hand was estimated to exceed 15 kV/m for the electric field and the corresponding value for the magnetic field was 16 µT. These calculations exceed the suggested international reference levels at 0.5 MHz (610 V/m and 4 µT, respectively).

Lim HB, Cook GG, Barker AT, Coulton LA. Effect of 900 MHz electromagnetic fields on nonthermal induction of heat-shock proteins in human leukocytes. Radiat Res. 163(1):45-52, 2005.

Despite many studies, the evidence as to whether radiofrequency fields are detrimental to health remains controversial, and the debate continues. Cells respond to some abnormal physiological conditions by producing cytoprotective heat-shock (or stress) proteins. The aim of this study was to determine whether exposure to mobile phone-type radiation causes a nonthermal stress response in human leukocytes. Human peripheral blood was sham-exposed or exposed to 900 MHz fields (continuous-wave or GSM-modulated signal) at three average specific absorption rates (0.4, 2.0 and 3.6 W/kg) for different durations (20 min, 1 h and 4 h) in a calibrated TEM cell placed in an incubator to give well-controlled atmospheric conditions at 37 degrees C and 95% air/5% CO(2). Positive (heat-stressed at 42 degrees C) and negative (kept at 37 degrees C) control groups were incubated simultaneously in the same incubator. Heat caused an increase in the number of cells expressing stress proteins (HSP70, HSP27), measured using flow cytometry, and this increase was dependent on time. However, no statistically significant difference was detected in the number of cells expressing stress proteins after RF-field exposure. These results suggest that mobile phone-type radiation is not a stressor of normal human lymphocytes and monocytes, in contrast to mild heating.

Lim JI, Fine SL, Kues HA, Johnson MA. Visual abnormalities associated with high-energy microwave exposure. Retina 13(3):230-233, 1993.

A 44-year-old man was accidentally exposed to high-energy microwave irradiation. After resolution of facial erythema and iritis, he noted a foreign body sensation and blurring of vision. Ophthalmoscopic examination showed bilateral, small hard drusen. Ancillary tests were consistent with abnormal cone function. Electroretinogram testing revealed a marked decrease in the flicker electroretinogram. Results of D15 and Farnsworth Munsel Hue 100 color tests were abnormal. Two years later, the patient's visual acuity was stable at 20/25 in both eyes; however, results of flicker electroretinogram test remain markedly decreased. (comment by: Appleton B, Osepchuk J, Cohen J. A case of color vision abnormality and reduced amplitude of the 30 Hz flicker dark-adapted electroretinographic

(ERG) Retina 15(2):170-172, 1995.)

Lin WT, Chang CH, Cheng CY, Chen MC, Wen YR, Lin CT, Lin CW. Effects of low amplitude pulsed radiofrequency stimulation with different waveform in rats for neuropathic pain. Conf Proc IEEE Eng Med Biol Soc. 2013 Jul;2013:3590-3593.

Pulsed-radiofrequency (PRF) electrical stimulation has been widely used for chronic pain treatment. It has been demonstrated with advantages of low temperature over traditional continuous radiofrequency (CRF) lesions with higher amplitude and mono polar electrode to treat pain in clinics (frequency 500 KHz, Pulse duration 20 msec, Amplitude 45 V, Treatment 2 min). We compare the effects of different pulse waveforms and PRF parameters (Pulse duration 25 ms, Treatment duration 5 min, low amplitude of 2.5/1.25 V) with a miniature bi-polar electrode on Dorsal root ganglion (DRG). The pain relief effect due to PRF is evaluated by using Von Frey method for the pain threshold index based on behavior response to mechanical stimulus of various strengths. Experimental results of Von Frey Score show that the sinusoidal group has higher responses than the square wave one. Both fast and secondary expressed proteins of c-fos and pp38 are measured from spinal cord tissue sectioning slides to characterize the pain associated inflammatory responses and their responses due to PRF stimulation.

Lindholm H, Alanko T, Rintamäki H, Kännälä S, Toivonen T, Sistonen H, Tiikkaja M, Halonen J, Mäkinen T, Hietanen M. Thermal effects of mobile phone RF fields on children: a provocation study. Prog Biophys Mol Biol. 107(3):399-403, 2011.

The aim of this study was to examine thermal and local blood flow responses in the head area of the preadolescent boys during exposure to radiofrequency (RF) electromagnetic fields produced by a GSM mobile phone. The design was a double-blinded sham-controlled study of 26 boys, aged 14-15 years. The SAR distribution was calculated and modelled in detail. The duration of the sham periods and exposures with GSM 900 phone was 15 min each, and the tests were carried out in a climatic chamber in controlled thermoneutral conditions. The ear canal temperatures were registered from both ear canals, and the skin temperatures at several sites of the head, trunk and extremities. The local cerebral blood flow was monitored by a near-infrared spectroscopy (NIRS), and the autonomic nervous system function by recordings of ECG and continuous blood pressure. During the short-term RF exposure, local cerebral blood flow did not change, the ear canal temperature did not increase significantly and autonomic nervous system was not interfered. The strengths of this study were the age of the population, multifactorial physiological monitoring and strictly controlled thermal environment. The limitations of the study were large inter-individual variation in the physiological responses, and short duration of the exposure. Longer provocation protocols, however, might cause in children distress related confounding physiological responses.

Linet MS, Taggart T, Severson RK, Cerhan JR, Cozen W, Hartge P, Colt J. Cellular telephones and non-Hodgkin lymphoma. Int J Cancer.119(10):2382-8, 2006.

Dramatic increase in hand-held cellular telephone use since the 1980s and excess risk of

lymphoproliferative malignancies associated with radio-frequency radiation (RFR) exposures in epidemiological and experimental studies motivated assessment of cellular telephones within a comprehensive US case-control investigation of non-Hodgkin lymphoma (NHL). A questionnaire ascertained cellular telephone use in 551 NHL cases and 462 frequency-matched population controls. Compared to persons who had never used cellular telephones, risks were not increased among individuals whose lifetime use was fewer than 10 (odds ratio (OR) = 0.9, 95% confidence intervals (CI): 0.6, 1.3), 10-100 (OR = 1.0, 95 % CI: 0.7, 1.5) or more than 100 times (e.g., regular users, OR = 0.9, 95% CI: 0.6, 1.4). Among regular users compared to those who had never used hand-held cellular telephones, risks of NHL were not significantly associated with minutes per week, duration, cumulative lifetime or year of first use, although NHL was non-significantly higher in men who used cellular telephones for more than 8 years. Little evidence linked use of cellular telephones with total, diffuse large B-cell lymphoma or follicular NHL. These findings must be interpreted in the context of less than 5% of the population reporting duration of use of 6 or more years or lifetime cumulative use of 200 or more hours.

Linet MS, Taggart T, Severson RK, Cerhan JR, Cozen W, Hartge P, Colt J. Cellular telephones and non-Hodgkin lymphoma. Int J Cancer. 119(10):2382-2388, 2006.

Dramatic increase in hand-held cellular telephone use since the 1980s and excess risk of lymphoproliferative malignancies associated with radio-frequency radiation (RFR) exposures in epidemiological and experimental studies motivated assessment of cellular telephones within a comprehensive US case-control investigation of non-Hodgkin lymphoma (NHL). A questionnaire ascertained cellular telephone use in 551 NHL cases and 462 frequency-matched population controls. Compared to persons who had never used cellular telephones, risks were not increased among individuals whose lifetime use was fewer than 10 (odds ratio (OR) = 0.9, 95% confidence intervals (CI): 0.6, 1.3), 10-100 (OR = 1.0, 95 % CI: 0.7, 1.5) or more than 100 times (e.g., regular users, OR = 0.9, 95% CI: 0.6, 1.4). Among regular users compared to those who had never used hand-held cellular telephones, risks of NHL were not significantly associated with minutes per week, duration, cumulative lifetime or year of first use, although NHL was non-significantly higher in men who used cellular telephones for more than 8 years. Little evidence linked use of cellular telephones with total, diffuse large B-cell lymphoma or follicular NHL. These findings must be interpreted in the context of less than 5% of the population reporting duration of use of 6 or more years or lifetime cumulative use of 200 or more hours.

Linz, KW, von Westphalen, C, Streckert, J, Hansen, V, Meyer, R, Membrane potential and currents of isolated heart muscle cells exposed to pulsed radio frequency fields. Bioelectromagnetics 20(8):497-511, 1999.

The influence of radio frequency (RF) fields of 180, 900, and 1800 MHz on the membrane potential, action potential, L-type Ca(2+) current and potassium currents of isolated ventricular myocytes was tested. The study is based on 90 guinea-pig myocytes and 20 rat myocytes. The fields were applied in rectangular waveguides (1800 MHz at 80, 480,

600, 720, or 880 mW/kg and 900 MHz, 250 mW/kg) or in a TEM-cell (180 MHz, 80 mW/kg and 900 MHz, 15 mW/kg). Fields of 1800 and 900 MHz were pulsed according to the GSM-standard of cellular phones. The specific absorption rates were determined from computer simulations of the electromagnetic fields inside the exposure devices by considering the structure of the physiological test arrangement. The electrical membrane parameters were measured by whole cell patch-clamp. None of the tested electrophysiological parameters was changed significantly by exposure to RF fields. Another physical stimulus, lowering the temperature from 36 degrees C to 24 degrees C, decreased the current amplitude almost 50% and shifted the voltage dependence of the steady state activation parameter d(infinity) and inactivation parameter f(infinity) of L-type Ca(2+) current by about 5 mV. However, at this lower temperature RF effects (900 MHz, 250 mW/kg; 1800 MHz, 480 mW/kg) on L-type Ca(2+) current were also not detected.

Lippi G, Danese E, Brocco G, Gelati M, Salvagno GL, Montagnana M. Acute effects of 30 minutes of exposure to a smartphone call on in vitro platelet function. Blood Transfus. 15(3):249-253, 2017.

BACKGROUND: Significant concerns are now regularly raised about the safety of excessive mobile phone use. This study was aimed to assess the acute effects of radiofrequency waves emitted by a commercial smartphone on platelet function. MATERIALS AND METHODS: Two sequential citrated blood samples were collected from 16 healthy volunteers recruited from laboratory staff. The first sample was placed in a plastic rack, 1 cm distant from a commercial smartphone receiving a 30-min call and emitting 900 MHz radiofrequency waves. The second sample was placed in another plastic rack, isolated from radiofrequency wave sources, for the same period. The platelet count and the mean platelet volume were then assessed in all blood samples, whereas platelet function was evaluated using the platelet function analyser-100 (PFA-100). RESULTS: A 30-min exposure of citrated blood to smartphone radiofrequency waves induced significant prolongation of collagen-epinephrine aggregation (median increase, 10%) and a considerable increase of mean platelet volume (median increase, 5%), whereas collagen-adenosine diphosphate aggregation and platelet count remained unchanged. DISCUSSION: This study demonstrates that smartphone radiofrequency waves induce significant perturbation of platelet structure and function, thus providing further support to concerns regarding excessive use of mobile phones. Caution should also be taken with regards to blood products containing platelets, which should be kept far away from mobile phones and smartphones throughout the production pipeline and storage period.

Lipping T, Rorarius M, Jantti V, Annala K, Mennander A, Ferenets R, Toivonen T, Toivo T, Varri A, Korpinen L. Using the nonlinear control of anesthesia-induced hypersensitivity of EEG at burst suppression level to test the effects of radiofrequency radiation on brain function. Nonlinear Biomed Phys.3(1):5, 2009.

ABSTRACT: BACKGROUND: In this study, investigating the effects of mobile phone radiation on test animals, eleven pigs were anaesthetised to the level where burst-

suppression pattern appears in the electroencephalogram (EEG). At this level of anaesthesia both human subjects and animals show high sensitivity to external stimuli which produce EEG bursts during suppression. The burst-suppression phenomenon represents a nonlinear control system, where low-amplitude EEG abruptly switches to very high amplitude bursts. This switching can be triggered by very minor stimuli and the phenomenon has been described as hypersensitivity. To test if also radio frequency (RF) stimulation can trigger this nonlinear control, the animals were exposed to pulse modulated signal of a GSM mobile phone at 890 MHz. In the first phase of the experiment electromagnetic field (EMF) stimulation was randomly switched on and off and the relation between EEG bursts and EMF stimulation onsets and endpoints were studied. In the second phase a continuous RF stimulation at 31 W/kg was applied for 10 minutes. The ECG, the EEG, and the subcutaneous temperature were recorded. RESULTS: No correlation between the exposure and the EEG burst occurrences was observed in phase I measurements. No significant changes were observed in the EEG activity of the pigs during phase II measurements although several EEG signal analysis methods were applied. The temperature measured subcutaneously from the pigs' head increased by 1.6 degrees Celsius and the heart rate by 14.2 bpm on the average during the 10 min exposure periods. CONCLUSIONS: The hypothesis that RF radiation would produce sensory stimulation of somatosensory, auditory or visual system or directly affect the brain so as to produce EEG bursts during suppression was not confirmed.

Litovitz TA, Krause D, Penafiel M, Elson EC, Mullins JM, The role of coherence time in the effect of microwaves on ornithine decarboxylase activity. Bioelectromagnetics 14(5):395-403, 1993.

Previously, we demonstrated the requirements for a minimum coherence time of an applied, small amplitude (10 microT) ELF magnetic field if the field were to produce an enhancement of ornithine decarboxylase activity in L929 fibroblasts. Further investigation has revealed a remarkably similar coherence time phenomenon for enhancement of ornithine decarboxylase activity by amplitude-modulated 915 MHz microwaves of large amplitude (SAR 2.5 W/kg). Microwave fields modulated at 55, 60, or 65 Hz approximately doubled ornithine decarboxylase activity after 8 h. Switching modulation frequencies from 55 to 65 Hz at coherence times of 1.0 s or less abolished enhancement, while times of 10 s or longer provided full enhancement. Our results show that the microwave coherence effects are remarkably similar to those observed with ELF fields.

Litovitz, TA, Penafiel, LM, Farrel, JM, Krause, D, Meister, R, Mullins, JM Bioeffects induced by exposure to microwaves are mitigated by superposition of ELF noise. Bioelectromagnetics 18(6):422-430, 1997.

We have previously demonstrated that microwave fields, amplitude modulated (AM) by an extremely low-frequency (ELF) sine wave, can induce a nearly twofold enhancement in the activity of ornithine decarboxylase (ODC) in L929 cells at SAR levels of the order of 2.5 W/kg. Similar, although less pronounced, effects were also observed from exposure to a typical digital cellular phone test signal of the same power level, burst modulated at 50 Hz. We have also shown that ODC enhancement in L929 cells produced by exposure

to ELF fields can be inhibited by superposition of ELF noise. In the present study, we explore the possibility that similar inhibition techniques can be used to suppress the microwave response. We concurrently exposed L929 cells to 60 Hz AM microwave fields or a 50 Hz burst-modulated DAMPS (Digital Advanced Mobile Phone System) digital cellular phone field at levels known to produce ODC enhancement, together with band-limited 30-100 Hz ELF noise with root mean square amplitude of up to 10 microT. All exposures were carried out for 8 h, which was previously found to yield the peak microwave response. In both cases, the ODC enhancement was found to decrease exponentially as a function of the noise root mean square amplitude. With 60 Hz AM microwaves, complete inhibition was obtained with noise levels at or above 2 microT. With the DAMPS digital cellular phone signal, complete inhibition occurred with noise levels at or above 5 microT. These results suggest a possible practical means to inhibit biological effects from exposure to both ELF and microwave fields.

Little MP, Rajaraman P, Curtis RE, Devesa SS, Inskip PD, Check DP, Linet MS. Mobile phone use and glioma risk: comparison of epidemiological study results with incidence trends in the United States. BMJ.344:e1147, 2012. doi: 10.1136/bmj.e1147.

OBJECTIVE: In view of mobile phone exposure being classified as a possible human carcinogen by the International Agency for Research on Cancer (IARC), we determined the compatibility of two recent reports of glioma risk (forming the basis of the IARC's classification) with observed incidence trends in the United States.DESIGN: Comparison of observed rates with projected rates of glioma incidence for 1997-2008. We estimated projected rates by combining relative risks reported in the 2010 Interphone study and a 2011 Swedish study by Hardell and colleagues with rates adjusted for age, registry, and sex; data for mobile phone use; and various latency periods.SETTING: US population based data for glioma incidence in 1992-2008, from 12 registries in the Surveillance, Epidemiology, and End Results (SEER) programme (Atlanta, Detroit, Los Angeles, San Francisco, San Jose-Monterey, Seattle, rural Georgia, Connecticut, Hawaii, Iowa, New Mexico, and Utah).PARTICIPANTS: Data for 24 813 non-Hispanic white people diagnosed with glioma at age 18 years or older.RESULTS: Age specific incidence rates of glioma remained generally constant in 1992-2008 (-0.02% change per year, 95% confidence interval -0.28% to 0.25%), a period coinciding with a substantial increase in mobile phone use from close to 0% to almost 100% of the US population. If phone use was associated with glioma risk, we expected glioma incidence rates to be higher than those observed, even with a latency period of 10 years and low relative risks (1.5). Based on relative risks of glioma by tumour latency and cumulative hours of phone use in the Swedish study, predicted rates should have been at least 40% higher than observed rates in 2008. However, predicted glioma rates based on the small proportion of highly exposed people in the Interphone study could be consistent with the observed data. Results remained valid if we used either non-regular users or low users of mobile phones as the baseline category, and if we constrained relative risks to be more than 1.CONCLUSIONS: Raised risks of glioma with mobile phone use, as reported by one (Swedish) study forming the basis of the IARC's re-evaluation of mobile phone exposure, are not consistent with observed incidence trends in US population data, although the US data could be consistent with the modest excess risks in the Interphone study.

Liu C, Duan W, Xu S, Chen C, He M, Zhang L, Yu Z, Zhou Z. Exposure to 1800 MHz radiofrequency electromagnetic radiation induces oxidative DNA base damage in a mouse spermatocyte-derived cell line. Toxicol Lett 218(1): 2-9, 2013.

Whether exposure to radiofrequency electromagnetic radiation (RF-EMR) emitted from mobile phones can induce DNA damage in male germ cells remains unclear. In this study, we conducted a 24 h intermittent exposure (5 min on and 10 min off) of a mouse spermatocyte-derived GC-2 cell line to 1800 MHz Global System for Mobile Communication (GSM) signals in GSM-Talk mode at specific absorption rates (SAR) of 1 W/kg, 2 W/kg or 4 W/kg. Subsequently, through the use of formamidopyrimidine DNA glycosylase (FPG) in a modified comet assay, we determined that the extent of DNA migration was significantly increased at a SAR of 4 W/kg. Flow cytometry analysis demonstrated that levels of the DNA adduct 8-oxoguanine (8-oxoG) were also increased at a SAR of 4 W/kg. These increases were concomitant with similar increases in the generation of reactive oxygen species (ROS); these phenomena were mitigated by co-treatment with the antioxidant α-tocopherol. However, no detectable DNA strand breakage was observed by the alkaline comet assay. Taking together, these findings may imply the novel possibility that RF-EMR with insufficient energy for the direct induction of DNA strand breaks may produce genotoxicity through oxidative DNA base damage in male germ cells.

Liu C, Gao P, Xu SC, Wang Y, Chen CH, He MD, Yu ZP, Zhang L, Zhou Z. Mobile phone radiation induces mode-dependent DNA damage in a mouse spermatocyte-derived cell line: a protective role of melatonin. Int J Radiat Biol. 2013 Aug 19. [Epub ahead of print]

Purpose: To evaluate whether exposure to mobile phone radiation (MPR) can induce DNA damage in male germ cells. Materials and methods: A mouse spermatocyte-derived GC-2 cell line was exposed to a commercial mobile phone handset once every 20 minutes in standby, listen, dialed or dialing modes for 24 h. DNA damage was determined using an alkaline comet assay. Results: The levels of DNA damage were significantly increased following exposure to MPR in the listen, dialed and dialing modes. Moreover, there were significantly higher increases in the dialed and dialing modes than in the listen mode. Interestingly, these results were consistent with the radiation intensities of these modes. However, the DNA damage effects of MPR in the dialing mode were efficiently attenuated by melatonin pretreatment. Conclusions: These results regarding mode-dependent DNA damage have important implications for the safety of inappropriate mobile phone use by males of reproductive age and also suggest a simple preventive measure, keeping our body from mobile phones as far away as possible, not only during conversations but during "dialed" and "dialing" operation modes as well. Since the "dialed" mode is actually part of the standby mode, mobile phones should be kept at a safe distance from our body even during standby operation. Furthermore, the protective role of melatonin suggests that it may be a promising pharmacological candidate for preventing mobile phone use-related reproductive impairments.

Liu H, Chen G, Pan Y, Chen Z, Jin W, Sun C, Chen C, Dong X, Chen K, Xu Z, Zhang S, Yu Y. (2014) Occupational Electromagnetic Field Exposures Associated with Sleep Quality: A Cross-Sectional Study. PLoS ONE 9(10): e110825. doi:10.1371/journal.pone.0110825.

BACKGROUND: Exposure to electromagnetic field (EMF) emitted by mobile phone and other machineries concerns half the world's population and raises the problem of their impact on human health. The present study aims to explore the effects of electromagnetic field exposures on sleep quality and sleep duration among workers from electric power plant. METHODS: A cross-sectional study was conducted in an electric power plant of Zhejiang Province, China. A total of 854 participants were included in the final analysis. The detailed information of participants was obtained by trained investigators using a structured questionnaire, which including socio-demographic characteristics, lifestyle variables, sleep variables and electromagnetic exposures. Physical examination and venous blood collection were also carried out for every study subject. RESULTS: After grouping daily occupational electromagnetic exposure into three categories, subjects with long daily exposure time had a significantly higher risk of poor sleep quality in comparison to those with short daily exposure time. The adjusted odds ratios were 1.68 (95%CI: 1.18, 2.39) and 1.57 (95%CI: 1.10, 2.24) across tertiles. Additionally, among the subjects with long-term occupational exposure, the longer daily occupational time apparently increased the risk of poor sleep quality (OR (95%CI): 2.12 (1.23~3.66) in the second tertile; 1.83 (1.07~3.15) in the third tertile). There was no significant association of long-term occupational exposure duration, monthly electric fee or years of mobile-phone use with sleep quality or sleep duration. CONCLUSIONS: The findings showed that daily occupational EMF exposure was positively associated with poor sleep quality. It implies EMF exposure may damage human sleep quality rather than sleep duration.

Liu K, Zhang G, Wang Z, Liu Y, Dong J, Dong X, Liu J, Cao J, Ao L, Zhang S. The protective effect of autophagy on mouse spermatocyte derived cells exposure to 1800MHz radiofrequency electromagnetic radiation. Toxicol Lett. 2014 May 8. pii: S0378-4274(14)00195-7. doi: 10.1016/j.toxlet.2014.05.004. [Epub ahead of print]

The increasing exposure to radiofrequency (RF) radiation emitted from mobile phone use has raised public concern regarding the biological effects of RF exposure on the male reproductive system. Autophagy contributes to maintaining intracellular homeostasis under environmental stress. To clarify whether RF exposure could induce autophagy in the spermatocyte, mouse spermatocyte-derived cells (GC-2) were exposed to 1800MHz Global System for Mobile Communication (GSM) signals in GSM-Talk mode at specific absorption rate (SAR) values of 1 w/kg, 2w/kg or 4w/kg for 24h, respectively. The results indicated that the expression of LC3-II increased in a dose- and time-dependent manner with RF exposure, and showed a significant change at the SAR value of 4w/kg. The autophagosome formation and the occurrence of autophagy were further confirmed by GFP-LC3 transient transfection assay and transmission electron microscopy (TEM) analysis. Furthermore, the conversion of LC3-I to LC3-II was enhanced by co-treatment with Chloroqrine (CQ), indicating autophagic flux could be enhanced by RF exposure. Intracellular ROS levels significantly increased in a dose- and time-dependent manner

after cells were exposed to RF. Pretreatment with anti-oxidative NAC obviously decreased the conversion of LC3-I to LC3-II and attenuated the degradation of p62 induced by RF exposure. Meanwhile, phosphorylated extracellular-signal-regulated kinase (ERK) significantly increased after RF exposure at the SAR value of 2w/kg and 4w/kg. Moreover, we observed that RF exposure did not increase the percentage of apoptotic cells, but inhibition of autophagy could increase the percentage of apoptotic cells. These findings suggested that autophagy flux could be enhanced by 1800MHz GSM exposure (4w/kg), which is mediated by ROS generation. Autophagy may play an important role in preventing cells from apoptotic cell death under RF exposure stress.

Liu ML, Wen JQ, Fan YB. Potential protection of green tea polyphenols against 1800 MHz electromagnetic radiation-induced injury on rat cortical neurons. Neurotox Res. 20(3):270-276, 2011.

Radiofrequency electromagnetic fields (EMF) are harmful to public health, but the certain anti-irradiation mechanism is not clear yet. The present study was performed to investigate the possible protective effects of green tea polyphenols against electromagnetic radiation-induced injury in the cultured rat cortical neurons. In this study, green tea polyphenols were used in the cultured cortical neurons exposed to 1800 MHz EMFs by the mobile phone. We found that the mobile phone irradiation for 24 h induced marked neuronal cell death in the MTT (3-(4,5-dimethylthiazole-2-yl)-2,5-diphenyl-tetrazolium bromide) and TUNEL (TdT mediated biotin-dUTP nicked-end labeling) assay, and protective effects of green tea polyphenols on the injured cortical neurons were demonstrated by testing the content of Bcl-2 Assaciated X protein (Bax) in the immunoprecipitation assay and Western blot assay. In our study results, the mobile phone irradiation-induced increases in the content of active Bax were inhibited significantly by green tea polyphenols, while the contents of total Bax had no marked changes after the treatment of green tea polyphenols. Our results suggested a neuroprotective effect of green tea polyphenols against the mobile phone irradiation-induced injury on the cultured rat cortical neurons.

Liu X, Shen H, Shi Y, Chen J, Chen Y, Ji A. The microarray study on the stress gene transcription profile in human retina pigment epithelial cells exposed to microwave radiation. Zhonghua Yu Fang Yi Xue Za Zhi 36(5):291-294, 2002.

OBJECTIVE: To study the difference in stress and apoptosis related genes transcription between hTERT-RPE1 cells exposed to simulated microwave radiation and the cells with heat water bath, and the effects of microwave on gene transcription in cultured human retina pigment epithelial cells. METHODS: cDNA microarray technique was used to detect the mRNA isolated from hTERT-RPE1 cells exposed to 2 450 MHz simulated microwave radiation and with heat water bath, respectively. RESULTS: Among the 97 related aim genes, there were seven genes up-regulating its transcription, i.e., M31166 (2.52fold), L24123 (2.66fold), AF039704 (2.22fold), U67156 (2.07fold), AF040958 (2.13fold), NM-001423 (2.63fold) and NM-005346 (3.68fold). But, no notably down-regulating gene in transcription was detected. CONCLUSIONS: Microwave could induce up-regulating in multiple stress and apoptosis related genes transcription in cultured human retina pigment epithelial cells, hTERT-RPE1 cells. Microwave radiation has

unique effect itself in addition to its heat effect.

Liu XY, Bian XM, Han JX, Cao ZJ, Fan GS, Zhang C, Zhang WL, Zhang SZ, Sun XG. [Risk factors in the living environment of early spontaneous abortion pregnant women] Zhongguo Yi Xue Ke Xue Yuan Xue Bao. 29(5):661-664, 2007.[Article in Chinese]

OBJECTIVE: To study the relationship between early spontaneous abortion and living environment, and explore the risk factors of spontaneous abortion. METHODS: We conducted analysis based on the interview of 200 spontaneous abortion cases and the matched control (age +/- 2 years) by using multifactor Logistic regression analysis. RESULTS: The proportions of watching TV > or =10 hours/week, operating computer > or =45 hours/week, using copycat, microwave oven and mobile phone, electromagnetism equipment near the dwell or work place, e. g. switch room < or =50 m and launching tower < or =500 m in the cases are significantly higher than those in the controls in single factor analysis (all P < 0.05). After adjusted the effect of other risk factors by multifactor analysis, using microwave oven and mobile phone, contacting abnormal smell of fitment material > or =3 months, having emotional stress during the first term of pregnancy and spontaneous abortion history were significantly associated with risk of spontaneous abortion. The odds ratios of these risk factors were 2.23 and 4.63, respectively. CONCLUSION: Using microwave oven and mobile phone, contacting abnormal smell of fitment material > or =3 months, having emotional stress during the first term of pregnancy, and spontaneous abortion history are risk factors of early spontaneous abortion.

Liu Y, Wang ML, Zhong RG, Ma XM, Wang Q, Zeng Y. The Induction of Epstein-Barr Virus Early Antigen Expression in Raji Cells by GSM Mobile Phone Radiation. Biomed Environ Sci. 26(1):76-78, 2013.

No abstract available.

Liu YQ, Gao YB, Dong J, Yao BW, Zhao L, Peng RY. Pathological changes in the sinoatrial node tissues of rats caused by pulsed microwave exposure. Biomed Environ Sci. 28(1):72-75, 2015.

To observe microwave induced dynamic pathological changes in the sinus nodes, wistar rats were exposed to 0, 5, 10, 50 mW/cm2 microwave. In 10 and 50 mW/cm2 groups, disorganized sinoatrial node cells, cell swelling, cytoplasmic condensation, nuclear pyknosis, and anachromasis, swollen, and empty mitochondria, and blurred and focally dissolved myofibrils could be detected from 1 to 28 d, while reduced parenchymal cells, increased collagen fibers, and extracellular matrix remodeling of interstitial cells were observed from 6 to 12 months. In conclusion, 10 and 50 mW/cm2 microwave could cause structural damages in the sinoatrial node and extracellular matrix remodeling in rats.

Liu YX, Tai JL, Li GQ, Zhang ZW, Xue JH, Liu HS, Zhu H, Cheng JD, Liu YL, Li AM, Zhang Y. Exposure to 1950-MHz TD-SCDMA Electromagnetic Fields Affects the Apoptosis of Astrocytes via Caspase-3-Dependent Pathway. PLoS One.

7(8):e42332, 2012.

The usage of mobile phone increases globally. However, there is still a paucity of data about the impact of electromagnetic fields (EMF) on human health. This study investigated whether EMF radiation would alter the biology of glial cells and act as a tumor-promoting agent. We exposed rat astrocytes and C6 glioma cells to 1950-MHz TD-SCDMA for 12, 24 and 48 h respectively, and found that EMF exposure had differential effects on rat astroctyes and C6 glioma cells. A 48 h of exposure damaged the mitochondria and induced significant apoptosis of astrocytes. Moreover, caspase-3, a hallmark of apoptosis, was highlighted in astrocytes after 48 h of EMF exposure, accompanied by a significantly increased expression of bax and reduced level of bcl-2. The tumorigenicity assays demonstrated that astrocytes did not form tumors in both control and exposure groups. In contrast, the unexposed and exposed C6 glioma cells show no significant differences in both biological feature and tumor formation ability. Therefore, our results implied that exposure to the EMF of 1950-MHz TD-SCDMA may not promote the tumor formation, but continuous exposure damaged the mitochondria of astrocytes and induce apoptosis through a caspase-3-dependent pathway with the involvement of bax and bcl-2.

Liu YX, Li GQ, Fu XP, Xue JH, Ji SP, Zhang ZW, Zhang Y, Li AM. Exposure to 3G mobile phone signals does not affect the biological features of brain tumor cells.BMC Public Health. 15(1):764, 2015.

BACKGROUND: The increase in mobile phone use has generated concerns about possible risks to human health, especially the development of brain tumors. Whether tumor patients should continue to use mobile telephones has remained unclear because of a paucity of information. Herein, we investigated whether electromagnetic fields from mobile phones could alter the biological features of human tumor cells and act as a tumor-promoting agent. METHODS: Human glioblastoma cell lines, U251-MG and U87-MG, were exposed to 1950-MHz time division-synchronous code division multiple access (TD-SCDMA) at a specific absorption rate (maximum SAR = 5.0 W/kg) for 12, 24, and 48 h. Cell morphologies and ultra-structures were observed by microscopy and the rates of apoptosis and cell cycle progression were monitored by flow cytometry. Additionally, cell growth was determined using the CKK-8 assay, and the expression levels of tumor and apoptosis-related genes and proteins were analyzed by real-time PCR and western blotting, respectively. Tumor formation and invasiveness were measured using a tumorigenicity assay in vivo and migration assays in vitro. RESULTS: No significant differences in either biological features or tumor formation ability were observed between unexposed and exposed glioblastoma cells. Our data showed that exposure to 1950-MHz TD-SCDMA electromagnetic fields for up to 48 h did not act as a cytotoxic or tumor-promoting agent to affect the proliferation or gene expression profile of glioblastoma cells. CONCLUSIONS: Our findings implied that exposing brain tumor cells in vitro for up to 48 h to 1950-MHz continuous TD-SCDMA electromagnetic fields did not elicit a general cell stress response.

Lixia S, Yao K, Kaijun W, Deqiang L, Huajun H, Xiangwei G, Baohong W, Wei Z, Jianling L, Wei W. Effects of 1.8GHz radiofrequency field on DNA damage and expression of heat shock protein 70 in human lens epithelial cells. Mutat Res.602(1-2):135-142, 2006.

To investigate the DNA damage, expression of heat shock protein 70 (Hsp70) and cell proliferation of human lens epithelial cells (hLEC) after exposure to the 1.8GHz radiofrequency field (RF) of a global system for mobile communications (GSM). An Xc-1800 RF exposure system was used to employ a GSM signal at 1.8GHz (217Hz amplitude-modulated) with the output power in the specific absorption rate (SAR) of 1, 2 and 3W/kg. After 2h exposure to RF, the DNA damage of hLEC was accessed by comet assay at five different incubation times: 0, 30, 60, 120 and 240min, respectively. Western blot and RT-PCR were used to determine the expression of Hsp70 in hLECs after RF exposure. The proliferation rate of cells was evaluated by bromodeoxyuridine incorporation on days 0, 1 and 4 after exposure. The results show that the difference of DNA-breaks between the exposed and sham-exposed (control) groups induced by 1 and 2W/kg irradiation were not significant at any incubation time point ($P>0.05$). The DNA damage caused by 3W/kg irradiation was significantly increased at the times of 0 and 30min after exposure ($P<0.05$), a phenomenon that could not be seen at the time points of 60, 120 or 240min ($P>0.05$). Detectable mRNA as well as protein expression of Hsp70 was found in all groups. Exposure at SARs of 2 and 3W/kg for 2h exhibited significantly increased Hsp70 protein expression ($P<0.05$), while no change in Hsp70 mRNA expression could be found in any of the groups ($P>0.05$). No difference of the cell proliferation rate between the sham-exposed and exposed cells was found at any exposure dose tested ($P>0.05$). The results indicate that exposure to non-thermal dosages of RF for wireless communications can induce no or repairable DNA damage and the increased Hsp70 protein expression in hLECs occurred without change in the cell proliferation rate. The non-thermal stress response of Hsp70 protein increase to RF exposure might be involved in protecting hLEC from DNA damage and maintaining the cellular capacity for proliferation.

Logani MK, Agelan A, Ziskin MC. Effect of millimeter wave radiation on catalase activity. Electromag Biol Med 21:303-308, 2002.

Millimeter wave therapy has been reported to reduce the toxic side effects of chemo- and radiation therapy in the treatment of cancer. In order to understand the mechanisms involved in this reduction, the effect of millimeter electromagnetic waves (MWs) on catalase activity was examined in mouse blood. SKH-1 hairless mice were irradiated on their midbacks with 42.2±0.2 GHz millimeter waves. The incident power density used was 31±5 mW/cm^2 and the peak SAR was 622±100 W/kg as measured using infrared thermography. The animals were irradiated before or after administration of cyclophosphamide (CPA), an anticancer drug. The sham control groups were treated in a similar manner, but not irradiated. MW irradiation, before or after administration of CPA did not significantly reduce the toxic effect of CPA on catalase activity in mouse blood.

Lokhmatova SA, [The effect of low-intensity prolonged impulse electromagnetic

irradiation in the UHF range on the testes and the appendages of the testis in rats]. Radiats Biol Radioecol 34(2):279-285, 1994. [Article in Russian]

The influence of the long (4 months, 2 hr/day) impulsive electromagnetic irradiation with the power density of 0.25 mW/cm2 on the testes and epididymides was studied. The results demonstrate the high sensitivity of the rat testes and epididymides to electromagnetic field of 3 GHz. Some destructive changes both in the seminiferous tubules and testicular tissue were found. The full recovery has not been observed even 4 months after irradiation was finished.

Lonappan A, Rajasekharan C, Thomas V, Bindu G, Mathew KT. Dielectric properties of human colostrum at microwave frequencies. J Microw Power Electromagn Energy. 41(2):33-38, 2007.

This article communicates the study of both the dielectric properties of human colostrums and breast milk at microwave frequencies. The colostrum samples were taken immediately after child birth and breast milk samples were collected at weekly intervals following the delivery. Rectangular cavity perturbation technique is used for the measurements of dielectric properties at the S-band of microwave frequency. The dielectric constants of the colostrums samples and breast milk samples are found to increase as weeks elapse, which is attributed to the reduced fat content and increased lactose concentration. The conductivity of these samples is similarly found to increase due to the increased dilution.

Lonn S, Klaeboe L, Hall P, Mathiesen T, Auvinen A, Christensen HC, Johansen C, Salminen T, Tynes T, Feychting M. Incidence trends of adult primary intracerebral tumors in four Nordic countries. Int J Cancer. 108(3):450-455, 2004.

Brain tumors are some of the most lethal adult cancers and there is a concern that the incidence is increasing. It has been suggested that the reported increased incidence can be explained by improvements in diagnostic procedures, although this has not been totally resolved. The aim of our study was to describe the incidence trends of adult primary intracerebral tumors in four Nordic countries during a period with introduction of new diagnostic procedures and increasing prevalence of mobile phone users. Information about benign and malignant primary intracerebral tumor cases 20-79 years of age was obtained from the national cancer registries in Denmark, Finland, Norway and Sweden for the years 1969-98 and estimates of person-years at risk were calculated from the information obtained from national population registries. Annual age standardized incidence rates per 100,000 person-years were calculated and time trends analyses were carried out using Poisson regression. The overall incidence of all intracerebral tumors ranged from 8.4-11.8 for men and 5.8-9.3 for women, corresponding to an average annual increase of 0.6% for men (95% confidence interval [CI] = 0.4, 0.7) and 0.9% for women (95% CI = 0.7, 1.0). The increase in the incidence was confined to the late 1970s and early 1980s and coinciding with introduction of improved diagnostic methods. This increase was largely confined to the oldest age group. After 1983 and during the period with increasing prevalence of mobile phone users, the incidence has remained relatively stable for both men and women.

Lonn S, Forssen U, Vecchia P, Ahlbom A, Feychting M. Output power levels from mobile phones in different geographical areas; implications for exposure assessment. Occup Environ Med. 61(9):769-772, 2004.

BACKGROUND: The power level used by the mobile phone is one of the most important factors determining the intensity of the radiofrequency exposure during a call. Mobile phone calls made in areas where base stations are densely situated (normally urban areas) should theoretically on average use lower output power levels than mobile phone calls made in areas with larger distances between base stations (rural areas). AIMS: To analyse the distribution of power levels from mobile phones in four geographical areas with different population densities. METHODS: The output power for all mobile phone calls managed by the GSM operator Telia Mobile was recorded during one week in four defined areas (rural, small urban, suburban, and city area) in Sweden. The recording included output power for the 900 MHz and the 1800 MHz frequency band. RESULTS: In the rural area, the highest power level was used about 50% of the time, while the lowest power was used only 3% of the time. The corresponding numbers for the city area were approximately 25% and 22%. The output power distribution in all defined urban areas was similar. CONCLUSION: In rural areas where base stations are sparse, the output power level used by mobile phones are on average considerably higher than in more densely populated areas. A quantitative assessment of individual exposure to radiofrequency fields is important for epidemiological studies of possible health effects for many reasons. Degree of urbanisation may be an important parameter to consider in the assessment of radiofrequency exposure from mobile phone use.

Lonn S, Ahlbom A, Hall P, Feychting M. Mobile phone use and the risk of acoustic neuroma. Epidemiology. 15(6):653-659, 2004.

BACKGROUND:: Radiofrequency exposure from mobile phones is concentrated to the tissue closest to the handset, which includes the auditory nerve. If this type of exposure increases tumor risk, acoustic neuroma would be a potential concern. METHODS:: In this population-based case-control study we identified all cases age 20 to 69 years diagnosed with acoustic neuroma during 1999 to 2002 in certain parts of Sweden. Controls were randomly selected from the study base, stratified on age, sex, and residential area. Detailed information about mobile phone use and other environmental exposures was collected from 148 (93%) cases and 604 (72%) controls. RESULTS:: The overall odds ratio for acoustic neuroma associated with regular mobile phone use was 1.0 (95% confidence interval = 0.6-1.5). Ten years after the start of mobile phone use the estimates relative risk increased to 1.9 (0.9-4.1); when restricting to tumors on the same side of the head as the phone was normally used, the relative risk was 3.9 (1.6-9.5). CONCLUSIONS:: Our findings do not indicate an increased risk of acoustic neuroma related to short-term mobile phone use after a short latency period. However, our data suggest an increased risk of acoustic neuroma associated with mobile phone use of at least 10 years' duration.

Lonn S, Ahlbom A, Hall P, Feychting M. Long-term mobile phone use and brain tumor risk. Am J Epidemiol. 161(6):526-535, 2005.

Handheld mobile phones were introduced in Sweden during the late 1980s. The purpose of this population-based, case-control study was to test the hypothesis that long-term

mobile phone use increases the risk of brain tumors. The authors identified all cases aged 20-69 years who were diagnosed with glioma or meningioma during 2000-2002 in certain parts of Sweden. Randomly selected controls were stratified on age, gender, and residential area. Detailed information about mobile phone use was collected from 371 (74%) glioma and 273 (85%) meningioma cases and 674 (71%) controls. For regular mobile phone use, the odds ratio was 0.8 (95% confidence interval: 0.6, 1.0) for glioma and 0.7 (95% confidence interval: 0.5, 0.9) for meningioma. Similar results were found for more than 10 years' duration of mobile phone use. No risk increase was found for ipsilateral phone use for tumors located in the temporal and parietal lobes. Furthermore, the odds ratio did not increase, regardless of tumor histology, type of phone, and amount of use. This study includes a large number of long-term mobile phone users, and the authors conclude that the data do not support the hypothesis that mobile phone use is related to an increased risk of glioma or meningioma.

Lonn S, Ahlbom A, Christensen HC, Johansen C, Schuz J, Edstrom S, Henriksson G, Lundgren J, Wennerberg J, Feychting M. Mobile phone use and risk of parotid gland tumor. Am J Epidemiol. 164(7):637-643, 2006.

Handheld mobile phones were introduced in Denmark and Sweden during the late 1980s. This makes the Danish and Swedish populations suitable for a study aimed at testing the hypothesis that long-term mobile phone use increases the risk of parotid gland tumors. In this population-based case-control study, the authors identified all cases aged 20-69 years diagnosed with parotid gland tumor during 2000-2002 in Denmark and certain parts of Sweden. Controls were randomly selected from the study population base. Detailed information about mobile phone use was collected from 60 cases of malignant parotid gland tumors (85% response rate), 112 benign pleomorphic adenomas (88% response rate), and 681 controls (70% response rate). For regular mobile phone use, regardless of duration, the risk estimates for malignant and benign tumors were 0.7 (95% confidence interval: 0.4, 1.3) and 0.9 (95% confidence interval: 0.5, 1.5), respectively. Similar results were found for more than 10 years' duration of mobile phone use. The risk estimate did not increase, regardless of type of phone and amount of use. The authors conclude that the data do not support the hypothesis that mobile phone use is related to an increased risk of parotid gland tumors.

Loos N, György T, Ghosn R, Brenet-Dufour V, Liabeuf S, Selmaoui B, Jean-Pierre L, Bach V, Diouf M, de Seze R. Is the effect of mobile phone radiofrequency waves on human skin perfusion non-thermal? Microcirculation. 2013 Apr 17. doi: 10.1111/micc.12062. [Epub ahead of print]

OBJECTIVE: to establish whether skin micro blood flow can be modified by exposure to the radiofrequency waves emitted by a mobile phone when the latter is held against the jaw and ear. METHODS: Variations in skin micro blood flow and skin temperature in adult volunteers were simultaneously recorded with a thermostatic laser Doppler system during a 20-minute "radiofrequency" exposure session and a 20-minute "sham" session. The skin microvessels' vasodilatory reserve was assessed with a heat challenge at the end of the protocol. RESULTS: During the radiofrequency exposure session, skin micro blood flow increased (vs. baseline) more than during the sham exposure session. The sessions did not differ significant in terms of the skin temperature time-course response.

The skin microvessels' vasodilatory ability was found to be greater during radiofrequency exposure than during sham exposure. CONCLUSIONS: Our results reveal the existence of a specific vasodilatory effect of mobile phone radiofrequency emission from mobile phones.

López-Furelos A, Leiro-Vidal JM, Salas-Sánchez AÁ, Ares-Pena FJ, López-Martín ME. Evidence of cellular stress and caspase-3 resulting from a combined two-frequency signal in the cerebrum and cerebellum of sprague-dawley rats. Oncotarget. 7(40):64674-64689, 2016.

Multiple simultaneous exposures to electromagnetic signals induced adjustments in mammal nervous systems. In this study, we investigated the non-thermal SAR (Specific Absorption Rate) in the cerebral or cerebellar hemispheres of rats exposed in vivo to combined electromagnetic field (EMF) signals at 900 and 2450 MHz.Forty rats divided into four groups of 10 were individually exposed or not exposed to radiation in a GTEM chamber for one or two hours. After radiation, we used the Chemiluminescent Enzyme-Linked Immunosorbent Assay (ChELISA) technique to measure cellular stress levels, indicated by the presence of heat shock proteins (HSP) 90 and 70, as well as caspase-3-dependent pre-apoptotic activity in left and right cerebral and cerebellar hemispheres of Sprague Dawley rats.Twenty-four hours after exposure to combined or single radiation, significant differences were evident in HSP 90 and 70 but not in caspase 3 levels between the hemispheres of the cerebral cortex at high SAR levels. In the cerebellar hemispheres, groups exposed to a single radiofrequency (RF) and high SAR showed significant differences in HSP 90, 70 and caspase-3 levels compared to control animals. The absorbed energy and/or biological effects of combined signals were not additive, suggesting that multiple signals act on nervous tissue by a different mechanism.

Lopez-Martin E, Relova-Quinteiro JL, Gallego-Gomez R, Peleteiro-Fernandez M, Jorge-Barreiro FJ, Ares-Pena FJ. GSM radiation triggers seizures and increases cerebral c-Fos positivity in rats pretreated with subconvulsive doses of picrotoxin. Neurosci Lett.398(1-2):139-144,2006.

This study investigated the effects of mobile-phone-type radiation on the cerebral activity of seizure-prone animals. When rats transformed into an experimental model of seizure-proneness by acute subconvulsive doses of picrotoxin were exposed to 2h GSM-modulated 900MHz radiation at an intensity similar to that emitted by mobile phones, they suffered seizures and the levels of the neuronal activity marker c-Fos in neocortex, paleocortex, hippocampus and thalamus increased markedly. Non-irradiated picrotoxin-treated rats did not suffer seizures, and their cerebral c-Fos counts were significantly lower. Radiation caused no such differences in rats that had not been pretreated with picrotoxin. We conclude that GSM-type radiation can induce seizures in rats following their facilitation by subconvulsive doses of picrotoxin, and that research should be pursued into the possibility that this kind of radiation may similarly affect brain function in human subjects with epileptic disorders.

López-Martín E, Bregains J, Relova-Quinteiro JL, Cadarso-Suárez C, Jorge-Barreiro FJ, Ares-Pena FJ.The action of pulse-modulated GSM radiation increases regional changes in brain activity and c-Fos expression in cortical and subcortical

areas in a rat model of picrotoxin-induced seizure proneness. J Neurosci Res.87(6):1484-1499, 2009.

The action of the pulse-modulated GSM radiofrequency of mobile phones has been suggested as a physical phenomenon that might have biological effects on the mammalian central nervous system. In the present study, GSM-exposed picrotoxin-pretreated rats showed differences in clinical and EEG signs, and in c-Fos expression in the brain, with respect to picrotoxin-treated rats exposed to an equivalent dose of unmodulated radiation. Neither radiation treatment caused tissue heating, so thermal effects can be ruled out. The most marked effects of GSM radiation on c-Fos expression in picrotoxin-treated rats were observed in limbic structures, olfactory cortex areas and subcortical areas, the dentate gyrus, and the central lateral nucleus of the thalamic intralaminar nucleus group. Nonpicrotoxin-treated animals exposed to unmodulated radiation showed the highest levels of neuronal c-Fos expression in cortical areas. These results suggest a specific effect of the pulse modulation of GSM radiation on brain activity of a picrotoxin-induced seizure-proneness rat model and indicate that this mobile-phone-type radiation might induce regional changes in previous preexcitability conditions of neuronal activation.

López-Martín E, Bregains J, Relova-Quinteiro JL, Cadarso-Suárez C, Jorge-Barreiro FJ, Ares-Pena FJ. The action of pulse-modulated GSM radiation increases regional changes in brain activity and c-Fos expression in cortical and subcortical areas in a rat model of picrotoxin-induced seizure proneness. J Neurosci Res. 87(6):1484-1499, 2009.

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Loscher W, Kas G, Extraordinary behavior disorders in cows in proximity to transmission stations. Der Praktische Tierarz 79:437-444, 1998. (Article in German)

In addition to reduction of milk yield and increased health problems, behavioral abnormalities were observed over a period of two years in a herd of diary cows maintained in close proximity to a TV and cell phone transmitting antenna. Evaluation of possible factors which could explain the abnormalities in the live stock did not disclose any factors other than the high-frequency electromagnetic fields. An experiment in which

a cow with abnormal behavior was brought to a stable 20 km away from the antenna resulted in a complete normalization of the cow within five days, whereas symptoms returned when the cow was brought back to the stable nearby the antenna. In view of the previous described effects of electromagnetic fields, it might be possible that the observed abnormalities in cows are related to electromagnetic field exposure. (power densities measured 0.02-7 mW/m2).

Loughran SP, Wood AW, Barton JM, Croft RJ, Thompson B, Stough C. The effect of electromagnetic fields emitted by mobile phones on human sleep. Neuroreport. 16(17):1973-1976, 2005.

Previous research has suggested that exposure to radiofrequency electromagnetic fields increases electroencephalogram spectral power in non-rapid eye movement sleep. Other sleep parameters have also been affected following exposure. We examined whether aspects of sleep architecture show sensitivity to electromagnetic fields emitted by digital mobile phone handsets. Fifty participants were exposed to electromagnetic fields for 30 min prior to sleep. Results showed a decrease in rapid eye movement sleep latency and increased electroencephalogram spectral power in the 11.5-12.25 Hz frequency range during the initial part of sleep following exposure. These results are evidence that mobile phone exposure prior to sleep may promote rapid eye movement sleep and modify the sleep electroencephalogram in the first non-rapid eye movement sleep period.

Loughran SP, McKenzie RJ, Jackson ML, Howard ME, Croft RJ. Individual differences in the effects of mobile phone exposure on human sleep: rethinking the problem.Bioelectromagnetics. 33(1):86-93, 2012.

Mobile phone exposure-related effects on the human electroencephalogram (EEG) have been shown during both waking and sleep states, albeit with slight differences in the frequency affected. This discrepancy, combined with studies that failed to find effects, has led many to conclude that no consistent effects exist. We hypothesised that these differences might partly be due to individual variability in response, and that mobile phone emissions may in fact have large but differential effects on human brain activity. Twenty volunteers from our previous study underwent an adaptation night followed by two experimental nights in which they were randomly exposed to two conditions (Active and Sham), followed by a full-night sleep episode. The EEG spectral power was increased in the sleep spindle frequency range in the first 30 min of non-rapid eye movement (non-REM) sleep following Active exposure. This increase was more prominent in the participants that showed an increase in the original study. These results confirm previous findings of mobile phone-like emissions affecting the EEG during non-REM sleep. Importantly, this low-level effect was also shown to be sensitive to individual variability. Furthermore, this indicates that previous negative results are not strong evidence for a lack of an effect and, given the far-reaching implications of mobile phone research, we may need to rethink the interpretation of results and the manner in which research is conducted in this field.

Loughran SP, Benz DC, Schmid MR, Murbach M, Kuster N, Achermann P. No increased sensitivity in brain activity of adolescents exposed to mobile phone-like

emissions. Clin Neurophysiol. 2013 Feb 18. pii: S1388-2457(13)00051-5. doi: 10.1016/j.clinph.2013.01.010. [Epub ahead of print]

OBJECTIVE: To examine the potential sensitivity of adolescents to radiofrequency electromagnetic field (RF EMF) exposures, such as those emitted by mobile phones. METHODS: In a double-blind, randomized, crossover design, 22 adolescents aged 11-13years (12 males) underwent three experimental sessions in which they were exposed to mobile phone-like RF EMF signals at two different intensities, and a sham session. During exposure cognitive tasks were performed and waking EEG was recorded at three time-points subsequent to exposure (0, 30 and 60min). RESULTS: No clear significant effects of RF EMF exposure were found on the waking EEG or cognitive performance. CONCLUSIONS: Overall, the current study was unable to demonstrate exposure-related effects previously observed on the waking EEG in adults, and also provides further support for a lack of an influence of mobile phone-like exposure on cognitive performance. SIGNIFICANCE: Adolescents do not appear to be more sensitive than adults to mobile phone RF EMF emissions.

Lourencini da Silva R , Albano F, Lopes dos Santos LR , Tavares AD, Felzenszwalb I, The effect of electromagnetic field exposure on the formation of DNA lesions. Redox Rep 5(5):299-301, 2000.

In an attempt to determine whether electromagnetic field (EMF) exposure might lead to DNA damage, we exposed SnCl2-treated pBR322 plasmids to EMF and analysed the resulting conformational changes using agarose gel electrophoresis. An EMF-dependent potentiation of DNA scission (i.e. the appearance of relaxed plasmids) was observed. In confirmation of this, plasmids pre-exposed to EMF also were less capable of transforming Escherichia coli. The results indicate that EMF, in the presence of a transition metal, is capable of causing DNA damage. These observations support the idea that EMF, probably through secondary generation of reactive oxygen species, can be clastogenic and provide a possible explanation for the observed correlation between EMF exposure and the frequency of certain types of cancers in humans.

Lowden A, Akerstedt T, Ingre M, Wiholm C, Hillert L, Kuster N, Nilsson JP, Arnetz B. Sleep after mobile phone exposure in subjects with mobile phone-related symptoms. Bioelectromagnetics. 32(1):4-14, 2011.

Several studies show increases in activity for certain frequency bands (10-14 Hz) and visually scored parameters during sleep after exposure to radiofrequency electromagnetic fields. A shortened REM latency has also been reported. We investigated the effects of a double-blind radiofrequency exposure (884 MHz, GSM signaling standard including non-DTX and DTX mode, time-averaged 10 g psSAR of 1.4 W/kg) on self-evaluated sleepiness and objective EEG measures during sleep. Forty-eight subjects (mean age 28 years) underwent 3 h of controlled exposure (7:30-10:30 PM; active or sham) prior to sleep, followed by a full-night polysomnographic recording in a sleep laboratory. The results demonstrated that following exposure, time in Stages 3 and 4 sleep (SWS, slow-wave sleep) decreased by 9.5 min (12%) out of a total of 78.6 min, and time in Stage 2 sleep increased by 8.3 min (4%) out of a total of 196.3 min compared to sham. The latency to Stage 3 sleep was also

prolonged by 4.8 min after exposure. Power density analysis indicated an enhanced activation in the frequency ranges 0.5-1.5 and 5.75-10.5 Hz during the first 30 min of Stage 2 sleep, with 7.5-11.75 Hz being elevated within the first hour of Stage 2 sleep, and bands 4.75-8.25 Hz elevated during the second hour of Stage 2 sleep. No pronounced power changes were observed in SWS or for the third hour of scored Stage 2 sleep. No differences were found between controls and subjects with prior complaints of mobile phone-related symptoms. The results confirm previous findings that RF exposure increased the EEG alpha range in the sleep EEG, and indicated moderate impairment of SWS. Furthermore, reported differences in sensitivity to mobile phone use were not reflected in sleep parameters.

Lu L, Xu H, Wang X, Guo G.Increased nitric oxide synthase activity is essential for electromagnetic-pulse-induced blood-retinal barrier breakdown in vivo.Brain Res. 1264:104-10, 2009.

PURPOSE: To examine whether electromagnetic pulses (EMPs) affected the permeability of the blood-retinal barrier (BRB), gene expression of occludin and activity of nitric oxide synthase (NOS).**METHODS:** Sprague-Dawley (SD) rats were used and randomized into EMP and control groups. Retinas were removed immediately, and 2 h or 24 h after EMP radiation. BRB permeability was analyzed by transmission electron microscopy and Evans Blue staining. Retinal NOS activity and concentrations of nitrite and nitrate were measured. Occludin mRNA and protein levels were detected by RT-PCR and Western blotting.**RESULTS:** Exposure of SD rats to EMP resulted in increased BRB permeability, with the greatest decrease in occludin at 24 h. Moreover, this permeability defect was also correlated with significant increases in the formation of NO and induction of NOS activity in SD rats. Furthermore, we found that treatment with NOS inhibitor N-nitro-L-arginine methyl ester (L-NAME) blocked BRB breakdown and prevented the increase in NO formation and induction of NOS activity, as well as the decrease in occluding expression.**CONCLUSION:** Taken together, these results support the view that NOS-dependent NO production is an important factor that contributes to EMP-induced BRB dysfunction, and suggests that NOS induction may play an important role in BRB breakdown.

Lu ST, Mathur SP, Akyel Y, Lee JC, Ultrawide-band electromagnetic pulses induced hypotension in rats. Physiol Behav 65(4-5):753-761, 1999; Corrected and republished in Physiol Behav;67(3):753-761, 1999.

The ultrawide-band (UWB) electromagnetic pulses are used as a new modality in radar technology. Biological effects of extremely high peak E-field, fast rise time, ultrashort pulse width, and ultrawide band have not been investigated heretofore due to the lack of animal exposure facilities. A new biological effects database is needed to establish personnel protection guidelines for these new type of radiofrequency radiation. Functional indices of the cardiovascular system (heart rate, systolic, mean, and diastolic pressures) were selected to represent biological end points that may be susceptible to the UWB radiation. A noninvasive tail-cuff photoelectric sensor sphygmomanometer was used. Male Wistar-Kyoto rats were subjected to sham exposure, 0.5-kHz (93 kV/m, 180 ps rise time, 1.00 ns pulse width, whole-body averaged specific absorption rate, SAR = 70

mW/kg) or a 1-kHz (85 kV/m, 200 ps rise time, 1.03 ns pulse width, SAR = 121 mW/kg) UWB fields in a tapered parallel plate GTEM cell for 6 min. Cardiovascular functions were evaluated from 45 min to 4 weeks after exposures. Significant decrease in arterial blood pressures (hypotension) was found. In contrast, heart rate was not altered by these exposures. The UWB radiation-induced hypotension was a robust, consistent, and persistent effect.

Lu ST, Mathur SP, Stuck B, Zwick H, D'Andrea JA, Ziriax JM, Merritt JH, Lutty G, McLeod DS, Johnson M, Effects of high peak power microwaves on the retina of the rhesus monkey. Bioelectromagnetics 21(6):439-454, 2000.

We studied the retinal effects of 1.25 GHz high peak power microwaves in Rhesus monkeys. Preexposure fundus photographs, retinal angiograms, and electroretinograms (ERG) were obtained to screen for normal ocular structure and function and, after exposure, as endpoints of the study. Histopathology of the retina was an additional endpoint. Seventeen monkeys were randomly assigned to receive sham exposure or pulsed microwave exposures. Microwaves were delivered anteriorly to the face at 0, 4.3, 8.4, or 20.2 W/kg spatially and temporally averaged retinal specific absorption rates (R-SAR). The pulse characteristics were 1.04 MW (approximately 1.30 MW/kg temporal peak R-SAR), 5.59 &mgr;s pulse length at 0, 0.59, 1. 18, and 2.79 Hz pulse repetition rates. Exposure was 4 h per day and 3 days per week for 3 weeks, for a total of nine exposures. The preexposure and postexposure fundus pictures and angiograms were all within normal limits. The response of cone photoreceptors to light flash was enhanced in monkeys exposed at 8.4 or 20.2 W/kg R-SAR, but not in monkeys exposed at 4.3 W/kg R-SAR. Scotopic (rod) response, maximum (combined cone and rod) response, and Naka-Rushton R(max) and log K of scotopic b-waves were all within normal range. Retinal histopathology revealed the presence of enhanced glycogen storage in photoreceptors among sham (2/5), 8.4 W/kg (3/3), and 20.2 W/kg (2/5) exposed monkeys, while enhanced glycogen storage was not observed in the 4.3 W/kg (0/4) exposed group. Supranormal cone photoreceptor b-wave was R-SAR dependent and may be an early indicator of mild injury. However no evidence of degenerative changes and ERG depression was seen. We concluded that retinal injury is very unlikely at 4 W/kg. Functional changes that occur at higher R-SAR are probably reversible since we saw no evidence of histopathologic correlation with ERG changes.

Lu ST, D'Andrea J, Chalfin S, Crane C, Marchello D, Garay R, Hatcher D, Ziriax J. Absence of corneal endothelium injury in non-human primates treated with and without ophthalmologic drugs and exposed to 2.8 GHz pulsed microwaves. Bioelectromagnetics.31(4):324-333,2010.

Microwave-induced corneal endothelial damage was reported to have a low threshold (2.6 W/kg), and vasoactive ophthalmologic medications lowered the threshold by a factor of 10-0.26 W/kg. In an attempt to confirm these observations, four adult male Rhesus monkeys (Macaca mulatta) under propofol anesthesia were exposed to pulsed microwaves in the far field of a 2.8 GHz signal (1.43 +/- 0.06 micros pulse width, 34 Hz pulse repetition frequency, 13.0 mW/cm(2) spatial and temporal average, and 464 W/cm(2) spatial and temporal peak (291 W/cm(2) square wave

equivalent) power densities). Corneal-specific absorption rate was 5.07 W/kg (0.39 W/kg/mW/cm(2)). The exposure resulted in a 1.0-1.2 degrees C increase in eyelid temperature. In Experiment I, exposures were 4 h/day, 3 days/week for 3 weeks (nine exposures and 36 h total). In Experiment II, these subjects were pretreated with 0.5% Timolol maleate and 0.005% Xalatan(R) followed by 3 or 7 4-h pulsed microwave exposures. Under ketamine-xylazine anesthesia, a non-contact specular microscope was used to obtain corneal endothelium images, corneal endothelial cell density, and pachymetry at the center and four peripheral areas of the cornea. Ophthalmologic measurements were done before and 7, 30, 90, and 180 days after exposures. Pulsed microwave exposure did not cause alterations in corneal endothelial cell density and corneal thickness with or without ophthalmologic drugs. Therefore, previously reported changes in the cornea exposed to pulsed microwaves were not confirmed at exposure levels that are more than an order of magnitude higher.

Lu X, Oda M, Ohba T, Mitsubuchi H, Masuda S, Katoh T. Association of excessive mobile phone use during pregnancy with birth weight: an adjunct study in Kumamoto of Japan Environment and Children's Study. Environ Health Prev Med. 22(1):52, 2017.

BACKGROUND: Low birth weight has been shown to be closely associated with neonatal mortality and morbidity, inhibited growth, poor cognitive development, and chronic diseases later in life. Some studies have also shown that excessive mobile phone use in the postnatal period may lead to behavioral complications in the children during their growing years; however, the relationship between mobile phone use during pregnancy and neonatal birth weight is not clear. The aim of the present study was to determine the associations of excessive mobile phone use with neonatal birth weight and infant health status. METHODS: A sample of 461 mother and child pairs participated in a survey on maternal characteristics, infant characteristics, and maternal mobile phone usage information during pregnancy. RESULTS: Our results showed that pregnant women tend to excessively use mobile phones in Japan. The mean infant birth weight was lower in the excessive use group than in the ordinary use group, and the frequency of infant emergency transport was significantly higher in the excessive use group than in the ordinary use group. CONCLUSIONS: Excessive mobile phone use during pregnancy may be a risk factor for lower birth weight and a high rate of infant emergency transport.

Lu Y, Xu S, He M, Chen C, Zhang L, Liu C, Chu F, Yu Z, Zhou Z, Zhong M. Glucose administration attenuates spatial memory deficits induced by chronic low-power-density microwave exposure. Physiol Behav. 106(5):631-637, 2012.

Extensive evidence indicates that glucose administration attenuates memory deficits in rodents and humans, and cognitive impairment has been associated with reduced glucose metabolism and uptake in certain brain regions including the hippocampus. In the present study, we investigated whether glucose treatment attenuated memory deficits caused by chronic low-power-density microwave (MW) exposure, and the effect of MW exposure on hippocampal glucose uptake. We exposed Wistar rats to

2.45 GHz pulsed MW irradiation at a power density of 1 mW/cm(2) for 3 h/day, for up to 30 days. MW exposure induced spatial learning and memory impairments in rats. Hippocampal glucose uptake was also reduced by MW exposure in the absence or presence of insulin, but the levels of blood glucose and insulin were not affected. However, these spatial memory deficits were reversed by systemic glucose treatment. Our results indicate that glucose administration attenuates the spatial memory deficits induced by chronic low-power-density MW exposure, and reduced hippocampal glucose uptake may be associated with cognitive impairment caused by MW exposure.

Lu Y, Yu J, Ren Y, Dielectric properties of human red blood cells in suspension at radio frequencies. Bioelectromagnetics 15(6):589-591, 1994.

Dielectric properties of human red blood cells (RBCs) in suspension (hematocrit 50%) from 243 healthy persons (120 males, 123 females) were measured at 25 degrees C in a frequency range of 1-500 MHz, with a coaxial transmission line reflection method (one-side measurement). The measuring system, controlled by an IBM-PC computer, was composed of a network analyzer (HP4195A), an impedance test adapter (HP41951-61001), a coaxial line sensor, and a temperature-controlling set. The data measured revealed a statistically significant age dependence, with a critical age of about 49 years, above which permittivity and conductivity of human RBCs in suspension decreased significantly.

Lu Y, He M, Zhang Y, Xu S, Zhang L, He Y, Chen C, Liu C, Pi H, Yu Z, Zhou Z. Differential Pro-Inflammatory Responses of Astrocytes and Microglia Involve STAT3 Activation in Response to 1800 MHz Radiofrequency Fields. PLoS One. 2014 Oct 2;9(9):e108318. doi: 10.1371/journal.pone.0108318.

Microglia and astrocytes play important role in maintaining the homeostasis of central nervous system (CNS). Several CNS impacts have been postulated to be associated with radiofrequency (RF) electromagnetic fields exposure. Given the important role of inflammation in neural physiopathologic processes, we investigated the pro-inflammatory responses of microglia and astrocytes and the involved mechanism in response to RF fields. Microglial N9 and astroglial C8-D1A cells were exposed to 1800 MHz RF for different time with or without pretreatment with STAT3 inhibitor. Microglia and astrocytes were activated by RF exposure indicated by up-regulated CD11b and glial fibrillary acidic protein (GFAP). However, RF exposure induced differential pro-inflammatory responses in astrocytes and microglia, characterized by different expression and release profiles of IL-1β, TNF-α, IL-6, PGE2, nitric oxide (NO), inducible nitric oxide synthase (iNOS) and cyclooxygenase 2 (COX2). Moreover, the RF exposure activated STAT3 in microglia but not in astrocytes. Furthermore, the STAT3 inhibitor Stattic ameliorated the RF-induced release of pro-inflammatory cytokines in microglia but not in astrocytes. Our results demonstrated that RF exposure differentially induced pro-inflammatory responses in microglia and astrocytes, which involved differential activation of STAT3 in microglia and astrocytes. Our data provide novel insights into the potential mechanisms of the reported

CNS impacts associated with mobile phone use and present STAT3 as a promising target to protect humans against increasing RF exposure.

Lu YS, Huang BT, Huang YX.Reactive oxygen species formation and apoptosis in human peripheral blood mononuclear cell induced by 900MHz mobile phone radiation.Oxid Med Cell Longev. 2012:740280, 2012.

We demonstrate that reactive oxygen species (ROS) plays an important role in the process of apoptosis in human peripheral blood mononuclear cell (PBMC) which is induced by the radiation of 900MHz radiofrequency electromagnetic field (RFEMF) at a specific absorption rate (SAR) of ~0.4 W/kg when the exposure lasts longer than two hours. The apoptosis is induced through the mitochondrial pathway and mediated by activating ROS and caspase-3, and decreasing the mitochondrial potential. The activation of ROS is triggered by the conformation disturbance of lipids, protein, and DNA induced by the exposure of GSM RFEMF. Although human PBMC was found to have a self-protection mechanism of releasing carotenoid in response to oxidative stress to lessen the further increase of ROS, the imbalance between the antioxidant defenses and ROS formation still results in an increase of cell death with the exposure time and can cause about 37% human PBMC death in eight hours.

Lukac N, Massanyi P, Roychoudhury S, Capcarova M, Tvrda E, Knazicka Z, Kolesarova A, Danko J. In vitro effects of radiofrequency electromagnetic waves on bovine spermatozoa motility. J Environ Sci Health A Tox Hazard Subst Environ Eng. 46(12):1417-1423, 2011.

In this study the effects of 1800 MHz GSM-like radiofrequency electromagnetic waves (RF-EMW) exposure on bovine semen was monitored. The experimental samples were analyzed in vitro in four time periods (0, 30, 120 and 420 min) and compared with unexposed samples (control). Spermatozoa motility was determined by computer assisted semen analyzer (CASA). Evaluation of the percentage of motile spermatozoa showed significant ($P < 0.001$) decrease in experimental groups after 120 and 420 min of culture when exposed to microwaves, in comparison to control. Similar spermatozoa motility inhibition was detected for the percentage of progressively motile spermatozoa, too. Average path distance decreased significantly ($p < 0.001$) in experimental groups after 30 and 420 min of culture. Path velocity increased in the experimental groups exposed to RF-EMW after 30 minutes of culture, but subsequently decreased after 420 min of culture, in comparison to control. This indicates a possible initial stimulation and subsequent velocity inhibition of bovine spermatozoa under RF-EMW exposure. Changes in spermatozoa motility were also detected for some fine parameters, too. A significant decrease ($P < 0.001$) was noted for amplitude of lateral head displacement in the experimental group after 420 minutes of culture. Detailed in vitro motility analysis of bovine spermatozoa exposed to microwave radiation suggested that the parameters of path and velocity at the beginning of the culture significantly increase, but after longer culture (420 minutes) a significant decrease occur in the experimental group as compared to

control. In general, results of this experiment indicate a negative time-dependent effect of 1800 MHz RF-EMW radiation on bovine spermatozoa motility.

Luo Q, Jiang Y, Jin M, Xu J, Huang HF. Proteomic Analysis on the Alteration of Protein Expression in the Early-Stage Placental Villous Tissue of Electromagnetic Fields Associated With Cell Phone Exposure. Reprod Sci. 2013 Feb 18. [Epub ahead of print]

Background:To explore the possible adverse effects and search for cell phone electromagnetic field (EMF)-responsive proteins in human early reproduction, a proteomics approach was employed to investigate the changes in protein expression profile induced by cell phone EMF in human chorionic tissues of early pregnancy in vivo.Methods:Volunteer women about 50 days pregnant were exposed to EMF at the average absorption rate of 1.6 to 8.8 W/kg for 1 hour with the irradiation device placed 10 cm away from the umbilicus at the midline of the abdomen. The changes in protein profile were examined using 2-dimensional electrophoresis (2-DE).Results:Up to 15 spots have yielded significant change at least 2- to 2.5-folds up or down compared to sham-exposed group. Twelve proteins were identified- procollagen-proline, eukaryotic translation elongation factor 1 delta, chain D crystal structure of human vitamin D-binding protein, thioredoxin-like 3, capping protein, isocitrate dehydrogenase 3 alpha, calumenin, Catechol-O-methyltransferase protein, proteinase inhibitor 6 (PI-6; SerpinB6) protein, 3,2-trans-enoyl-CoA isomerase protein, chain B human erythrocyte 2,3-bisphosphoglycerate mutase, and nucleoprotein.Conclusion:Cell phone EMF might alter the protein profile of chorionic tissue of early pregnancy, during the most sensitive stage of the embryos. The exposure to EMF may cause adverse effects on cell proliferation and development of nervous system in early embryos. Furthermore, 2-DE coupled with mass spectrometry is a promising approach to elucidate the effects and search for new biomarkers for environmental toxic effects.

Luo YP, Ma HR, Chen JW, Li JJ, Li CX. [Effect of American Ginseng Capsule on the liver oxidative injury and the Nrf2 protein expression in rats exposed by electromagnetic radiation of frequency of cell phone.] [Article in Chinese]. Zhongguo Zhong Xi Yi Jie He Za Zhi. 34(5):575-580, 2014. (In Chinese)

OBJECTIVE: To observe the effect of American Ginseng Capsule (AGC) on the liver oxidative injury and the Nrf2 protein expression in the liver tissue of rats exposed by 900 MHz cell phone electromagnetic radiation. METHODS: Totally 40 male SD rats were randomly divided into the normal control group, the model group, the Shuifei Jibin Capsule (SJC) group, and the AGC group,10 in each group. Rats in the normal control group were not irradiated. Rats in the rest three groups were exposed by imitated 900 MHz cellular phone for 4 h in 12 consecutive days. Meanwhile, rats in the SJC group and the AGC group were intragastrically administrated with suspension of SJC and AGC (1 mL/200 g body weight) respectively. Normal saline was administered to rats in the normal control group and the model group. The histolomorphological changes of the liver tissue were observed by HE staining. Contents of malonic dialdehyde (MDA), superoxide dismutase (SOD), glutathione (GSH), and glutathione peroxidase (GSH-PX)were

detected by colorimetry. The Nrf2 protein expression of hepatocytes was detected by immunohistochemical assay and Western blot. RESULTS: Compared with the normal control group, hepatocyte nucleus was atrophied or partially disappeared, the contents of liver MDA and Nrf2 protein obviously increased (P <0. 05, P <0. 01); contents of liver SOD and GSH decreased (P <0. 05) in the model group. Compared with the model group, karyopyknosis was obviously attenuated and approached to the normal level in the SJC group and the AGC group. The contents of liver MDA and Nrf2 protein expression decreased (P <0. 05), and the contents of liver SOD, GSH, and GSH-PX obviously increased (P < 0.05) in the SJC group. The contents of liver MDA and the Nrf2 protein expression decreased (P < 0.05), and contents of SOD and GSH obviously increased in the AGC group (P <0.01, P <0.05). CONCLUSIONS: The electromagnetic radiation induced by 900 MHz cell phone could affect the expression of Nrf2 protein, induce oxidative injury, and induce abnormal morphology of liver cells. SJC and AGC could promote the morphological recovery of the liver cells. Its mechanism might be related to affecting the expression of Nrf2 protein and attenuating oxidative damage of liver cells.

Luria R, Eliyahu I, Hareuveny R, Margaliot M, Meiran N. Cognitive effects of radiation emitted by cellular phones: the influence of exposure side and time.Bioelectromagnetics. 30(3):198-204, 2009.

This study examined the time dependence effects of exposure to radiofrequency radiation (RFR) emitted by standard GSM cellular phones on the cognitive functions of humans. A total of 48 healthy right-handed male subjects performed a spatial working memory task (that required either a left-hand or a right-hand response) while being exposed to one of two GSM phones placed at both sides of the head. The subjects were randomly divided into three groups. Each group was exposed to one of three exposure conditions: left-side of the head, right-side, or sham-exposure. The experiment consisted of 12 blocks of trials. Response times (RTs) and accuracy of the responses were recorded. It was found that the average RT of the right-hand responses under left-side exposure condition was significantly longer than those of the right-side and sham-exposure groups averaged together during the first two time blocks.These results confirmed the existence of an effect of exposure on RT, as well as the fact that exposure duration (together with the responding hand and the side of exposure) may play an important role in producing detectable RFR effects on performance. Differences in these parameters might be the reason for the failure of certain studies to detect or replicate RFR effects.

Lushnikov KV, Gapeev AB, Sadovnikov VB, Cheremis NK. [Effect of extremely high frequency electromagnetic radiation of low intensity on parameters of humoral immunity in healthy mice.] Biofizika 46(4):753-760, 2001. [Article in Russian]

The modification of indices of the humoral immune response to thymus-dependent antigen (sheep erythrocytes) after a whole-body exposure of healthy mice to low-intensity extremely-high-frequency electromagnetic radiation was studied. Male NMRI mice were exposed in the far-field zone of horn antenna at a frequency of 42.0 GHz and energy flux density of 0.15 mW/cm2 under different regimes: once for 20 min, for 20 min daily during 5 and 20 successive days before immunization, and for 20 min daily during 5 successive

days after immunization throughout the development of the humoral immune response. The intensity of the humoral immune response was estimated on day 5 after immunization by the number of antibody-forming cells of the spleen and antibody titers. Changes in cellularity of the spleen, thymus and red bone marrow were also assessed. The indices of humoral immunity and cellularity of lymphoid organs changed insignificantly after acute exposure and series of 5 exposures before and after immunization of the animals. However, after repeated exposures for 20 days before immunization, a statistically significant reduction of thymic cellularity by 17.5% ($p < 0.05$) and a decrease in cellularity of the spleen by 14.5% ($p < 0.05$) were revealed. The results show that low-intensity extremely-high-frequency electromagnetic radiation with the frequency and energy flux density used does not influence the humoral immune response intensity in healthy mice but influences immunogenesis under multiple repeated exposures.

Lustenberger C, Murbach M, Dürr R, Schmid MR, Kuster N, Achermann P, Huber R. Stimulation of the brain with radiofrequency electromagnetic field pulses affects sleep-dependent performance improvement. Brain Stimul. 6(5):805-811, 2013.

BACKGROUND: Sleep-dependent performance improvements seem to be closely related to sleep spindles (12-15 Hz) and sleep slow-wave activity (SWA, 0.75-4.5 Hz). Pulse-modulated radiofrequency electromagnetic fields (RF EMF, carrier frequency 900 MHz) are capable to modulate these electroencephalographic (EEG) characteristics of sleep. OBJECTIVE: The aim of our study was to explore possible mechanisms how RF EMF affect cortical activity during sleep and to test whether such effects on cortical activity during sleep interact with sleep-dependent performance changes. METHODS: Sixteen male subjects underwent 2 experimental nights, one of them with all-night 0.25-0.8 Hz pulsed RF EMF exposure. All-night EEG was recorded. To investigate RF EMF induced changes in overnight performance improvement, subjects were trained for both nights on a motor task in the evening and the morning. RESULTS: We obtained good sleep quality in all subjects under both conditions (mean sleep efficiency > 90%). After pulsed RF EMF we found increased SWA during exposure to pulse-modulated RF EMF compared to sham exposure ($P < 0.05$) toward the end of the sleep period. Spindle activity was not affected. Moreover, subjects showed an increased RF EMF burst-related response in the SWA range, indicated by an increase in event-related EEG spectral power and phase changes in the SWA range. Notably, during exposure, sleep-dependent performance improvement in the motor sequence task was reduced compared to the sham condition (-20.1%, $P = 0.03$). CONCLUSION: The changes in the time course of SWA during the exposure night may reflect an interaction of RF EMF with the renormalization of cortical excitability during sleep, with a negative impact on sleep-dependent performance improvement.

Lustenberger, C., Murbach, M., Tüshaus, L., Wehrle, F., Kuster, N., Achermann, P. and Huber, R. (2015), Inter-individual and intra-individual variation of the effects of pulsed RF EMF exposure on the human sleep EEG. Bioelectromagnetics. doi: 10.1002/bem.21893. First published online Feb 17, 2015.

Pulse-modulated radiofrequency electromagnetic fields (RF EMF) can alter brain activity

during sleep; increases of electroencephalographic (EEG) power in the sleep spindle (13.75–15.25 Hz) and delta-theta (1.25–9 Hz) frequency range have been reported. These field effects show striking inter-individual differences. However, it is still unknown whether individual subjects react in a similar way when repeatedly exposed. Thus, our study aimed to investigate inter-individual variation and intra-individual stability of field effects. To do so, we exposed 20 young male subjects twice for 30 min prior to sleep to the same amplitude modulated 900 MHz (2 Hz pulse, 20 Hz Gaussian low-pass filter and a ratio of peak-to-average of 4) RF EMF (spatial peak absorption of 2 W/kg averaged over 10 g) 2 weeks apart. The topographical analysis of EEG power during all-night non-rapid eye movement sleep revealed: (1) exposure-related increases in delta-theta frequency range in several fronto-central electrodes; and (2) no differences in spindle frequency range. We did not observe reproducible within-subject RF EMF effects on sleep spindle and delta-theta activity in the sleep EEG and it remains unclear whether a biological trait of how the subjects' brains react to RF EMF exists.

Luukkonen J, Hakulinen P, Mäki-Paakkanen J, Juutilainen J, Naarala J. Enhancement of chemically induced reactive oxygen species production and DNA damage in human SH-SY5Y neuroblastoma cells by 872MHz radiofrequency radiation. Mutat Res. 662(1-2):54-58, 2009.

The objective of the study was to investigate effects of 872MHz radiofrequency (RF) radiation on intracellular reactive oxygen species (ROS) production and DNA damage at a relatively high SAR value (5W/kg). The experiments also involved combined exposure to RF radiation and menadione, a chemical inducing intracellular ROS production and DNA damage. The production of ROS was measured using the fluorescent probe dichlorofluorescein and DNA damage was evaluated by the Comet assay. Human SH-SY5Y neuroblastoma cells were exposed to RF radiation for 1h with or without menadione. Control cultures were sham exposed. Both continuous waves (CW) and a pulsed signal similar to that used in global system for mobile communications (GSM) mobile phones were used. Exposure to the CW RF radiation increased DNA breakage ($p<0.01$) in comparison to the cells exposed only to menadione. Comparison of the same groups also showed that ROS level was higher in cells exposed to CW RF radiation at 30 and 60min after the end of exposure ($p<0.05$ and $p<0.01$, respectively). No effects of the GSM signal were seen on either ROS production or DNA damage. The results of the present study suggest that 872MHz CW RF radiation at 5W/kg might enhance chemically induced ROS production and thus cause secondary DNA damage. However, there is no known mechanism that would explain such effects from CW RF radiation but not from GSM modulated RF radiation at identical SAR.

Luukkonen J, Juutilainen J, Naarala J. Combined effects of 872 MHz radiofrequency radiation and ferrous chloride on reactive oxygen species production and DNA damage in human SH-SY5Y neuroblastoma cells. Bioelectromagnetics. 31(6):417-424, 2010.

The aim of the present study was to investigate possible cooperative effects of radiofrequency (RF) radiation and ferrous chloride (FeCl(2)) on reactive oxygen species (ROS) production and DNA damage. In order to test intracellular ROS production as a possible underlying mechanism of DNA damage, we applied the

fluorescent probe DCFH-DA. Integrity of DNA was quantified by alkaline comet assay. The exposures to 872 MHz RF radiation were conducted at a specific absorption rate (SAR) of 5 W/kg using continuous waves (CW) or a modulated signal similar to that used in Global System for Mobile Communications (GSM) phones. Four groups were included: (1) Sham exposure (control), (2) RF radiation, (3) Chemical treatment, (4) Chemical treatment, and RF radiation. In the ROS production experiments, human neuroblastoma (SH-SY5Y) cells were exposed to RF radiation and 10 microg/ml FeCl(2) for 1 h. In the comet assay experiments, the exposure time was 3 h and an additional chemical (0.015% diethyl maleate) was used to make DNA damage level observable. The chemical treatments resulted in statistically significant responses, but no effects from either CW or modulated RF radiation were observed on ROS production, DNA damage or cell viability.

Lv B, Chen Z, Wu T, Shao Q, Yan D, Ma L, Lu K, Xie Y. The alteration of spontaneous low frequency oscillations caused by acute electromagnetic fields exposure. Clin Neurophysiol. 2013 Sep 4. pii: S1388-2457(13)00976-0. doi: 10.1016/j.clinph.2013.07.018. [Epub ahead of print]

OBJECTIVE: The motivation of this study is to evaluate the possible alteration of regional resting state brain activity induced by the acute radiofrequency electromagnetic field (RF-EMF) exposure (30min) of Long Term Evolution (LTE) signal. METHODS: We designed a controllable near-field LTE RF-EMF exposure environment. Eighteen subjects participated in a double-blind, crossover, randomized and counterbalanced experiment including two sessions (real and sham exposure). The radiation source was close to the right ear. Then the resting state fMRI signals of human brain were collected before and after the exposure in both sessions. We measured the amplitude of low frequency fluctuation (ALFF) and fractional ALFF (fALFF) to characterize the spontaneous brain activity. RESULTS: We found the decreased ALFF value around in left superior temporal gyrus, left middle temporal gyrus, right superior temporal gyrus, right medial frontal gyrus and right paracentral lobule after the real exposure. And the decreased fALFF value was also detected in right medial frontal gyrus and right paracentral lobule. CONCLUSIONS: The study provided the evidences that 30min LTE RF-EMF exposure modulated the spontaneous low frequency fluctuations in some brain regions. SIGNIFICANCE: With resting state fMRI, we found the alteration of spontaneous low frequency fluctuations induced by the acute LTE RF-EMF exposure.

Lv B, Su C, Yang L, Xie Y, Wu T. Whole brain EEG synchronization likelihood modulated by long term evolution electromagnetic fields exposure. Conf Proc IEEE Eng Med Biol Soc. 2014:986-989, 2014.

In this paper, we aimed to investigate the possible interactions between human brain and radiofrequency electromagnetic fields (EMF) with electroencephalogram (EEG) technique. Unlike the previous studies which mainly focused on EMF effect on local brain activities, we attempted to evaluate whether the EMF emitted from Long Term Evolution (LTE) devices can modulate the functional connectivity of brain electrical activities. Ten subjects were recruited to participate in a crossover, double-blind exposure experiment which included two sessions (real and sham exposure). In each session, LTE EMF

exposure (power on or off) lasted for 30 min and the EEG signals were collected with 32 channels throughout the experiment. Then we applied the synchronization likelihood method to quantify the neural synchronization over the whole brain in different frequency bands and in different EEG record periods. Our results illustrated that the short-term LTE EMF exposure would modulate the synchronization patterns of EEG activation across the whole brain.

Ma HR, Ma ZH, Wang GY, Song CM, Ma XL, Cao XH, Zhang GH. Impacts of exposure to 900 MHz mobile phone radiation on liver function in rats. Zhongguo Ying Yong Sheng Li Xue Za Zhi. 31(6):567-571, 2015.

OBJECTIVE: To study the impacts of exposure to electromagnetic radiation (EMR) on liver function in rats. METHODS: Twenty adult male Sprague-Dawley rats were randomly divided into normal group and radiated group. The rats in normal group were not radiated, those in radiated group were exposed to EMR 4 h/ d for 18 consecutive days. Rats were sacrificed immediately after the end of the experiment. The serum levels of alanine aminotransferase (ALT) and aspartate aminotransferase (AST), and those of malondialdehyde (MDA) and glutathione (GSH) in liver tissue were evaluated by colorimetric method. The liver histopathological changes were observed by hematoxylin and eosin staining and the protein expression of bax and bcl- 2 in liver tissue were detected by immunohistochemical method. Terminal-deoxynucleotidyl transferase mediated nick and labelling (TUNEL) method was used for analysis of apoptosis in liver. RESULTS: Compared with the normal rats, the serum levels of ALT and AST in the radiated group had no obvious changes ($P>0.05$), while the contents of MDA increased ($P < 0.01$) and those of GSH decreased ($P < 0.01$) in liver tissues. The histopathology examination showed diffuse hepatocyte swelling and vacuolation, small pieces and focal necrosis. The immunohistochemical results displayed that the expression of the bax protein was higher and that of bcl-2 protein was lower in radiated group. The hepatocyte apoptosis rates in radiated group was higher than that in normal group (all $P < 0.01$). CONCLUSION: The exposure to 900 MHz mobile phone 4 h/d for 18 days could induce the liver histological changes, which may be partly due to the apoptosis and oxidative stress induced in liver tissue by electromagnetic radiation.

Maaroufi K, Save E, Poucet B, Sakly M, Abdelmelek H, Had-Aissouni L. Oxidative stress and prevention of the adaptive response to chronic iron overload in the brain of young adult rats exposed to a 150 kilohertz electromagnetic field. Neuroscience. 186:39-47, 2011.

Iron surcharge may induce an oxidative stress-based decline in several neurological functions. In addition, electromagnetic fields (EMF) of frequencies up to about 100 kHz, emitted by electric/electronic devices, have been suggested to enhance free radical production through an iron dependent pathway. The purpose of this study was therefore to determine a possible relationship between iron status, exposure to EMF, and brain oxidative stress in young adult rats. Samples were micro-dissected from prefrontal cortex, hippocampus, striatum, and cerebellum after chronic saline or iron overload (IO) as well as after chronic sham exposure or exposure to a 150 kHz EMF or after combining EMF exposure with IO. The brain samples were used to monitor

oxidative stress-induced lipid peroxidation and activity of the antioxidant enzymes superoxide dismutase and catalase. While IO did not induce any oxidative stress in young adult rats, it stimulated antioxidant defenses in the cerebellum and prefrontal cortex in particular. On the contrary, EMF exposure stimulated lipid peroxidation mainly in the cerebellum, without affecting antioxidant defenses. When EMF was coapplied with IO, lipid peroxidation was further increased as compared to EMF alone while the increase in antioxidant defenses triggered by the sole IO was abolished. These data suggest that EMF exposure may be harmful in young adults by impairing the antioxidant defenses directed at preventing iron-induced oxidative stress.

Maaroufi K, Had-Aissouni L, Melon C, Sakly M, Abdelmelek H, Poucet B, Save E. Spatial learning, monoamines and oxidative stress in rats exposed to 900MHz electromagnetic field in combination with iron overload. Behav Brain Res. 2013 Oct 18. pii: S0166-4328(13)00624-4. doi: 10.1016/j.bbr.2013.10.016. [Epub ahead of print]

The increasing use of mobile phone technology over the last decade raises concerns about the impact of high frequency electromagnetic fields (EMF) on health. More recently, a link between EMF, iron overload in the brain and neurodegenerative disorders including Parkinson's and Alzheimer's diseases has been suggested. Co-exposure to EMF and brain iron overload may have a greater impact on brain tissues and cognitive processes than each treatment by itself. To examine this hypothesis, Long-Evans rats submitted to 900MHz exposure or combined 900MHz EMF and iron overload treatments were tested in various spatial learning tasks (navigation task in the Morris water maze, working memory task in the radial-arm maze, and object exploration task involving spatial and non spatial processing). Biogenic monoamines and metabolites (dopamine, serotonin) and oxidative stress were measured. Rats exposed to EMF were impaired in the object exploration task but not in the navigation and working memory tasks. They also showed alterations of monoamine content in several brain areas but mainly in the hippocampus. Rats that received combined treatment did not show greater behavioral and neurochemical deficits than EMF-exposed rats. None of the two treatments produced global oxidative stress. These results show that there is an impact of EMF on the brain and cognitive processes but this impact is revealed only in a task exploiting spontaneous exploratory activity. In contrast, there are no synergistic effects between EMF and a high content of iron in the brain.

Maby E, Le Bouquin Jeannes R, Liegeois-Chauvel C, Gourevitch B, Faucon G.Analysis of auditory evoked potential parameters in the presence of radiofrequency fields using a support vector machines method. Med Biol Eng Comput. 42(4):562-568, 2004.

The paper presents a study of global system for mobile (GSM) phone radiofrequency effects on human cerebral activity. The work was based on the study of auditory evoked potentials (AEPs) recorded from healthy humans and epileptic patients. The protocol allowed the comparison of AEPs recorded with or without exposure to electrical fields. Ten variables measured from AEPs were employed in the design of a supervised support vector machines classifier. The classification performance measured the classifier's ability

to discriminate features performed with or without radiofrequency exposure. Most significant features were chosen by a backward sequential selection that ranked the variables according to their pertinence for the discrimination. Finally, the most discriminating features were analysed statistically by a Wilcoxon signed rank test. For both populations, the N100 amplitudes were reduced under the influence of GSM radiofrequency (mean attenuation of -0.36 microV for healthy subjects and -0.60 microV for epileptic patients). Healthy subjects showed a N100 latency decrease (-5.23 ms in mean), which could be consistent with mild, localised heating. The auditory cortical activity in humans was modified by GSM phone radiofrequencies, but an effect on brain functionality has not been proven.

Maby E, Jeannes RL, Faucon G, Liegeois-Chauvel C, De Seze R. Effects of GSM signals on auditory evoked responses. Bioelectromagnetics. 26(5):341-350, 2005.

The article presents a study of the influence of radio frequency (RF) fields emitted by mobile phones on human cerebral activity. Our work was based on the study of Auditory Evoked Potentials (AEPs) recorded on the scalp of healthy humans and epileptic patients. The protocol allowed us to compare AEPs recorded with or without exposure to RFs. To get a reference, a control session was also introduced. In this study, the correlation coefficients computed between AEPs, as well as the correlation coefficients between spectra of AEPs were investigated to detect a possible difference due to RFs. A difference in the correlation coefficients computed in control and experimental sessions was observed, but it was difficult to deduce the effect of RFs on human health.

Maby E, Jeannes Rle B, Faucon G. Scalp localization of human auditory cortical activity modified by GSM electromagnetic fields. Int J Radiat Biol. 82(7):465-472, 2006.

Purpose: This study attempted to determine whether there is a localized effect of GSM (Global System for Mobile communications) microwaves by studying the Auditory Evoked Potentials (AEP) recorded at the scalp of nine healthy subjects and six epileptic patients.Materials and methods: We determined the influence of GSM RadioFrequency (RF) on parameters characterizing the AEP in time or/and frequency domains. A parameter selection method using SVM (Support Vector Machines)-based criteria allowed us to estimate those most altered by the radiofrequencies. The topography of the parameter modifications was computed to determine the localization of the radiofrequency influence. A statistical test was conducted for selected scalp areas, in order to determine whether there were significant localized alterations due to the RF.Results: The epileptic patients showed a lengthening of the scalp component N100 (100 ms latency) in the frontal area contralateral to the radiation, which may be due to an afferent tract alteration. For the healthy subjects, an amplitude increase of the P200 wave (200 ms latency) was identified in the frontal area.Conclusions: The present study suggests that radiofrequency fields emitted by mobile phones modify the AEP. Nevertheless, no direct link between these findings and RF-induced damages in brain function was established.

Maby E, Le Bouquin Jeannes R, Faucon G. Short-term effects of GSM mobiles phones on spectral components of the human electroencephalogram. Conf Proc IEEE Eng Med Biol Soc. 1:3751-3754, 2006.

The aim of the study was to investigate whether the GSM (global system for mobile) signals affect the electrical activity of the human brain. Nine healthy subjects and six temporal epileptic patients were exposed to radiofrequencies emitted by a GSM mobile phone signals. Electroencephalographic (EEG) signals were recorded using surface electrodes with and without radiofrequency. In order to obtain a reference, a control session was also carried out. The spectral attributes of the EEG signals recorded by surface electrodes were analyzed. The significant decrease of spectral correlation coefficients under radiofrequency influence showed that the GSM signal altered the spectral arrangement of the EEG activity for healthy subjects as well as epileptic patients. For the healthy subjects, the EEG spectral energy decreased on the studied frequency band [0-40 Hz] and more precisely on occipital electrodes for the alpha-band. For the epileptic patients, these modifications were demonstrated by an increase of the power spectral density of the EEG signal. Nevertheless, these biological effects on the EEG are not sufficient to put forward some electrophysiological hypothesis.

Maccà I, Scapellato ML, Carrieri M, Pasqua di Bisceglie A, Saia B, Bartolucci GB. Occupational exposure to electromagnetic fields in physiotherapy departments. Radiat Prot Dosimetry. 128(2):180-190, 2008.

To assess occupational exposure to electromagnetic fields, 11 microwave (MW), 4 short-wave diathermy and 15 magneto therapy devices were analysed in eight physiotherapy departments. Measurements taken at consoles and environmental mapping showed values above European Directive 2004/40/EC and ACGIH exposure limits at approximately 50 cm from MW applicators (2.45 GHz) and above the Directive magnetic field limit near the diathermy unit (27.12 MHz). Levels in front of MW therapy applicators decreased rapidly with distance and reduction in power; this may not always occur in work environments where nearby metal structures (chairs, couches, etc.) may reflect or perturb electromagnetic fields. Large differences in stray field intensities were found for various MW applicators. Measurements of power density strength around MW electrodes confirmed radiation fields between 30 degrees and 150 degrees , with a peak at 90 degrees , in front of the cylindrical applicator and maximum values between 30 degrees and 150 degrees over the whole range of 180 degrees for the rectangular parabolic applicator. Our results reveal that although most areas show substantially low levels of occupational exposure to electromagnetic fields in physiotherapy units, certain cases of over-occupational exposure limits do exist.

Maes A, Verschaeve L, Arroyo A, De Wagter C, Vercruyssen L, In vitro cytogenetic effects of 2450 MHz waves on human peripheral blood lymphocytes. Bioelectromagnetics 14(6):495-501, 1993.

Cytogenetic analyses were performed on human peripheral blood lymphocytes exposed to 2450 MHz microwaves during 30 and 120 min at a constant temperature of 36.1 degrees C (body temperature). The temperature was kept constant by means of a temperature probe put in the blood sample which gives feedback to a microcomputer that controls the microwave supply. We found a marked increase in the frequency of chromosome aberrations (including dicentric chromosomes and acentric fragments) and micronuclei. On the other hand the microwave exposure did not influence the cell kinetics nor the sister chromatid exchange (SCE) frequency.

Maes A, Collier M, Slaets D, Verschaeve L, 954 MHz microwaves enhance the mutagenic properties of mitomycin C. Environ Mol Mutagen 28(1):26-30, 1996.

This paper focuses on the combined effects of microwaves from mobile communication frequencies and a chemical DNA damaging agent mitomycin C (MMC). The investigation was performed in vitro by exposing whole blood samples to a 954 MHz emitting antenna from a GSM (Global System for Mobile Communication) base station, followed by lymphocyte cultivation in the presence of MMC. A highly reproducible synergistic effect was observed as based on the frequencies of sister chromatid exchanges in metaphase figures.

Maes A, Collier M, Van Gorp U, Vandoninck S, Verschaeve L, Cytogenetic effects of 935.2-MHz (GSM) microwaves alone and in combination with mitomycin C. Mutat Res 393(1-2):151-156, 1997.

This paper focuses on the genetic effects of microwaves from mobile communication frequencies (935.2 MHz) alone and in combination with a chemical DNA-damaging agent (mitomycin C). Three cytogenetic endpoints were investigated after in vitro exposure of human whole blood cells. These endpoints were the 'classical' chromosome aberration test, the sister chromatid exchange test and the alkaline comet assay. No direct cytogenetic effect was found. The combined exposure of the cells to the radiofrequency fields followed by their cultivation in the presence of mitomycin C revealed a very weak effect when compared to cells exposed to mitomycin C alone.

Maes A, Collier M, Verschaeve L Cytogenetic investigations on microwavesemitted by a 455.7 MHz car phone. Folia Biol (Praha) 46(5):175-180, 2000.

The chromosome aberration or sister chromatid exchange frequency was determined in 455.7 MHz microwave-exposed human lymphocytes and in lymphocytes that were subsequently exposed to MMC or X-rays. The exposure was performed by placing the cells at 5 cm from the antenna of a car phone. In this way the specific absorption ratio was approximately 6.5 W/kg. The temperature and humidity was kept constant during the experiments. No statistically significant difference was found between microwave-exposed and unexposed control samples. When the microwave exposure was followed by exposure to MMC, some differences were found between the combined treatments and the MMC treatments alone. However, there was no consistency in the results. Combined treatments with X-rays did not provide any indication of a synergistic action between the RF fields and X-rays, either. Our data therefore do not support the hypothesis that RF fields act synergistically with chemical or physical mutagens.

Maes A, Collier M, Verschaeve L Cytogenetic effects of 900 MHz (GSM) microwaves on human lymphocytes. Bioelectromagnetics 22(2):91-96, 2001

The cytogenetic effects of 900 MHz radiofrequency fields were investigated with the chromosome aberration and sister chromatid exchange frequency methods. Three different modes of exposure (continuous, pseudo-random and dummy burst) were studied for different power outputs (0, 2, 8, 15, 25, 50 W). The specific absorption rates varied between 0 and 10 W/kg. We investigated the possible effects of the 900 MHz radiation alone as well as of combined exposure to the chemical or physical mutagens mitomycin C and X-rays. Overall, no indication was found of a mutagenic, and/or co-

mutagenic/synergistic effect of this kind of nonionizing radiation.

Maes A, Van Gorp U, Verschaeve L. Cytogenetic investigation of subjects professionally exposed to radiofrequency radiation. Mutagenesis. 21(2):139-142, 2006.

Nowadays, virtually everybody is exposed to radiofrequency radiation (RFR) from mobile phone base station antennas or other sources. At least according to some scientists, this exposure can have detrimental health effects. We investigated cytogenetic effects in peripheral blood lymphocytes from subjects who were professionally exposed to mobile phone electromagnetic fields in an attempt to demonstrate possible RFR-induced genetic effects. These subjects can be considered well suited for this purpose as their RFR exposure is 'normal' though rather high, and definitely higher than that of the 'general population'. The alkaline comet assay, sister chromatid exchange (SCE) and chromosome aberration tests revealed no evidence of RFR-induced genetic effects. Blood cells were also exposed to the well known chemical mutagen mitomycin C in order to investigate possible combined effects of RFR and the chemical. No cooperative action was found between the electromagnetic field exposure and the mutagen using either the comet assay or SCE test.

Maganioti AE, Hountala CD, Papageorgiou CC, Kyprianou MA, Rabavilas AD, Capsalis CN. Principal component analysis of the P600 waveform: RF and gender effects.Neurosci Lett. 478(1):19-23, 2010.

The aim of the present study was to examine the patterns of activation of the P600 waveform of the event-related potentials (ERP), applying principal component analysis (PCA) and repeated measures ANOVA, and whether these patterns are RF and gender dependent. The ERPs of thirty-nine healthy subjects (20 male and 19 female) were recorded during an auditory memory task in the presence and absence of RF, similar to that emitted by mobile phones. Both PCA and ANOVA produced congruent results, showing that activation of the P600 component occurs early and more intensely in the region of the posterior electrodes and in a less intense manner in the central electrodes. Conversely, the activation at the anterior electrodes arises later with a considerably reduced intensity. In the absence of RF female subjects exhibited significantly lower amplitudes at anterior electrodes and earlier latencies at central electrodes than male subjects. These differences disappear in the presence of RF. Consequently, the P600 component follows distinct patterns of activation in the anterior, central and posterior brain areas and gender differences are observed simultaneously at several electrodes within these areas. Finally, the gender-related functional architecture with regard the P600 component appears to be RF sensitive. In conclusion, the application of the PCA procedure provides an adequate model of the spatially distributed event-related dynamics that correspond to the P600 waveform.

Magras, IN, Xenos, TD, RF radiation-induced changes in the prenatal development of mice. Bioelectromagnetics 18(6):455-461, 1997.

The possible effects of radiofrequency (RF) radiation on prenatal development has been investigated in mice. This study consisted of RF level measurements and in vivo

experiments at several places around an "antenna park." At these locations RF power densities between 168 nW/cm2 and 1053 nW/cm2 were measured. Twelve pairs of mice, divided in two groups, were placed in locations of different power densities and were repeatedly mated five times. One hundred eighteen newborns were collected. They were measured, weighed, and examined macro- and microscopically. A progressive decrease in the number of newborns per dam was observed, which ended in irreversible infertility. The prenatal development of the newborns, however, evaluated by the crown-rump length, the body weight, and the number of the lumbar, sacral, and coccygeal vertebrae, was improved.

Mahfouz Z, Gati A, Lautru D, Wong MF, Wiart J, Hanna VF. Influence of traffic variations on exposure to wireless signals in realistic environments.Bioelectromagnetics. 2011 Sep 29. doi: 10.1002/bem.20705. [Epub ahead of print]

In this article, the general public daily exposure to broadcast signals and Global System for Mobile Communications (GSM) or Universal Mobile Telecommunications System (UMTS) mobile telephone signals in indoor areas is investigated. Temporal variations and traffic distributions during a day at different indoor sites in urban and rural zones are presented. The goal is to analyze the real exposure compared to the maximum assessment imposed by radio protection standards and to characterize the ratio between daily and maximum theoretical values. Hence, a realistic maximum is proposed based on the statistical analysis performed using measurements. Broadcast signals remain constant over the day so they are best fitted with a Normal distribution while the mobile telephone signals depend on the traffic demand during the day so they fit a three-Gaussian distribution model. A general mask is also constructed for underlining the maximum equivalent active traffic for different periods in the day. Also, relations between the mean values over 24 h, the realistic maximal values (at 99%) and the maximal theoretical values are presented. The realistic maximum is also presented with a sliding time average of 6 min applied to the measurements in accordance with international standards. An extrapolation factor is given for the different systems to easily assess the maximum values starting from an instantaneous measurement. The extrapolation factor is also given for a broadband measurement to estimate the maximum potential exposure during the day.

Mahmoudabadi FS, Ziaei S, Firoozabadi M, Kazemnejad A. Use of mobile phone during pregnancy and the risk of spontaneous abortion. J Environ Health Sci Eng. 13:34, 2015.

BACKGROUND: Exposure to electromagnetic fields of cell phones increasingly occurs, but the potential influence on spontaneous abortion has not been thoroughly investigated. METHODS: In a case-control study, 292 women who had an unexplained spontaneous abortion at < 14 weeks gestation and 308 pregnant women > 14 weeks gestation were enrolled. Two data collection forms were completed; one was used to collect data about socioeconomic and obstetric characteristics, medical and reproductive history, and lifestyles. Another was used to collect data about the use of cell phones during pregnancy. For the consideration of cell phone effects, we measured the average calling

time per day, the location of the cell phones when not in use, use of hands-free equipment, use of phones for other applications, the specific absorption rate (SAR) reported by the manufacturer and the average of the effective SAR (average duration of calling time per day × SAR). Analyses were carried out with statistical package state software(SPSS)v.16. RESULTS: All the data pertaining to mobile phones were different between the two groups except the use of hands free devices ($p < 0.001$). CONCLUSION: Our result suggests that use of mobile phones can be related to the early spontaneous abortions.

Maier R, Greter SE, Maier N. Effects of pulsed electromagnetic fields on cognitive processes - a pilot study on pulsed field interference with cognitive regeneration. Acta Neurol Scand. 110(1):46-52, 2004.

BACKGROUND: Due to the ubiquitous use of cellular phones much has been speculated on secondary effects of electromagnetic irradiation emitted by those. Additionally, several studies have reported vegetative alterations as well as effects on the neuronal and molecular levels in humans. Here, using a psycho-physiological test paradigm, we examined effects of exposure to pulsed electromagnetic fields on cognitive performance. MATERIALS AND METHODS: In 11 volunteers, we tested cognitive processing under field exposure (GSM standard) and under field-free conditions. To examine the hypothesized effect of pulsed fields, we applied an auditory discrimination task and determined the participant's current 'Order Threshold' value. Following a first test cycle, the volunteers had to relax for 50 min while being, or not, exposed to pulsed electromagnetic fields. Subsequently, the test was repeated. Data acquired before and after the resting phase were compared from both experimental conditions. RESULTS: We found that nine of the 11 test participants (81.8%) showed worse results in their auditory discrimination performance upon field exposure as compared with control conditions. Group data comparison revealed a statistical significance of $P = 0.0105$. CONCLUSION: We could show that the participants' cognitive performance was impaired after exposure to pulsed electromagnetic fields. With regard to this finding, we recommend that the use of cellular phones should be restricted generally and in particular in respect of physical hazard of high-risk groups, e.g. elderly, children and ill people.

Mailankot M, Kunnath AP, Jayalekshmi H, Koduru B, Valsalan R. Radio frequency electromagnetic radiation (RF-EMR) from GSM (0.9/1.8GHz) mobile phones induces oxidative stress and reduces sperm motility in rats. Clinics (Sao Paulo). 64(6):561-565, 2009.

INTRODUCTION: Mobile phones have become indispensable in the daily lives of men and women around the globe. As cell phone use has become more widespread, concerns have mounted regarding the potentially harmful effects of RF-EMR from these devices. OBJECTIVE: The present study was designed to evaluate the effects of RF-EMR from mobile phones on free radical metabolism and sperm quality. MATERIALS AND METHODS: Male albino Wistar rats (10-12 weeks old) were exposed to RF-EMR from an active GSM (0.9/1.8 GHz) mobile phone for 1 hour continuously per day for 28 days. Controls were exposed to a mobile phone without a battery for the same period. The phone was kept in a cage with a wooden bottom in order to address concerns that

the effects of exposure to the phone could be due to heat emitted by the phone rather than to RF-EMR alone. Animals were sacrificed 24 hours after the last exposure and tissues of interest were harvested. RESULTS: One hour of exposure to the phone did not significantly change facial temperature in either group of rats. No significant difference was observed in total sperm count between controls and RF-EMR exposed groups. However, rats exposed to RF-EMR exhibited a significantly reduced percentage of motile sperm. Moreover, RF-EMR exposure resulted in a significant increase in lipid peroxidation and low GSH content in the testis and epididymis. CONCLUSION: Given the results of the present study, we speculate that RF-EMR from mobile phones negatively affects semen quality and may impair male fertility.

Maillefer RH, Quock RM. Naltrexone-sensitive analgesia following exposure of mice to 2450-MHz radiofrequency radiation. Physiol Behav 52(3):511-514, 1992.

To determine whether exposure to radiofrequency radiation (RFR) would induce sufficient thermal stress to activate endogenous opioid mechanisms, male Swiss Webster mice were exposed to 10, 15, and 20 mW/cm2 RFR in a 2450-MHz waveguide system for 10 min at specific absorption rates (SARs) of 23.7, 34.6, and 45.5 W/kg, respectively, then tested in the abdominal constriction paradigm. Confinement in the RFR exposure chamber alone did not appreciably alter body temperature but did appear to induce a stress-associated analgesia that was not blocked by naltrexone. Exposure of confined mice to RFR raised body temperature and further increased analgesia in an SAR-dependent manner. The high SAR-induced analgesia, but not the hyperthermia, was blocked by naltrexone. These findings suggest that 1) RFR produces SAR-dependent hyperthermia and analgesia, and 2) RFR-induced analgesia is mediated by opioid mechanisms while confinement-induced analgesia involves nonopioid mechanisms.

Manta AK, Papadopoulou D, Polyzos AP, Fragopoulou AF, Skouroliakou AS, Thanos D, Stravopodis DJ, Margaritis LH. Mobile-phone radiation-induced perturbation of gene-expression profiling, redox equilibrium and sporadic-apoptosis control in the ovary of Drosophila melanogaster. Fly (Austin). 11(2):75-95, 2017.

The daily use by people of wireless communication devices has increased exponentially in the last decade, begetting concerns regarding its potential health hazards. Drosophila melanogaster four days-old adult female flies were exposed for 30 min to radiation emitted by a commercial mobile phone at a SAR of 0.15 W/kg and a SAE of 270 J/kg. ROS levels and apoptotic follicles were assayed in parallel with a genome-wide microarrays analysis. ROS cellular contents were found to increase by 1.6-fold (x), immediately after the end of exposure, in follicles of pre-choriogenic stages (germarium - stage 10), while sporadically generated apoptotic follicles (germarium 2b and stages 7-9) presented with an averaged 2x upregulation in their sub-population mass, 4 h after fly's irradiation with mobile device. Microarray analysis revealed 168 genes being differentially expressed, 2 h post-exposure, in response to radiofrequency (RF) electromagnetic field-radiation exposure (≥1.25x, $P < 0.05$) and associated with multiple and critical biological processes, such as basic metabolism and cellular subroutines related to stress response and apoptotic death. Exposure of adult flies to mobile-phone radiation for 30 min has an immediate impact on ROS production in animal's ovary, which seems to cause a global,

systemic and non-targeted transcriptional reprogramming of gene expression, 2 h post-exposure, being finally followed by induction of apoptosis 4 h after the end of exposure. Conclusively, this unique type of pulsed radiation, mainly being derived from daily used mobile phones, seems capable of mobilizing critical cytopathic mechanisms, and altering fundamental genetic programs and networks in D. melanogaster.

Marjanovic Cermak AM, Pavicic I, Tariba Lovakovic B, Pizent A, Trosic I. In vitro non-thermal oxidative stress response after 1800 MHz radiofrequency radiation. Gen Physiol Biophys. 36(4):407-414, 2017.

In this study possible connection between radiofrequency exposure (RF) and development of oxidative stress was investigated by measuring impairment in cellular oxidation-reduction balance immediately after RF exposure. Fibroblast cells V79 were exposed for 10, 30 and 60 minutes to 1800 MHz RF radiation. Electric field strength was 30 V/m and specific absorption rate (SAR) was calculated to be 1.6 W/kg. Electromagnetic field was generated within Gigahertz Transversal Electromagnetic Mode cell (GTEM) equipped by signal generator, amplifier and modulator. Cell viability was determined by CCK-8 colorimetric assay and level of reactive oxygen species (ROS) was detected by dihydroethidium staining. Reduced glutathione (GSH) and glutathione peroxidase (GSH-Px) were used to assess cell antioxidant activity while lipid oxidative damage was evaluated measuring concentration of malondialdehyde. Viability of V79 cells remained within normal physiological values regardless of exposure time. Increased level of superoxide radicals was detected after 60-min exposure. Significantly higher GSH level was observed immediately after 10-min exposure with higher but insignificant activity of GSH-Px. Lipid oxidative damage in exposed cell samples was not observed. Short-term RF exposure revealed transient oxidation-reduction imbalance in fibroblast cells following adaptation to applied experimental conditions.

Mokarram P, Sheikhi M, Mortazavi SMJ, Saeb S[4] 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.

Malek F, Rani KA, Rahim HA, Omar MH. Effect of Short-Term Mobile Phone Base Station Exposure on Cognitive Performance, Body Temperature, Heart Rate and Blood Pressure of Malaysians. Sci Rep. 5:13206, 2015.

Individuals who report their sensitivity to electromagnetic fields often undergo cognitive impairments that they believe are due to the exposure of mobile phone technology. The aim of this study is to clarify whether short-term exposure at 1 V/m to the typical Global System for Mobile Communication and Universal Mobile Telecommunications System (UMTS) affects cognitive performance and physiological parameters (body temperature, blood pressure and heart rate). This study applies counterbalanced randomizing single blind tests to determine if sensitive individuals experience more negative health effects when they are exposed to base station signals compared with sham (control) individuals. The sample size is 200 subjects with 50.0% Idiopathic Environmental Intolerance attributed to electromagnetic fields (IEI-EMF) also known as sensitive and 50.0% (non-IEI-EMF). The computer-administered Cambridge Neuropsychological Test Automated Battery (CANTAB eclipse(TM)) is used to examine cognitive performance. Four tests are chosen to evaluate Cognitive performance in CANTAB: Reaction Time (RTI), Rapid Visual Processing (RVP), Paired Associates Learning (PAL) and Spatial Span (SSP). Paired sample t-test on the other hand, is used to examine the physiological parameters. Generally, in both groups, there is no statistical significant difference between the exposure and sham exposure towards cognitive performance and physiological effects (P's > 0.05).

Malka N. Halgamuge, See Kye Yak and Jacob L. Eberhardt. Reduced growth of soybean seedlings after exposure to weak microwave radiation from GSM 900 mobile phone and base station. Bioelectromagnetics. Article first published online: Jan 21, 2015. DOI: 10.1002/BEM.21890

The aim of this work was to study possible effects of environmental radiation pollution on plants. The association between cellular telephone (short duration, higher amplitude) and base station (long duration, very low amplitude) radiation exposure and the growth rate of soybean (Glycine max) seedlings was investigated. Soybean seedlings, pre-grown for 4 days, were exposed in a gigahertz transverse electromagnetic cell for 2 hrs. to global system for mobile communication (GSM) mobile phone pulsed radiation or continuous wave (CW) radiation at 900 MHz with amplitudes of 5.7 and 41 volts per meter, and outgrowth was studied one week after exposure. The exposure to higher amplitude (41 V m−1) GSM radiation resulted in diminished outgrowth of the epicotyl. The exposure to lower amplitude (5.7 V m−1) GSM radiation did not influence outgrowth of epicotyl, hypocotyls, or roots. The exposure to higher amplitude CW radiation resulted in reduced outgrowth of the roots whereas lower CW exposure resulted in a reduced outgrowth of the hypocotyl. Soybean seedlings were also exposed for 5 days to an extremely low level of radiation (GSM 900 MHz, 0.56 V m−1) and outgrowth was studied 2 days later. Growth of epicotyl and hypocotyl was found to be reduced, whereas the outgrowth of roots was stimulated. Our findings indicate that the observed effects were significantly dependent on field strength as well as amplitude modulation of the applied field.

Malkemper EP, Eder SH, Begall S, Phillips JB, Winklhofer M, Hart V, Burda H. Magnetoreception in the wood mouse (Apodemus sylvaticus): influence of weak frequency-modulated radio frequency fields. Sci Rep. 2015 Apr 29;4:9917. doi: 10.1038/srep09917.

The mammalian magnetic sense is predominantly studied in species with reduced vision such as mole-rats and bats. Far less is known about surface-dwelling (epigeic) rodents with well-developed eyes. Here, we tested the wood mouse Apodemus sylvaticus for magnetoreception using a simple behavioural assay in which mice are allowed to build nests overnight in a visually symmetrical, circular arena. The tests were performed in the ambient magnetic field or in a field rotated by 90°. When plotted with respect to magnetic north, the nests were bimodally clustered in the northern and southern sectors, clearly indicating that the animals used magnetic cues. Additionally, mice were tested in the ambient magnetic field with a superimposed radio frequency magnetic field of the order of 100 nT. Wood mice exposed to a 0.9 to 5 MHz frequency sweep changed their preference from north-south to east-west. In contrast to birds, however, a constant frequency field tuned to the Larmor frequency (1.33 MHz) had no effect on mouse orientation. In sum, we demonstrated magnetoreception in wood mice and provide first evidence for a radical-pair mechanism in a mammal.

Malyapa RS, Ahern EW, Straube WL, Moros EG, Pickard WF, Roti Roti JL, Measurement of DNA damage after exposure to 2450 MHz electromagnetic radiation. Radiat Res 148(6):608-617, 1997.

Recent reports suggest that exposure to 2450 MHz electromagnetic radiation causes DNA single-strand breaks (SSBs) and double-strand breaks (DSBs) in cells of rat brain irradiated in vivo (Lai and Singh, Bioelectromagnetics 16, 207-210, 1995; Int. J. Radiat. Biol. 69, 513-521, 1996). Therefore, we endeavored to determine if exposure of cultured

mammalian cells in vitro to 2450 MHz radiation causes DNA damage. The alkaline comet assay (single-cell gel electrophoresis), which is reportedly the most sensitive method to assay DNA damage in individual cells, was used to measure DNA damage after in vitro 2450 MHz irradiation. Exponentially growing U87MG and C3H 10T1/2 cells were exposed to 2450 MHz continuous-wave (CW) radiation in specially designed radial transmission lines (RTLs) that provided relatively uniform microwave exposure. Specific absorption rates (SARs) were calculated to be 0.7 and 1.9 W/kg. Temperatures in the RTLs were measured in real time and were maintained at 37 +/- 0.3 degrees C. Every experiment included sham exposure(s) in an RTL. Cells were irradiated for 2 h, 2 h followed by a 4-h incubation at 37 degrees C in an incubator, 4 h and 24 h. After these treatments samples were subjected to the alkaline comet assay as described by Olive et al. (Exp. Cell Res. 198, 259-267, 1992). Images of comets were digitized and analyzed using a PC-based image analysis system, and the "normalized comet moment" and "comet length" were determined. No significant differences were observed between the test group and the controls after exposure to 2450 MHz CW irradiation. Thus 2450 MHz irradiation does not appear to cause DNA damage in cultured mammalian cells under these exposure conditions as measured by this assay.

Malyapa RS, Ahern EW, Bi C, Straube WL, LaRegina M, Pickard WF, Roti RotiJL, DNA damage in rat brain cells after in vivo exposure to 2450 MHz electromagnetic radiation and various methods of euthanasia. Radiat Res 149(6):637-645, 1998.

The present study was done to confirm the reported observation that low-intensity acute exposure to 2450 MHz radiation causes DNA single-strand breaks (Lai and Singh, Bioelectromagnetics 16, 207-210, 1995). Male Sprague-Dawley rats weighing approximately 250 g were irradiated with 2450 MHzcontinuous-wave (CW) microwaves for 2 h at a specific absorption rate of 1.2 W/kg in a cylindrical waveguide system (Guy et al., Radio Sci. 14, 63-74, 1979). There was no associated rise in the core body temperature of the rats. After the irradiation or sham treatments, rats were euthanized by either CO2 asphyxia or decapitation by guillotine (eight pairs of animals per euthanasia group). After euthanasia the brains were removed and immediately immersed in cold Ames medium and the cells of the cerebral cortex and the hippocampus were dissociated separately and subjected to the alkaline comet assay. Irrespective of whether the rats were euthanized by CO2 asphyxia or decapitated by guillotine, no significant differences were observed between either the comet length or the normalized comet moment of cells from either the cerebral cortex or the hippocampus of sham-treated rats and those from the irradiated rats. However, the data for the rats asphyxiated with CO2 showed more intrinsic DNA damage and more experiment-to-experiment variation than did the data for rats euthanized by guillotine. Therefore, the guillotine method of euthanasia is the most appropriate in studies relating to DNA damage. Furthermore, we did not confirm the observation that DNA damage is produced in cells of the rat cerebral cortex or the hippocampus after a 2-h exposure to 2450 MHz CW microwaves or at 4 h after the exposure.

Malyapa RS, Ahern EW, Straube WL, Moros EG, Pickard WF, Roti Roti JL. Measurement of DNA damage after exposure to electromagnetic radiation in the cellular phone communication frequency band (835.62 and 847.74 MHz). Radiat Res 148(6):618-627, 1997.

Mouse C3H 10T1/2 fibroblasts and human glioblastoma U87MG cells were exposed to cellular phone communication frequency radiations to investigate whether such exposure produces DNA damage in in vitro cultures. Two types of frequency modulations were studied: frequency-modulated continuous-wave (FMCW), with a carrier frequency of 835.62 MHz, and code-division multiple-access (CDMA) centered on 847.74 MHz. Exponentially growing (U87MG and C3H 10T1/2 cells) and plateau-phase (C3H 10T1/2 cells) cultures were exposed to either FMCW or CDMA radiation for varying periods up to 24 h in specially designed radial transmission lines (RTLs) that provided relatively uniform exposure with a specific absorption rate (SAR) of 0.6 W/kg. Temperatures in the RTLs were monitored continuously and maintained at 37 +/- 0.3 degrees C. Sham exposure of cultures in an RTL (negative control) and 137Cs gamma-irradiated samples (positive control) were included with every experiment. The alkaline comet assay as described by Olive et al. (Exp. Cell Res. 198, 259-269, 1992) was used to measure DNA damage. No significant differences were observed between the test group exposed to FMCW or CDMA radiation and the sham-treated negative controls. Our results indicate that exposure of cultured mammalian cells to cellular phone communication frequencies under these conditions at an SAR of 0.6 W/kg does not cause DNA damage as measured by the alkaline comet assay.

Mancinelli F, Caraglia M, Abbruzzese A, d'Ambrosio G, Massa R, Bismuto E.Non-thermal effects of electromagnetic fields at mobile phone frequency on the refolding of an intracellular protein: myoglobin. J Cell Biochem. 93(1):188-196, 2004.

Non-thermal effects induced by exposure to microwave electromagnetic field (MW-EMF) at 1.95 MHz, a frequency used in mobile communication, have been observed on the refolding kinetics of the heme binding site in an intracellular protein: tuna myoglobin, starting from acidic conditions. We have selected myoglobin because it can be considered a good model to study protein interactions with MW-EMF for its well-known high-resolution crystallographic structure. Myoglobin solutions at pH 3.0 were subjected to 3 h exposure to microwave field (with a specific absorption rate of 51 +/- 1 mW/g); the heme site refolding has been followed by measuring the molecular absorption in the Soret spectral region and the data were fitted to a bi-exponential model. The kinetics of exposed samples appear to be slowered by MW-EMF action. Moreover, the tryptophanyl lifetime distribution of the exposed protein, as deduced by the analysis of the fluorescence emission decay from its single tryptophan, appears sharper if compared to non-exposed protein samples. This observation suggests that the presence of MW-EMF could affect the propensity of protein molecules to populate specific conformational substates among which myoglobin molecules fluctuate at acidic pH. Changes in the structural fluctuation caused by MW perturbation can affect differently the aggregation process that occurs competitively during the protein folding, so representing a potential risk for protein "misfolding." These data suggest that MW-EMF could have also biochemical and, consequently, biological effects on eukaryotic cells that are still under investigation.

Mandalà M, Colletti V, Sacchetto L, Manganotti P, Ramat S, Marcocci A, Colletti L. Effect of Bluetooth headset and mobile phone electromagnetic fields on the human

auditory nerve. Laryngoscope. 2013 Apr 25. doi: 10.1002/lary.24103. [Epub ahead of print]

OBJECTIVES/HYPOTHESIS: The possibility that long-term mobile phone use increases the incidence of astrocytoma, glioma and acoustic neuroma has been investigated in several studies. Recently, our group showed that direct exposure (in a surgical setting) to cell phone electromagnetic fields (EMFs) induces deterioration of auditory evoked cochlear nerve compound action potential (CNAP) in humans. To verify whether the use of Bluetooth devices reduces these effects, we conducted the present study with the same experimental protocol. STUDY DESIGN: Randomized trial. METHODS: Twelve patients underwent retrosigmoid vestibular neurectomy to treat definite unilateral Ménière's disease while being monitored with acoustically evoked CNAPs to assess direct mobile phone exposure or alternatively the EMF effects of Bluetooth headsets. RESULTS: We found no short-term effects of Bluetooth EMFs on the auditory nervous structures, whereas direct mobile phone EMF exposure confirmed a significant decrease in CNAPs amplitude and an increase in latency in all subjects. CONCLUSIONS: The outcomes of the present study show that, contrary to the finding that the latency and amplitude of CNAPs are very sensitive to EMFs produced by the tested mobile phone, the EMFs produced by a common Bluetooth device do not induce any significant change in cochlear nerve activity. The conditions of exposure, therefore, differ from those of everyday life, in which various biological tissues may reduce the EMF affecting the cochlear nerve. Nevertheless, these novel findings may have important safety implications.

Mann, K, Roschke, J, Effects of pulsed high-frequency electromagnetic fields on human sleep. Neuropsychobiology 33(1):41-47, 1996.

In the present study we investigated the influence of pulsed high-frequency electromagnetic fields of digital mobile radio telephones on sleep in healthy humans. Besides a hypnotic effect with shortening of sleep onset latency, a REM suppressive effect with reduction of duration and percentage of REM sleep was found. Moreover, spectral analysis revealed qualitative alterations of the EEG signal during REM sleep with an increased spectral power density. Knowing the relevance of REM sleep for adequate information processing in the brain, especially concerning mnestic functions and learning processes, the results emphasize the necessity to carry out further investigations on the interaction of this type of electromagnetic fields and the human organism.

Mann, K, Roschke, J, Connemann, B, Beta, H, No effects of pulsed high-frequency electromagnetic fields on heart rate variability during human sleep. Neuropsychobiology;38(4):251-256, 1998.

The influence of pulsed high-frequency electromagnetic fields emitted by digital mobile radio telephones on heart rate during sleep in healthy humans was investigated. Beside mean RR interval and total variability of RR intervals based on calculation of the standard deviation, heart rate variability was assessed in the frequency domain by spectral power analysis providing information about the balance between the two branches of the autonomic nervous system. For most parameters, significant differences between different sleep stages were found. In particular, slow-wave sleep was characterized by a

low ratio of low- and high-frequency components, indicating a predominance of the parasympathetic over the sympathetic tone. In contrast, during REM sleep the autonomic balance was shifted in favor of the sympathetic activity. For all heart rate parameters, no significant effects were detected under exposure to the field compared to placebo condition. Thus, under the given experimental conditions, autonomic control of heart rate was not affected by weak-pulsed high-frequency electromagnetic fields.

Mann, K, Wagner, P, Brunn, G, Hassan, F, Hiemke, C, Roschke, J, Effects of pulsed high-frequency electromagnetic fields on the neuroendocrine system. Neuroendocrinology 67(2):139-144, 1998.

The influence of pulsed high-frequency electromagnetic fields emitted from a circularly polarized antenna on the neuroendocrine system in healthy humans was investigated (900 MHz electromagnetic field, pulsed with 217 Hz, average power density 0.02 mW/cm2). Nocturnal hormone profiles of growth hormone (GH), cortisol, luteinizing hormone (LH) and melatonin were determined under polysomnographic control. An alteration in the hypothalamo-pituitary-adrenal axis activity was found with a slight, transient elevation in the cortisol serum level immediately after onset of field exposure which persisted for 1 h. For GH, LH and melatonin, no significant effects were found under exposure to the field compared to the placebo condition, regarding both total hormone production during the entire night and dynamic characteristics of the secretion pattern. Also the evaluation of the sleep EEG data revealed no significant alterations under field exposure, although there was a trend to an REM suppressive effect. The results indicate that weak high-frequency electromagnetic fields have no effects on nocturnal hormone secretion except for a slight elevation in cortisol production which is transient, pointing to an adaptation of the organism to the stimulus.

Manta AK, Stravopodis DJ, Papassideri IS, Margaritis LH. Reactive oxygen species elevation and recovery in Drosophila bodies and ovaries following short-term and long-term exposure to DECT base EMF. Electromagn Biol Med. 2013 Jun 19. [Epub ahead of print]

Abstract The objective of this study was to approach the basic mechanism(s) underlying reported ovarian apoptotic cell death and fecundity decrease induced by nonionizing radiation (NIR) in Drosophila melanogaster. ROS (Reactive Oxygen Species) levels were measured in the bodies and the ovaries of (sexually mature) 4-day-old flies, following exposure for 0.5, 1, 6, 24 and 96 h to a wireless DECT (Digital Enhanced Cordless Telephone) base radiation (1.88-1.90 GHz). Electrical field intensity was 2.7 V/m, measured within the fly vials and calculated SAR (Specific Absorption Rate) value = 0.009 W/Kg. Male and female bodies showed twofold increase in ROS levels ($p < 0.001$) after 6 h of exposure, slightly increasing with more irradiation (24 and 96 h). Ovaries of exposed females had a quick response in ROS increase after 0.5 h (1.5-fold, $p < 0.001$), reaching 2.5-fold after 1 h with no elevation thereafter at 6, 24 and 96 h. ROS levels returned to normal, in the male and the female bodies 24 h after 6 h of exposure of the flies ($p < 0.05$) and in the ovaries 4 h after 1 h exposure of the females ($p < 0.05$). It is postulated that the pulsed (at 100 Hz rate and 0.08 ms duration) idle state of the DECT base radiation is capable of inducing free radical formation albeit the very low SAR, leading rapidly to

accumulation of ROS in a level-saturation manner under continuous exposure, or in a recovery manner after interruption of radiation, possibly due to activation of the antioxidant machinery of the organism.

Manta AK, Papadopoulou D, Polyzos AP, Fragopoulou AF, Skouroliakou AS, Thanos D, Stravopodis DJ, Margaritis LH. Mobile-phone Radiation-induced Perturbation of Gene-expression Profiling, Redox Equilibrium and Sporadic-apoptosis Control in the Ovary of Drosophila melanogaster. Fly (Austin). 2016 Dec 14:0. [Epub ahead of print]

BACKGROUND: The daily use by people of wireless communication devices has increased exponentially in the last decade, begetting concerns regarding its potential health hazards. METHODS: Drosophila melanogaster four days-old adult female flies were exposed for 30 min to radiation emitted by a commercial mobile phone at a SAR of 0.15 W/kg and a SAE of 270 J/kg. ROS levels and apoptotic follicles were assayed in parallel with a genome-wide microarrays analysis. RESULTS: ROS cellular contents were found to increase by 1.6 fold (x), immediately after the end of exposure, in follicles of pre-choriogenic stages (germarium - stage 10), while sporadically generated apoptotic follicles (germarium 2b and stages 7-9) presented with an averaged 2x upregulation in their sub-population mass, 4 h after fly's irradiation with mobile device. Microarray analysis revealed 168 genes being differentially expressed, 2 h post-exposure, in response to radiofrequency (RF) electromagnetic field-radiation exposure (≥1.25x, $P<0.05$) and associated with multiple and critical biological processes, such as basic metabolism and cellular subroutines related to stress response and apoptotic death. CONCLUSION: Exposure of adult flies to mobile-phone radiation for 30 min has an immediate impact on ROS production in animal's ovary, which seems to cause a global, systemic and non-targeted transcriptional reprogramming of gene expression, 2 h post-exposure, being finally followed by induction of apoptosis 4 h after the end of exposure. Conclusively, this unique type of pulsed radiation, mainly being derived from daily used mobile phones, seems capable of mobilizing critical cytopathic mechanisms, and altering fundamental genetic programs and networks in D. melanogaster.

Manti L, Braselmann H, Calabrese ML, Massa R, Pugliese M, Scampoli P, Sicignano G, Grossi G. Effects of modulated microwave radiation at cellular telephone frequency (1.95 GHz) on X-ray-induced chromosome aberrations in human lymphocytes in vitro. Radiat Res. 169(5):575-583, 2008.

The case for a DNA-damaging action produced by radiofrequency (RF) signals remains controversial despite extensive research. With the advent of the Universal Mobile Telecommunication System (UMTS) the number of RF-radiation-exposed individuals is likely to escalate. Since the epigenetic effects of RF radiation are poorly understood and since the potential modifications of repair efficiency after exposure to known cytotoxic agents such as ionizing radiation have been investigated infrequently thus far, we studied the influence of UMTS exposure on the yield of chromosome aberrations induced by X rays. Human peripheral blood lymphocytes were exposed in vitro to a UMTS signal (frequency carrier of 1.95 GHz) for 24 h at 0.5 and 2.0 W/kg specific absorption rate

(SAR) using a previously characterized waveguide system. The frequency of chromosome aberrations was measured on metaphase spreads from cells given 4 Gy of X rays immediately before RF radiation or sham exposures by fluorescence in situ hybridization. Unirradiated controls were RF-radiation- or sham-exposed. No significant variations due to the UMTS exposure were found in the fraction of aberrant cells. However, the frequency of exchanges per cell was affected by the SAR, showing a small but statistically significant increase of 0.11 exchange per cell compared to 0 W/kg SAR. We conclude that, although the 1.95 GHz signal (UMTS modulated) does not exacerbate the yield of aberrant cells caused by ionizing radiation, the overall burden of X-ray-induced chromosomal damage per cell in first-mitosis lymphocytes may be enhanced at 2.0 W/kg SAR. Hence the SAR may either influence the repair of X-ray-induced DNA breaks or alter the cell death pathways of the damage response.

Marconi A, Tasteyre A, de Seze R, Fogel P, Simoneau G, Conti M, Sarbach C, Young SS, Gilbert J-E, Thomas Y. Multivariate Entropy Analysis of Oxidative Stress Biomarkers Following Mobile Phone Exposure of Human Volunteers: A Pilot StudyJournal Scientific Exploration. 29 (3): 449-465, 2015.

A multidisciplinary project was conducted to study the possible biological impact of mobile phone emissions. As part of that project, we conducted a pilot study on 18 human volunteers, with the treatment being GSM mobile phone exposure. The volunteers were randomized and the study was a double-blind, crossover design. Two categories of oxidative stress biomarkers were followed and measured in blood and exhaled air: those assessing oxidative attacks of cell membrane lipids (malondialdehyde, exhaled alkanes, aldehydes, and isoprene) and those accounting for the organism's antioxidant defense systems (superoxyde dismutase, glutathion Peroxydase, and exhaled halogenated alkanes).The overall entropy of the system with and without GSM exposure was then calculated for each volunteer, using a statistical approach based on the global entropie difference of raw data. A significant modulation of organization of the biomarkers after 30 minutes of mobile phone exposure was found, as evidenced by a decreased entropy of the dataset associated to the emitting mobile phone condition. While these results illustrate neither deleterious effects nor the innocuity of mobile phone use, they nonetheless constitute evidence of actual interactions of these wavelengths with complex biological systems. These results will need to be confirmed in larger, future studies.

Margaritis LH, Manta AK, Kokkaliaris CD, Schiza D, Alimisis K, Barkas G, Georgiou E, Giannakopoulou O, Kollia I, Kontogianni G, Kourouzidou A, Myari A, Roumelioti F, Skouroliakou A, Sykioti V, Varda G, Xenos K, Ziomas K. Drosophila oogenesis as a bio-marker responding to EMF sources. Electromagn Biol Med. 2013 Aug 5. [Epub ahead of print]

The model biological organisms Drosophila melanogaster and Drosophila virilis have been utilized to assess effects on apoptotic cell death of follicles during oogenesis and reproductive capacity (fecundity) decline. A total of 280 different experiments were performed using newly emerged flies exposed for short time daily for 3-7 d to various EMF sources including: GSM 900/1800 MHz mobile phone, 1880-1900 MHz

DECT wireless base, DECT wireless handset, mobile phone-DECT handset combination, 2.44 GHz wireless network (Wi-Fi), 2.44 GHz blue tooth, 92.8 MHz FM generator, 27.15 MHz baby monitor, 900 MHz CW RF generator and microwave oven's 2.44 GHz RF and magnetic field components. Mobile phone was used as a reference exposure system for evaluating factors considered very important in dosimetry extending our published work with D. melanogaster to the insect D. virilis. Distance from the emitting source, the exposure duration and the repeatability were examined. All EMF sources used created statistically significant effects regarding fecundity and cell death-apoptosis induction, even at very low intensity levels (0.3 V/m blue tooth radiation), well below ICNIRP's guidelines, suggesting that Drosophila oogenesis system is suitable to be used as a biomarker for exploring potential EMF bioactivity. Also, there is no linear cumulative effect when increasing the duration of exposure or using one EMF source after the other (i.e. mobile phone and DECT handset) at the specific conditions used. The role of the average versus the peak E-field values as measured by spectrum analyzers on the final effects is discussed.

Marinelli F, La Sala D, Cicciotti G, Cattini L, Trimarchi C, Putti S, Zamparelli A, Giuliani L, Tomassetti G, Cinti C. Exposure to 900 MHz electromagnetic field induces an unbalance between pro-apoptotic and pro-survival signals in T-lymphoblastoid leukemia CCRF-CEM cells. J Cell Physiol. 198(2):324-332, 2004.

It has been recently established that low-frequency electromagnetic field (EMFs) exposure induces biological changes and could be associated with increased incidence of cancer, while the issue remains unresolved as to whether high-frequency EMFs can have hazardous effect on health. Epidemiological studies on association between childhood cancers, particularly leukemia and brain cancer, and exposure to low- and high-frequency EMF suggested an etiological role of EMFs in inducing adverse health effects. To investigate whether exposure to high-frequency EMFs could affect in vitro cell survival, we cultured acute T-lymphoblastoid leukemia cells (CCRF-CEM) in the presence of unmodulated 900 MHz EMF, generated by a transverse electromagnetic (TEM) cell, at various exposure times. We evaluated the effects of high-frequency EMF on cell growth rate and apoptosis induction, by cell viability (MTT) test, FACS analysis and DNA ladder, and we investigated pro-apoptotic and pro-survival signaling pathways possibly involved as a function of exposure time by Western blot analysis. At short exposure times (2-12 h), unmodulated 900 MHz EMF induced DNA breaks and early activation of both p53-dependent and -independent apoptotic pathways while longer continuous exposure (24-48 h) determined silencing of pro-apoptotic signals and activation of genes involved in both intracellular (Bcl-2) and extracellular (Ras and Akt1) pro-survival signaling. Overall our results indicate that exposure to 900 MHz continuous wave, after inducing an early self-defense response triggered by DNA damage, could confer to the survivor CCRF-CEM cells a further advantage to survive and proliferate.

Marino AA, Nilsen E, Frilot C. Nonlinear changes in brain electrical activity due to cell phone radiation. Bioelectromagnetics 24(5):339-346, 2003.

We studied the effect of an electromagnetic field from a cellular telephone on brain electrical activity, using a novel analytical method based on a nonlinear model. The

electroencephalogram (EEG) from rabbits was embedded in phase space and local recurrence plots were calculated and quantified using recurrence quantitation analysis to permit statistical comparisons between filtered segments of exposed and control epochs from individual rabbits. When the rabbits were exposed to the radiation from a standard cellular telephone (800 MHz band, 600 mW maximum radiated power) under conditions that simulated normal human use, the EEG was significantly affected in nine of ten animals studied. The effect occurred beginning about 100 ms after initiation of application of the field and lasted approximately 300 ms. In each case, the fields increased the randomness in the EEG. A control procedure ruled out the possibility that the observations were a product of the method of analysis. No differences were found between exposed and control epochs in any animal when the experiment was repeated after the rabbits had been sacrificed, indicating that absorption of radiation by the EEG electrodes could not account for the observed effect. No effect was seen when deposition of energy in the brain was minimized by repositioning the radiating antenna from the head to the chest, showing that the type of tissue that absorbed the energy determined the observed changes in the EEG. We conclude that, in normal use, the fields from a standard cellular telephone can alter brain function as a consequence of absorption of energy by the brain.

Marino AA, Carrubba S. The effects of mobile-phone electromagnetic fields on brain electrical activity: a critical analysis of the literature. Electromagn Biol Med. 28(3):250-274, 2009.

We analyzed the reports in which human brain electrical activity was compared between the presence and absence of radio-frequency and low-frequency electromagnetic fields (EMFs) from mobile phones, or between pre- and post-exposure to the EMFs. Of 55 reports, 37 claimed and 18 denied an EMF-induced effect on either the baseline electro encephalogram (EEG), or on cognitive processing of visual or auditory stimuli as reflected in changes in event-related potentials. The positive reports did not adequately consider the family-wise error rate, the presence of spike artifacts in the EEG, or the confounding role of the two different EMFs. The negative reports contained neither positive controls nor power analyses. Almost all reports were based on the incorrect assumption that the brain was in equilibrium with its surroundings. Overall, the doubt regarding the existence of reproducible mobile-phone EMFs on brain activity created by the reports appeared to legitimate the knowledge claims of the mobile-phone industry. However, it funded, partly or wholly, at least 87% of the reports. From an analysis of their cognitive framework, the common use of disclaimers, the absence of information concerning conflicts of interest, and the industry's donations to the principal EMF journal, we inferred that the doubt was manufactured by the industry. The crucial scientific question of the pathophysiology of mobile-phone EMFs as reflected in measurements of brain electrical activity remains unanswered, and essentially unaddressed.

Marino C, Cristalli G, Galloni P, Pasqualetti P, Piscitelli M, Lovisolo GA , Effects of microwaves (900 MHz) on the cochlear receptor: exposure systems and preliminary results. Radiat Environ Biophys 39(2):131-136, 2000.

The purpose of this paper is to present the experimental device and the work in progress

performed in search for objective organic correlation of damage to hearing, examining possible acoustic otofunctional effects on the cochlear epithelium of the rat due to exposure to microwaves (900 MHz). Two experiments using male Sprague-Dawley rats were carried out with a far-field exposure in a cubic chamber. No statistically significant evidence was obtained at both specific absorption rate (SAR) values. The exposure system and the diagnostic apparatus are extremely useful to investigate a potential effect on the auditory system: however, with the parameters applied in these experiments, no evidence was observed.

Marjanović AM, Pavičić I, Trošić IBiological indicators in response to radiofrequency/microwave exposure. Arh Hig Rada Toksikol. 2012 Sep 25;63(3):407-416, 2012.

Over the years, due to rapid technological progress, radiation from man-made sources exceeded that of natural origin. There is a general concern regarding a growing number of appliances that use radiofrequency/ microwave (RF/MW) radiation with particular emphasis on mobile communication systems. Since nonthermal biological effects and mechanisms of RF/MW radiation are still uncertain, laboratory studies on animal models, tissues, cells, and cell free system are of extraordinary importance in bioelectromagnetic research. We believe that such investigations play a supporting role in public risk assessment. Cellular systems with the potential for a clear response to RF/MW exposures should be used in those studies. It is known that organism is a complex electrochemical system where processes of oxidation and reduction regularly occur. One of the plausible mechanisms is connected with generation of reactive oxygen species (ROS). Depending on concentration, ROS can have both benefi cial and deleterious effects. Positive effects are connected with cell signalling, defence against infectious agents, and proliferative cell ability. On the other hand, excessive production, which overloads antioxidant defence mechanism, leads to cellular damage with serious potential for disease development. ROS concentration increase within the cell caused by RF/MW radiation seems to be a biologically relevant hypothesis to give clear insight into the RF/MW action at non-thermal level of radiation. In order to better understand the exact mechanism of action and its consequences, further research is needed in the fi eld. We would like to present current knowledge on possible biological mechanisms of RF/MW actions.

Marjanovic AM, Pavicic I, Trosic I. Cell oxidation-reduction imbalance after modulated radiofrequency radiation. Electromagn Biol Med. 2015 Aug 28:1-6. [Epub ahead of print]

Aim of this study was to evaluate an influence of modulated radiofrequency field (RF) of 1800 MHz, strength of 30 V/m on oxidation-reduction processes within the cell. The assigned RF field was generated within Gigahertz Transversal Electromagnetic Mode cell equipped by signal generator, modulator, and amplifier. Cell line V79, was irradiated for 10, 30, and 60 min, specific absorption rate was calculated to be 1.6 W/kg. Cell metabolic activity and viability was determined by MTT assay. In order to define total protein content, colorimetric method was used. Concentration of oxidised proteins was evaluated by enzyme-linked immunosorbent assay. Reactive oxygen species (ROS) marked with

fluorescent probe 2',7'-dichlorofluorescin diacetate were measured by means of plate reader device. In comparison with control cell samples, metabolic activity and total protein content in exposed cells did not differ significantly. Concentrations of carbonyl derivates, a product of protein oxidation, insignificantly but continuously increase with duration of exposure. In exposed samples, ROS level significantly ($p < 0.05$) increased after 10 min of exposure. Decrease in ROS level was observed after 30-min treatment indicating antioxidant defence mechanism activation. In conclusion, under the given laboratory conditions, modulated RF radiation might cause impairment in cell oxidation-reduction equilibrium within the growing cells.

Marjanovic Cermak AM, Pavicic I, Tariba Lovakovic B, Pizent A, Trosic I. In vitro non-thermal oxidative stress response after 1800 MHz radiofrequency radiation. Gen Physiol Biophys. 2017 Aug 24. doi: 10.4149/gpb_2017007. [Epub ahead of print]

In this study possible connection between radiofrequency exposure (RF) and development of oxidative stress was investigated by measuring impairment in cellular oxidation-reduction balance immediately after RF exposure. Fibroblast cells V79 were exposed for 10, 30 and 60 minutes to 1800 MHz RF radiation. Electric field strength was 30 V/m and specific absorption rate (SAR) was calculated to be 1.6 W/kg. Electromagnetic field was generated within Gigahertz Transversal Electromagnetic Mode cell (GTEM) equipped by signal generator, amplifier and modulator. Cell viability was determined by CCK-8 colorimetric assay and level of reactive oxygen species (ROS) was detected by dihydroethidium staining. Reduced glutathione (GSH) and glutathione peroxidase (GSH-Px) were used to assess cell antioxidant activity while lipid oxidative damage was evaluated measuring concentration of malondialdehyde. Viability of V79 cells remained within normal physiological values regardless of exposure time. Increased level of superoxide radicals was detected after 60-min exposure. Significantly higher GSH level was observed immediately after 10-min exposure with higher but insignificant activity of GSH-Px. Lipid oxidative damage in exposed cell samples was not observed. Short-term RF exposure revealed transient oxidation-reduction imbalance in fibroblast cells following adaptation to applied experimental conditions.

Markakis I, Samaras T. Radiofrequency exposure in greek indoor environments. Health Phys. 104(3):293-301, 2013.

This is the first measurement campaign that takes place in Greece in order to assess the exposure levels in different microenvironments (offices, bedrooms, living rooms, schools). Due to the exponential growth in the use of wireless network devices, the aim of this work was to perform indoor measurements with the use of personal dosimeters. The measurement period was 3 d in each of the 40 different locations that were selected, both in the urban and suburban area of Thessaloniki, the second largest city of Greece. The measurements took place from 23 July 2010 to 19 January 2012. After processing the obtained data with the robust regression on order statistics (ROS) method, various statistical exposure quantities were calculated. Compared to similar measurement

campaigns across Europe, a larger proportion of measurement data above the detection limit for specific frequency bands (at most 56% for the DCS Rx frequency band) was found. Furthermore, mean exposure levels in the mobile downlink frequency bands were higher than those in other studies (GSM Rx: 0.259 V m, DCS Rx: 0.131 V m, UMTS Rx: 0.12 V m), yet many times below the ICNIRP guidelines. On the other hand, maximum exposures were found to be of the same magnitude (GSM Rx: 0.38 V m, DCS Rx: 0.3 V m, UMTS Rx: 0.28 V m). These measurement results indicate that signals from mobile base stations are dominant in workplaces and schools, whereas wireless phones and computer networks play the leading role in home environments. While the former reach their maximum values during daytime, the latter have an observable increase in the evening after work hours.

Markkanen A, Penttinen P, Naarala J, Pelkonen J, Sihvonen A-P, Juutilainen J.Apoptosis induced by ultraviolet radiation is enhanced by amplitude modulated radiofrequency radiation in mutant yeast cells Bioelectromagnetics 25:127-133, 2004.

The aim of this study was to investigate whether radiofrequency (RF) electromagnetic field (EMF) exposure affects cell death processes of yeast cells. Saccharomyces cerevisiae yeast cells of the strains KFy417 (wild-type) and KFy437 (cdc48-mutant) were exposed to 900 or 872 MHz RF fields, with or without exposure to ultraviolet (UV) radiation, and incubated simultaneously with elevated temperature (+37°C) to induce apoptosis in the cdc48-mutated strain. The RF exposure was carried out in a special waveguide exposure chamber where the temperature of the cell cultures can be precisely controlled. Apoptosis was analyzed using the annexin V-FITC method utilizing flow cytometry. Amplitude modulated (217 pulses per second) RF exposure significantly enhanced UV induced apoptosis in cdc48-mutated cells, but no effect was observed in cells exposed to unmodulated fields at identical time-average specfic absorption rates (SAR, 0.4 or 3.0 W/kg). The findings suggest that amplitude modulated RF fields, together with known damaging agents, can affect the cell death process in mutated yeast cells.

Markova E, Hillert L, Malmgren L, Persson BR, Belyaev IY. Microwaves from GSM Mobile Telephones Affect 53BP1 and gamma-H2AX Foci in Human Lymphocytes from Hypersensitive and Healthy Persons. Environ Health Perspect. 113(9):1172-1177, 2005.

The data on biologic effects of nonthermal microwaves (MWs) from mobile telephones are diverse, and these effects are presently ignored by safety standards of the International Commission for Non-Ionizing Radiation Protection (ICNIRP). In the present study, we investigated effects of MWs of Global System for Mobile Communication (GSM) at different carrier frequencies on human lymphocytes from healthy persons and from persons reporting hypersensitivity to electromagnetic fields (EMFs). We measured the changes in chromatin conformation, which are indicative of stress response and genotoxic effects, by the method of anomalous viscosity time dependence, and we analyzed tumor suppressor p53-binding protein 1 (53BP1) and phosphorylated histone H2AX (gamma-H2AX), which have been shown to colocalize in distinct foci with DNA double-strand breaks (DSBs), using immunofluorescence confocal laser microscopy. We

found that MWs from GSM mobile telephones affect chromatin conformation and 53BP1/gamma-H2AX foci similar to heat shock. For the first time, we report here that effects of MWs from mobile telephones on human lymphocytes are dependent on carrier frequency. On average, the same response was observed in lymphocytes from hypersensitive and healthy subjects. Key words: 53BP1 and gamma-H2AX foci, chromatin, DNA double-strand breaks, hypersensitivity to electromagnetic fields, stress response.

Marjanovic Cermak AM, Pavicic I, Trosic I. Oxidative stress response in SH-SY5Y cells exposed to short-term 1800 MHz radiofrequency radiation. J Environ Sci Health A Tox Hazard Subst Environ Eng. 2017 Nov 17:1-7. doi: 10.1080/10934529.2017.1383124.

The exact mechanism that could explain the effects of radiofrequency (RF) radiation exposure at non-thermal level is still unknown. Increasing evidence suggests a possible involvement of reactive oxygen species (ROS) and development of oxidative stress. To test the proposed hypothesis, human neuroblastoma cells (SH-SY5Y) were exposed to 1800 MHz short-term RF exposure for 10, 30 and 60 minutes. Electric field strength within Gigahertz Transverse Electromagnetic cell (GTEM) was 30 V m-1 and specific absorption rate (SAR) was calculated to be 1.6 W kg-1. Cellular viability was measured by MTT assay and level of ROS was determined by fluorescent probe 2',7'-dichlorofluorescin diacetate. Concentrations of malondialdehyde and protein carbonyls were used to assess lipid and protein oxidative damage and antioxidant activity was evaluated by measuring concentrations of total glutathione (GSH). After radiation exposure, viability of irradiated cells remained within normal physiological values. Significantly higher ROS level was observed for every radiation exposure time. After 60 min of exposure, the applied radiation caused significant lipid and protein damage. The highest GSH concentration was detected after 10 minute-exposure. The results of our study showed enhanced susceptibility of SH-SY5Y cells for development of oxidative stress even after short-term RF exposure.

Masuda H, Hirota S, Ushiyama A, Hirata A, Arima T, Watanabe H, Wake K, Watanabe S, Taki M, Nagai A, Ohkubo C. No Changes in Cerebral Microcirculatory Parameters in Rat During Local Cortex Exposure to Microwaves. In Vivo. 29(2):207-215, 2015.

The aim of this study was to determine whether cerebral microcirculatory parameters in rats were modified during local cortex exposure to a radiofrequency electromagnetic field (RF) under non-thermal conditions. The cortex tissue targeted was locally exposed to 1439 MHz RF using a figure-8 loop antenna at an averaged specific absorption rate of 2.0 W/kg in the target area for 50 min. Three microcirculatory parameters related to cerebral inflammation were measured by the cranial window method in real-time under RF exposure. No extravasation of intravenously injected fluorescent dye was observed during RF exposure. There was no significant difference either in pial venule blood flow velocity or diameter between exposed and sham-exposed rats. Histological evaluation for the brain immediately after RF exposure did not reveal any serum albumin leakage sites