

News from Science

The following contributions refer to recent original scientific studies on the effects of radiofrequency fields used in mobile communication. Publications have been selected by the author himself, based on his personal judgement of relevance.

by Roland Glaser

Genotoxic effects of mobile communication fields?

No micronuclei in the blood even after long-term exposure. In 2001 and 2003, a working group from three Finnish institutes (Kuopio) published long-term experiments in mice investigating, on the one hand, the effects of radiofrequency fields on the carcinogenic effects of gamma rays) (Heikkinen et al., *Radiat. Res.* **156**, 2001, 775-785) and, on the other hand, their interaction with UV irradiation regarding the development of skin cancer (Heikkinen et al., *Int. J. Radiat. Biol.* **79**, 2003, 221-233). Both experiments showed no effects (see also News from Science 2, 2002 and 3, 2003). In these experiments, the animals were exposed to gamma and UV radiation in the first weeks and to various mobile radio frequencies, i.e. continuous 902.5 MHz NMT fields, pulsed 902.4 MHz GSM fields and pulsed 849 MHz DAMPS fields, for the whole period of 78 and 52 weeks, respectively. The authors now publish the findings from the final blood smears obtained from the animals of both studies, pursuing the question whether any genotoxic effects have occurred during exposure. The frequency of micronuclei in poly- and normochromatic red blood cells was measured (blinded evaluation). The result was negative in all samples, also compared to cage controls. The situation that even UV and gamma radiation showed no effects is explained by the authors by the fact that UV radiation, in principle, affects only the skin and, therefore, cannot affect the blood-forming organs. Any damage that was certainly caused by gamma radiation at the start of the experiments was, however, compensated in the blood count before the end of the tests. In a detailed discussion, the authors emphasize that these genotoxic effects are obviously very temperature-sensitive and therefore occur immediately at thermal exposure. This demonstrates at the same time the high sensitivity of this test and thus the value of the negative evidence found here.

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. (2007) 83, 213-220.

Effects on cell growth and development

Is there an effect of RF fields on ornithine decarboxylase (ODC) after all?

As already reported (News from Science 3, 2006), measurements of temperature dependency of ODC activity could refute the often repeated assertion that there were non-thermal RF effects on this process. – Even a temperature increase of 1 degree decreased the ODC contents in cultures of mouse fibroblasts by 57%! (Höytö et al., *Radiat. Environ. Biophys.* 2006, **45**, 231). This working group from Finland continued

this line of work, extending the experiments both to higher intensities (872 MHz, continuous and GSM pulsed fields, 1.5, 2.5, 6.0 W/kg) and to further cell types (L929 mouse fibroblasts, C6 rat glioblastoma cells, SH-SY5Y human neuroblastoma cells and primary cultures of astrocytes from the rat brain). Thereby, former findings could be confirmed, where the three transformed cell types, properly thermostated, showed no effects. In primary cultures, however, there was a decrease in ODC activity even at 1.5 W/kg. Even though this effect was low compared to positive controls, i.e., the changes occurring at a renewal of culture solutions, it was still statistically significant. The authors conclude that there is a higher sensitivity of these primary cells compared to transformed cell line cultures. This would be an important conclusion, as it concerns the cells in the healthy brain. But: Is there actually a higher sensitivity to RF fields or not perhaps to temperature variations that are characteristic of primary cell cultures? Comparative measurements of the temperature dependency of this process would be desirable!

Höytö A; Juutilainen J; Naarala J: Ornithine decarboxylase activity is affected in primary astrocytes but not in secondary cell lines exposed to 872 MHz RF radiation. Int. J. Radiat. Biol. 83 (2007), 367-374.

On the effects of RF fields on sensory cells

No effects of long-term exposure to GSM fields on the hair cells of the inner ear, even after interference by antibiotics. After the group around Galloni et al. (Bioelectromagnetics **26**, 2005, 536) has already shown that even strong GSM fields cannot induce damages in hair cells in the ear of the rat (see News from Science 4, 2005), it was now examined whether the damage of the inner ear occurring as a side effect of a treatment with aminoglycoside antibiotics could be affected by additional long-term exposure to GSM fields (900 MHz, 4 W/kg, 2 hours a day, for 4 weeks). Four groups of 8 rats each were examined with the following combinations: field alone; field + antibiotic (gentamicin 150 mg/kg, for 15 days); sham exposure + antibiotic; sham exposure without antibiotic. Prior to, during and after the exposure, the hearing of the animals was measured by otoacoustic emission testing (DPOAE). This is the measurement of active sound emissions of inner ear hair cells, experimentally triggered by two interfering sound frequencies. In the high-frequency range above 6 kHz, the interferences by the side effects of the antibiotic were clearly detectable, but were not affected by the field, though. As in prior experiments, field exposure alone showed no effect either.

Parazzini M; Galloni P; Piscitelli M; Pinto R; Lovisolio GA; Tognola G; Ravazzani P; Marino C: Possible combined effects of 900 MHz continuous-wave electromagnetic fields and gentamicin on the auditory system of rats. Radiat. Res. (2007) 167, 600-605.

Mobile communication and cancer

Mobile communication and skin cancer? Both UV radiation and ionizing radiation of higher quantum energy are known as skin cancer promoters. Does this apply also to non-ionizing radiation used by mobile communication? Three studies of Bordeaux University are devoted to this question. First, the acute influence on the skin of hairless rats was investigated that were fixed in special PVC tubes and were subjected for 2 hours to a precisely localised exposure to GSM-900 and -1800 MHz (5 W/kg). The animals were killed immediately after the experiment, and their skin was histologically and histochemically examined (skin thickness, proliferation index, filaggrin, elastin and collagen content and localization). In contrast to the positive controls, however, which were exposed to UVB (400 mJ/cm²), no changes could be detected. In a second study, the authors report on long-term experiments in which the animals were exposed for 12 weeks (2 hours/day, 5 days/week). There, the same method was used to find out whether the field could affect the cycle of skin regeneration, which takes 6-7

weeks. There was detected only a difference in weight among cage controls and exposed as well as sham-exposed animals, a fact explained by the stress of handling and observed by various authors in similar experiments. Finally, it was investigated whether there is an activation of heat-shock proteins (HSP70, HSC70, HSP27) during exposure. In contrast to other studies using transformed cell lines of skin cells, primary cultures of human keratinocytes and fibroblasts were applied here. These were exposed for 48 hours to 217-Hz pulsed 1800 MHz (2 W/kg). Also here, no effect was shown, contrary to the positive controls under UVB exposure. Hence, the authors conclude that there is no evidence of skin cancer induction by mobile communication fields.

Masuda H; Sanchez S; Dulou PE; Haro E; Anane R; Billaudel B; Lévêque P; Veyret B: Effect of GSM-900 and -1800 signals on the skin of hairless rats. I: 2-hour acute exposures. Int. J. Radiat. Biol. (2006) 82, 669-674. Sanchez S; Masuda H; Billaudel B; Haro E; Anane R; Lévêque P; Ruffié G; Lagroye I; Veyret B: Effect of GSM-900 and -1800 signals on the skin of hairless rats. II: 12-week chronic exposure. Int. J. Radiat. Biol. (2006) 82, 675-680.

Sanchez S; Haro E; Ruffié G; Veyret B; Lagroye I: In vitro study of the stress response of human skin cells to GSM-1800 mobile phone signals compared to UVB radiation and heat shock. Radiat. Res. (2007) 167, 572-580.

Long-term experiments in mice: Comprehensive investigations on possible cancer initiation by GSM (902 MHz) and DCS (1747 MHz) fields were performed in a long-term (2 years) experiment in mice at the Fraunhofer-Institute of Toxicology and Experimental Medicine (ITEM). In 18 groups with 65 animals each, male and female mice were exposed separately to three intensity levels for 5 days a week and 2 hours a day and compared to sham-exposed controls. Three pulse patterns were consecutively used during the 120-minute exposure, for 40 minutes each, called „GSM Basic“ with the highest intensity, simulating a continued, uninterrupted call, „GSM Talk“ with medium and „GSM Environment“ with the lowest time averaged intensity. Independently of that, three different doses were applied. The groups with „intensive“ exposure, with an average SAR of 4 W/kg, were distinctly above the value usually encountered when making a phone call, whereas the „middle“ group with 1.3 W/kg and the „weakly“ exposed group with 0.4 W/kg were closer to the realistic value of mobile phone use. The calculated exposure of individual organs under the different conditions is given in a table. While 15 of the 65 animals in each group were already examined after one year, 50 animals each stayed in the experiment for 24 months. The pathological analysis comprised the brain, heart, lungs, liver, spleen, kidneys, adrenals and gonads. Furthermore, a comprehensive blood screening was performed. All data, including the exposure parameters, were encoded and not made available until the end of the experiment. This two-year study with three dose levels thus met all conditions for checking possible chronic effects of chemical, pharmaceutical or environmental agents. The authors conclude that exposure of the B6C3F1 mice under these conditions produces no evidence of any adverse health effects, including the incidence of neoplastic and non-neoplastic alterations.

Tillmann T; Ernst H; Ebert S; Kuster N; Behnke W; Rittinghausen S; Dasenbrook C: Carcinogenicity study of GSM and DCS wireless communication signals in B6C3F1 mice. Bioelectromagnetics (2007) 28, 173-187.

Thermal effects

Blood flow compensates temperature elevation even at high SAR values. A Japanese working group conducted control experiments in the ears of rabbits after exposure to 1.5 GHz with average SARs of 2.3, 10.0, and 34.3 W/kg. Using IR thermography, the temperature course was observed every 10 s over 20 min of exposure and 10 minutes after. When interrupting the blood flow, there was a significant temperature rise al-

ready at 2.3 W/kg. With intact circulation, even 34.5 W/kg could be compensated. The authors emphasize the need to consider blood flow in model calculations and phantom measurements.

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 (2007) 28, 163-172.

Investigations in volunteers


Does electromagnetic hypersensitivity (EHS) correlate with an increased sensitivity to low-frequency (50 Hz) currents? This question was tested in three volunteer groups and compared to standard values of 708 persons. The sensitivity was measured by electrodes fixed to the forearm. The perception threshold at rising current intensity was indicated by pushing a button. As women are known to respond more sensitively than men, the threshold currents measured in women were divided by the quotient 0.77. Thus the values could be pooled with those of male volunteers. The results showed that the values of group 1 (37 persons from a self-help group of electrosensitives) did not differ from those of the control group. Significant decreases in threshold values, however, were measurable in group 2 (29 persons, who had answered a newspaper ad and attributed health problems to EMF) and in group 3 (24 persons, who had come forward spontaneously and attributed sleep disorders to nearby transmission masts). The significances were confirmed by different statistical methods. The authors emphasize that these findings do not reveal anything about the mechanism of EHS. There is no evidence either that an increased sensitivity to 50 Hz currents is the cause of EHS. It is rather a correlation that was also found otherwise between EHS and psycho-physical constellations of these persons.

Schröttner J; Leitgeb N; Hillert L: Investigation of electric current perception thresholds of different EHS groups. Bioelectromagnetics (2007) 28, 208-213.

No influence on sleep and cognitive functions of volunteers even at repeated exposure to a GSM field. For the first time, the University of Kiel investigated whether repeated exposure of volunteers to a GSM field led to alterations in sleep or different cognitive functions after sleep. The double-blinded tests were conducted in two groups of healthy young men (ten persons per group) during eight consecutive nights. The first night served for adaptation, the second night for determining reference values (baseline). In the following nights, the volunteers of one group were exposed, those of the other group were sham-exposed. A polysomnographic analysis was performed, based on continuous EEG, EMG and EOG measurements as well as on visual observation. In the morning after sleep, a combined test battery followed using several methods for examining psychological characteristics. The volunteers were exposed for the entire sleep period in a partly field-shielded room by an antenna close to their heads (900 MHz, SAR < 1W/kg in the brain, 0.024 W/kg whole-body dose). However, even after 6 times repeated exposure, no difference between exposed and sham-exposed persons could be detected. The small alterations in the EEG previously found by other authors could not be confirmed either.

Fritzer G; Göder R; Friegle 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 (2007) 28, 316-325.

Uncertain and difficult to reproduce results in the EEG of volunteers under the conditions of psychotests. The group around Christina Krause (Helsinki) has investigated possible effects of mobile phone fields on the learning behaviour of test persons and on the EEG, respectively, (see News from Science 2, 2004) for several years. Now



a publication of another double-blinded study is available, trying to replicate prior results in 36 male volunteers and to find possible differences between continuous and pulsed fields. The volunteers, exposed to a transmitter mounted on their heads, again were subjected to acoustic and optical tests of the short-term memory, and EEG measurements were performed. Differences in the psychotests could not be detected. Sometimes, there were small, but significant differences in the EEG, which the authors, however, characterize as „unsystematic“ and „inconsistent“. Partially, significant differences between the right and the left side of the head occurred at sham-exposure. This demonstrates the uncertainty of the methodology and the weight that may be given to other statistically significant differences of this study. The authors conclude that the EEG effects either do not exist at all or are so sensitive to additional conditions that they cannot be verified systematically.

Krause CM; Pesonen M; Björnberg CH; Hämäläinen H: Effects of pulsed and continuous wave 902 MHz mobile phone exposure on brain oscillatory activity during cognitive processing. Bioelectromagnetics (2007) 28, 296-308.