



22nd annual of the Bioele



by Frank Gollnick

The program of this year's meeting held in the quarters of the Technical University, Munich, in English was divided into 18 lecture sessions, each with several contributions focusing on the following 14 topics:

- Genotoxicity
- Theory, models & mechanisms
- Mobile phones in radio communications
- Cells & tissues
- Dosimetry
- Medical devices
- Exposure assessment
- Clinical applications: Epilepsy
- Electromedicine
- Nervous system & sensory physiology
- Human studies
- Animal studies
- Epidemiology & public policy
- RF Effects on cells & molecules

Besides, there were three main lecture events, two of which were divided into several contributions. In three poster sessions 220 contributions were presented by participating authors. As in precedent years, though, in the lecture sessions American contributors were strongly overrepresented. Besides, certain working groups presented several contributions during one session, thus hardly helping to achieve the initial aim to discuss matters from all possible scientific angles. Interesting new insights often were hidden in poster presentations receiving less attention because of the abundance of material. But there were also contributions clearly distinguished by form and/or their scanty contents from the otherwise high scientific standard of the meeting. Because of the great number of contributions and the fact that no outstanding new insights into the effects of electromagnetic fields (EMF) on living organisms and their biological substance was reported, in the following we will concentrate on what might be seen as the highlights of the meeting from a scientific point of view.

Genotoxicity

The investigations - partly pilot studies - presented in the lectures on genotoxicity (damaging of genetic material or disorders of connected mechanisms) with one exception referred to the impact of low



meeting

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frequency fields resulting from power supply or railway lines.

Positive findings exclusively resulted from relatively strong exposures of cell cultures (Yaguchi et al., Fujimori et al., both Japan) in the range of 50-100 mT or from environments of occupationally exposed persons (Nordenson et al., Sweden; Mashevich et al., Israel). The results are yet to be confirmed statistically.

In a study on human lymphocytes (white blood cells, immune cells) under a frequency and amplitude modulated 1.8 GHz exposure no statistically significant genotoxic effects could be measured (d'Ambrosio et al., Italy).

In this context poster presentations showed only in one single case (of five) an increased mutation rate in a cell culture of genetically altered human malign glioma cells (M054), again caused by a relatively strong ELF field (60 Hz, 5 mT; Ding et al., China & Japan).

In another cell culture of mouse the transformations (cancerigenous alterations) caused by x-rays even were suppressed or reduced by a six-week exposure to an ELF-MF (5-400 mT; Fujimori et al., Japan & China). A 15 min unpulsed 1.748 GHz field exposure (SAR value, i.e. Specific Absorption Rate: 2 mW/g) applied in a further study showed no genotoxic effect on isolated human lymphocytes (see above; d'Ambrosio et al., Italy).

Theory, models and interaction mechanisms

During the discussion of theory, models and interaction mechanisms regarding potential field impacts on biological systems besides concrete knowledge there were also presented highly hypothetical contributions, again mainly concerning the area of low frequency fields.

In this context Blank & Soo (USA) introduced new studies on the 'moving charge interaction (MCI) model' which claims an interaction between electromagnetic fields and electrons moving within molecule chains. During in vitro studies the scientists claim to have observed an acceleration (10%) of an oscillating redox reaction at an exposure to magnetic fields (60 Hz, 10 μ T (!)). According to the scientists, this result quantitatively corresponds to the alteration (increase) of observed enzyme (i.e. catalyzed by certain albumen) reactions under exposure to EMF. Based upon these observations Blank & Soo presented the possible impact of electromagnetic fields on DNA and/or the introduction of DNA transcription processes (reading of genetic information). This contribution led to animated discussions among the audience.

Subsequently, Walleczek & Carson (USA) presented the results of an in vitro study aimed to confirm the significance of the 'radical pair mechanism' as a possible

mechanism of the impact of magnetic fields on biological systems. At an exposure to direct magnetic fields (1-100 mT) also used in magnetic field therapy, a significant alteration of the oscillation activity of the peroxidase/oxidase/enzyme system has been observed. This could indeed be interpreted as a confirmation of the scientists' assumption that complex enzyme systems show a highly sensitive reaction to alterations of the magnetic field.

Weaver & Vaughan (USA) suggested a new theoretical approach that may provide higher reliability in demonstrating the actual occurrence of weak field effects during in vitro and in vivo experiments by means of an improved differentiation of interferences during evaluation (differentiated observation of the signal-to-noise ratio).

Based upon an in vitro study Pernodet et al. (USA) suggested that the extracellular albumen fibronectin necessary for cell adhesion with its matrix formation and adhesion behaviour may be the target of possible damaging field effects. Yet, appropriate experiments regarding induced surface charges under exposure are still to be developed.

Polk (USA) presented interesting calculations concerning effects of direct and ELF fields as well as temperature effects of high frequency fields in the molecular level of DNA. In his view, sudden

Agenda

of the 22nd annual meeting of the Bioelectromagnetics Society

main events

side events

Friday 06-09

IEEE SCC28 Meeting

Saturday 06-10

IEEE SCC28 Meeting

COST 244bis Workshop

COMAR Meeting

COST reception at the Hofbräuhaus



Sunday 06-11

US Air Force Workshop

EBEA Council Meeting

COST Premountaineering Tour



Monday 06-12

BEMS lectures

reception at the Deutsches Museum hangar Oberschleißheim

Tuesday 06-13

BEMS lectures

reception of the mayor in the Altes Rathaus

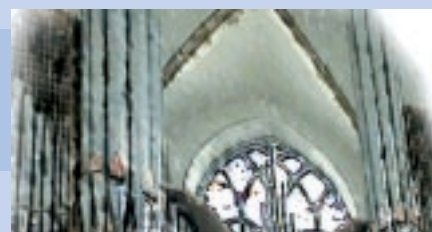


Wednesday 06-14

BEMS lectures

Colloquium honoring Prof. Brinkmann

guided tour of the Residenzmuseum



Thursday 06-15

BEMS lectures

organ recital at the cathedral „Unserer lieben Frau“ with Prof. Franz Lehrndorfer

Friday 06-16

BEMS lectures

panel discussion

press conference





temperature rises in the DNA molecule caused by quite high field strengths could lead to alterations of the molecular structure and to string breaks, as were observed, though less often, by Lai & Singh (1995) at a SAR value of 1.2 W/kg.

Vistnes & Gjøtterud (Norway) assessed the photon density of visible light compared to 50 Hz and/or 60 Hz fields of power lines. They concluded that the common view of ELF fields of high voltage lines as photons (as in light quanta) can lead to massive errors regarding the assessment of their possible impact. Assessments of 50 Hz and/or 60 Hz electric and magnetic fields therefore should only be made on the basis of classical electrodynamic fields.

Liboff (USA) did not find any physical evidence in theoretical approaches concerning the impact of devices for permanent magnet therapy on cells and tissue which might explain an actual effectivity. The assessed physical powers at the site of obscure effects in all cases were much too weak.

Out of eight poster presentations on this topic one particular contribution that dealt with a theoretical model on the impact of high frequency fields is worth mentioning: Bruna et al. (Italy) introduced a new approach that could provide an explanation of the impact of weak HF fields on living cells through the influence on ion binding in its specific membrane channels as well as the influence on channel behaviour itself. As a model system served calcium-activated calcium channels responsible for neuronal excitation, particularly considering the binding behaviour of calcium ions at the regulatory albumen calmodulin. In conclusion, the meeting did not bring forth fundamentally new aspects of possible interaction mechanisms.

Mobile phone devices and telecommunications

Sessions and poster presentations on mobile phone devices and telecommunications focused on various topics, the center of attention being the area of dosimetry. Kubacki et al. (Poland) and Conover et al. (USA) concluded from their investigations that the protection of workers in radio transmission and radar stations could be further improved if the actual dose of the exposure in the HF field could be determined more precisely by refined methods (in-detail monitoring of intensity and temporal summarisation as well as measuring of induced body currents, particularly in the vicinity of metal structures).

Neubauer (Austria) and Cooper et al. (Germany) presented freeland and/or laboratory measurements concerning security distances to antennas of mobile radio base stations (GSM 900 and DCS 1800 standards). All measurements made in the vicinity of base stations lay far below ICNIRP guidelines limit values of 1998 (maximum measured value: 3.3% of limit value); only eight out of 202 measurement values lay above 1 mW/m². The German measurements were made at a human whole body phantom filled with liquid in front of a typical D net base station antenna (Urban 120). After calculations of the SAR value the resulting data were compared to ICNIRP limit values for different environments (see below). Accordingly, limit values are only exceeded when a person approaches the antenna of the mentioned type up to a distance of 6 cm, 50 cm or 65 cm (exposure at workplace, general population at part or whole body exposure).

Animal experiments of Anane et al. (France) on experimentally neurodegenerated (brain damaged) rats exposed

in narrow tubes (GSM 900, 1-4 W/kg local SAR value at the head, for 21 days, 2 h per day) did not show any significant field effect concerning the course of the artificially induced illness (encephalomyelitis) in exposed versus non-exposed animals. The experimentally induced encephalomyelitis is a model for autoimmune reactions in the brain due to multiple sclerosis.

A much discussed contribution of Goodman & Blank (USA) showed that in a standard cancer cell culture („HeLa“ cells) stress proteins are induced by low frequency fields (pulsed frequencies of mobile radio stations; down to 0.8 μ T !) at initial energies lying 14 tenth powers below the cases where the energy is induced by heating. As the currently valid limit values all are based upon resilience limits of biological systems through heating, the authors demand a comprehensive review of existing security standards in the area of mobile radio. However, the high





actuality of the topic claimed by the two authors seems doubtful: The results obtained from the used cancer cell culture can not automatically be applied to health relevant aspects in humans. The pulsed frequencies of mobile radio applied in nearly „homeopathic“ energy doses in experiments obviously were simulated rather quickly with a Helmholtz spindle. Until now no other investigation did find effects resulting from such low field strengths. For a more thorough assessment of the study we have to wait for the printed version soon to be published in the „Journal of Cellular Biochemistry“ (Jin, Blank & Goodman). The very low field strengths applied in the experiments led to critical observations regarding the results in the plenum.

Dale et al. (France) did measurements and calculations at homogeneous and inhomogeneous head models (phantoms). They found that the average SAR value depends rather from differences in the conductivity of the tissue simulating liquid than from various dielectric properties. Besides, it is important to ensure that the model's ears show the appropriate tissue qualities - a problem dealt with in more detail in the poster presentation of Kanda et al. (USA). They conclude that it is not important concerning the SAR value whether the auditory canal is filled with air or liquid. Increased SAR values can be found at the edge, the seams and the folds of the auricle and the auditory canal.

A contribution of Kainz et al. (Austria) came to the result that GSM 900 or GSM 1800 signals did not interfere tested implantable neurological pulse generators. Such brain pacemakers are mainly used in the treatment of Parkinson patients in order to send aimed pulses to certain brain regions. The measurements were made at models of the human body.

Opening Address for of the Bioe

by undersecretary **Christa Stewens**

Poster presentations on the topic „Mobile radio devices and telecommunications“ introduced quite a few studies showing how the calculation or computerised „modelling“ of low frequency fields' energy actually absorbed by body tissue (SAR value) may be further improved. Body shape as well as the position of the transmission devices and other conditions of basic tests were considered. In addition, new developments and methods regarding exposure setups were presented. For example, Schüler et al. (Germany, Switzerland) made a suggestion for a general test signal improving simulation of actual mobile phoning in experiments. Contrary to present use, different transmission elements of mobile phones and base stations were examined under exposure to a mixture of pulsed frequencies. The test signal has already been applied by investigators in Germany (see below).

In a study on rats (exposed in narrow tubes) Lagroye et al. (France) at 900 MHz (1-4 W/kg local SAR value at the head, 2 h exposure) did not find any DNA damages in the brain tissue of the exposed animals. The tissue was examined with the same technology already used by Lai & Singh (1995, 1996) who at similar experiments applying pulsed microwaves (2450 MHz) did find a damaging effect.

Preliminary results of a Finnish working group (Heikkinen et al.) showed no effect of one-year exposure of mice to mobile radio frequencies on the development of artificially induced tumors. A 902.4 MHz GSM signal (217 Hz pulsed) and a 849 MHz signal of the DAMPS standard (50 Hz pulsed) were applied at an exposure of 1.5 hours per day and 5 days per week. The examined skin tumors were induced by UV radiation in normal mice and in mice with a certain metabolism deficiency.

Kraczyk et al. (Germany) did not find

any alterations of the electric brain activity (waking EEG and so-called 'visually evoked potentials', VEP, produced during the test through stimulation of the eyes with light) in 39 healthy study subjects during the use of commercial mobile phones. The tested objects were a mobile car phone (8 W), a D net mobile phone (2 W) and a E net mobile phone (1 W transmission power).

The brain can be a main target for the damaging activity of so-called 'free radicals' (particularly aggressive oxidative bindings in cells), since the brain cell membranes are abounding with polyunsaturated fatty acids. A part of the fields emitted by mobile phones 'hit' the brain substance. Therefore, Anane et al. (France) examined the impact of an exposure to mobile radio (GSM 900, 1-4 W/kg local SAR value in the head, applied for 7 days, 2 h per day) in 40 rats held in narrow tubes. The oxidation index (extent of oxygen bonding, i.e. oxidative damaging) of the fats from the rats' brain substance, was evaluated. There were no differences shown between exposed and non-exposed animals.

A poster of Veyret & Wiart (France) presented the French research program COMOBIO, an association of 15 research groups cooperating in eight research projects. The intention is to fill knowledge gaps which are not/or not sufficiently considered by other current large-scale projects as the EMF Project of WHO and the 5th European Framework Program. COMOBIO combines dosimetric studies and studies on humans (particularly the effects on hearing) with animal studies, all with the exception of cancer diseases. Final results will be available in 2002.

An independent replication study of Uttridge et al. (Australia) following the cancer study of Repacholi et al. that met

with a lot of attention in 1997 because of its positive findings was presented focusing on improved methods. 1540 mice of the same type and from the same supplier as in Repacholi et al. were examined at four different exposure levels (instead of one). Further, for the benefit of an improved assessment of the interacting field the animals were not exposed in cages but each individually in tubes. The result will be available at the end of 2001.

Cells and tissue

At the start of the sessions on 'Cells and tissues' an American research group (Henderson et al.) presented their results concerning the impact of EMF on signaling pathways within the cell. Accordingly, 60 Hz magnetic fields (100 μ T, applied up to 24 h) can have a similar influence on the growth behaviour (cell maturing process, so-called 'differentiation') of leukemia cells (cell culture HL-60) as the known tumor promoter TPA (tetradecanoyl phorbol acetate). Parts of the TPA signaling pathway are already known. The investigation was aimed to demonstrate at which sites the signaling pathway, influenced by the magnetic field, agrees with and/or differs from the TPA channel. It was shown that the magnetic fields activate a certain metabolism channel. Thus, the authors are convinced that there are complementing effects of magnetic field and TPA. Based upon their results, they do not exclude that the two different stimuli have an influence on different metabolism channels, but in the end cause the same effect. Thus, signal transduction channels in cells again are a possible focus of field effects.

In the same cell stem Sontag (Germany) observed the impact of 'interferential currents' on the chemically stimulated release of the neurotransmitter cAMP



within the cells. There cAMP has a crucial transmission function. 'Interferential currents' emerge through an overlapping of two alternating currents of slight frequency differences. 4 kHz currents with frequency differences from 0-50 Hz (power density: 8.5-2500 $\mu\text{A}/\text{cm}^2$, exposure: 5-15 min) are used. The interferential current led to an additional increase of the cAMP release, though only as a window effect at average chemical stimulation (maximum effect at 250 $\mu\text{A}/\text{cm}^2$ for 10 min). Other window effects were observed at interferential frequencies of 15 Hz and 32 Hz. The decomposing metabolism channel of the neurotransmitter was not influenced. The study confirmed earlier evidence for 'window effects' with maximum response at an impact on signaling pathways in cells by weak fields. In another lecture of Gottwald et al. (Germany) from the same research group such effects at the molecular level using material from cardiac cells, however, could not be confirmed.

Macrophages (white blood cells, important immune cells) of the mouse were examined by Simkó et al. (Germany) regarding the phagocytosis rate (absorption of smallest latex particles as a model for the destruction of bacteria) and the internal production of 'free radicals' (see above). The impact of a 50 Hz magnetic field (0.5-1.5 mT; 45 min-4 h) was tested. The phagocytosis rate was dose relationally increased by the field impact (as in a immune response), whereas the development of free radicals showed as good as no influence. The increase of the phagocytosis rate at a magnetic flux density of 1 mT was equivalent to the impact of 1 nmol/l TPA (see above) which activates a certain metabolism signaling pathway via the enzyme protein kinase C. The simultaneous appliance of magnetic field and TPA did not lead to a further

increase of the effect. Thus, the authors excluded a field impact on protein kinase C.





Sisken et al. (USA) identified effects of a static magnetic field (22.5-90 mT, 1 h/day for two days) on the outgrowth of in laboratory cultivated nerve cells isolated from chick embryos. The growth was significantly increased at 45 mT and 90 mT, though only in combination with 10 ng/ml NGF (Nerve Growth Factor, a substance necessary for the normal growth of such nerve cells). The addition of NGF alone without the magnetic field led to a relatively small growth.

During an examination of mimosa Nimtz et al. (Germany) identified alterations by needle electrodes of the so-called action potential of the plants (AP, internal electrical excitation for stimulus conduction) when treated with electromagnetic fields of a mobile radio frequency (1.87 GHz, 217 Hz frequency modulated, 10 mW/cm²) in the non-thermal field strength range. At the known touch response of mimosa leaves the relatively slow stimulus conduction (1 cm/s) - similar to and based upon in principle analogous processes in animals and humans - may be shown by

means of an electrical record. 300 measurements in 27 plants at field exposure resulted in a small (5%) decrease of the action potential at the beginning of its formation, not at conduction. Because of the very small effect and the obviously inaccurately applied measurement method the drawn conclusions were fiercely criticized by experts in the plenum.

Khizhnyak et al. (Russia, USA) could prove skin alterations in anesthetized genetically altered mice (BALB/C) following an exposure of 5x5 mm skin areas to mm-waves (42.25 GHz, 40 mW/cm², 15 min exposure). These alterations ranged from vasodilatation and infiltration by immune cells to changes within skin cells or even cellular death. The strongest alterations within the cells occurred in the vicinity of the sweat glands, though they very nearly receded after 48 hours. The applied radiation strength was equivalent to power peaks that can occur during application of microwave therapy devices. According to the authors, it is possible that the observed effects can also trigger whole body responses.

The ability of human immune cells (white blood cells, here T-lymphocytes and

<p>general population</p> 	<p>epidemiological studies search for effects of high frequency electromagnetic fields based upon a great number of subjects</p>
<p>Individual</p> 	<p>animal studies Does a controlled use of a certain factor (f.e. an electromagnetic field) trigger a measurable response in the body?</p>
<p>cells and tissues</p> 	<p>cellbiological studies Can electromagnetic fields have an impact on cell behaviour?</p>
<p>moleculs</p> 	<p>biochemical and bio-molecular studies Can biochemical responses or molecular structures be influenced by electromagnetic fields?</p>

monocytes) to contribute to a immune response under the influence of radar was examined by Stankiewicz et al. (Poland) (1300 MHz, not pulsed or 330 Hz pulsed, 10 W/m², 1 h exposure). The cells were isolated from freshly extracted blood. The average SAR value was 2 W/kg. The evaluation of a series of various immune tests following radiation generally showed an increased response activity of the cells being stronger in the pulse modulated field than at exposure to the unpulsed field.

Three other studies (Fitzsimmons & Dillman, USA; Nerucci et al., USA, Germany; Supronowicz et al., USA) searched for the biological fundamentals of improved bone fracture healing through magnetic field therapy devices. In cell cultures of bone and cartilage cells exposed to low frequency fields produced by corresponding therapy devices an increased formation rate of differentiated (i.e. fully developed) bone cells was measured. The second study provided evidence of an increased production of proteoglycans which are important for the stability and the mechanical properties of the joint cartilage. The third research group mentioned above also reported a significantly increased depositing of calcium (the basic stabilizing substance of the bones) in the cell intervals.

In the following, we will refer only to a small selection out of over 50 poster presentations on the topic 'Cells and tissues': Concerning assumptions that there is an increased brain tumor risk near high voltage powerlines Sekijima et al. (Japan) examined whether the expression of certain genes (actual reading/use of available genetic information) in brain cells is altered by a 60 Hz magnetic field (500 μ T, 0.5-3 h exposed). Since no alterations caused by the field are identifiable, a possible promotion of brain tumors at this - intentionally

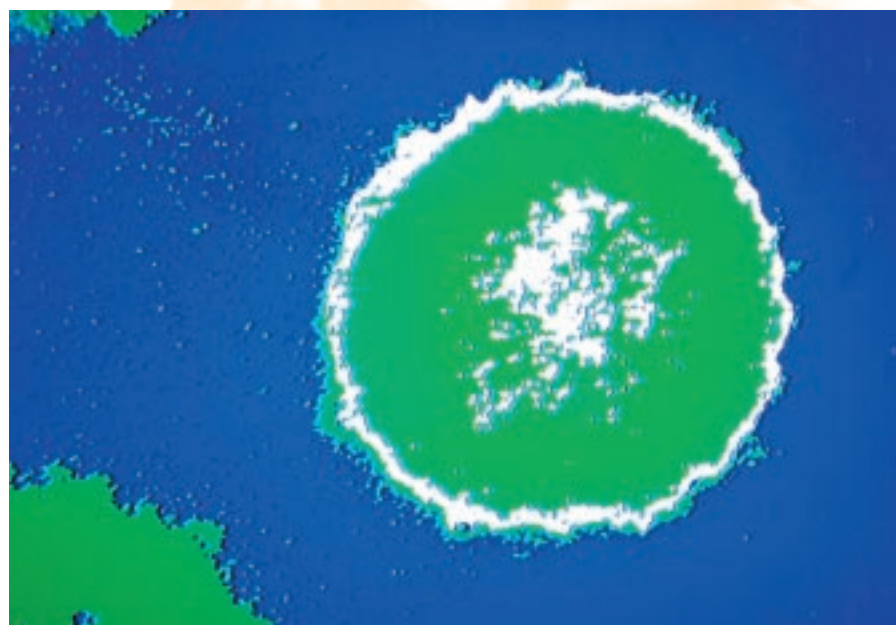
selected - lower, highly sensitive level of potential stimulus responses can be excluded.

Gollnick et al. (Germany) found no hint of an altered calcium metabolism at exposure to mobile radio fields in pinealocytes (cells from the pineal gland which produce melatonin) taken from hamsters and in retinoblastoma cells (culture of cells of the human retina). Calcium signals (i.e. short concentration peaks) cause many different reactions in cells which - excited at the wrong time - possibly may lead to damaging consequences. Both weak and strong fields (900 MHz with SAR values of 0.08 and 24 W/kg; 1.8 GHz with SAR values of 0.08 and 24 w/kg) were pulsed with a frequency mixture simulating the conditions of mobile phoning more realistically than ever (see above, Schüller et al.). Measurements were taken before, during and after a 9 min exposure.

Weak field effects on the calcium metabolism that show only with the application of a certain statistical test

method were demonstrated by Schubert & Glaser, Habel et al. and Haberland & Glaser (all Germany) in different human cell cultures (bone cells, white blood cells) at carrier frequencies in the kHz range or up to 150 MHz (frequency modulated and unmodulated). Various limitations of the reliability of results were discussed. In the range up to 200 kHz strong electric field components (100 V/m) were the centre of attention.

In two contributions Lerchl et al. (Germany) demonstrated effects of a pulsed police radio frequency (383 MHz, TETRA standard) planned for the future as well as a mobile radio frequency (900 MHz spectrum: mobile radio similar frequency mixture, see above) on young conifers and on corn seedlings. In one of three conifer types an increased growth during field exposure and disadvantageous alterations in the distribution of two leaf dyes (chlorophyll a and b; leads to reduced light use) were reported. The corn seedlings grow faster at both tested frequencies. Temperature effects are thought to be



unlikely by the authors, though the ground temperature during field exposure increased by 1–2 °C. Until now, leaf temperature has not been measured.

Winters et al. (Germany) found an increased permeability in a petri dish model of the so-called blood/brain barrier after being exposed to fields of the mobile phone E net (1.8 GHz, 217 Hz pulsed) over a period of 4 days (average SAR value: 0.3 W/kg). However, the barrier function of the used model anyway weakened in due time to a certain extent; the permeability was only relatively increased by the field. Further, the size of the sample (i.e. the statistical relevance) was very small. The blood/brain barrier provides a particularly stable ‘wall lining’ of the blood vessels in the human brain preventing damaging materials in blood from penetrating into the brain cells.

A genetically changed bacteria culture of salmonellae exposed to a 2.45 GHz field (8 mW/cm²) was examined by Perrin et al. (France). The field was applied for 17 hours during growth phase and/or for 1.5 hours during the following treatment of the culture with a mutagen (substance causing genetic alterations). The aim was to examine whether the mutation rate caused by the mutagen increases through the impact of the high frequency field. However, no statistically significant increase was identified.

The effect of a new high frequency signal used by the military (‘pulsed ultrawide band signal’, UWB) on cell cultures of human connective tissue cells (fibroblasts) and cultures of cells of the eye lens (corneal cells) of the rabbit was examined by Hambrook et al. (England). Through different tests (for example measurements of the membrane heat shock protein HSP 70) carried out one and two days after a three-hour UWB exposure (5.4 kV/m peak field

strength; 2.17 kHz pulsation) the viability of the cells was explored. The result showed that the radiation has no influence on cell density and other parameters in both cell types.

In examining lymphocytes (see above) from the blood of healthy study subjects exposed to a sinusoidal 8 Hz magnetic field (21 µT) Belyaev et al. (Sweden, Russia) measured statistically weak effects regarding two of three examined cell properties, mainly the internal organisation (morphology) of the cells, and, to a smaller extent, DNA fragmentation. For positive control gamma radiation and heat were used.

The possibility to stimulate the activity of lymphocytes (see above) in rats exposed to a 50 Hz magnetic field (100 µT) for two weeks before extracting a blood sample was examined by Gollnick et al. (Germany) comparing an exposed group with a control group. Response rate and strength of the cellular calcium metabolism after being activated through induction of the mitogenic stimulus Concanavalin A (a substance that stimulates cell division) were observed. In general, a calcium signal in cells initiates the cell division process. The strength of response in both groups statistically showed no significant difference. However, approximately twice as many cells in the group of exposed animals (16,9%) did not react to the mitogenic stimulus compared with 7,7% of the cells in non-exposed animals. This could be interpreted as a certain weakening of the immune system by field exposure, though the small number of examined animals did not fully support this conclusion.

Cultivated human brain tumor cells (neuroblastoma, LAN-5) also showed a response to a 50 Hz magnetic field (2 mT, exposed for 5 days; Pozzi et al., Italy): The

cell division rate decreased by 30%; further, an increased cell maturing (‘differentiation’) and an increased growth of cell runners were observed preceded by significant alterations of the internal organisation (morphology) of the cells.

Regarding damaging effects on prenatal development Guan et al. (Switzerland, Germany) examined cultures of non-developed embryonic cells exposed to a field of 1.71 GHz (217 Hz pulsed, SAR value: 2 W/kg, 22 or 40 h exposure in the rhythm 5 min ‘on’, 30 min ‘off’). Assumed effects on a number of observed parameters such as cell maturing behaviour, duration of cell division cycles and genetic expression (see above) of important indicator genes were not confirmed.

Dosimetry / Exposure assessment

The topic ‘dosimetry’ was the focus of a session complemented by two lecture series on ‘Exposure assessment’. Two contributions referred to the dosimetry of static magnetic fields (Engström et al., USA; Muehsam & Pilla, USA) connecting their effects with following phenomena: the activating of action potentials (see above), alterations of cell size, epilepsy and pain treatment. As field effects often do not occur at maximum field strength or field gradient sites, the first contribution dealt with a theoretical model forwarding a more precise determination of field site characteristics. This method is also claimed to be a reliable tool to assess magnetic field gradients based upon measurement data or numeric models regarding data with high interference factor. The second research team mentioned above presented a theoretical interaction model which allows to draw conclusions on bioeffects caused by static magnetic fields that occur in connection with ion ligand bindings



(ligands = electrically charged binding sites for ions). A saturation effect is claimed to occur in clinical applications at increasing field strength and prolonged treatment.

Ardoino et al. (Italy) presented a TEM cell for in vitro and in vivo exposure at 900 MHz enabling scientists to control temperature and CO₂ and meeting a number of conditions under which different living organisms can be examined at a highly homogeneous field distribution. At in vivo experiments the cell for example allows a simultaneous exposure of four mice under identical field conditions. The rest of the contributions dealt with new refined or updated calculations and computer models on thermal effects, SAR values, dielectric properties of tissues and permeability/conductivity of the body tissue in respect to certain waveforms.

During the two sessions on 'Exposure assessment' new exposure chambers were introduced, too: A waveguide chamber designed for simultaneous exposure of 25 severely restrained mice at 900 MHz (Puranen et al., Finland), a horn chamber with a parallel plate system providing a simultaneous and uniform (± 3 dB) exposure of non-restrained rodents in 18 standard cages at 1.6 GHz (Wilson et al., USA) as well as a horizontal radial waveguide with cages for the exposure of various non-restrained rodents (for example 48 rats simultaneously) at the boundaries of the setup at frequencies

around 900 MHz (in rats 13% field variation inside the cages; Bitz et al., Germany). Further, two contributions introduced new measurements of field strain of strongly exposed workers in electric plants (Bracken et al., Bowman et al., both USA).

A highly interesting thesis of Fewes et al. (England; Int. J. Rad. Biol. 75, 1523-1531, 1999) which is already available in print was amplified by adding more detailed data in the corresponding lecture. According to this thesis, electrically charged particles of harmful substances in the air below high voltage lines are responsible for as yet doubtful and unsolved hints of increased cancer rates in children living in the vicinity of such lines. As we know, cancer in children may be caused by air pollution from traffic. This means that fields emitted by high voltage lines over 100 kV (around 100 V/m) would not - as is often suggested, but not fully confirmed - have a direct influence on humans, but instead through the charging (and thus concentration) of pollutants in the air. This effect would only be observed downwind (not upwind) in areas up to 200-500 m from the lines. Since until now only electrical measurements concerning air charging are available, the mentioned conclusions are still hypothetical.

Based upon their measurements in the USA, Kavet et al. (USA) suggested that contact currents (for example via metal cases of grounded appliances or water fittings) in the domestic environment may provide a lacking link of the chain of proof for a connection between the influence of powerlines and child leukemia.

In a theoretical study Kotnik & Miklavcic (Slovenia, France) demonstrated that in experiments with cell cultures exposed to the MHz and GHz range the power loss of the fields in the cell membrane can

surmount the value measured in surrounding culture fluid by a hundred times. This means that in spite of the lacking evidence of heating of the whole system we can not exclude effects in the microscopic dimensions of cell membranes. However, these calculations lack conviction in so far as the layered molecular structure of the membranes was not taken into consideration.

A noteworthy contribution (Hamnerius & Uddmar, Sweden) dealt with measurements of high frequency fields (30-2000 MHz in 8 technically used bands from TV to mobile radio) at 26 sites in Sweden. The highest measured power flux density was 3 mW/m² in urban areas (mainly 900 MHz mobile radio). The average value for all measurement sites (urban and rural areas) amounted to 0.5 mW/m², for the city to 0.8 mW/m², for rural areas to 0.0016 mW/m² and inside buildings (average value urban and rural areas) to 0.0055 mW/m². In comparison, in 1978 an average value of 0.05 mW/m² was measured in 50 US cities, i.e. a value 16 times smaller for cities than in the current study. The emissions mainly (47% in all areas, 61% in cities) came from 900 MHz mobile radio base stations, with the exception of rural areas (48% TV stations). The highest measured power flux density at all still lay a thousand times below recommended limit values.

The over 30 poster presentations on this topic contained measurement data concerning the exposure of the general population and of workers to low frequency and high frequency fields. Van der Plas et al., for example, presented a survey on relevant sources of low frequency and high frequency emissions in the Netherlands comparing exposure strengths with valid limit values.

A survey from Korea (Kim & Cho) compared measurements of 60 Hz magnetic

fields for 55 occupationally exposed persons and for 50 not occupationally exposed persons. The result shows that persons in the occupational environment are exposed to higher magnetic field strengths. Field strengths in households lay between 0.03 and 0.17 μT , the average value of outdoor areas (without occupational exposure) lay below 0.1 μT .

Schüz et al. (Germany) presented the results of the residential measurements promoted by the German Ministry for the Environment as a part of an ongoing demographic studies on child leukemia in connection with low frequency field exposure (50 Hz electricity system power and 16 2/3 Hz railway system power). 1841 (out of 1900) evaluated 24-hour measurements (50 Hz) made in the rooms of affected children and of a control group showed an average value of more than 0.2 μT only in 1.5% of the cases. 50% of the residences had an average value below 0.03 μT , 95% of the households lay below 0.12 μT . The highest measured 24-hours average value was 0.73 μT . At night the values did not lie significantly below daytime emissions. There was a certain tendency to higher values in houses with more inhabitants and in streets with much traffic. Compared to the United States and Canada German values were significantly lower. The connection of these data with the case-control study on child leukemia is currently made (see below). Here, only the relatively small number of cases with an average household value of 0.2 μT were taken into consideration. This threshold value was established before the start of the study.

Two contributions from Finland (Kantell et al., Kotiniitty et al.) presented results and methods for measuring electric and magnetic field strengths in various environments (households, outdoor and working areas). In no area valid limit values

were exceeded. Extreme industrial working areas (for example in the vicinity of arc furnaces), however, were not considered.

Further, following posters were presented: measurements of induced currents from whole body exposure of different polarisation, suggestions for new appliances designed for experimental exposure or for exposure measurements, new calibration methods for such appliances as well as measurements of the impact of high frequency fields on cardiac pacemakers. In this context a study of Geisbusch et al. (Germany) should be mentioned exploring disturbing effects on cardiac pacemakers (assuming a worst case scenario) through coupling of high frequency fields (in the range of 50 MHz-500 MHz) with the pacemaker's electrode. The electrode can operate like an antenna in respect to disturbing fields. Results were obtained via field measurements at models and elaborate computations. Distant field conditions showed distinct resonant phenomena (i.e. a possible interference depending on the distance/power of the transmitter) in the frequency range around 80 MHz (range of radio and TV transmission frequencies). Under near field conditions the interference was less distinct. No electrode type was identified posing a particular hazard. As the contributions on dosimetry often were highly abstract, we will not discuss them in detail. Poster presentations on improved calculation or testing methods aimed to obtain exact data on the impact of fields of various frequencies on biological material prevailed. Next to mobile radio frequencies security systems (kHz/MHz range, Chadwick, England), static magnetic fields (Pilla, USA), radar frequencies (Kubacki et al., Poland) and low frequency fields (Gobba et al., Italy) played an important role.

Gajsek et al.(USA) dealt in detail with dielectric constants of different tissues needed for the calculation of SAR values. Klar et al. (Germany) developed a new very fast SAR testing system to obtain data on high frequency fields inside homogeneous body models in connection with security limit values.

Nervous system & sensory physiology

Here, at first an impact of pulsed low frequent magnetic fields on the human vestibular system was reported (Prato & Thomas, Canada). In corresponding tests with 31 study subjects the standing balance with eyes open and with eyes closed under varying light conditions at a site with and without magnetic field (200 μT) was examined. With eyes open there was no effect. With eyes closed the standing balance at field exposure deteriorated, though only under poor light conditions. Strong light conditions even improved the standing balance compared with the control situation. The offered explanations of this phenomenon, though, seemed highly hypothetical.

Szmigielski et al. (Poland) compared 38 exposed workers in radio/transmission stations (10-50 MHz) with the same number of non-exposed workers (average age: 45 years). Compared were 24-hours electrocardiogram (ECG) and blood pressure recordings in connection with individual high frequency recordings during the 12-hours shift. As in an earlier study of the same research group on workers of medium wave radio transmitters (0.7-1.5 MHz), increased rates of ECG irregularities in exposed workers were identified (in 74% versus 41% of the control group). The blood pressure values showed a similar trend. Therefore, the scientists assumed that several years of work at workplaces with a

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in the interest of manufacturers and network operators, as the adoption of a new technology to a great part depends on public acceptance.

Having recognized this, the Research Association for Radio Applications from the start strove for strictly neutral and scientific selection criteria in commissioning research projects. The studies exclusively are carried out by independent research institutions and universities, following the strict guidelines of WHO. However, with this approach we do not only seek to gain public acceptance, but also - or mainly - international scientific acceptance.

In the meantime we all - and especially you, dear ladies and gentlemen - were able to contribute through our work to the fact that the debate in Germany on „Elektrosmog“ lately has become more objective.

In conclusion I would like to thank you, dear participants of BEMS 2000, for all the work you have done so far and surely will do in the next few days here in Munich, discussing in detail the results of your research. Your work will remain hugely important, and I wish you every success in your future efforts. Besides, I wish to express my thanks to the organisers of BEMS and to Munich for giving us the opportunity to meet in this beautiful city. Thank you very much indeed.

corresponding high frequency strain poses an increased risk of cardiac/circulatory disorders. A clinical relevance of the obtained data is still to be verified.

In a time perception response test based upon rewards on rhesus monkeys D'Andrea et al. (USA) did not prove any influence of a 500 MHz field on the head (average SAR value in the brain: 0.6 W/kg, measured at body phantom models). Whole body SAR values were in the range from 1-4 W/kg. During the test the monkeys were tied at the neck.

The perception of so-called „phosphanes“ at exposure to low frequent amplitude modulated (20 Hz) 900 MHz fields was examined by Taki et al. (Japan) in four study subjects (phosphanes: light perception inside the eye, known at exposure to highly effective low frequent fields; threshold value for the perception at 20 Hz: 5 mT at the retina). At 900 MHz near field radiation with very high local SAR values up to 40 W/kg (!) no phosphanes are perceived (exposure duration: 1 min). At lower carrier frequencies (52.2 and 18.4 MHz) no effects were observed either.

Two other contributions of the same working group dealt with the phenomenon of 'microwave hearing' and with the memory of rats under the impact of pulsed high frequency fields (GSM and Japanese PDC standard). 'Microwave hearing' is a phenomenon also known in humans, meaning that high pulse energies of radar impulses through minimal thermoelastic prolongation (mechanical pressure wave) of the brain tissue produce clicking, knocking or hissing noises in the inner ear. An experiment with a 1 W peak transmission power combining numeric computations and studies on restrained rats (at 915 MHz, GSM standard and 2450 MHz, pulse duration 10 μ s) showed that the peak SAR value at 915 MHz must lie at 600-

1200 W/kg in order to trigger 'microwave hearing' in animals (Watanabe et al., Japan). This would be equivalent to a 90 W operated monopole antenna 2 cm in front of the rat's head. During the discussion following the lecture Veyret (France) confirmed that he, too, was not able to trigger 'microwave hearing' in experiment at peak SAR values of 40 W/kg in guinea pigs.

The experiments of Yamaguchi et al. (Japan) on the memory of rats were carried out in a T-shaped labyrinth with or without exposure to a 1439 MHz field (Japanese mobile radio standard). Restrained groups of six rats (test and control groups) were exposed or sham exposed for an hour (SAR values: brain: 7.4 W/kg, whole body: 1.4 W/kg) at four subsequent days before the experiment. The evaluation was aimed to determine whether the animals provided with food bowls positioned at two ends of the labyrinth remembered the filled one (16 tests per day with each animal). The result was that the field exposure caused no effects on memory.

Again, only a few examples out of the many poster contributions on the topic shall be mentioned: Bornhausen & Scheingraber (Germany) carried out learning tests on rats in so-called 'Skinner boxes'. The applied method differentiated the cognitive abilities of the animals more clearly than normally used methods. 40 developed rats in utero exposed for 20 days to a 900 MHz field (GSM standard, SAR value: 17.5-75 mW/kg) did not learn better or worse than the 40 examined control animals in utero without field exposure.

Nerve channels from frogs were examined under exposure to strong magnetic direct fields (up to 14 T; Ishihama et al., Japan). There was no impact shown on nerve excitation.



Several posters presented results of studies on brain tissue. Testylier et al. (France) found an increased release of acetylcholine (a neurotransmitter in the brain) in the brains of rats at an unmodulated 2.45 GHz and an amplitude modulated (32 Hz) 800 MHz field exposure. Deans et al. as well as Scott & Tattersall (all England), too, found effects on brain tissue of rats during the exploration of excitation of the nerve tissue influenced by an unmodulated or modulated (16 Hz sinusoidal or rectangle modulation) 700 MHz field. Temperature influences over 0.1 C° were excluded.

Thuróczy et al. (Hungary) detected a certain lengthening of the conduction of hearing stimuli to the brain; corresponding reaction tests used high frequency hearing stimuli switched on for 15 min (2 W peak transmission power) when the study subjects held a mobile phone to their ear (without their knowing). The obtained data, also based upon cognitive tests, came from the examination of only 10 study subjects and therefore statistically are not fully secured. Interpretation models regarding the effects assumed a small temperature rise and/or ion transfers in the inner ear.

Studies on humans

The much expected session on 'Studies in humans' was opened by Adair et al. (USA). Based upon earlier studies, physiological measurements were made at three different site temperatures in (only) 7 study subjects partly exposed to high frequency radiation (2.45 GHz unpulsed, SAR values up to 7.7 W/kg) of an antenna. A new aspect was a simultaneous easy body exertion of the study subjects (pedal trainer, 15 min before or during the 45 min exposure phase) in order to achieve a better impression of the role of the metabolism. The measurements were made

at different body parts: skin temperature, sweat secretion, blood circulation in the skin and whole body temperature. Reported results were an increase of the three first mentioned parameters through the exertion, but mostly through field exposure. The whole body temperature though showed nearly no effect at all (0.2 C°). The assumption was that body exertion and field exposure at the experiments have an additive instead of a synergetic effect.

Kutumbos & Barnes (USA) detected an increase or a decrease (!) of the blood oxygen factor in the index finger of study subjects after producing a static magnetic field at this spot (50-500 mT, effects only from 300 mT upwards). Questions regarding the relevance of this finding remained unanswered.

From a double blind sleep study from Switzerland on the phenomenon of electrohypersensitivity reported Müller et al. Electrosensitive persons at home were temporarily exposed to electric and magnetic 50 Hz fields (80-160 V/m, 2-6 µT) during sleep without knowing whether or when the field was switched on. Sleep quality and well-being on the following morning were measured via subjective and objective parameters (diary, interview, psychological tests, physiological parameters). The result was a positive interrelation between field exposure and well-being in the morning. The sleep quality was not impaired.

Out of 15,000 randomly selected adults (19-80 years old) in Sweden (Hillert et al.) 167 persons (1.5%) claimed to be electrosensitive, partly combined with an amalgam incompatibility. The thorough study considered many side influences (asthma, allergies, incompatibilities etc.). Among the identified electrosensitives were more women, better educated persons and immigrants than in the total sample.

Statistics confirmed that the 1.5% self-defined electrosensitive persons react stronger to all possible environmental influences or disturbances than the average population (all sorts of incompatibilities, noise, weather, air pollution etc.).

Hietanen & Hämäläinen (Finland) in a provocation study examined 20 study subjects claiming to be electrosensitive in connection with mobile phones. In an environment with low background fields (lonely wooden hut in the woods without power supply) they were exposed to mobile phones (900 or 1800 MHz, GSM/NMT standard) directly at the head. Object of the examination was the ability to sense the (directed by computer) 'on' and 'off' modus of the phones. All subjective feelings during the 30 min single experiments were recorded. All participants experienced the more or less significant subjective impression of being impaired during the tests. Nobody, though, could distinguish clearly between an actual exposure (on modus) and a sham exposure (off modus). During sham exposures even more symptoms were described, mainly by women.

The poster presentations on the topic did not provide ultimate evidence of the phenomenon 'electrosensitivity' gained under objectively controlled conditions either. In this respect both low frequent fields as well as fields of mobile radio were taken into consideration. An impact on sleep quality, this time at an exposure to 900 MHz fields (GSM standard), could not be confirmed (Espa et al., France). The size of samples mostly seemed too small (often well below 20 participants).

Animal studies

Compared to the great number of animal studies actually carried out this topic was given very little time during a short lecture

session. Many of the animal studies of course got their due attention during sessions on other topics as well as during poster presentations. Lerchl et al. (Germany) presented experiments with non-constrained hamsters in cages exposed to a continuous high frequency field for 60 days (cages in the radial waveguide, see above under 'Exposure assessment'). Groups of 120 animals (120 non-exposed control animals) in three experiments were exposed to mobile radio frequencies of 900 MHz, 1800 MHz (pulsed with a frequency mixture, see above) and to a future police radio frequency (383 MHz, TETRA standard) with a calculated SAR value of 80 mW/kg (variations 30%). Results: At 383 MHz and 900 MHz (but not at 1800 MHz) the body weight of the animals in due time showed a statistically relevant increase bigger than that of the control animals. In all experiments the growth rates of testicle tissue showed a significant increase (testicle cells show one of the highest natural division activity in the animal and the human body, similar to unnatural tumor tissue defying any physiological control).

Also noteworthy is a report from Fredericks et al. (USA) who obviously achieved a strengthening of the immune system in the body of 20 examined rabbits (10 exposed, 10 sham exposed) through a device for electrotherapy operated by low frequency pulses (15 Hz). During an operation at the shin the animals were infected with bacteria (staphylococci). After 14 days of magnetic field treatment (or sham treatment; 3 h per day) tissue samples were extracted from the infected bone area and examined for bacteria foci. Whereas all non-treated animals showed bacteria foci, 56% of the exposed animals showed no traces of bacteria colonies at all. The number of examined animals, though, seems too small in order to speak of a scientifically valid finding.

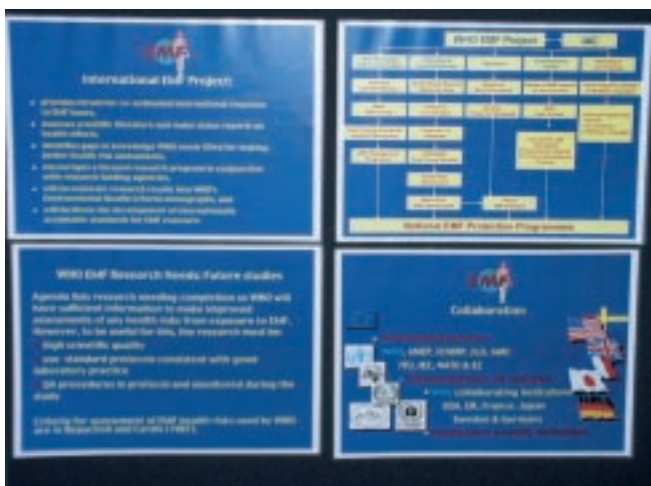
Comparisons of heat conduction from the skin into the body caused by strong millimeter waves (around 100 GHz) led to differences between animals and humans as well as between different animal species (rats, rhesus monkeys; Walters et al., USA). In humans the blood circulation in the skin exposed to weak millimeter waves plays a crucial part. The results again

implied that knowledge gained from animals in this respect can not be simply applied to humans.

A leukocyte deficiency (to below 50%) caused experimentally by cyclophosphamide (substance used in chemotherapy in humans) could not be suppressed by a treatment with millimeter waves (42.2 GHz), as already shown in earlier studies (Logani et al., USA). Without the cyclophosphamide treatment a notable increase (> 45%) of the number of leukocytes in the exposed and sham exposed animals restrained in narrow tubes was observed.

Out of the great number of poster presentations on this topic we will only sum up a few positive findings (positive and negative findings all in all were balanced):

Static magnetic fields (0.35 T, 0.5 T as well as ground magnetic field) could have an influence on pressure receptors in the arteries partly leading to healing and partly to unfavorable effects on blood pressure (Gmitrov & Ohkubo; Slovenia, Japan). Study subjects were rabbits and humans.



Static magnet fields (0.3-0.4 T) diminished the velocity of nerve channel conduction in the spinal cord of rats. This may have a pain suppressing effect (Tatsuoka et al., Japan).

Through strong rotating magnetic fields (0.4-0.6 T) the serotonin contents (neurotransmitter in the brain) sank in the brain of mice, at the same time rising in the peripheral blood (Xiaoyang et al., China).

Strong magnetic fields (up to 8 T) had no effect on oxygen bonding to the red blood dye haemoglobine in rats. The decoupling of oxygen from haemoglobine in vitro, though, was affected; this process may therefore possibly occur also in the lungs (Yoshimura et al., Japan).

A 42 GHz distant field (0.15 mW/cm²) had a suppressing effect on some general (non-specific) immune responses (phagocytosis activity, number of leukocytes) in mice (Gapeyev et al., Russia).

A 50 Hz magnetic field (1 mT) diminished the activity of N-acetyltransferase (NAT) in rats. The enzyme (catalytic protein) participates in the nocturnal production of the neurotransmitter melatonin in the pineal gland (Chacón & Massot, France).

The immune system of mice was affected by an exposure to a 50 Hz magnetic field (2 mT). Cells of different lymphatic tissues altered in number and response behaviour. Within 21 days, though, by counter-regulation normal conditions were restored (Frasca et al., Italy).

Demographic studies and social politics

In a cohort study on death occurrences among the employees of a manufacturer of mobile radio products (Motorola) data concerning 200,000 workers from the years 1976-1996 were evaluated (Kelsh et al., USA). The workers were qualitatively



divided into four categories according to the intensity of their occupational exposure to high frequency fields. The main focus lay on death causes, with special attention to brain tumors, lymphatic cancer and leukemia. No case confirmed an increased risk in connection with the occupational high frequency exposure.

A demographic study from Canada (Lavallois et al.) compared 221 women living 150 m or nearer to a 735 kV high voltage line with 195 women living 400 m or farer from the line. The electric/magnetic field strain showed an average difference of the factor 2 or 3. The deposit of the neurotransmitter melatonin in morning urine was measured (as an indicator for the nocturnal melatonin production). The suppression of the nocturnal melatonin production by magnetic fields is relatively well proven by experiments with rodents; for humans, however, such evidence is lacking. A statistically clear reduction of the melatonin deposit could be detected only in a small group of older heavily overweight women with strong field exposure. For more comprehensive interpretations this group was too small.

A lecture of Bernhardt & Matthes (Germany) depicted the tasks of the International Commission for Non-Ionizing Radiation Protection (ICNIRP) explaining on which basis and along which scientific evaluation criteria the commission decides on international recommendations for limit values.

Further interesting results on this complex issue were presented by following posters: In a pre-study of a large demographic study in Belge (Crasson et al.) with 111 persons the determination of the melatonin deposit in urine samples (see above) was combined with the evaluation of questionnaires on psychological well-being, on life organisation (including application of electrical devices) and on health status. Besides, the 50 Hz field strain in residences and electrical consumption were measured. The results showed no connection between different magnetic field strains and the psychological well-being or the functioning of the (melatonin producing) pineal gland.

Thier et al. (Germany) found out through his studies on available literature and researches on biological effects of



electromagnetic fields that an intelligent combination of the information from various data bases would significantly improve the efficiency of access to scientific knowledge. In this respect evaluation techniques and search routines were developed and applied. This aspect is especially important as the search for relevant results on the theme complex in question becomes increasingly complicated because of the great mass of published results as well as the wide range of study objectives and aims.

Schüz et al. (Germany) made risk calculations on child leukemia cases in connection with the demographic study above already mentioned under 'Dosimetry/exposure assessment'. According to statistics, each year 4.7 out of 100,000 children in Germany fall ill with leukemia, i.e. there are about 600 new cases annually. In 1.5% of the measured households magnetic fields above 0.2 μT were found. At this selected threshold value for the inclusion of children in the case-control study (see above) the calculated risk factor of the general population was 0.7%. Under these conditions theoretically only about 4 new child leukemia cases per year could be explained by an exposure to a stronger magnetic field. However, this assumption is still not confirmed by the evaluation of the overall study. The evaluation will be finished at the end of 2000.

High frequency effects on cells and molecules

This lecture session was very different. There was no general discussion about effects on cells and molecules; instead single effects on the genetic substance and DNA molecules were separately discussed. At first, numbers were presented that underline the everyday character of natural

temporary DNA damages: In a human cell each day occur about 16,000 so-called 'depurinations' (separation of a sugar-base-binding in the molecule), during our life each gene is damaged about 1010 times, and in a body cell continuously and simultaneously occur more than 3000 single strand breaks (each DNA molecule consists of two very long connected molecule strands). If these events occur with the mentioned normal frequency, they do not lead to damages of the whole organism. Each cell has effective recovering mechanisms which permanently repair the damages in the molecules (almost to perfection).

As earlier Lagroye et al. (see above under 'Mobile phone devices & telecommunications'), Cedervall & Lange (Sweden, USA) examined the reliability of a verification technique ('Comet Assay') used by Lai & Singh (1995, 1996) to prove a damaging effect on DNA strands applying pulsed high frequency fields (3450 MHz). They found out that the results of the verifying method mostly are interpreted incorrectly by the users, since in most cases an invalid interpolation of the measurements has become general use. A calibration of the evidence at applying ionising or UV radiation is valid only for a specific dose range. Consequently, the velocity of available repair mechanisms (see above) often is assessed incorrectly: This means that there may be made a wrong assessment of DNA strand breaks actually caused by test treatments (particularly at weak field effects).

Also with finding evidence of DNA strand breaks dealt Roti Roti et al. (USA), again with regard to the publications of Lai & Singh (see above). By means of the already mentioned 'Comet Assay' the effects of different field exposures on DNA samples were explored (2.45 MHz, unpulsed

and pulsed, SAR values: 0.6-1.9 W/kg; 835.62 MHz access method FDMA as well as 847.74 MHz access method FDMA, SAR values: 0.6-5 W/kg). From their own studies and in comparison to other contributions to the topic the authors concluded that it is highly uncertain whether high frequency fields at all can cause DNA damages.

Vijayalaxmi et al. (USA) reported from experiments to prove DNA damages in freshly isolated human lymphocytes (white blood cells, immune cells). The samples were exposed for two hours to a pulsed 2.45 MHz field at an average SAR value of 2.135 W/kg. Samples for positive controls were treated with ionising radiation. Again, the 'Comet Assay' was the applied measurement method. As a result, there were found no single strand breaks in the DNA molecules as a consequence of high frequency field exposure, neither immediately after the exposure nor four hours later.

As the three lectures of this session referred to the same topic complex, there was a vivacious discussion about results and even more so about the used method for finding evidence during which doubts concerning the results of Lai & Singh (see above) were expressed.

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