HOW SUSCEPTIBLE ARE GENES TO MOBILE PHONE RADIATION?

State of the Research – Endorsements of Safety and Controversies – Self-Help Recommendations

With Articles by Franz Adlkofer, Igor Y. Belyaev, Karl Richter, Vladislav M. Shiroff

Effects of Wireless Communication Technologies

A Brochure Series by the
Competence Initiative for the Protection of Humanity,
Environment and Democracy

Brochure 3

Effects of Wireless Communication Technologies

A Brochure Series by the Competence Initiative for the Protection of Humanity, Environment and Democracy
Brochure 3

Published by Prof. Dr. med. Karl Hecht, Dr. med. Markus Kern, Prof. Dr. phil. Karl Richter, and Dr. med. Hans-Christoph Scheiner

General Editor: Prof. Dr. Karl Richter in cooperation with Uwe Dinger and Peter Hensinger

International and Interdisciplinary Advisory Board:
Life Siences, Environmental Sciences and Medicine:
Dr. med. Christine Aschermann, Dr. med. Wolf Bergmann, Dr. med. Karl Braun von Gladiß,
Dr. med. Horst Eger, Prof. Dr. med. Rainer Frentzel-Beyme, Dr. med. Joachim Mutter,
Dr. med. Gerd Oberfeld (Austria), Dr. med. dent. Claus Scheingraber,
Dipl. Met. Walter Sönning (medical meterologist), Dr. rer. nat. Ulrich Warnke,
Prof. Dr. med. Guido Zimmer
Physics, Biophysics and Technology:
Prof. Dr. rer. nat. Klaus Buchner, Prof. Dr. rer. nat. Eberhard Ganßauge,
Prof. Dr. rer. nat. Klaus Goebbels, Daniel Oberhausen (France),
Prof. Dr. Gerard Hyland (England), Vladislav. M. Shiroff,
Dr. Ing. Dipl. Phys. Volker Schorpp, Dr. rer. nat. Dipl.-Phys. Stefan Spaarmann
Building Biology:
Katharina Gustavs (Canada), Wolfgang Maes, Prof. Dr. rer. nat. Anton Schneider
Law and Social Sciences:
Prof. Dr. jur. Erich Schöndorf, Dr. jur. Eduard Christian Schöpfer (Austria), Dr. rer. pol. Birgit Stöcker (First Chairperson of the Bundesverband Elektrosmog e. V.)
Interdisciplinary Cooperation:
Arnfrid Astel (writer), Dipl.-Biol. Heike-Solweig Bleuel (biology, environmental didactics),
Andrea Klein (intercultural communication / England),
Prof. Dr. phil. Ernst Liebhart (experimental and clinical psychology),
Prof. Dr. phil. Dr. h.c. Walter Müller-Seidel (literature studies, history of science),
Prof. Dr. phil. Jochen Schmidt (literature studies, interdisciplinary cooperation),
Prof. Dr. theol. Werner Thiede (Protestant theology)
International Partner:
Cindy Sage, MA (Coinitiator of the BioInitiative Working Group and coeditor of its report/USA),
Ingrid Pastl-Dickenson (Director of h.e.s.e. U.K./England),
Jeannot Pesché (President of Eurotinnitus and Luxembourg Tinnitus League/Luxembourg)

Title image: Competence Initiative e. V.

All rights reserved.
St. Ingbert, 1st edition November 2008, ISBN 978-3-9812598-1-0
English Edition March 2009

The translation was sponsored by :

Johann Wolfgang von Goethe-Stiftung, Basel
Fondation Johann Wolfgang von Goethe, Bâle
Johann Wolfgang von Goethe Foundation, Basle

How Susceptible Are Genes to Mobile Phone Radiation?

State of the Research – Endorsements of Safety and Controversies – Self-Help Recommendations

With Articles by Franz Adlkofer, Igor Y. Belyaev, Karl Richter, Vladislav M. Shiroff

Translated by Katharina Gustavs (p. 1 – 23, 29 – 47) and Paul Morris (p. 48 – 61)

Foreword by the Editors 4

The Endorsement of Safety by the German Mobile Telecommunication Research Programme (DMF) Regarding the Health Risks of Mobile Phone Radiation Is Based Rather on Wishful Thinking than Facts
Franz Adlkofer 6

Risk Assessment of Chronic Exposures to Non-Thermal Microwaves from Mobile Communication
Igor Y. Belyaev 24

DNA and Chromosome Damage: A Crucial Non-Thermal Biological Effect of Microwave Radiation
Vladislav M. Shiroff 29

Possible Health Effects of Mobile Phone Radiation in Children and Youth: The MOPHORAD Project
Franz Adlkofer 44

Self-Help in a Time of Systematic Mental Corruption
Karl Richter 47

About the Authors 61

Wishful Thinking as Health Protection?

For Real Research into the Risks of Mobile Phone Radiation

Foreword by the Editors

Since wireless technologies of mobile phones and other communication networks have become big business, we also find conflicting tendencies side by side. Our living environment is being swamped with electromagnetic fields that raise intensity levels and show a wide range of novel characteristics. Independent research provides more and more consistent evidence for serious consequences. Yet the responsible authorities of all stakeholder groups constantly assure the public that such effects are unknown to them. Contrary to the currently available data, representatives responsible for public health and environmental policy whole-heartedly promote messages of safety as happened when the results of the German Mobile Telecommunication Research Programme were presented in June 2008.

In this document *How susceptible are genes to mobile phone radiation? State of the Research—Endorsements of Safety and Controversies—Self-Help Recommendations*, Franz Adlkofer considers the endorsement of safety by the German Mobile Telecommunication Research Programme the result of wishful thinking, which ignores the scientific facts. Experts in biomedicine and biosciences, Prof. F. Adlkofer, Prof. I. Y. Belyaev, and V. M. Shiroff share in their respective articles what is known about biological effects in the international literature. Furthermore, they also explain what may make UMTS radiation especially dangerous. And all of them are in agreement that the issue is about long-term and non-thermal effects. Both of these parameters, however, were not considered in the setting of the current exposure guidelines.

The articles also show how many parameters of possible effects must be considered in order to gain a realistic understanding of the biological effects, which makes further research indispensable. Consequently, Prof. Franz Adlkofer submitted a new project proposal to the European Union, in which he suggests building upon the REFLEX project. Different research approaches should be integrated into this new project, and a broad international framework shall provide the foundation for a reliable clarification of the potential risks. Children and youth, who seem to be especially susceptible, shall receive priority consideration.

The chances, however, that such an important and well-founded project, which has been classified as an outstanding project by even biased members of the EU commission, can actually be carried out is more than doubtful. Since the prospect of a realistic fact-finding mission into the risks makes such a project inconvenient, indeed threatening to the industry, but also any government involved with its schemes, it provokes all kinds of resistance including controversies and affairs. In such situations, the simplest mode of gaining control is naturally the influence on the decision, which project is financed and which is not. At the moment, projects and contractors who do not question the current exposure limits and claims of harmlessness seem to have the best chances of winning financial support. Together the German government and industry spent 17 million euro on the German Mobile Telecommunication Research Programme in such a way that the endorsement of safety was preprogrammed and the delicate questions of long-term effects or the special vulnerability of children were not even touched. The collaboration between political power, industrial power, and exploited "experts" has given rise to dealing with the truth, the citizens, and the protective laws of a democracy in such a way that the commercial interests are accommodated whenever possible, yet our health, environment, and future are carelessly neglected. It now has become the norm that new wireless technologies are introduced prior to conducting research on their health effects. Only that information, which does not interfere with their commercial interests, is selected from the international knowledge base. The government's approach to safety is based on exposure guidelines, which do not acknowledge non-thermal effects, exposure duration, or the existence of special groups at risk. Each single act of ignorance adds up to a system of pretend safety, which gives the industry almost carte blanche, but at the same time disempowers and disfranchises affected citizens, leaving them without protection.

Yet, responsible citizens of a democracy—whether scientist or layperson—are not obliged to put up—for any length of time—with the unprecedented arrogance of this kind of mobile phone radiation politics. In fact, the number of citizens who reach for self-help and think of democratic resistance keeps growing. Our brochure series *Effects of Wireless Communication Technologies*, which hereby continues with the third publication, also regards itself as such a self-help project. The brochures are meant to make available the knowledge we have today and which official authorities ignore, deny, and withhold it from the public. The brochures offer access to the global knowledge base in this field and especially to specific research areas, which have been omitted by the German Mobile Phone Radiation Programme. The brochures wish to be a corrective voice and counterbalance to the public "awareness" campaign that covers up and "disposes of" scientifically well-documented risks.

We see this brochure as another pilot project for self-help, declaring our support for the project *Possible Health Effects of Mobile Phone Radiation in Children and Youth* suggested by Prof. Franz Adlkofer. First of all, we call on the European Commission and the European Parliament to make a real effort for research into the risks in real life and to financially support projects, including the one mentioned above. We also call on the European governments to share in the raising of the necessary funds. In addition, we will support the initiators of this project in search of non-governmental funding sources. And in the event of a lack of funding, we will turn to all European citizens for donations. 17 million euro alone were spent on the German Mobile Telecommunication Research Programme. Should a project with much greater hope for more reliable research results not even get started because of a lack of 3.5 million? After publishing the analyses in the German brochure *Mobile Phone Radiation Hazards and Injuries Among Children,* we now continue our support for this relevant research project.

Only as scientists can the authors of this brochure show how far government, industry, and their scientific backers are away from the international body of evidence. For laypersons interested in modern science, certain technical terms may sometimes be a challenge; one is well advised to simply pass over some of the more challenging parts and/or to consult the recommended research links for further information. Altogether, however, the brochures offer a unique opportunity to participate in and support the scientific debate. In the end, the fight for a healthy world and future will only be successful if scientists *and* ordinary citizens join forces, supported by their very own kind of "capital": solidarity, common sense, and the joint commitment to all those values that make life human!

We thank the Johann Wolfgang von Goethe Foundation (Basle / Switzerland) for having financed this translation.

Prof. Dr. Karl Hecht

Dr. med. Markus Kern

Prof. Dr. Karl Richter

Dr. med. Hans-Christoph Scheiner

The Endorsement of Safety by the German Mobile Telecommunication Research Programme (DMF) Regarding the Health Risks of Mobile Phone Radiation Is Based Rather on Wishful Thinking than Facts

Franz Adlkofer

Summary

The reliability of any assessment concerning a mobile phone radiation health risk based on epidemiological data is strongly dependent on whether there are biological concepts to explain it plausibly. Latest research results from studies of isolated cell systems and from animal experiments show that mobile phone radiation can trigger irreversible damage in genomes and reversible one in epigenomes. Biologically speaking, UMTS (Universal Mobile Telecommunications System; 3G or third generation) appears to be more active than GSM (Global System for Mobile Communications; 2G or second generation).

These findings support the suspicion that there is a causal link between the increase in brain tumor risk as already observed in a number of epidemiological studies on the long-term use of mobile phones. For the increased tumor risk, it is a prerequisite that the duration of mobile phone use reaches a minimum of ten years, which coincides with the minimum latency period necessary before a malignant process manifests itself. Consequently, this observation could be an early clue, indicating that mobile phone radiation encourages the development of brain tumors. The overall body of evidence, resulting from the available research, gives every indication that the quick clarification of possible health risks in the form of focused research efforts must be given high priority and that for the protection of public health the precautionary principle should be urgently recognized by the decision-makers in industry and government, until verified evidence for a final decision becomes available. The endorsement of safety by the German Mobile Telecommunication Research Programme (DMF), which has no basis in scientific fact, clashes with the interests of the citizens of Europe.

1. Introduction

Genes, environment, and behavior are three aspects that significantly determine life expectancy and types of diseases a person may be plagued with. Environmental and behavior stressors decide whether a genetic disposition will become manifest. To what extent, radiofrequency electromagnetic fields (RF-EMF) utilized by wireless communication technologies must be counted among those stressors, science cannot say with certainty at this time. It is imperative that this issue be clarified because almost all of the European population is exposed to mobile phone radiation by now—and this in close proximity and at unprecedented intensity levels.

Shortly before the turn of the century, the International Commission on Non-Ionizing Radiation Protection (ICNIRP) developed exposure guidelines for the protection of the general public, which, upon compliance, will prevent bodily harm resulting from heating caused by RF-EMF (1). The European Union recommended its members adopt these exposure guidelines. Most of the member states, including the Federal Republic of Germany, followed this recommendation. But because of the latest scientific insights, the question becomes more and more urgent as to whether current exposure guidelines sufficiently rule out the possibility of health risks for the general public. About 40 percent of European citizens now have serious doubts that respective reassurances by the government and industry can be trusted. The recently completed German Mobile Telecommunication Research Programme (DMF) tries to remove such doubts. Developed at the expense of 17 million euro over the past six years, it came to the reassuring conclusion that, at this point in time, concerns about health impacts are not warranted as long as the exposure limits are observed.

In case these officially documented reassurances by the DMF were valid, the following questions, currently asked by persons concerned about their health, would have to be answered in the affirmative:

1.1 Questions

Question 1: In its assessment of possible health risks, did the DMF give sufficient consideration to the results of fundamental research from laboratory investigations, animal experiments, and epidemiological studies?

That mobile phone radiation is biologically active can be derived from results of available laboratory investigations and animal experiments, and is not any longer seriously disputed by any scientific institution. Major differences in opinion only concern the importance of the observed biological effects in relation to disease development. The advantage of *laboratory investigations* lies in the fact that they can be conducted under exactly controlled experimental conditions. It is their objective to record biological markers for diseases that possibly manifest later in life, but whose endpoint will not be reached in the experiment. To calculate the risk to humans from such data is not possible. The results gathered, however, allow for testing whether the observed effects are relevant to disease development and, consequently, may be suited as indicators for its development and through which mechanisms they come into existence.

Animal experiments, which also can be conducted under controlled experimental conditions and even at the highest possible exposure level, often include the endpoint of the disease or at least its preliminary stages. Yet, the extrapolation of these observations to humans is generally problematic.

Epidemiological studies can only be controlled to a very limited degree, but they are the most suitable to establish an association between radiation exposure and a disease caused by it. From a precautionary point of view, results gathered in this way will become available far too late because there is usually a latency period of many years or even decades between the initial damage and the onset of disease.

Due to the different strengths and weaknesses of all three research approaches, the risk assessment usually is the result of a *panoramic view*. Even if in vitro or animal experiments, or epidemiological studies cannot be consistent by themselves, they can certainly all point in a similar direction. Whether the DMF actually applied such a panoramic view of the available scientific knowledge and research approaches in its risk analysis, is of vital importance to the credibility of their widely circulated declaration of safety.

Question 2: In view of the current state of research, is it still acceptable for exposure guidelines to not consider the existence of non-thermal effects of mobile phone radiation and their different signal characteristics?

The idea that mobile phone radiation is harmless, as propagated by the government and industry, is mostly based on the assumption that non-thermal biological effects do not exist. It is assumed that all known biological effects are exclusively of a thermal nature and that current exposure limits provide sufficient protection for this. If proof could be provided that this assumption was indeed valid, there would certainly be no basis for concerns of adverse health consequences upon compliance with these exposure limits. However, if non-thermal effects can also occur, health risks cannot be ruled out any longer, especially if the latter effects involve the structure and function of genes. Consequently, the question arises how convincing the evidence is for the existence of non-thermal effects of mobile phone radiation in addition to thermal effects, which then could be the real cause of possible health impacts. This also applies to the question of whether biological effects of mobile phone radiation are dependent on the carrier frequency, signal characteristics, and exposure duration. In this context, a possible difference of biological activity between UMTS radiation (Universal Mobile Telecommunications System; 3G or third generation) and GSM radiation (Global System for Mobile Communications; 2G or second generation) is of special interest. Whether the available research results and current exposure limits can still be reconciled in light of these considerations needs urgent clarification. The endorsement of safety given by the DMF, which is based on the assumption of the validity of official exposure guidelines, makes such a clarification all the more imperative.

Question 3: Is it justified to assess the effects of mobile phone radiation in children and adolescents, whose anatomical and physiological characteristics are different from those of in adults, in the same way as for adults, and to assume that both children and adults will be equally protected by the current exposure guidelines?

Concerning possible health impacts, children and adolescents pose a special problem because today they count among the most eager users of mobile phones. In Germany, almost 80 percent of all girls between 14 and 17 years currently own a mobile phone, and their male counterparts rank closely behind them (2). That this trend con-

tinues further down through much younger age groups can be assumed with certainty. Owing to their anatomical and physiological characteristics, however, it must be concluded that the brain structure of children and adolescents is exposed to much higher RF radiation levels than the brain of adults, provided that the frequency of mobile phone use is the same for both groups. Also, the question arises whether the organism of a person who is still developing physically, e.g. central nervous system or bone marrow, may be more susceptible to mobile phone radiation, and whether their long life expectancy may involve an even more significant health risk. Children have a much higher likelihood of surviving the latency period of often many years or even decades, spanning between the initial damage and the onset of a chronic disease such as cancer and Alzheimer's than adults. It is, therefore, of utmost importance to clarify the question whether current exposure guidelines address the special characteristics of children and adolescents. The credibility of the endorsement of safety by the DMF rests to a large extent on whether the special problems associated with children and adolescents were sufficiently considered in the risk assessment.

1.2 Purpose

To address the above posed questions, this article will discuss the most important results from the latest laboratory investigations, animal experiments, and epidemiological studies insofar as they indicate a possible health risk of mobile phone radiation. It was a conscious decision to not report about the numerous papers that did not find any indication of RF-EMF effects associated with relevant diseases. No matter how many negative research findings there are, they would never be able to invalidate even one single positive finding of a study that was carried out correctly. And, of course, replication studies under "seemingly" comparable conditions with negative outcomes still do not constitute proof that the first findings were incorrect. The conclusions drawn from the results of the three different research approaches address first the question of whether the safety message by the DMF concerning possible health risks is scientifically validated. Second, based on this answer, due thought will be given to strategies about how to accelerate knowledge gain, which is imperative for the better protection of public health than has been the case so far. Third, a recommendation is made how to bridge the time gap until a reliable risk analysis can be carried out based on validated research results.

REFLEX Study Results

Below the current exposure limit of 2 W/kg, GSM-1800 and GSM-900 change the structure and function of genes in various human and animal cells after intermittent and continuous RF radiation exposures. The following effects were observed:

- **Increase in single- and double-strand DNA breaks in human fibroblasts, HL60 cells, and rat granulosa cells, but not in human lymphocytes (9,10,11)**
- **Increase in micronuclei and chromosome aberrations in human fibroblasts (9)**
- **Change in gene and protein expression of several cell types, but especially in human endothelial cells and mouse embryo stem cells (9,12,13,14)**

A significant increase in DNA strand breaks was observed in human fibroblasts at an SAR level as low as 0.3 W/kg.

2. Research Results from Laboratory Investigations, Animal Experiments, and Epidemiological Studies

2.1 Laboratory Investigations

The development of a tumor requires the genetic transformation of a cell whose program is changed in such a way that it can grow uncontrollably. In vitro investigations researching a tumor risk, therefore, are based on the concept that each agent capable of producing stable genetic mutations, in general, may also be capable of inducing malignant tumors (3). Genetic damage can be verified by means of comet assays, micronuclei tests, and chromosome analysis. The comet assay measures single- and double-strand DNA breaks, which are formed in different manners and at different phases of the cycle during cell division. The micronuclei test shows chromosome damage, which is the result of either DNA damage, e.g. double-strand breaks, or disturbances in spindle function during cell division. After the application of a special stain, damaged or altered chromosomes can be counted directly under the microscope.

For quite a number of years, it has now been regarded as scientifically validated that during the development of malignant tumors epigenetic changes in somatic cells play a role of equal importance as compared with genetic ones. It is only the epigenetic mechanisms responsible for the implementation of genetic information, in

turn, affecting such processes as cell division, cell proliferation, cell differentiation, apoptosis (programmed cell death), and DNA repair, that provide a cell with the properties required for its uncontrolled growth. However, activation or inhibition of epigenetic mechanisms may either intensify the effects of environmental carcinogens or attenuate them. Just like genetic changes, epigenetic changes, which as opposed to genetic changes are reversible, also occur as a result of environmental impacts (4). During the development of chronic diseases other than cancer and probably also during acute manifestations of individual health symptoms, it is almost exclusively epigenetic changes that trigger and maintain the disease formation. When taking all of this information into consideration, the question arises whether RF-EMFs have the potential to cause changes in the genome or epigenome, which are important for the development of cancer or other chronic diseases.

Already in the middle of the past century, genetic damage was observed for the first time in plant cells after their exposure to pulsed shortwave radiation (27 MHz) (5). Regardless, the majority of scientists still believe up to the present day that the many inconsistent results of the in vitro research in this area would more likely cancel each other out than actually explain processes of this kind inside a cell (6, 7, 8). Such a notion, however, no longer does justice to the now available observations from basic scientific research. In this process of finding answers, the REFLEX study*, which between 2000 to 2004 had been carried out by 12 research groups from seven European countries with funding of the EU Commission in the 5th Framework Programme (FP5), gains special importance (9). This study strongly indicates that RF-EMFs can change genetic structures and functions in various, but not all human cells (see box).

Fig. 1: Dose-dependent increase in DNA strand breaks (comet assay, light blue columns) and chromosome damage (micronuclei, dark blue columns) in fibroblast cultures from human skin biopsies after 24-h exposure of UMTS modulated electromagnetic field. The comet assay tail factor in % is a measure for the increase in single- and double-strand DNA breaks.

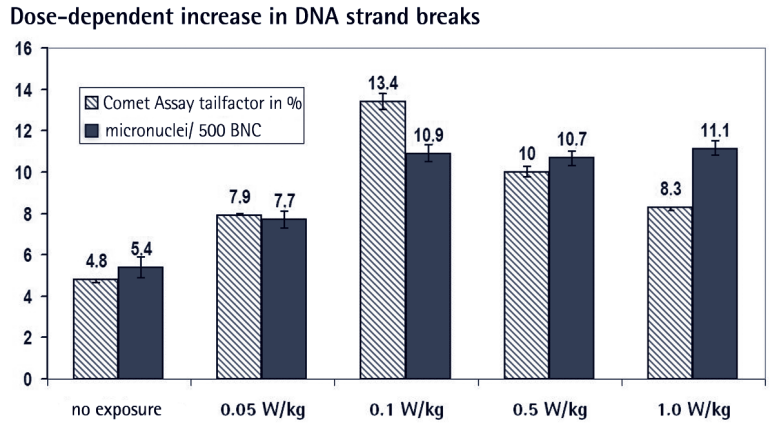
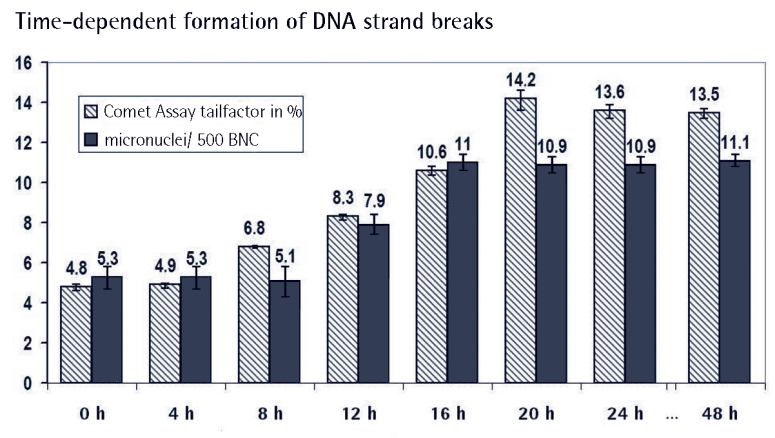


Fig. 2: Time-dependent formation of DNA strand breaks (comet assay, light blue columns) and chromosome damage (micronuclei, dark blue columns) due to UMTS modulated EMF exposure of human fibroblast cultures at a SAR level of 0.1 W/kg



In the meantime, the results of the REFLEX study have been impressively confirmed in a follow-up investigation (15). Figure 1 shows that genotoxic changes in human fibroblasts occur already at a UMTS radiation exposure with a specific absorption rate (SAR) of 0.05 W/kg. These results were produced by utilizing two different cytogenetic procedures: the comet assay and the micronuclei test. The current SAR limit of 2.0 W/kg for mobile phones exceeds this value by a factor of 40. The rate of decrease of DNA strand breaks after exposure to a SAR > 0.1 W/kg can probably be ascribed to DNA repair, which has been activated by the preceding genome damage. Figure 2 shows the increase of genotoxic changes in relation to the exposure duration. A significant increase

* Risk evaluation of potential environmental hazards from low energy electro magnetic field exposure using sensitive in vitro methods (QLK4-CT-1999-01574)

in DNA strand breaks was observed after 8 hours and in micronuclei after 12 hours. Just as human lymphocytes do not respond to GSM signals, they also do not respond to UMTS signals (results not shown). The reasons for this are unknown.

The results of the REFLEX study and its follow-up investigation, which in the meantime have been in part confirmed by at least three other working groups (16,17; Xu et al., Zhejiang University School of Medicine, China, personal communication), are still doubted by many scientists, especially since a deliberate rumor was spread, suggesting that the research results were falsified (see article by Richter, p. 48). But there are also numerous other publications on genotoxic and epigenetic effects of RF-EMFs that lead to comparable conclusions. They confirm not only genotoxic effects of mobile phone radiation (table 1), but epigenetic changes as well (table 2). That the latter also occurred at levels below existing exposure limits could be demonstrated in numerous investigations over the past years.

2.2 Animal Experiments

When considering animal experiments, one must distinguish between RF-EMF exposures over an entire lifespan and those that are applied for short periods of time only. While long-term animal experiments test whether RF-EMF exposures can contribute to tumor development through initiation or promotion, short-term animal experiments pursue the question whether RF-EMF causes changes at the genetic or epigenetic level, which would indicate a preliminary stage of disease formation. The research results available to date are inconsistent (6) so that it is not possible to draw reliable conclusions regarding humans. Technical problems with the exposure setup that can lead to stress reactions in laboratory animals (45), as well as the fact that the metabolisms of humans and animals differ greatly due to their genetic constitution, make it a rather dubious undertaking to extrapolate results to humans. Furthermore, in order to be on the safe side, typical animal experiments, in part to make them financially feasible, are carried out with dosages that are several orders of magnitude higher than can be measured in the environment or occupational settings. Due to the development of heat, this procedure cannot be used with RF-EMF exposures.

Provided that the same radiation level elucidates the same effect in humans and animals, the much lower life expectancy of laboratory animals alone does not allow for the assumption that a higher tumor risk could be found in these animals in comparison with humans. But unless a doubling of the relative tumor risk can be achieved, evidence through animal experiments is not possible. As an acceptable alternative to this dilemma, a substantial increase in the numbers of animals could be considered, but this would exceed the financial and technical possibilities of research institutes. Another reasonable alternative would be to use animals that have already a lifelong cumulative tumor incidence for a certain type of cancer due to the application of a carcinogen or due to a genetic modification, which could be increased further through RF-EMF exposure. If, however, the background rate of the tumor is too high or the rise of the incidence curve too steep, a higher than pre-existing incidence cannot be established by RF-EMF exposure anymore.

Like the REFLEX study, the PERFORM-A project* (the most elaborate study of its kind to date and one that had been largely financed by the industry) was also part of the FP5. The outcome of the latter study was mostly negative (46). After a long-term exposure of the head with RF-EMF (GSM and DCS; SAR 0.4, 1.3 and 4.0 W/kg; 2 hours/day; 5 days/week; 2 years), the tumor rate in B6C3F1 mice and Wistar rats was not increased (46, 47, 48). In Eμ-Pim1 transgenic mice, which have a tendency to spontaneously develop lymphomas, a further increase in the formation of lymphomas did not occur after the RF-EMF exposure (46, 49), which is in direct contrast to a similar study that had been conducted earlier (55). Only a study with Sprague-Dawley rats, which for the induction of mammary carcinomas had received dimethylbenzanthracene (DMBA), revealed after a six-month exposure with RF-EMF a significant increase above the DMBA expected tumor rate (46,50).

Another study with Fischer344 rats also pointed in the direction of a carcinogenic potential of RF-EMFs (head SAR < 2 W/kg; 90 minutes/day; 5 days/week; 2 years). At least in the female animals, which were the offspring of mothers that had received N-ethyl-nitrosourea during gestation, a trend was observed that showed an increase in brain tumor rates after the additional exposure to RF-EMFs (51). Thus, there are also animal studies that cast doubt on the safety of RF-EMF exposures, indicating a carcinogenic potential of this radiation (table 3). Yet, all of these studies stand accused that either the results of replication studies could not confirm the original findings or that follow-up investigations are still pending. This is totally disregarding the fact that negative outcomes of replication studies do not constitute proof that the findings of the original studies are wrong.

A not-yet-published study from the Fraunhofer Institute of Toxicology and Experimental Medicine in Han-

* In vivo research on possible health effects of the use of mobile telephones and base stations (Carcinogenicity studies in rats and mice) (QLK4-CT-1999-01476)

Table 1: Evidence of Genetic Damage in Isolated Animal and Human Cells, Very Likely Induced by Non-thermal Effects of Mobile Phone Radiation

Author	Title	Effects
Phillips JL, Ivaschuk O, Ishida-Jones T, Jones RA, Campbell-Beachler M, Haggren W. (18)	DNA damage in Molt-4 T-lymphoblastoid cells exposed to cellular telephone radiofrequency fields in vitro. Bioelectrochem Bioenerg 1998; 45(1):103-10.	Increased genetic damage (DNA strand breaks) in lymphoblastoid cells after intermittent exposure at SAR 24 mW/kg (813 and 836 MHz; pulsed; 2, 3 and 21 hours), decrease of genetic damage at SAR 2.4 mW/kg
Zotti-Martelli L, Peccatori M, Scarpato R, Migliore L (19)	Induction of micronuclei in human lymphocytes exposed in vitro to microwave radiation. Mutat Res 2000; 472(1-2): 51-8.	Increased genetic damage (micronuclei) in human lymphocytes after 30- or 60-min RF radiation exposure (2.45 und 7.7 GHz; 30 mW/cm2)
d'Ambrosio G, Massa R, Scarfi MR, Zeni O (20)	Cytogenetic damage in human lymphocytes following GMSK phase modulated microwave exposure. Bioelectromagnetics 2002; 23(1): 7-13.	Increased genetic damage (micronuclei) in human lymphocytes after 15-min exposure to phase modulated RF-EMF signals (18 MHz; 2.2 W/kg)
Zhang MB, He JL, Jin LF, Lu DQ (21)	Study of low-intensity 2450-MHz microwave exposure enhancing the genotoxic effects of mitomycin C using micronucleus test and comet assay in vitro. Biomed Environ Sci 2002; 15(4): 283-90.	The increased genetic damage (DNA strand breaks, micronuclei) in human lymphocytes induced by mitomycin C is significantly increased by RF radiation exposure (2450 MHz; 5 mW/cm2; 2 hours).
Mashevich M, Folkman D, Kesar A, Barbul A, Korenstein R, Jerby E, Avivi L (22)	Exposure of human peripheral blood lymphocytes to electromagnetic fields associated with cellular phones leads to chromosomal instability. Bioelectromagnetics 2003; 24(2): 82-90.	Increased genetic damage (aneuploidy in chromosome region 17) in human lymphocytes after 3-day RF-EMF exposure (CW 830 MHz; 1.6 to 8.8 W/kg)
Tice RR, Hook GG, Donner M, McRee DI, Guy AW (23)	Genotoxicity of radiofrequency signals. Investigation of DNA damage and micronuclei induction in cultured human blood cells. Bioelectromagnetics 2002; 23(2): 113-26.	Increased chromosome damage in human lymphocytes after 24-h RF-EMF signal exposure of blood (SAR 5 W/kg and higher)
Sarimov R, Malmgren LOG, Markova E, Persson BRR, Belyaev IY (24)	Nonthermal GSM microwaves affect chromatin conformation in human lymphocytes similar to heat shock. IEEE Trans Plasma Sci 2004; 32(4): 1600-08.	Increased genetic damage (chromatin conformation, chromatin condensation) in human lymphocytes after 30-min or 60-min RF radiation exposure (GSM 895-915 MHz; 5.4 mW/kg)
Belyaev IY, Hillert L, Protopopova M, Tamm C, Malmgren LO, Persson BR, Selivanova G, Harms-Ringdahl M (25)	915 MHz microwaves and 50 Hz magnetic field affect chromatin conformation and 53BP1 foci in human lymphocytes from hypersensitive and healthy persons. Bioelectromagnetics 2005; 26(3): 173-84.	Increased genetic damage (chromatin conformation, 53BP1 DNA repair foci) in human lymphocytes after RF-EMF exposure (GSM 950 MHz; 37 mW/kg) or ELF-EMF exposure (50 Hz; 15 µT)
Diem E, Schwarz C, Adlkofer F, Jahn O, Rüdiger H (10)	Non-thermal DNA breakage by mobilephone radiation (1800 MHz) in human fibroblasts and in transformed GFSH-R17 rat granulosa cells in vitro. Mutat Res 2005; 583(2): 178-83.	Increased genetic damage (single- and double-strand DNA breaks, micronuclei) in human fibroblasts and rat granulosa cells after 4-, 16- and 24-h RF-EMF exposure (CW and modulated 1800 MHz; intermittent and continuous; 1.2 and 2 W/kg).
Markova E; Hillert L, Malmgren L, Persson BRr, Belyaev IY (26)	Microwaves from GSM mobile telephones affect 53BP1 and gamma-H2AX foci in human lymphocytes from hypersensitive and healthy persons. Environ Health Perspect 2005; 113(9): 1172-7.	Increased genetic damage (chromatin conformation, gamma-HwAX foci) in human lymphocytes after RF-EMF exposure (GSM 915 and 905 MHz; 37 mW/kg; 1 hour). No difference between hypersensitive and healthy individuals!
Zotti-Martelli L, Peccatori M, Maggiuni V, Ballardin M, Barale R (27)	Individual responsiveness to induction of micronuclei in human lymphocytes after exposure in vitro to 1800 MHz microwave radiation. Mut Res 2005; 582(1-2): 42-52.	Increased genetic damage (micronuclei) in human lymphocytes after RF-EMF exposure (CW 1800 MHz; 5, 10, 20 mW/m2; 60, 120, 180 minutes) depends on exposure duration and power density level.
Baohong W, Jiliang H, Lifen J, Deqiang L, Wei Z, Jianlin L, Hongping D (28)	Studying the synergistic damage effects induced by 1.8 GHz radiofrequency field radiation (RFR) with four chemical mutagens in human lymphocytes DNA using comet assay in vitro. Mut Res 2005; 578(1-2): 149-57.	The increased genetic damage (DNA strand breaks) in human lymphocytes induced by mitomycin C and 4-nitroquinoline-1-oxide is significantly enhanced by RF-EMF exposure (1.8 GHz; 3 W/kg; 2 hours).
Zhang DY, Xu ZP, Chiang H, Lu DQ, Zeng QL (29)	Effects of GSM 1800 MHz radiofrequency electromagnetic fields on DNA damage in Chinese hamster lung cells. Zhonghua Yu Fang Yi Xue Za Zhi 2006; 40(3): 149-52. [Chinese]	Increased genetic damage (gamma H2AX foci) in CHL cells after RF-EMF exposure (GSM 1800 MHz; 3.0 W/kg; 24 hours; intermittent 5 minutes on/10 minutes off). No DNA damage after 1-hour exposure
Khubnazar LV (16)	DNA-Strangbrüche in humanen HL-60 Promyelozytenleukämiezellen zur Einschätzung biologischer Wirkungen nach Exposition mit hochfrequenten elektromagnetischen Feldern (2450 MHz). German Dissertation 2006; Charité Berlin	Increased genetic damage (single- and double-strand DNA breaks) in human immortal HL60 cells after RF-EMF exposure (2450 MHz; 1.1 W/kg; 24 hours)
Lixia S, Yao K, Kaijun W, Deqiang L, Huajun H, Xiangwei G, Baohong W, Wei Z, Jianling L, Wei W (30)	Effects of 1.8 GHz radiofrequency field on DNA damage and expression of heat shock protein 70 in human lens epithelial cells. Mut Res 2006; 602(1-2): 135-42.	Increased DNA damage (strand breaks) in human lens epithelial cells after GSM exposure (GSM 1800; 3 W/kg; 2 hours), which could be observed up to 30 minutes after exposure

Author	Title	Effects
Baohong W, Lifen J, Lanjuan L, Jianlin L, Deqiang L, Wei Z, Jiliang H (31)	Evaluating the combinative effects on human lymphocyte DNA damage induced by ultraviolet ray C plus 1.8 GHz microwaves using comet assay in vitro. Toxicology 2007; 232(3): 311-6.	The UV-induced increase in genetic damage (DNA strand breaks) in human lymphocytes is significantly decreased after 1.5-h RF-EMF exposure (1.8 GHz; 3 W/kg), and significantly increased after 4-h RF-EMF exposure.
Mazor R, Korenstein-Ilan A, Barbul A, Eshet Y, Shahadi A, Jerby E, Korenstein R (32)	Increased levels of numerical chromosome aberrations after in vitro exposure of human peripheral blood lymphocytes to radiofrequency electromagnetic fields for 72 hours. Radiat Res 2008; 169(1): 28-37.	Increased genetic damage (aneuploidy in chromosome regions 1, 10, 11, and 17) in human lymphocytes after a 72-h RF-EMF exposure (CW 800 MHz; 2.9 and 4.1 W/kg)
Kim JY, Hong SY, Lee YM, Yu SA, Koh WS, Hong JR, Son T, Chang SK, Lee M (33)	In vitro assessment of clastogenicity of mobile-phone radiation (835 MHz) using the alkaline comet assay and chromosomal aberration test. Environ Toxicol 2008; 23(3): 319-27.	Increased genetic damage (DNA strand breaks), chromosome aberrations), in with genotoxic substances treated cells is further enhanced after RF-EMF exposure (835 MHz)
Schrader T, Münter K, Kleine-Ostmann T, Schmid E (34)	Spindle disturbances in human-hamster hybrid (A(L)) cells induced by mobile communication frequency range signals. Bioelectromagnetics 2008; Epub ahead of print	Increased chromosome damage through disturbances in spindle function of FC2 cells after RF-EMF exposure (835 MHz; up to 60 mW/kg; 0.5-2 hours)
Schwarz C, Kratochvil E, Pilger A, Kuster N, Adlkofer F, Rüdiger HW (15)	Radiofrequency electromagnetic fields (UMTS, 1.950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes. Int Arch Occup Environ Health 2008; 81(6): 755-67	Increased genetic damage (DNA strand breaks, micronuclei) in human fibroblasts after RF-EMF exposure (UMTS 1950 MHz, 0.05-2 W/kg, 24 hours), demonstrated at as low as 0.05 W/kg
Manti L, Braselmann H, Calabrese ML, Massa R, Pugliese M, Scampoli P, Sicignano G, Grossi G (35)	Effects of modulated microwave radiation at cellular telephone frequency (1.9 GHz) on X-ray-induced chromosome aberrations in human lymphocytes in vitro. Radiat Res 2008; 169(5): 575-83	The x-ray induced chromosome damage in human lymphocytes is significantly increased by UMTS radiation (1.95 GHz; 2 W/kg; 24 hours).
Yao K, Wu W, Wang K, Ni S, Ye P, Yu Y, Ye J, Sun L (36)	Electromagnetic noise inhibits radio-frequency radiation-induced DNA-damage and reactive oxygen species increase in human lens epithelial cells. Mol Vis 2008; 14: 964-9	Increased DNA damage (strand break) in human lens epithelial cells after intermittent GSM exposure (GSM 1800; 3 and 4 W/kg; 2 hours). Additional electromagnetic noise prevents increase

nover, which was presented at a workshop in Berlin in May 2008, holds profound implications for the future. In this study, it was demonstrated that in the sense of tumor initiation UMTS radiation shows only a rather small genotoxic effect in mice, but in the sense of tumor promotion quite a pronounced epigenetic effect could be observed. In the case of mice treated prenatally with N-ethyl-nitrosourea, UMTS radiation levels well below current safety levels caused a significant increase in the tumor rate of liver and lung above the expected rate for N-ethyl-nitrosourea. This effect occurred when RF radiation exposure was started in utero immediately after administering N-ethyl-nitrosourea and continued for the entire life span after birth. The UMTS radiation exposure by itself only resulted in the development of precancerous lesions in the animals' livers (52).

As far as the endpoint tumor is concerned, the Perform-A and the Fraunhofer studies allow the conclusion that the harmful effects of UMTS radiation may substantially surpass those of GSM radiation, and that this effect appears to unfold itself especially at the epigenetic level. This requires further research for clarification. Other results from animal experiments for various reasons tend to contribute more to confusion than to add to our knowledge (45). In the future, the search for molecular biological changes in animals and humans, which are considered important for the occurrence of disease processes, might be of more importance than the histological detection of the endpoint tumor. Numerous investigations of this kind demonstrate already now the benefits of such a research approach (table 3).

Verified genotoxic and epigenetic effects of mobile phone radiation directly observed in humans would have a great impact on the risk analysis. In this event, the present claim of overall safety would finally collapse.

2.3 Epidemiological Studies

At first glance, the conclusions of the majority of studies conducted so far speak against an increased tumor risk in mobile phone users (6,70,71,72, table 4). Whether these studies carry sufficient weight so that conclusions for public health policies might be drawn from them, however, seems doubtful. Sources of error can distort the real risk, including insufficient collection of exposure data regarding intensity and duration, shortcomings in the comparability of study groups, non-consideration of additional disease factors, memory gaps in study participants, bias especially on the part of sick persons, but also on part of their investigators (73).

But the validity of the existing studies is largely and mainly limited because the latency period between the onset of RF radiation expo-

continued on page 16

Table 2: Evidence of Epigenetic Changes in Isolated Animal and Human Cells, Very Likely Induced by Non-thermal Effects of Mobile Phone Radiation

Author	Title	Effects
Pancini S, Ruggiero M, Sardi I, Aterini S, Gulisano F, Gulisano M (37)	Exposure to Global System for Mobile Communication (GSM) Cellular Phone Radiofrequency Alters Gene Expression, Proliferation, and Morphology of Human Skin Fibroblasts. Oncol Res 2002; 13: 19-24.	Morphological changes and expression of genes for signal transduction, cell division, and apoptosis in human fibroblasts after RF-EMF exposure (GSM 902.4 MHz; 0.6 W/kg; 1 hour)
Nylund R, Leszczynski D (12)	Proteomics analysis of human endothelial cell line EA.hy926 after exposure to GSM radiation. Proteomics 2004; 4(5): 359-65.	Expression of 38 different proteins, including two isoforms of vimentin important for the cytoskeleton, after RF-EMF exposure (GSM 900 MHz; 2.4 W/kg; 1 hour).
Czyz J, Guan K, Zeng Q, Nikolova T, Meister A, Schönborn F, Schuderer J, Kuster N, Wobus AM (14)	High frequency electromagnetic fields affect gene expression levels in tumor suppressor p53-deficient embryonic stem cells. Bioelectromagnetics 2004; 25(4): 296-307.	Expression of different genes (Hsp70, c-jun, c-mxc, p21) in p53-deficient but not normal mouse stem cells after RF-EMF exposure (GSM 1710; < 2 W/kg; 48 hours). Evidence for the importance of genetic background!
Lee S, Johnson D, Dunbar K, Dong H, Ge X, Kim Y, Wing C, Jayathilaka N, Emmanuel N, Zhou C, Gerber H, Tseng C, Wang S (38)	2.45 GHz radiofrequency fields alter gene expression in cultured human cells. FEBS Lett 2005; 579(21): 4829-36.	Expression of 221 genes in HL60 cells after 2-h and 750 genes after 6-h RF-EMF exposure (2450 MHz (pulsed); 10 W/kg; 2 or 6 hours)
Nylund R, Leszczynski D (13)	Mobile phone radiation causes changes in gene and protein expression in human endothelian cell lines and the response seems to be genome- and proteome-dependent. Proteomics 2006; 6(17): 4769-80.	Expression of various genes and proteins in two different human endothelial cell lines through RF-EMF exposure (GSM 900 MHz; 2.8 W/kg; 1 hour)
Remondini D, Nylund R, Reivinen J, Poulettier de Gannes F, Veyret B, Lagroye I, Haro E, Trillo MA, Capri M, Franceschi C, Sclatterer K, Gminski R, Fitzner R, Tauber R, Schuderer J, Kuster N, Leszczynski D, Bersani F, Maerker C (39)	Gene expression changes in human cells after exposure to mobile phone microwaves Proteomics 2006; 6(17): 4745-54	Expression of various genes in HL60 cells, EA.hy-926 cells, and U937 cells after RF-EMF exposure (900 and 1800 MHz; 1, 1.3 and 2.5 W/kg; 1 or 24 hours); affected genes include those responsible for coding ribosomal proteins for cellular metabolism
Lixia S, Yao K, Kaijun W, Deqiang L, Huajun H, Xiangwei G, Baohong W, Wei Z, Jianling L, Wei W (30)	Effects of 1.8 GHz radiofrequency field on DNA damage and expression of heat shock protein 70 in human lens epithelial cells. Mut Res 2006; 602(1-2): 135-42	Increased expression of Hsp70 protein in human lens epithelial cells after GSM exposure (GSM 1800; 2 and 3 W/kg; 2 hours)
Buttiglione M, Roca L, Montemurno E,Vitiello F, Capozzi V, Cibelli G (40)	Radiofrequency radiation (900 MHz) induces Egr-1 gene expression and affects cell cycle control in human neuroblastoma cells. J Cell Physiol 2007; 213(3): 759-67	Egr-1 gene expression maximum 15 minutes after begin of RF-EMF exposure (900 MHz pulsed; 1 W/kg; 5, 15, 30 minutes, 6 and 24 hours). Activation of various MAPKs. Inhibition of expression of the bcl-2 and the surviving genes (apoptosis) after 24-h exposure
Zhao TY, Zou SP, Knapp PE (41)	Exposure to cell phone radiation up-regulates apoptosis genes in primary cultures of neurons and astrocytes. Neurosci Lett 2007; 412(1): 34-8	Upregulation of genes for the apoptosis signal pathway (caspase-2, caspase-6, Bax) in mouse neurons and astrocytes after RF-EMF exposure (GSM1900 MHz of a normal mobile phone; 2 hours)
Zhao R, Zhang S, Xu Z, Ju L, Lu D, Yao G (42)	Studying gene expression profile of rat neuron exposed to 1800 MHz radiofrequency electromagnetic fields with cDNA microarray. Toxicology 2007; 235(3): 167-75	Regulation of numerous genes in rat brain neurons through RF-EMF (GSM 1800 MHz; 2 W/kg; 24 hours intermittent); a broad range of cellular functions is affected
Friedman J, Kraus S, Hauptman Y, Schiff Y, Seger R (43)	Mechanism of short-term ERK activation by electromagnetic fields at mobile phone frequencies. Biochem 2007; 405(3): 559-68	MAPK activation through RF-EMF (ca. 900 MHz; 0.07-0.35 mW/cm2; 2-30 minutes) with modification of signal transduction in HeLa and rat cells
Shckorbatov YG, Pasiuga VN, Grabina VA, Kolchigin NN, Batrakov DO, Kalashnikov VV, Ivanchenko DD, Bykov VN (44)	The influence on microwave radiation on the state of chromatin in human cells. Sept 2008; http://arXiv.org /list/q-bio/0809: 0559	Increased chromatin condensation in human buccal epithelial cells and damage of cell membrane after RF-EMF exposure (35 GHz; 30 µW/cm2; 10 seconds). Effect dependent on polarization
Yao K, Wu W, Wang K, Ni S, Ye P, Yu Y, Ye J, Sun L (36)	Electromagnetic noise inhibits radio-frequency radiation-induced DNA-damage and reactive oxygen species increase in human lens epithelial cells. Mol Vis 2008; 14: 964-9	Increased level of reactive oxygen species in human lens epithelial cells after intermittent GSM exposure (GSM 1800; 2, 3 and 4 W/kg; 2 hours). Additional electromagnetic noise prevents increase

Table 3: Evidence of Non-thermal Effects of RF-EMF (GSM, UMTS) on the Genome and Epigenome of Various Animal and Human Cell Systems after In Vivo Exposure

Author	Title	Effects
Sarkar S, Ali S, Behari J (53)	Effect of low power microwave on the mouse genome: a direct DNA analysis. Mutat Res 1994; 320(1-2): 141-7.	Changes in the DNA sequences in testicles and brain of mice after RF-EMF exposure (2.45 GHz; 1 mW/cm2; 2 hours/days; 120, 150 or 200 days)
Lai H, Singh NP (54)	Single- and double-strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromagnetic radiation. Int J Radiat Biol 1996; 69(4): 513-21.	Increased genetic damage (single- and double-strand DNA breaks) in brain cells of rats 4 hours after ending whole-body RF-EMF exposure (2450 MHz; 1.2 W/kg; 2 hours)

Lai H, Singh NP (54)	Single- and double-strand DNA breaks in rat brain cells after acute exposure to radiofrequency electro-magnetic radiation. Int J Radiat Biol 1996; 69(4): 513-21.	Increased genetic damage (single- and double-strand DNA breaks) in brain cells of rats 4 hours after ending whole-body RF-EMF exposure (2450 MHz; 1.2 W/kg; 2 hours)
Repacholi MH, Basten A, Gebski V, Noonan D, Finnie J, Harris AW (55)	Lymphomas in E mu-Pim1 transgenic mice exposed to pulsed 900 MHz electromagnetic fields. Radiat Res 1997; 147(5): 631-40.	Increased lymphoma rate in Eμ-Pim1 transgenic mice after RF-EMF exposure (GSM 900 MHz; 0.13-1.4 W/kg; 2 x 30 minutes/day; 18 months)
Trosić I (56)	Multinucleated giant cell appearance after whole body microwave irradiation of rats. Int J Hyg Environ Health 2001; 204(2-3): 133-8.	Increased genetic damage (micronuclei) in alveolar macrophages after whole-body exposures of rats (2450 MHz; 5-15 mW/cm2; 2 hours, 2-22 times) after 1, 8, 16, and 30 days
Sykes PJ, McCallum BD, Bangay MJ, Hooker AM, Morley AA (57)	Effect of exposure to 900 MHz radiofrequency radiation on intrachromosomal recombination in pKZ1 mice. Radiat Res 2001; 156(5 Pt 1): 495-502.	Decreased intrachromosomal recombination frequency in the spleen of pKZ1 mice after RF-EMF exposure (GSM 900 MHz; 4 W/kg; 30 minutes/day; 25 days). No changes after 1-day or 5-day exposure
Trosic I, Busljeta I, Kasuba V, Rozgaj R (58)	Micronucleus induction after whole-body microwave irradiation of rats. Mutat Res 2002; 26; 521(1-2): 73-9.	Increased genetic damage (micronuclei) in polychromatic erythrocytes of Wistar rats after whole-body RF-EMF exposure for 2, 8, and 15 days (2450 MHz; 5-10 mW/cm2; 2 hours/day; 7 days/week)
Salford LG, Brun AE, Eberhardt JL, Malmgren L, Persson BR (59)	Nerve cell damage in mammalian brain after exposure to microwaves from GSM mobile phones. En-viron Health Perspect 2003; 111(7): 881-3; discussion A408	Nerve cell damage in brain of Fischer344 rats 28-50 days after a 2-hour whole-body RF-EMF exposure (GSM; 0.2 W/kg); mechanism of damage unknown
Trosic I, Busljeta I, Modlic B (60)	Investigation of the genotoxic effect of microwave irradiation in rat bone marrow cells: in vivo exposure. Mutagenesis 2004; 19(5): 361-4.	Increased genotoxic damage (micronuclei) in red cells of bone marrow of Wistar rats after whole-body RF-EMF exposure for 15 days (2450 MHz; 5-10 mW/cm2; 2 hours/day; 7 days/week)
Aitken RJ, Bennetts LE, Sawyer D, Wiklendt AM, King BV (61)	Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline. Int J Androl 2005; 28(3): 171-9.	Increased DNA damage in spermatozoa of mice after whole-body RF-EMF exposure for 7 days (900 MHz; 90 mW/kg; 12 hours/day)
Lai H, Singh NP (62)	Interaction of microwaves and a temporally incoherent magnetic field on single and double DNA strand breaks in rat brain cells. Electromagn Biol Med 2005; 24(1): 23-9.	Increased genetic damage (single- and double-strand DNA breaks) in rat brain cells 4 hours after a 2-hour continuous whole-body exposure (2450 MHz; 0.6 W/kg)
Gandhi GA (63)	Genetic damage in mobile phone users: some preliminary findings. Indian J Hum Genet 2005; 11: 99-104.	Increased genetic damage (DNA strand breaks, micronuclei) in lymphocytes in a group of 24 mobile phone users in comparison to a control group of non-users
Ferreira AR, Knakievicz T, Pasquali MA, Gelain DP, DalPizzol F, Fernández CE, de Salles AA, Ferreira HB, Moreira JC (64)	Ultra high frequency-electromagnetic field irradiation during pregnancy leads to an increase in erythrocytes micronuclei incidence in rat offspring. Life Sci 2006; 80(1): 43-50.	Increased micronuclei of newborn Wistar rats, which had been exposed to RF-EMF radiation during embryogenesis (834 MHz; 0.55-1.23 W/kg; 8.5 hours/day; fertilization to birth)
Belyaev IY, Koch CB, Terenius O, Roxstrom-Lindquist K, Malmgren LO, Sommer W, Salford LG, Persson BR (65)	Exposure of rat brain to 915 MHz GSM microwaves induces changes in gene expression but not double straded DNA breaks or effects on chromatin conformation. Bioelectromagnetics 2006; 27(4): 295-306.	Expression of 12 genes in the cerebellum of Fischer344 rats after whole-body RF-EMF exposure for 2 hours (GSM 915 MHz; 0.4 W/kg)
Paulraj R, Behari J (66)	Single strand DNA breaks in rat brain cells exposed to microwave radiation. Mutat Res 2006; 596(1-2): 76-80.	Increased genetic damage (DNA strand breaks) in rat brain cells after whole-body RF-EMF exposure for 35 days (2450 MHz; 1 W/kg; 2 hours/day)
Trosic I, Busljeta I (67)	Erythropoietic dynamic equilibrium in rats maintained after microwave irradiation. Exp Toxicol Pathol 2006; 57(3): 247-51.	Increased genetic damage (micronuclei) in polychromatic erythrocytes of rat bone marrow after a 15-day exposure of peripheral blood and after an 8-day whole-body exposure (2450 MHz; 1.25 +/-0.36 W/kg, 2 hours/day, 7 days/week)
Shirai T, Ichihara T, Wake K, Watanabe SI, Yamanaka Y, Kawabe M, Taki M, Fujiwara O, Wang J, Takahashi S, Tamano S (51)	Lack of promoting effects of chronic exposure to 1.95-GHz W-CDMA signals for IMT-2000 cellular sys-tem on development of N-ethylnitrosourea-induced central nervous system tumors in F344 rats. Bioelec-tromagnetics 2007; 28(7): 562-72.	Non-significant increase in brain tumors in female rats, which received N-ethyl-nitrosourea prenatally and were exposed (head only) to RF-EMF radiation after their birth from week 5 (1950 MHz; SAR 0.67 und 2.0 W/kg; 90 minutes/day; 5 days/week; 2 years)
Hruby, R, Neubauer G, Kuster N, Frauscher M (50)	Study on potential effects of "902-MHz GSM-type wireless communication signals" on DMBA-induced mammary tumours in Sprague-Dawley rats. Mutat Res 2008; 649(1-2): 34-44.	Increase in DMBA induced tumor rates in rats after addition RF-EMF exposure (GSM 902 MHz; 0.4, 1.3 und 4.0 W/kg; 4 hours/day; 5 days/week; 6 months)
Karinen A, Heinävaara S, Nyland R, Leszczynski D (68)	Mobile phone radiation might alter protein expres-sion in human skin. BMC Genomics 2008; 9: 77.	Protein expression in biopsies from skin areas of 10 study subjects after in vivo RF-EMF exposure (GSM 900 MHz; 1.3 W/kg; 1 hour)
Yadav AS, Sharma MK (69)	Increased frequency of micronucleated exfoliated cells among humans exposed in vivo mobile telephone radiations. Mut Res 2008; 650(2): 175-80.	Increased genetic damage (micronuclei) in oral mucosa (exfoliated cells) of users of normal mobile phones with an average of one hour per day
Tillmann T, Ernst H, Reinhardt T, Bitz A, Streckert J, Hansen V, Mohr U, Dasenbrock C (52)	Tumor promotion by chronic UMTS-modulated radio-frequency exposure in mice prenatally treated with ENU. Lecture. Workshop on „Omics for Assessing Unclear Risks", 26.-28. May 2008	Increase in tumor rate of liver and lung in B6C3F1 mice, which received N-ethyl-nitrosourea and in addition were exposed to whole-body UMTS radiation until birth and thereafter for their entire life (4.8 and 48 W/m2; 20 hours/day; 7 days/week)

Table 4: Results of Epidemiological Studies on the Question of a Tumor Risk Because of Mobil Phone Radiation

Author	Title	Effects
Stang A, Anastassiou G, Ahrens W, Bromen K, Bornfeld N, Jöckel KH (80)	The possible role of radiofrequency in the development of uveal melanoma. Epidemiology 2001; 12(1): 7-12.	Overall increased risk of uveal melanoma in mobile phone users
Lönn S, Ahlbom A, Hall P, Feychting M (81)	Mobile phone use and the risk of acoustic neuroma. Epidemiology 2004; 15(6): 653-9.	Increased risk of acoustic neuroma in mobile phone users after 10 or more years, significant for the side of the head used for making phone calls
Christensen HC, Schüz J, Kosteljanetz M, Poulsen HS, Thomson J, Johansen C (82)	Cellular telephone use and risk of acoustic neuroma. Am J Epidemiol 2004; 159(3): 277-83.	No increased risk of acoustic neuroma after mobile phone user duration of 10 and more years, but significantly increased tumor volume
Schoemaker MJ, Swerdlow AJ, Ahlbom A, Auvinen A, Blaasaas KG, Cardis E, Christensen HC, Feychting M, Hepworth SJ, Johansen C, Klaeboe L, Lönn S, McKinney PA, Muir K, Rai-tanen J, Salminen T, Thomsen J, Tynes T (83)	Mobile phone use and risk of acoustic neuro-ma: results of the Interphone case-control study in five North European countries. Br J Cancer 2005; 93(7): 842-8.	Significantly increased risk of acoustic neuroma after mobile phone use of 10 or more years on the same side of head used for mobile phone
Lönn S, Ahlbom A, Hall P, Feychting M (Interphone Study Group, Sweden) (84)	Long-term mobile phone use and brain tumor risk. Am J Epidemiol 2005; 161(6): 526-35.	Slightely but not significantly increased risk of meningeoma and glioma after mobile phone use of 10 and more years on the same side of head used for mobile phone
Christensen HC, Schüz J, Kosteljanetz M, Poulsen HS, Boice JD Jr, McLaughlin JK, Johansen C (85)	Cellular telephones and risk for brain tumors: a population-based, incident case-control study. Neurology 2005; 64(7): 1189-95.	Slightly but not significantly increased risk for astrocytoma I-II after mobile phone use of 10 and more years, no increased risk for high-grade astrocytoma and meningeoma
Schüz J, Böhler E, Berg G, Schlehofer B, Hettinger I, Schlaefer K, Wahrendorf J, Kunna-Grass K, Blettner M (Interphone Study Group, Germany) (86)	Cellular phones, cordless phones, and the risks of glioma and meningioma. Am J Epidemiol 2006; 163(6): 512-20.	Slightly but not significantly increased risk for glioma after mobile phone use of 10 and more years
Hepworth SJ, Schoemaker MJ, Muir KR, Swerdlow AJ, von Tongeren MJ, McKinney PA (87)	Mobile phone use and risk of glioma in adults: case-control study. BMJ 2006; 332(7546): 883-7.	Slightly but not significantly increased risk of glioma after mobile phone use of 10 and more years, significant increase on the same side of the head used for mobile phone
Hardell L, Carlberg M, Hansson Mild K (88)	Pooled analysis of two case-control studies on the use of cellular and cordless telephones and the risk of malignant brain tumours diagnosed during 1997-2003. Int Arch Occup Environ Health 2006; 79(8): 630-9.	Significantly increased risk of brain tumors in mobile and cordless phone users after a usage period of 10 and more years on the same side of the head used for making phone calls
Hardell L, Carlberg M, Hansson Mild K (89)	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 2006; 28(2): 509-18.	Significantly increased risk of acoustic neuroma in mobile and cordless phone users after a usage period of 10 and more years and on the same side of the head used for making phone calls
Lahkola A, Auvinen A, Raitanen J, Schoemaker MJ, Christensen HC, Feychting M, Johansen C, Klaeboe L, Lönn S, Swerdlow AJ, Tynes T, Salminen T (90)	Mobile phone use and risk of glioma in 5 North European countries. Int J Cancer 2007; 120(8): 1769-75.	Significantly increased risk of glioma after mobile phone use of 10 and more years on the same side of the head used for mobile phone
Hours M, Bernard M, Montestrucq L, Arslan M, Bergeret A, Deltour I, Cardis E (91)	Cell phone and risk of brain and acoustic nerve tumours: the French Interphone case-control study. M Rev Epidemiol Santé Publique 2007; 55(5): 321-32.	Slightly but not significantly increased risk of glioma in long-term users, frequent users, and users of two mobile phones
Sadetzki S, Chetrit A, Jarus-Hakak A, Cardis E, Deutch Y, Duvdevani S, Zultan A, Novikov I, Freedman L, Wolf M (92)	Cellular phone use and risk of benign and malignant parotid gland tumors - a nation-wide case-control-study. Am J Epidemiol 2008; 167(4): 457-67	Significantly increased risk of parotid gland tumors in regular and heavy users of mobile phones; tumor rate significantly increased on the same side of the head used for mobile phone

Meta Analyses

Author	Title	Effects
Hardell L, Carlberg M, Söderqvist F, Hansson Mild K, Morgan LL (77)	Long-term use of cellular phones and brain tumours - increased risk associated with use for > or = 10 years. Occup Environ Med 2007; 64(9): 626-32.	Significantly increased risk of glioma and acoustic neuroma after mobile phone use of 10 and more years; the highest tumor rate on the same side of the head used for mobile phone.
Kan P, Simonsen SE, Lyon JL, Kestle JR (78)	Cellular phone use and brain tumor: a meta-analysis. J Neurooncol 2008; 86(1): 71-8.	Significantly increased risk of brain tumors after mobile phone use of 10 and more years; no increased risk for shorter usage periods
Hardell L, Carlberg M, Söderqvist F, Hansson Mild K (79)	Meta-analysis of long-term mobile phone use and the association with brain tumours. Int J Oncol 2008; 32(5): 1097-1103.	Significantly increased risk of glioma and acoustic neuroma after mobile phone use of 10 and more years on the same side of the head used for mobile phone

continued from page 12

sure and the manifestation of a tumor is still too short. Only if the growth of already developing tumors accelerated due to the promoter effect of a RF radiation (74) would it be possible to see an increase in the tumor rate right now. For solid tumors, as they occur in brains, it is unlikely that one will make such an assumption (75). Similar considerations also apply to neurodegenerative diseases like Alzheimer's, which are also discussed in association with RF-EMF exposures.

However, there is one fact that sticks out and should discomfit anybody who deals with this issue, that is, almost all studies that cover an exposure duration of ten years or longer point towards the existence of an increased tumor risk in the head area (table 4). This is particularly true of sub-studies of the important INTERPHONE project*, which since 2000 was carried out like REFLEX and PERFORM-A as part of the FP5 of the EU whereby all 13 participating countries followed the same study design. Obviously, the long overdue final report, in which all studies are evaluated collectively, has not been published yet because the authors cannot agree on how to explain to the public a significantly increased brain tumor risk in long-term users (76). One group of them is convinced that the results already support the assumption of an increased tumor risk, a second group downplays the observed risk increase as a false positive due to bias, and a third group cannot make up its mind to say anything at all. With so-called meta-analyses, other authors have already pre-empted the expected final result (77,78,79, table 4). As to the reliability of such meta-analyses, all objections remain that were raised for any of the single epidemiological studies they are based on.

Even if some day the tumor risk should turn out to be rather small, it would be inadmissible to deny its practical relevance. Since the number of mobile phone users worldwide will probably pass the three billion mark by the end of 2008, a calculated risk increase of only ten percent, which is almost impossible to detect in epidemiological studies, would result in a frightening number of cancer cases.

3. Discussion

The conclusions drawn from the results of the three different research approaches lead to the realization that the endorsement of safety by the German Mobile Telecommunication Research Programme is not justified – neither when considering its own research results nor the international body of evidence.

3.1 Conclusions

The questions, raised at the beginning in connection with the endorsement of safety by the German Mobile Telecommunication Research Programme, may be answered on the basis of the research results discussed in this article as follows:

As to question 1: In the German Mobile Telecommunication Research Programme (DFM), the research results of many international working groups remain unaccounted for so long as they cannot be harmonized with its endorsed statement. Regarding the assessment of risk, numerous research results from in vitro studies, animal experiments, and epidemiological investigations point into the same direction. They speak rather for than against adverse health effects in the general population, thereby being at odds with the endorsement of safety by the DFM.

The study results from the areas of fundamental research (tables 1 and 2), animal experiments (table 3), and epidemiological studies (table 4) lead to the conclusion that none of the research approaches by itself is able to prove a human health risk of mobile phone radiation with sufficient certainty. Since these three research approaches, however, complement each other, together they provide strong evidence for the assumption that mobile phone radiation may pose a risk to human health.

In borderline cases, the validity of epidemiological data depends on whether it can be made consistent with biology concepts and thus become plausible. As the results of the REFLEX project and the numerous other laboratory and animal experiments (tables 1-3) show, this is actually the case with regard to RF radiation. In fact, the increased brain tumor risk found in long-term mobile phone users might be after all due to chance (table 4), but there is an equal chance of this being an early, though uncertain indication that mobile phone radiation is involved in the development of brain tumors. That representatives of the government and industry use the negative epidemiological study results associated with mobile phone use of less than ten years is inconsistent with the current state of scientific knowledge. At a minimum, a latency period of ten years, better yet 20 or 30 years must pass before the tumor will manifest as a disease. For cancer development caused by smoking, the la-

* International case control studies of cancer in relation to mobile telephone use (QLK4-CT-1999-01563)

tency period from the onset of smoking to the manifestation of a malignant process is determined by a smoker's individual constitution, the carcinogenic potential of the tobacco smoke and the intake level of toxins based on the number of cigarettes smoked per day, generally ranging up to thirty years and more in bronchial and other tumors.

At present, no institution can rule out with sufficient certainty a comparable development of brain tumors as a result of mobile phone radiation exposure. Whether additional chronic diseases are to be expected, as is the case in smoking, appears to be possible when considering the available results from the area of basic research, but they are virtually uninvestigated. There is no need to repeat that the numerous studies, which did not find any biological effect of RF-EMFs, are not suited to disprove the positive results of the studies presented here. Research into the effects of mobile phone radiation is a difficult endeavor, and not every investigator has the skills to master the technical problems or the tenacity to get to the bottom of this issue.

As to question 2: The exposure limits, which currently apply to wireless technologies and which the endorsement of safety by the DMF is based on, promise safety without the necessary prerequisites because neither non-thermal effects nor effects dependent on the characteristics of a signal were taken into account when they were set. They are not consistent with the current state of knowledge.

The assumption that the current exposure limits, which were developed exclusively on the basis of acute thermal effects, would sufficiently protect from possible health risks is in conflict with our current state of knowledge. It must rather be assumed that it is much more likely that biological effects of mobile phone radiation are not exclusively based on heating, but that there are also so-called non-thermal biological effects, which are relevant for disease development. Whether the results are from laboratory investigations or animal experiments (table 1-3), numerous experimental investigations all point in this direction. They clearly demonstrate that disease-relevant changes in the structure and function of genes occur often at levels well below the SAR limit of 2.0 W/kg for mobile phones. The argument that e.g. the genotoxic effect of mobile phone radiation must be doubtful because the amount of energy contained in this type of radiation is not nearly enough to break chemical bonds has no basis. Probably, all the observed effects are produced via indirect pathways. And there is a rather high likelihood that they can be traced back to the formation of free radicals (36), which starts immediately after the onset of exposure, gradually reaching a concentration level sufficient for genetic damage.

Adjusting exposure guidelines to the current state of knowledge based on biological criteria also seems to be imperative for another reason. It becomes ever more obvious that the biological effects of mobile phone radiation can be quite different at the same SAR values, depending on their carrier frequency and especially their signal characteristics. In this context, the observation by Belyaev (93) deserves special attention. He was the first to point out that the genotoxic effect of UMTS radiation may possibly surpass that of GSM radiation due to its unique type of signal pattern. This is in agreement with both the findings of the REFLEX follow-up investigation and the results of the mouse study conducted at the Fraunhofer Institute in Hannover (15, 52). In the publication by Schwarz et al. (15), it was astoundingly demonstrated that genotoxic effects of UMTS radiation could be detected at SAR values as low as 0.05 W/kg. After all, this value is forty times smaller than the current exposure limit of 2 W/kg. Under otherwise comparable conditions, a SAR value of 0.3 W/kg was necessary for GSM radiation to significantly increase the rate of DNA strand breaks (9). In the publication by Tillman et al. (52), it could be shown that, in a mouse model, a power density of 4.8 W/m^2, i.e. half of the exposure limit for UMTS base stations, was sufficient to significantly increase the lung and liver tumor rate in the animals due to its apparent promoter effect. When the power density is converted to the whole-body SAR of a mouse, it may amount to roughly 0.2 W/kg. In addition, the results of the Dutch TNO study (94) also support the notion that the effect of UMTS radiation is stronger than that of GSM radiation. In a controlled trial, the persons exposed to UMTS radiation were able to recognize the radiation exposure due to the onset of their individual symptoms whereas they were unable to do so in the case of GSM radiation.

A possible correlation of the effect with the signal characteristics would also have to be considered for the introduction of the new WiMax technology, which is destined to cover the last dead zones in Germany. As usual, the installation of this wireless area network seems to go ahead without any prior clarification of its biological compatibility for the general public, which is again a scandal of the highest order.

As to question 3: Children and adolescents most likely face considerably higher risks. There are reasons to fear that the adverse health impacts of mobile phone radiation—should they eventually be proven beyond doubt—will be much greater in children and adolescents than in adults because they have special anatomical and physiological characteristics.

In the risk assessment of children, there are further imponderables to consider in addition to the set of adult problems. RF radiation absorption in brains of children under the age of eight is twice as high as in adults (95), and in bone marrow, where leukemia starts, it is to be assumed that the absorption factor is even ten times higher in comparison to adults. There is a possibility that the increased absorption rate of bone marrow may explain the increased leukemia rate, which parallel to the technological application of EMFs emerged over the past decades. For quite some time now, power-frequency electromagnetic fields (ELF) and increasingly also RF radiation have been suspected to be a significant contributory cause. Whether, as assumed by many scientists, on top of all that children may also display an increased tissue susceptibility appears to be possible in view of their physiological characteristics, but has not yet been resolved. Health consequences, which in such a situation may not be ruled out at all, could manifest themselves as e.g. leukemia during childhood; but once damage has occurred at a molecular level, it may—after a shorter or longer latency period—also become the cause of chronic diseases such as brain tumors later in life. Due to the high life expectancy of children, there is hardly any time limit to the repercussions. And in view of the above-described state of affairs, there is no need to emphasize again that the current exposure limits take the special circumstances of children even less into account than those of adults.

How credible, then, is the endorsement of safety by the DMF?

The assessment of possible health risks caused by mobile phone radiation, as evident in the current knowledge base of international research, is in marked contrast to the conclusions drawn from the results of the DMF, which only recently had been presented to the public with a lot of media pomp. In its summary assessment prepared by the Radiation Protection Commission (SSK) of the Federal Office of Radiation Protection (BfS), the DMF comes to the conclusion that all in all there is no reason to have any doubts that the current exposure limits protect from health risks. Problems that most likely are associated with non-thermal effects of mobile phone radiation are simply ignored. Also, nothing is said about what consequences may follow if the biological effects of mobile phone radiation differ in their intensity depending on signal characteristics. Nobody seems to have noticed so far that the exposure limit for UMTS base stations at a power density of 10 W/m^2 is higher than that for GSM base stations even though the extent of their respective radiation effects appears to be the other way around. The admission that the DMF cannot give any conclusive answers to the most pressing questions is especially disconcerting. Furthermore, the DMF concedes that there is very little known about the possible long-term consequences of mobile phone radiation in adults, and with regard to children "very little" translates into "nothing."

Thus, the message of safety by the German Federal Government is not even backed by the results of its own research program, and certainly not by the available body of evidence from the international literature (table 1 - 4). In view of the questions left unanswered in the DMF paper and the insights of the international literature, it would have been the order of the day to demand and implement precautionary strategies instead of this endorsement of safety. With its rather vague recommendation, telling the public to be somewhat cautious when using mobile phones, the Federal Government does not fulfill its mandate in providing a responsible and prudent health care policy. For the so-called Radiation Protection Commission (SSK), an advisory body of the German Federal Government comprised exclusively of scientists, at least, it should have been possible to recognize the public health threat created by the DMF endorsement of safety. Yet, the SSK seems to be unable or unwilling to gain the appropriate insights from the latest literature available to them. It is only right, then, that this advisory body will be held accountable for the mistake of the German Federal Government should the endorsement of safety promoted by the DMF eventually turn out to be wrong. Both the German Federal Government as well as the industry will then claim to have acted to the best of their ability and conscience. Indeed, they will be convinced of having stuck to science and relied on the evidence in their assessment of correlations. It is not too unlikely that this scenario will actually occur some day. The members of the SSK should be aware of this possibility even though some of them will perhaps not live to see this hour of truth.

3.2 Perspectives of a Future Research Direction

As the DMF clearly showed, to the problems associated with telecommunication technologies, there is no solution to be expected from either the government or industry in the foreseeable future. The time-tested and indeed absurd method of the industry to counteract any publications with positive results they dislike with the same or a higher number of publications with negative results, as a way of disposing of them, sorted itself out when it became known that research projects funded by the industry—in contrast to independent sources—almost regularly come to a null result (97). Although the occasional attempt to get rid of unwelcome research results by a targeted smear campaign may appear to be success-

ful for a short period of time due to the associated time delay, it is usually doomed to failure in the long term.

More and more publications are released that demonstrate biological effects of mobile phone radiation well below the exposure limits. The reason for that lies in the quality of the mobile phone research, which for the past decades could hardly have led a more shadowy existence, but which now finally starts to catch up with the level that has been standard procedure in fundamental research in biology for quite some time. The current body of evidence relies heavily on new research results (table 1-4) that are based on improved methodology and in essence come to similar conclusions. No matter how many negative research results, whose existence shall not be denied, there are, they cannot distract from the fact of the positive ones.

It must be acknowledged that the breadth of mobile phone research to date is astounding, but in its focus on the essential aspects it is all the more tenuous. For the results of epidemiological studies, whose reliability is very solid, we will probably have to wait for many more years or perhaps even decades. In order to base the implementation of precautionary measures on them, they will most certainly come too late.

As suggested by Belyaev and Grigoriev (98), we must act without delay. Furthermore, urgent clarification is required as to whether the changes in the structure and function of genes observed in isolated animal and human cells in test tubes after an RF radiation exposure (table 1 and 2) also occur under in vivo conditions, as already indicated by the results of several studies (table 3). And if this is the case, it must be clarified what the mechanisms are involved in these changes.

This type of research approach allows searching for biomarkers for the quantitative and qualitative evaluation of RF radiation exposures, also including respective frequencies and modulations whose biological activity is as low as possible. While biomarkers would considerably improve the reliability of epidemiological studies, the identification of RF signals without biological activity could allow for the development of risk-free wireless communication technologies.

Should this type of research confirm the suspicion that RF radiation may actually affect the genetic blueprint of humans in vivo, however, we would have a major sociopolitical problem at hand that could no longer be denied by any responsible level of government and industry. Such evidence would allow predicting with some certainty the final results of epidemiological research, which are not anticipated for much earlier than 20 to 30 years from now. Any decisions for the necessary regulations of precautionary measures could be put on a scientific basis soon, and any vague recommendations based on pure speculation only, which often upset people more than they actually help, would belong to the past.

Unfortunately, there is no funding available for this type of research approach. Apart from government organizations and those institutions, which were founded by the mobile phone industry for the purpose of representing their interests and which, therefore, oppose this type of research on principle, nobody has access to the amount of funds required for such research. Even the EU Commission, which until recently has provided the European research community in this area with important impetus, seems to lack interest or understanding. For the time being, it does not look as though a research project of this type will be supported within its 7th Framework Programme (FP7)

Perhaps the only alternative left is a joint initiative by affected European citizens in order to prevent the current uncertainty about possible health risks of mobile phone radiation from having to be accepted as a permanent condition. Those who are rightly concerned about themselves as well as their families and are not ready to permanently accept this untenable state of affairs will probably have no other option than raising the required research funds on their own. This applies equally to both those who willingly expose themselves to mobile phone radiation because they do not want to or cannot do without the advantages of mobile communication, as well as those who feel threatened by the RF radiation they are unwillingly exposed to from base stations. Only if we are successful in breaking up the research monopoly of the government and industry, will we be able to build the kind of pressure clearly required to force decision-makers of the government and industry to act.

3.3 Recognition of the Precautionary Principle Based on the Current Body of Evidence

The insistence on the current exposure limits, below which, according to official thinking, nothing much can happen to people's health, blocks any effort toward a profound risk assessment and, furthermore, prevents progress in research activities. The assumption of non-thermal biological effects, for which no threshold values may exist, would necessitate an entirely different type of protection for the general public: 1. Based on the available body of evidence and with due consideration of biological criteria, current exposure limits would have to be adjusted to the needs of the human organism. 2. The

present assessment of mobile phone radiation risks regarding both chronic diseases and individual symptoms would have to be thoroughly re-evaluated. 3. The issue of electromagnetic hypersensitivity, which is currently affecting up to five percent of the general public, would be addressed in the area of fundamental research. Numerous research results already indicate that individual symptoms, as they were observed in the above-mentioned TNO study (94), may possibly be explained as a result of non-thermal epigenetic effects of mobile phone radiation.

Though we are not even close to knowing all the answers to the many questions raised in this context, the available research results already speak a clear language, suggesting that the precautionary principle should be adopted by the decision-makers in government and industry to protect the general public. In contrast to the endorsement of safety by the DMF, which cannot be justified even on the basis of its own results, a steadily growing number of scientists (99,100,101) agrees with this recommendation. Today, they know of enough reasons to not only warn against possible health risks from the continuously developing wireless technologies, but also to regulate and implement precautionary measures. This call for precaution is not about fearmongering, as politicians and industry representatives occasionally like to insinuate, but about learning our lesson in due time from examples of missed precaution. It would justify the hope that in the future we may be spared this particular lesson whose extent nobody can even begin to estimate at this time.

Literature

1 ICNIRP (1998) Guidelines for limiting exposure to time-varying, electric, magnetic, and electromagnetic fields (up to 300 GHz). Health Physics 74(4): 494-522.

2 Lampert T, Sygusch R, Schlack R (2007) Nutzung elektronischer Medien im Jugendalter. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 50(5-6): 643-52.

3 Ames BN, Lee FD, Durston WE (1973) An improved bacterial test system for the detection and classification of mutagens and carcinogens. Proc Natl Acd Sci USA 70(3): 782-6.

4 Jaenisch R, Bird A (2003) Epigenetic regulation of gene expression: how the genome integrates intrinsic and environmental signals. Nat Genet (33 Suppl): 245-254.

5 Heller JH, Teixeira-Pinto AA (1959) A new physical method of creating chromosomal aberrations. Nature 183(4665): 905-6

6 Krewski D, Glickmann BW, Habash RW, Habbick B, Lotz WG, Mandeville R, Prato FS, Salem T, Weaver DF (2007) Recent advances in research on radiofrequency fields and health 2001-2003. J Toxicol Environ Health B Crit Rev 10(4): 287-318.

7 Meltz ML (2003) Radiofrequency exposure and mammalian cell toxicity, genotoxicity, and transformation. Bioelectromagnetics (Suppl 6): S196-213.

8 Vijayalaxmi, Obe G (2004) Controversial cytogenetic observations in mammalian somatic cells exposed to radiofrequency radiation. Radiat Res 2004; 162(5): 481-96.

9 REFLEX Consortium (2004) Risk evaluation of potential environmental hazards from low energy electromagnetic field exposure using sensitive in vitro methods. Final Report. Request from: verum@verum-foundation.de

10 Diem E, Schwarz C, Adlkofer F, Jahn O, Rüdiger H (2005) Non-thermal DNA breakage by mobile phone radiation (1800 MHz) in hu-man fibroblasts and transformed GFSH-R17 (rat granulosa) cells in vitro. Mutat Res 583(2): 178-83.

11 Schlatterer K, Gminski R, Tauber R, Fitzner R (2003) Genotoxic effects of RF-EMF on cultured cells in vitro. Abstract Book, BEMS 25th Annual Meeting: 130.

12 Nylund R, Leszczynski D (2004) Proteomics analysis of human endothelial cell line EA.hy926 after exposure to GSM radiation. Proteomics 4(5): 1359-65.

13 Nylund R, Leszczynski D (2006) Mobile phone radiation causes changes in gene and protein expression in human endothelian cell lines and the response seems to be genome- and proteome-dependent. Proteomics 6(17): 4769-80.

14 Czyz J, Guan K, Zeng Q, Nikolova T, Meister A, Schönborn F, Schuderer J, Kuster N, Wobus AM (2004) High frequency electromagnetic fields affect gene expression levels in tumor suppressor p53-deficient embryonic stem cells. Bioelectromagnetics 25(4): 296-307.

15 Schwarz C, Kratochvil E, Pilger A, Kuster N, Adlkofer F, Rüdiger HW (2008) Radiofrequency electromagnetic fields (UMTS, 1.950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes. Int Arch Occup Environ Health 81(6): 755-67.

16 Khubnazar LV (2006) DNA-Strangbrüche in humanen HL-60 Promyelozytenleukämiezellen zur Einschätzung biologischer Wirkungen nach Exposition mit hochfrequenten elektromagnetischen Feldern (2450 MHz). Dissertation im Fachbereich Medizinische Fakultät Charité - Universitätsmedizin Berlin. http://www.diss.fu-berlin.de/2006/566/

17 Schär P (2008) Genotoxicity of EMFs: Exploring DNA directed effects and experimental discrepancies. Vortrag. Swiss NRP57 Workshop, 5. - 6. Mai 2008, Zürich

18 Phillips JL, Ivaschuk O, Ishida-Jones T, Jones RA, Campbell-Beach-ler M, Haggren W (1998) DNA damage in Molt-4 T-lymphoblastoid cells exposed to cellular telephone radiofrequency fields in vitro. Bioelectrochem Bioenerg 45(1): 103-10.

19 Zotti-Martelli L, Peccatori M, Scarpato R, Migliore L (2000) Induc-tion of micronuclei in human lymphocytes exposed in vitro to microwave radiation. Mutat Res 472(1-2): 51-8.

20 d'Ambrosio G, Massa R, Scarfi MR, Zeni O (2002) Cytogenetic damage in human lymphocytes following GMSK phase modulated microwave exposure. Bioelectromagnetics 23(1): 7-13.

21 Zhang MB, He JL, Jin LF, Lu DQ (2002) Study of low-intensity 2450-MHz microwave exposure enhancing the genotoxic effects of mitomycin C using micronucleus test and comet assay in vitro. Biomed Environ Sci 15(4): 283-90.

22 Mashevich M, Folkman D, Kesar A, Barbul A, Korenstein R, Jerby E, Avivi L (2003) Exposure of human peripheral blood lymphocytes to electromagnetic fields associated with cellular phones leads to chromosomal instability. Bioelectromagnetics 24(2): 82-90.

23 Tice RR, Hook GG, Donner M, McRee DI, Guy AW (2002) Genotoxi-city of radiofrequency signals. Investigation of DNA damage and micronuclei induction in cultured human blood cells. Bioelectromagnetics 23(2): 113-26.

24 Sarimov R, Malmgren LOG, Markova E, Persson BRR, Belyaev IY (2004) Nonthermal GSM microwaves affect chromatin conformation in human lymphocytes similar to heat shock. IEEE Trans Plasma Sci 32(4): 1600-08.

25 Belyaev IY, Hillert L, Protopopova M, Tamm C, Malmgren LO, Persson BR, Selivanova G, Harms-Ringdahl M (2005) 915 MHz microwaves and 50 Hz magnetic field affect chromatin conformation and 53BP1 foci in human lymphocytes from hypersensitive and healthy persons. Bioelectromagnetics 26(3): 173-84.

26 Markovà E, Hillert L, Malmgren L, Persson BRr, Belyaev IY (2005) Microwaves from GSM mobile telephones affect 53BP1 and gamma-H2AX foci in human lymphocytes from hypersensitive and healthy persons. Environ Health Perspect 113(9): 1172-7.

27 Zotti-Martelli L, Peccatori M, Maggini V, Ballardin M, Barale M (2005) Individual responsiveness to induction of micronuclei in human lymphocytes after exposure in vitro to 1800-MHz microwave radiation. Mutat Res 582(1-2): 42-52.

28 Baohong W, Jiliang H, Lifen J, Deqiang L, Wei Z, Jianlin L, Hongping D (2005) Studying the synergistic damage effects induced by 1.8 GHz radiofrequency field radiation (RFR) with four chemical mutagens on human lymphocyte DNA using comet assay in vitro. Mutat Res 578(1-2): 149-57.

29 Zhang DY, Xu ZP, Chiang H, Lu DQ, Zeng QL (2006) Effects of GSM 1800 MHz radiofrequency electromagnetic fields on DNA damage in Chinese hamster lung cells. Zhonghua Yu Fang Yi Xue Za Zhi 40(3): 149-52. [Chinese]

30 Lixia S, Yao K, Kaijun W, Deqiang L, Huajun H, Xiangwei G, Baohong W, Wei Z, Jianling L, Wei W (2006) Effects of 1.8 GHz radiofrequency field on DNA damage and expression of heat shock protein 70 in human lens epithelial cells. Mutat Res 602(1-2): 135-42.

31 Baohong W, Lifen J, Lanjuan L, Jianlin L, Deqiang L, Wei Z, Jiliang H (2007) Evaluating the combinative effects on human lymphocyte DNA damage induced by ultraviolet ray C plus 1.8 GHz microwaves using comet assay in vitro. Toxicology 232(3): 311-6.

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

33 Kim JY, Hong SY, Lee YM, Yu SA, Koh WS, Hong JR, Son T, Chang SK, Lee M (2008) In vitro assessment of clastogenicity of mobilephone radiation (835 MHz) using the alkaline comet assay and chromosomal aberration test. Environ Toxicol 23(3): 319-27.

34 Schrader T, Münter K, Kleine-Ostmann T, Schmid E (2008) Spindle disturbances in human-hamster hybrid (A(L)) cells induced by mobile communication frequency range signals. Bioelectromag-netics; Epub ahead of print

35 Manti L, Braselmann H, Calabrese ML, Massa R, Pugliese M, Scampoli P, Sicignano G, Grossi G (2008) Effects of modulated micro-wave radiation at cellular telephone frequency (1.95 GHz) on X-ray-induced chromosome aberrations in human lymphocytes in vitro. Radiat Res 169(5): 575-83.

36 Yao K, Wu W, Wang K, Ni S, Ye P, Yu Y, Ye J, Sun L (2008) Electromagnetic noise inhibits radiofrequency radiation-induced DNA damage and reactive oxygen species increase in human lens epithelial cells. Mol Vis (14): 964-9.

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

38 Lee S, Johnson D, Dunbar K, Dong H, Ge X, Kim Y, Wing C, Jayathilaka N, Emmanuel N, Zhou C, Gerber H, Tseng C, Wang S (2005) 2.45 GHz radiofrequency fields alter gene expression in cultured human cells. FEBS Lett 579(21): 4829-36.

39 Remondini D, Nylund R, Reivinen J, Poulettier de Gannes F, Veyret B, Lagroye I, Haro E, Trillo MA, Capri M, Franceschi C, Sclatterer K, Gminski R, Fitzner R, Tauber R, Schuderer J, Kuster N, Les-zczynski D, Bersani F, Maercker C (2006) Gene expression changes in human cells after exposure to mobile phone microwaves. Proteomics 6(17): 4745-54.

40 Buttiglione M, Roca L, Montemurno E, Vitiello F, Capozzi V, Cibel-li G (2007) Radiofrequency radiation (900 MHz) induces Egr-1 gene expression and affects cell cycle control in human neuroblastoma cells. J Cell Physiol 213(3): 759-67.

41 Zhao TY, Zou SP, Knapp PE (2007) Exposure to cell phone radiation up-regulates apoptosis genes in primary cultures of neurons and astrocytes. Neurosci Lett 412(1): 34-8.

42 Zhao R, Zhang S, Xu Z, Ju L, Lu D, Yao G (2007) Studying gene expression profile of rat neuron exposed to 1800 MHz radiofrequency electromagnetic fields with cDNA microarray. Toxicology 235(3): 167-75.

43 Friedman J, Kraus S, Hauptman Y, Schiff Y, Seger R (2007) Mecha-nism of short-term ERK activation by electromagnetic fields at mobile phone frequencies. Biochem 405(3): 559-68.

44 Shckorbatov YG, Pasiuga VN, Grabina VA, Kolchihin NN, Batrakov DO, Kalashnikov VV, Ivanchenk DD, Bykov VN (2008) The influence of microwave radiation on the state of chromatin in human cells. http://arXiv.org/list/q-bio/0809: No. 0559

45 Slesin L (2007) Wheel on trial. Microwave News. http://www.micro wavenews.com/docs/PERFORM.pdf

46 PERFORM-A Consortium (2007) In vivo research on possible health effects of the use of mobile telephones and base stations. Final Report. http://www.item.fhg.de/geschaeftsfelder/hygiene/pdf/PERFORMA.pdf

47 Tillmann T, Ernst H, Ebert S, Kuster N, Behnke W, Rittinghausen S, Dasenbrock C (2007) Carcinogenicity study of GSM and DCS wire-less communication signals in B6C3F1 mice. Bioelectromagnetics 28(3): 173-87.

48 Smith P, Kuster N, Ebert S, Chevalier HJ (2007) GSM and DCS wireless communication signals: combined chronic toxicity/carcinogenicity study in the Wistar rat. Rad Res 168(4): 480-92.

49 Oberto G, Rolfo K, Yu P, Carbonatto M, Peano S, Kuster N, Ebert S, Tofani S (2007) Carcinogenicity study of 217 Hz pulsed 900 MHz electromagnetic fields in Pim1 transgenic mice. Radiat Res 168(3): 316-26.

50 Hruby, R, Neubauer G, Kuster N, Frauscher M (2008) 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.

51 Shirai T, Ichihara T, Wake K, Watanabe S, Yamanaka Y, Kawabe M, Taki M, Fujiwara O, Wang J, Takahashi S, Tamano S (2007) Lack of promoting effects of chronic exposure to 1.95-GHz W-CDMA signals for IMT-2000 cellular system on development of N-ethylni-trosourea-induced central nervous system tumors in F344 rats. Bioelectromagnetics 28(7): 562-72.

52 Tillmann T, Ernst H, Reinhardt T, Bitz A, Streckert J, Hansen V, Mohr U, Dasenbrock C (2008) Tumor promotion by chronic UMTS-modulated radiofrequency exposure in mice prenatally treated with ENU. Vortrag. Workshop „Omics for Assessing Unclear Risks", 26. - 28.Mai 2008, Berlin

53 Sarkar S, Ali S, Behari J (1994) Effect of low power microwave on the mouse genome: a direct DNA analysis. Mutat Res 320(1-2): 141-7.

54 Lai H, Singh NP (1996) Single- and double-strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromag-netic radiation. Int J Radiat Biol 69(4): 513-21.

55 Repacholi MH, Basten A, Gebski V, Noonan D, Finnie J, Harris AW (1997) Lymphomas in Emu-Pim1 transgenic mice exposed to pulsed 900 MHz electromagnetic fields. Radiat Res 147(5): 631-40.

56 Trosic I (2001) Multinucleated giant cell appearance after whole body microwave irradiation of rats. Int J Hyg Environ Health 204(2-3): 133-8.

57 Sykes PJ, McCallum BD, Bangay MJ, Hooker AM, Morley AA (2001) Effect of exposure to 900 MHz radiofrequency radiation on intra-chromosomal recombination in pKZ1 mice. Radiat Res 156(5 Pt 1): 495-502.

58 Trosic I, Busljeta I, Kasuba V, Rozgaj R (2002) Micronucleus induction after whole-body microwave irradiation of rats. Mutat Res 521(1-2): 73-9.

59 Salford LG, Brun AE, Eberhardt JL, Malmgren L, Persson BR (2003) Nerve cell damage in mammalian brain after exposure to micro-waves from GSM mobile phones. Environ Health Perspect 111(7): 881-3; discussion A408.

60 Trosic I, Busljeta I, Modlic B (2004) Investigation of the genotoxic effect of microwave irradiation in rat bone marrow cells: in vivo exposure. Mutagenesis 19(5): 361-4.

61 Aitken RJ, Bennetts LE, Sawyer D, Wiklendt AM, King BV (2005) Im-pact of radio frequency electromagnetic radiation on DNA integrity in the male germline. Int J Androl 28(3): 171-9.

62 Lai H, Singh NP (2005) Interaction of microwaves and a temporally incoherent magnetic field on single and double DNA strand breaks in rat brain cells. Electromagn Biol Med 24(1): 23-9.

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

64 Ferreira AR, Knakievicz T, Pasquali MA, Gelain DP, Dal-Pizzol F, Fernández CE, de Salles AA, Ferreira HB, Moreira JC (2006) 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.

65 Belyaev IY, Koch CB, Terenius O, Roxstrom-Lindquist K, Malmgren LO, Sommer W, Salford LG, Persson BR (2006) Exposure of rat brain to 915 MHz GSM microwaves induces changes in gene ex-pression but not double stranded DNA breaks or effects on chro-matin conformation. Bioelectromagnetics 27(4): 295-306.

66 Paulraj R, Behari J (2006) Single strand DNA breaks in rat brain cells exposed to microwave radiation. Mutat Res 596(1-2): 76-80.

67 Trosic I, Busljeta I (2006) Erythropoietic dynamic equilibrium in rats maintained after microwave irradiation. Exp Toxicol Pathol 57(3): 247-51.

68 Karinen A, Heinävaara S, Nylund R, Leszczynski D (2008) Mobile phone radiation might alter expression in human skin. BMC Genomics 9: 77.

69 Yadav AS, Sharma MK (2008) Increased frequency of micronucleated exfoliated cells among humans exposed in vivo to mobile tele-phone radiations. Mutat Res 650(2): 175-80.

70 Schüz J, Jacobsen R, Olsen JH, Boice JD, McLaughlin JK, Johan-sen C (2006) Cellular telephone use and cancer risk: update of a nationwide Danish cohort. J Natl Cancer Inst 98(23): 1707-13.

71 Takebayashi T, Akiba S, Kikuchi Y, Taki M, Wake K, Watanabe S, Yamaguchi N (2006) Mobile phone use and acoustic neuroma risk in Japan. Occup Environ Med 63(12): 802-7.

72 Klaeboe L, Blaasaas KG, Tynes T (2007) Use of mobile phones in Norway and risk of intracranial tumours. Eur J Cancer Prev 16(2): 158-64.

73 Kundi M, Mild K, Hardell L, Mattsson MO (2004) Mobile telephones and cancer - a review of epidemiological evidence. J Toxicol Environ Health B Crit Rev 7(5): 351-84.

74 Inskip PD, Tarone RE, Hatch EE, Wilcosky TC, Shapiro WR, Selker RG, Fina HA, Black PM, Loeffler JS, Linet MS (2001) Cellular-telephone use and brain tumors. N Engl J Med 344(2): 79-86.

75 Kundi M (2004) Mobile phone use and cancer. Occup Environ Med 61(6): 560-70, 487.

76 Slesin L (2008) Interphone Project: The cracks begin to show. Microwave News. http://www.microwavenews.com/docs/mwn. 6(5)-08.pdf

77 Hardell L, Carlberg M, Söderqvist F, Hansson Mild K, Morgan LL (2007) Long-term use of cellular phones and brain tumours: increa-sed risk associated with use for > or = 10 years. Occup Environ Med 64(9): 626-32.

78 Kan P, Simonsen SE, Lyon JL, Kestle JR (2008) Cellular phone use and brain tumor: a meta-analysis. J Neurooncol 86(1): 71-8.

79 Hardell L, Carlberg M, Söderqvist F, Hansson Mild K (2008) Meta-analysis of long-term mobile phone use and the association with brain tumours. Int J Oncol 32(5): 1097-103.

80 Stang A, Anastassiou G, Ahrens W, Bromen K, Bornfeld N, Jöckel KH (2001) The possible role of radiofrequency in the development of uveal melanoma. Epidemiology 12(1): 7-12.

81 Lönn S, Ahlbom A, Hall P, Feychting M (2004) Mobile phone use and the risk of acoustic neuroma. Epidemiology 15(6): 653-9.

82 Christensen HC, Schüz J, Kosteljanetz M, Poulsen HS, Thomson J, Johansen C (2004) Cellular telephone use and risk of acoustic neuroma. Am J Epidemiol 159(3): 277-83.

83 Schoemaker MJ, Swerdlow AJ, Ahlbom A, Auvinen A, Blaasaas KG, Cardis E, Christensen HC, Feychting M, Hepworth SJ, Johansen C, Klaeboe L, Lönn S, McKinney PA, Muir K, Raitanen J, Salminen T, Thomsen J, Tynes T (2005) Mobile phone use and risk of acoustic neuroma: results of the Interphone case-control study in five North European countries. Br J Cancer 93(7): 842-8.

84 Lönn S, Ahlbom A, Hall P, Feychting M; Swedish Interphone Study Group (2005) Long-term mobile phone use and brain tumor risk. Am J Epidemiol 161(6): 526-35.

85 Christensen HC, Schüz J, Kosteljanetz M, Poulsen HS, Boice JD Jr, McLaughlin JK, Johansen C (2005) Cellular telephones and risk for brain tumors: a population-based, incident case-control study. Neurology 64(7): 1189-95.

86 Schüz J, Böhler E, Berg G, Schlehofer B, Hettinger I, Schlaefer K, Wahrendorf J, Kunna-Grass K, Blettner M (2006) Cellular phones, cordless phones, and the risks of glioma and meningioma (Interphone Study Group, Germany). Am J Epidemiol 163(6): 512-20.

87 Hepworth SJ, Schoemaker MJ, Muir KR, Swerdlow AJ, von Tongeren MJ, McKinney PA (2006) Mobile phone use and risk of glioma in adults: case-control study. BMJ 332(7546): 883-7.

88 Hardell L, Carlberg M, Hansson Mild K (2006) Pooled analysis of two case-control studies on the use of cellular and cordless telephones and the risk of malignant brain tumours diagnosed during 1997-2003. Int Arch Occup Environ Health 79(8): 630-9.

89 Hardell L, Carlberg M, Hansson Mild K (2006) 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): 509-18.

90 Lahkola A, Auvinen A, Raitanen J, Schoemaker MJ, Christensen HC, Feychting M, Johansen C, Klaeboe L, Lönn S, Swerdlow AJ, Tynes T, Salminen T (2007) Mobile phone use and risk of glioma in 5 North European countries. Int J Cancer 120(8): 1769-75.

91 Hours M, Bernard M, Montestrucq L, Arslan M, Bergeret A, Deltour I, Cardis E (2007) Cell phone and risk of brain and acoustic nerve tumours: the French INTERPHONE case-control study. M Rev Epidemiol Sante Publique 55(5): 321-32.

92 Sadetzki S, Chetrit A, Jarus-Hakak A, Cardis E, Deutch Y, Duvdeva-ni S, Zultan A, Novikov I, Freedman L, Wolf M (2008) Cellular phone use and risk of benign and malignant parotid gland tumors - a nationwide case-control study. Am J Epidemiol 167(4): 457-67.

93 Belyaev IY (2005) Non thermal biological effects of microwaves: current knowledge, further perspectives and urgent needs. Vortrag. Workshop "Do sinusoidal versus non-sinusoidal waveforms make a difference?" 17./18. Februar 2005, Zürich

94 Zwamborn APM, Vossen SHJA, Van Leersum BJAM, Ouwens MA, Makel WN (2003) Effects of global communication system radio-frequency fields on well-being and cognitive functions of human subjects with and without subjective complaints. Netherlands Organisation for Applied Scientific Research (TNO) FEL-03-C148

95 Wiart J, Hadjem A, Wong MF, Bloch I (2008) Analysis of RF exposure in the head tissues of children and adults. Phys Med Biol 53(13): 3681-95.

96 Slesin L (2008) The brains of young children absorb twice as much RF energy ... . Microwave News, July 22, 2008: http://www.microwavenews.com

97 Huss A, Egger M, Hug K, Huwiler-Müntener K, Röösli M (2007) Source of funding and results of studies of health effects of mobile phone use: systematic review of experimental studies. Environ Health Perspect 155(1): 1-4.

98 Belyaev IY, Grigoriev YG (2007) Problems in assessment of risks from exposure to microwaves of mobile communication. Radiats Biol Radioecol 47(6): 727-32.

99 BioInitiative Working Group (2007) BioInitiative Report: A rationale for a biologically-based public exposure standard for electromagnetic fields (ELF and RF). http://www.bioinitiative.org/report/index.htm

100 International Commission for Electromagnetic Safety (ICEMS) (2008) The Venice resolution. http://www.icems.eu/resolution.htm (Deutsch: http://www.icems.eu/docs/resolution_german.pdf)

101 Advice from University of Pittsburg Cancer Institute based on advice from an international expert panel (2008) The case for precau-tion in the use of cell phones. http://environmentaloncology.org/files/file/Publications/UPCICellPhonesAppeal. pdf

Risk Assessment of Chronic Exposures to Non-Thermal Microwaves from Mobile Communication[1]

Igor Y. Belyaev, Stockholm University

Summary

This article shows that current safety guidelines (e.g. ICNIRP) do not provide effective protection for the general population against the health effects of mobile phone radiation. That is because non-thermal effects and effects of chronic exposures are not taken into consideration. To exclusively base exposure limits on the SAR value or power density, however, is inconsistent with many study results, demonstrating that biological effects of mobile phone radiation depend on different variables (e.g. frequency, modulation, polarization). In order to thoroughly research these biological effects, it is imperative to use mobile phone signals of the real world. In contrast, simulated mobile phone signals—as have been used in numerous studies—can lead to different effects, making a reliable assessment of the health risk associated with real-life mobile phone signals impossible. The author calls for using the guidelines of the Russian commission on radiation protection (RNCNIRP) as a basis for risk assessments because the latter already have taken non-thermal and chronic effects into consideration. (Summary by the Editors)

1. Introduction

Numerous sources of mobile communication result in chronic exposure of general population to microwaves (MWs) at the non-thermal (NT) levels. Since pioneering investigations published in the beginning of 1970th [1, 2], various biological responses to NT MWs including adverse health effects have been reported by many groups over the world [3, 4]. Numerous experimental data have provided strong evidence for the NT MW effects and have also indicated dependence of these effects on several physical parameters and biological variables: dependence on carrier frequency of „resonance-type" within specific frequency windows; dependence on modulation and polarization; non-linear dependence on intensity within specific intensity windows including super-low power densities (PDs)/specific absorption rates (SARs) comparable with intensities from base stations; narrowing of the frequency windows with decrease in intensity; high sensitivity of the NT MW effects to the duration and intermittence of exposure; dependence on cell density that suggests cell-to-cell interaction during response to NT MWs; dependence on genetic background, physiological variables during exposure and a potential of radical scavengers/antioxidants to minimize the MW effects. There are not yet confirmed observations that gender, individual traits, oxygen concentration, static magnetic fields (SMF) and stray electromagnetic field (EMF) during exposure may be of importance for the effects of NT MWs [5]. Most of these regularities clearly indicate that the MW effects at low intensities cannot be accounted for any type of thermal effects.

Despite of considerable body of studies with NT MWs in biology, only few studies were performed to replicate the original data on the NT MW effects. It should be noted, that the „replications" are usually not comparable with the original studies because of either missing description of important parameters of exposure or significant differences in these parameters between original study and replication.

2. Risk Assessment of Signals Used in Mobile Communication

The safety recommendations of some organizations such as ICNIRP [6] are based on thermal effects in acute exposures and cannot protect from eventual non-thermal effects of chronic exposures to the NT MWs from mobile communication. Some national authorities such as RCNIRP have established significantly lower safety recom-

[1] First Publication: VALDOR Symposium „Values in Decisions on Risks", published by K. Andersson, Stockholm (Sweden), 2006. p. 290 – 297. http://www.congrex.com/valdor2006/papers/40_Belyaev.pdf

mendations that are based on studies with chronic exposures and acceptance of non-thermal effects [7]. At present, new situation arose when general population is exposed chronically (much longer than previously investigated durations of exposures) to NT MWs from different types of mobile communication including GSM and UMTS/3G phones and base stations, WLAN (Wireless Local Area Networks), WPAN (Wireless Personal Area Networks such as Bluetooth), DECT (Digital Enhanced (former European) Cordless Telecommunications) wireless phones. RCNIRP admit that the established safety standards do not correspond to the present situation when general population is exposed to variety of MW signals with durations of exposure comparable with the lifespan [8].

Most of the real MW signals that are in use in mobile communication have not been tested so far for adverse effects. Very little research has been done with real signals and for durations and intermittences of exposure that are relevant to chronic exposures from mobile communication. In some studies, so-called „mobile communication-like" signals were investigated that in fact were different from the real exposures in such important aspects as carrier frequency, modulation, polarization, duration and intermittence. To what degree such studies are relevant to evaluation of health risks from MWs of mobile communication is not known. For example, GSM users are exposed to MWs at different carrier frequencies during their talks. There are 124 different channels/frequencies, which are used in Europe for GSM900. They differ by 0.2 MHz in the frequency range from 890 MHz to 915 MHz. Mobile phone users are supplied by various frequencies from the base stations depending on the number of connected users. The base station can change the frequency during the same talk. We have shown that adverse effects of NT MWs from GSM mobile phones depend on carrier frequency [9-11]. Frequency-dependent effects of GSM MWs on the 53BP1/γ-H2AX DNA repair foci in human lymphocytes from healthy and hypersensitive to EMF persons, human fibroblasts and human stem cells were observed in replicated studies [9-11].

GSM uses GMSK modulation (Gaussian Minimum Shift Keying). Contrary to GSM phones, UMTS mobile phones of the 3rd generation (3G) use essentially QPSK (Quadrature Phase Shift Keying) modulation and irradiate wide-band signals with the bandwidth of 5 MHz. UMTS MWs may hypothetically result in a higher biological effect because of eventual „effective" frequency windows within the bands. We tested one of the real UMTS signals as used by 3G mobile phones in Sweden. UMTS MWs induced significant adverse effects in human lymphocytes, fibroblasts and stem cells [9, 11]. The results obtained were in line with our hypothesis that UMTS MWs may produce stronger adverse effects than GSM MWs because of the nature of signal.

3. Urgent Needs and Further Perspectives in Risk Assessment

It should be anticipated that some part of population, such as children, pregnant women and groups of hypersensitive persons could be especially sensitive to the NT MW exposures. It is becoming more and more clear that the SAR concept that has been widely adopted for safety standards may not be useful alone for the evaluation of health risks from MWs of mobile communication. How the role of other exposure parameters such as carrier frequency, modulation, polarization, duration, and intermittence of exposure should be taken into account is an urgent question to solve. Solving this question would greatly benefit from the knowledge of the biophysical mechanisms of the NT MW effects. The understanding of mechanisms for the NT MW effects is far from comprehensive. Many questions remain to be addressed such as whether the effects of NT MWs depend on electromagnetic noise and static magnetic field during exposure. Besides fundamental importance, this knowledge would facilitate the development of safe mobile communication.

So far, most laboratory and almost all epidemiological studies did not control the important features of the NT MW effects and therefore, very limited conclusion regarding health effects of MWs from mobile communication can be drawn from these studies. It should be noted that one group of epidemiologists with a long-lasting experience in studying the relationship between mobile phone usage and cancer risk have consistently been concerned regarding importance of the type of MW signal and the exposure duration [12-15]. The group of Hardell was the first epidemiological group in attempting to study separately the MW signals from cordless phones, analogue phones and digital phones. As a rule, analogue phones had the highest association with the cancer risk. Cordless phones were associated with the risk for brain tumors, acoustic neuroma, and T-cell lymphoma strong-

[2] Safety Guidelines: "All current standards including the Russian ones." (Igor Belyeav comm. by mail from 9 Jun 2008).

[3] Definition "Mechanistic point of view": "Approach of Hardell is more based on the current knowledge regarding the mechanisms of the nonthermal effects of microwaves than approaches of other epedemiological groups." (Igor Belyeav comm. by mail from 9 Jun 2008). Belyaev uses this term in the sense of "understanding the effect mechanisms."

er or in the same degree as digital and analogue phones despite significantly lower SAR values were produced by cordless phones [12, 14-16]. This important result can be considered as an independent conformation, at the epidemiological level, of the observations from specially designed in vitro and in vivo studies that the NT MW effects depend not solely on SAR/PD but also on other parameters. It should be also noted that epidemiological data are controversial and methodological differences are a subject of debates between various research groups [16, 17]. However, the approach of the Hardell's group is more valid from the mechanistic point of view and this should be taken into account when comparing with results with other epidemiological groups that are either not aware of or ignore the complex dependencies of the NT MW effects on variety of physical and biological parameters [17].

The data about the effects of MWs at super low intensities and significant role of duration of exposure in these effects along with the data showing that adverse effects of NT MWs from GSM/UMTS mobile phones depend on carrier frequency and type of the MW signal suggest that MWs from base-stations/masts can also produce adverse effects at prolonged durations of exposure and encourage studies using real signals from base stations/masts [18].

The dependence of adverse effects of NT MWs on carrier frequency and type of signal should be taken into account in settings of safety standards and in planning of in vivo and epidemiological studies. One important conclusion stemming from the available in vitro and in vivo studies is that epidemiological studies should not be given priority for risk assessment before proper design of these studies will be available as based on mechanistic understanding of the NT MW effects. This conclusion is based on two principle arguments. First, it is almost impossible to select control-unexposed groups because the whole population in many countries is exposed to a wide range of MW signals from various sources such as mobile phones and base stations/masts of various kinds, WLAN, WPAN, DECT wireless phones and given that duration of exposure (must be at least 10 years for cancer latency period) may be more important for the adverse health effects of NT MWs than PD/SAR. It should be stressed, that the inappropriate definition of control-unexposed groups is a typical flow in those epidemiological studies that are not based on mechanistic issues regarding the NT MW effects [19]. Subjective dividing of telephone users into „exposed" and „unexposed-control" groups make such studies inconclusive. It is clear, that such epidemiological studies cannot be used as a background for risk assessment. Second, the adverse effects of „detrimental" signals are masked because people are exposed to various signals/frequencies including non-effective or even hypothetically beneficial. Therefore, current epidemiological studies may be either inconclusive, if results are negative (no risks were found), or underestimate significantly the hazard of using specific detrimental signals, if results are positive.

The RNCNIRP proposed that guidelines and risk assessment for NT MWs should be urgently developed by studies based on the next priorities [7]:

1. Acute and chronic bioeffects of real MW signals as currently in use (GSM, UMTS/3G phones and base stations...) should be tested in experiments with primary human cells and using appropriate techniques. In these tests, a potential of specific MW signals to produce adverse effects should be evaluated. Those „ineffective" signals and frequency channels/bands, which do not affect human cells, should be identified for further development of safe mobile communication.
2. Studies with animals and volunteers under controlled conditions of chronic exposures to both detrimental and ineffective MW signals as revealed by in vitro studies with primary human cells. The data from the acute exposures of volunteers have very limited value for risk assessment because possible accumulation of effects during real chronic exposures is not evaluated.
3. Development of reliable and relevant methods to control personal exposures.
4. Based on mechanistic studies, epidemiological investigations of various postponed adverse health effects should be planned. Because NT MWs affect a variety of cell types such as brain cells [20, 21], blood cells [9-11, 22-24], skin and fibroblasts [9, 25-28], stem cells [9, 29, 30], reproductive organs and sperm quality [31-35], prenatal development and fertility [36, 37], different types of cancer (tumors of various localization and leukemia) and also other relevant diseases should be tested. Recent data suggest that different cancer types have a fundamentally common basis that is grounded on epigenetic changes in stem cells [38]. Therefore, the experimental findings regarding effects of NT MWs on stem cells [9, 29, 30] may be especially important for cancer risk assessment.

The collaborative efforts of scientific groups within special national and international programs are needed for the risk assessment of the NT MW exposures. This collaboration should involve scientists with diverse expertise including those having experience in studying the mechanisms of the NT MW effects. Otherwise, misleading conclusions or inconclusive results may be expected.

Acknowledgements

Financial support of the Swedish Council for Working Life and Social Research, the Swedish Radiation Protection Authority, the Russian Foundation for Basic Research is gratefully acknowledged.

References

[1] N. D. Devyatkov, "Influence of electromagnetic radiation of millimeter range on biological objects (in Russian)," *Usp Fiz Nauk*, pp. 453-454, 1973.

[2] R. L. Vilenskaya, A. Z. Smolyanskaya, V. G. Adamenko, Z. N. Buldasheva, E. A. Gelvitch, M. B. Golant , and D. Y. Goldgaber, "Induction of the lethal colicin synthesis in E. coli K12 C600 (E1) by means the millimeter radiation (in Russian)," *Bull. Eksperim. Biol. Med.*, vol. 4, pp. 52-54, 1972.

[3] W. R. Adey, "Cell and molecular biology associated with radiation fields of mobile telephones," in *Review of Radio Science, 1996-1999*, S. Ueno, Ed. Oxford: Oxford University Press, 1999, pp. 845-872.

[4] H. Lai, "Biological effects of radiofrequency electromagnetic field," in Encyclopedia of Biomaterials and Biomedical Engineering, G. L. Bowlin, Ed. New York, NY: Marcel Decker, 2005, pp. 1-8.

[5] I. Belyaev, "Non-thermal Biological Effects of microwaves," *Microwave Review*, vol. 11, pp. 13-29, http://www.mwr.medianis.net/pdf/Vol11No2-03-IBelyaev.pdf, 2005.

[6] ICNIRP, "ICNIRP Guidelines. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)," *Health Physics*, vol. 74, pp. 494-522, 1998.

[7] Y. Grigoriev, V. Nikitina, N. Rubtcova, L. Pokhodzey, O. Grigoriev, I. Belyaev, and A. Vasin, "The Russian National Committee on Non-Ionizing Radiation Protection (RNCNIRP) and the radiation guidelines," presented at Transparency Forum for Mobile Telephone Systems, Stockholm, 2005.

[8] Y. G. Grigoriev, "Electromagnetic fields of mobile radio communication and danger estimation for the population," presented at 6th International Symposium on Electromagnetic Compatibility and Electromagnetic Ecology, Saint-Petersburg, Russia, 2005.

[9] E. Markova, V. Altanerova, L. Malmgren, B. Persson, and I. Belyaev, "Specific signals from mobile communication induce adverse effects in primary human cells of different types: stem cells, lymphocytes, fibroblasts," *Lancet, submitted*, 2006.

[10] E. Markova, L. Hillert, L. Malmgren, B. R. Persson, and I. Y. Belyaev, "Microwaves from GSM Mobile Telephones Affect 53BP1 and gammaH2AX Foci in Human Lymphocytes from Hypersensitive and Healthy Persons," *Environ Health Perspect*, vol. 113, pp. 1172-1177, 2005.

[11] I. Y. Belyaev, E. Markova, L. Hillert, L. O. G. Malmgren, and B. R. R. Persson, "Non-thermal microwaves from UMTS and GSM mobile phones result in long-lasting effects on DNA repair 53BP1/gamma-H2AX foci in human lymphocytes," Environ Health Perspect, submitted, 2005.

[12] L. Hardell, M. Eriksson, M. Carlberg, C. Sundstršm, and K. Hansson Mild, "Use of cellular or cordless telephones and the risk for non-Hodgkin's lymphoma," Int Arch Occup Environ Health, vol. DOI 10.1007/s00420005-0003-5, 2005.

[13] L. Hardell and K. H. Mild, "Mobile phone use and acoustic neuromas," Epidemiology, vol. 16, pp. 415; author reply 417-418, 2005.

[14] L. Hardell, K. H. Mild, and M. Carlberg, "Further aspects on cellular and cordless telephones and brain tumours," Int J Oncol, vol. 22, pp. 399-407, 2003.

[15] L. Hardell, K. H. Mild, A. Pahlson, and A. Hallquist, "Ionizing radiation, cellular telephones and the risk for brain tumours," Eur J Cancer Prev, vol. 10, pp. 523-529, 2001.

[16] M. Kundi, K. Mild, L. Hardell, and M. O. Mattsson, "Mobile telephones and cancer -a review of epidemiological evidence," J Toxicol Environ Health B Crit Rev, vol. 7, pp. 351-384, 2004.

[17] A. Ahlbom, A. Green, L. Kheifets, D. Savitz, and A. Swerdlow, "Epidemiology of health effects of radiofrequency exposure," Environ Health Perspect, vol. 112, pp. 1741-1754, 2004.

[18] I. Belyaev, "Nonthermal Biological Effects of Microwaves: Current Knowledge, Further Perspective, and Urgent Needs," Electromagnetic Biology and Medicine, vol. 24, pp. 375 -403, 2005.

[19] S. Lonn, A. Ahlbom, P. Hall, and M. Feychting, "Long-term mobile phone use and brain tumor risk," Am J Epidemiol, vol. 161, pp. 526-35, 2005.

[20] A. Ilhan, A. Gurel, F. Armutcu, S. Kamisli, M. Iraz, O. Akyol, and S. Ozen, "Ginkgo biloba prevents mobile phone-induced oxidative stress in rat brain," Clin Chim Acta, vol. 340, pp. 153-62, 2004.

[21] L. G. Salford, A. E. Brun, J. L. Eberhardt, L. Malmgren, and B. R. R. Persson, "Nerve cell damage in mammalian brain after exposure to microwaves from GSM mobile phones," Environmental Health Perspectives., vol. 111, pp. 881-883, 2003.

[22] G. d'Ambrosio, R. Massa, M. R. Scarfi, and O. Zeni, "Cytogenetic damage in human lymphocytes following GMSK phase modulated microwave exposure," Bioelectromagnetics, vol. 23, pp. 7-13, 2002.

[23] I. Y. Belyaev, L. Hillert, M. Protopopova, C. Tamm, L. O. Malmgren, B. R. R. Persson, G. Selivanova, and M. Harms-Ringdahl, "915 MHz microwaves and 50 Hz magnetic field affect chromatin conformation and 53BP1 foci in human lymphocytes from hypersensitive and healthy persons," Bioelectromagnetics, vol. 26, pp. 173-184, 2005.

[24] R. Sarimov, L. O. G. Malmgren, E. Markova, B. R. R. Persson, and I. Y. Belyaev, "Non-thermal GSM microwaves affect chromatin conformation in human lymphocytes similar to heat shock," IEEE Transactions on Plasma Science, vol. 32, pp. 1600-1608, 2004.

[25] F. Ozguner, G. Aydin, H. Mollaoglu, O. Gokalp, A. Koyu, and G. Cesur, "Prevention of mobile phone induced skin tissue changes by melatonin in rat: an experimental study," Toxicol Ind Health, vol. 20, pp. 133-139, 2004.

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

[27] E. Diem, C. Schwarz, F. Adlkofer, O. Jahn, and H. Rudiger, "Non-thermal DNA breakage by mobile-phone radiation (1800 MHz) in human fibroblasts and in transformed GFSH-R17 rat granulosa cells in vitro," Mutat Res, vol. 583, pp. 178-183, 2005.

[28] T. A. Litovitz, D. Krause, M. Penafiel, E. C. Elson, and J. M. Mullins, "The role of coherence time in the effect of microwaves on ornithine decarboxylase activity," Bioelectromagnetics, vol. 14, pp. 395-403, 1993.

[29] J. Czyz, K. Guan, Q. Zeng, T. Nikolova, A. Meister, F. Schonborn, J. Schuderer, N. Kuster, and A. M. Wobus, "High frequency electromagnetic fields (GSM signals) affect gene expression levels in tumor suppressor p53deficient embryonic stem cells," Bioelectromagnetics, vol. 25, pp. 296-307, 2004.

[30] T. Nikolova, J. Czyz, A. Rolletschek, P. Blyszczuk, J. Fuchs, G. Jovtchev, J. Schuderer, N. Kuster, and A. M. Wobus, "Electromagnetic fields affect transcript levels of apoptosis-related genes in embryonic stem cell-derived neural

progenitor cells," *Faseb J*, 2005.
[31] M. Ozguner, A. Koyu, G. Cesur, M. Ural, F. Ozguner, A. Gokcimen, and N. Delibas, "Biological and morphological effects on the reproductive organ of rats after exposure to electromagnetic field," *Saudi Med J*, vol. 26, pp. 405-410, 2005.
[32] D. J. Panagopoulos, A. Karabarbounis, and L. H. Margaritis, "Effect of GSM 900-MHz Mobile Phone Radiation on the Reproductive Capacity of Drosophila melanogaster," *Electromagnetic Biology and Medicine*, vol. 23, pp. 29 -43, 2004.
[33] I. Fejes, Z. Za Vaczki, J. Szollosi, R. S. Kolosza, J. Daru, L. Kova Cs, and L. A. Pa, "Is there a relationship between cell phone use and semen quality?," *Arch Androl*, vol. 51, pp. 385-93, 2005.
[34] R. J. Aitken, L. E. Bennetts, D. Sawyer, A. M. Wiklendt, and B. V. King, "Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline," *Int J Androl*, vol. 28, pp. 171-9, 2005.
[35] B. Balmori, "Possible Effects of Electromagnetic Fields from Phone Masts on a Population of White Stork (Ciconia ciconia)," *Electromagnetic Biology and Medicine*, vol. 24, pp. 109 -119, 2005.
[36] I. N. Magras and T. D. Xenos, "RF radiation-induced changes in the prenatal development of mice," *Bioelectromagnetics*, vol. 18, pp. 455-61, 1997.
[37] A. Pyrpasopoulou, V. Kotoula, A. Cheva, P. Hytiroglou, E. Nikolakaki, I. N. Magras, T. D. Xenos, T. D. Tsiboukis, and G. Karkavelas, "Bone morphogenetic protein expression in newborn rat kidneys after prenatal exposure to radiofrequency radiation," *Bioelectromagnetics*, vol. 25, pp. 216-27, 2004.
[38] A. P. Feinberg, R. Ohlsson, and S. Henikoff, "The epigenetic progenitor origin of human cancer," *Nat Rev Genet*, vol. 7, pp. 21-33, 2006.

DNA and Chromosome Damage: A Crucial Non-Thermal Biological Effect of Microwave Radiation

An Overview of Studies and Models on the Effect Mechanism

Vladislav M. Shiroff

This article will discuss that (i) low-level (SAR < 2 W/kg) radiofrequency electromagnetic fields can also trigger biological effects (so-called non-thermal effects) whereby different variables (e.g. frequency, exposure level, exposure dose, modulation, type of polarization) determine the type and intensity of a given effect; that (ii) a large number of existing studies were able to demonstrate DNA and chromosome damage from RF-EMF exposure, and that (iii) the biological effect mechanism of these genotoxic effects is largely based on the formation of oxidative/nitrosative stress. At the end, the implications of this knowledge are discussed regarding the use of mobile phones.

Which studies show that the exposure of a living organism to radiofrequency electromagnetic fields leads to DNA and chromosome damage? And what is the latest state of research that explains such genotoxic effects of RF radiation? This article is dedicated to answering these questions. It offers an overview of the current state of research in a field that is of utmost importance to public health.

1 Introduction

While exposure to high (SAR > 2 W/kg) radiofrequency electromagnetic fields (RF-EMF) leads to thermal effects in biological systems, a large number of studies show that the exposure to *low-level* (SAR < 2 W/kg) RF-EMFs also triggers biological effects (so-called *non-thermal effects*). An effect is always referred to as non-thermal when it cannot be explained by a rise in temperature (Fröhlich, 1982). The type and intensity of such non-thermal effects depend on different variables (Belyaev, 2005), including *radiation* (e. g. frequency, exposure level, exposure dose, continuous or intermittent exposure, modulation, type of polarization), *exposed organism* (e. g. cell type, cell density, phase of cell cycle, antioxidant status, latency period), and *exposure environment* (e. g. presence of an additional static magnetic field).

The controversy over non-thermal effects of RF-EMFs continues further for two main reasons. On the one hand, it is difficult to replicate a successfully demonstrated effect since many more variables impact the outcome than previously assumed. On the other hand, the effect mechanism of non-thermal effects is not yet very well understood, which has everything to do with its complexity—but nothing with its alleged non-existence. Latest research studies, however, continue to greatly improve our understanding.

Below follows an overview of different variables and their importance regarding the initiation of non-thermal effects (also compare *figure 1*).

i) Frequency

In *E. coli.*, the strongest inhibition of DNA repair mechanisms can be demonstrated for RF-EMF exposures in the frequency intervals 51.62 to 51.84 GHz and 41.25 to 41.50 GHz as well as at intensity levels of 3×10^{-3} W/cm^2 down to 10^{-19} W/cm^2 (Belyaev et al., 1992a, 1992b, 1996; Belyaev and Harms-Ringdahl, 1996). Other studies, for example, showed that a 2-hour exposure of *Lemna minor L.* (duckweed) to 900 MHz signals at 23 V/m decreased its growth whereas the exposure to 400 MHz signals did not cause any such effect (Tkalec et al., 2005).

ii) Exposure Level

Non-thermal RF-EMF effects only occur within certain ranges of low exposure levels. It could be demonstrated, for example, that the DNA repair mechanism of *E. coli.* is inhibited at the resonance frequency 51.675 GHz and only at the exposure range from 10^{-18} to 10^{-8} W/cm^2 (Shcheglov et al., 1997).

iii) Exposure Dose

For e. g. SAR values at 0.021 and 2.1 mW/kg, studies of human epithelial cells showed a linear relationship between SAR value, exposure duration, and changes of cell proliferation: The longer the exposure duration was, the greater the changes in cell proliferation would be (Kwee and Raskmark, 1998). Changes in the chromatin con-

formation of E. coli. and rat thymocytes also showed a dose-dependent relationship. An exposure of 10^{-5} to 10^{-3} W/cm^2 for 5 to 10 min resulted in changes of chromatin conformation similar to those found at an exposure of 10^{-14} to 10^{-17} W/cm^2 for 20 to 40 min (Belyaev et al., 1994). For the initiation of biological effects, the exposure dose not only plays a major role in ionizing radiation but in *non-ionizing* EMFs as well.

iv) Continuous or Intermittent Exposure

Studies on human fibroblasts and rat granulosa cells showed that it is important whether a continuous or intermittent exposure pattern is applied. An intermittent (5 min on, 10 min off) microwave exposure at 1.8 GHz (SAR 1.2 or 2 W/kg) resulted in greater single- and double-strand DNA breaks than a continuous exposure of the same intensity level (Diem et al., 2005).

v) Polarization

It could be shown that the exposure of *E. coli.* to the resonance frequency of 51.76 GHz resulted in an inhibition of its DNA repair activity only if linear or right-hand circularly polarized microwaves were used; left-hand circularly polarized microwaves caused no effects. An exposure with the resonance frequency 41.32 GHz reversed the relationship: In this case, only linear or left-hand circularly polarized RF radiation caused a change in the DNA repair activity (Belyaev et al., 1992b, 1992c, 1992d). In both experiments, the right-hand as well as the left-hand circularly polarized RF radiation triggered a greater effect level than the linear polarized alone. If the DNA structure was altered (intercalation by ethidium bromide), a change in the polarization-dependent effect level could be demonstrated (Ushakov et al., 1999), which is regarded as an indication of the role the DNA plays in the relationship between the effect level and the polarization of an exposure.

vi) Modulation

Human lymphocytes showed chromosome damage when they were exposed to phase-modulated (GMSK) GSM-1800 signals whereas a non-modulated microwave signal with the same frequency and at the same exposure level caused *no* effect (D'Ambrosio et al., 2002). Experiments with neutrophil granulocytes of mice showed that the release of an oxidative burst (release of reactive oxygen species) only occurs at a microwave radiation exposure at 41.95 GHz and 50 µW/cm^2 when its amplitude is modulated at 1 Hz; the modulation 0.1, 16, or 50 Hz did *not* trigger any effect (Gapeev et al., 1997). Studies on mutant Saccharomyces cerevisiae cells (brewer's yeast) demonstrated an increased rate of UV-induced apoptosis when the amplitude of the microwave radiation (900 MHz or 875 MHz, SAR 0.4 W/kg) they were exposed to was modulated at 217 Hz (Markkanen et al., 2004).

vii) Presence of a Static Magnetic Field

In various studies, it was found that the presences of a static magnetic field could either increase or decrease the biological effect of RF-EMFs (Blackman et al., 1985; Belyaev, 1993; Blanchard and Blackman, 1994; Lednev, 1996; Litovitz et al., 1997; Di Carlo et al., 2002). In this context, the impact on the half-life of free radicals appears to be a crucial effect mechanism (Harkins and Grissom, 1994; Scaiano et al., 1994, 1995a, 1995b; Eichwald and Walleczek, 1996).

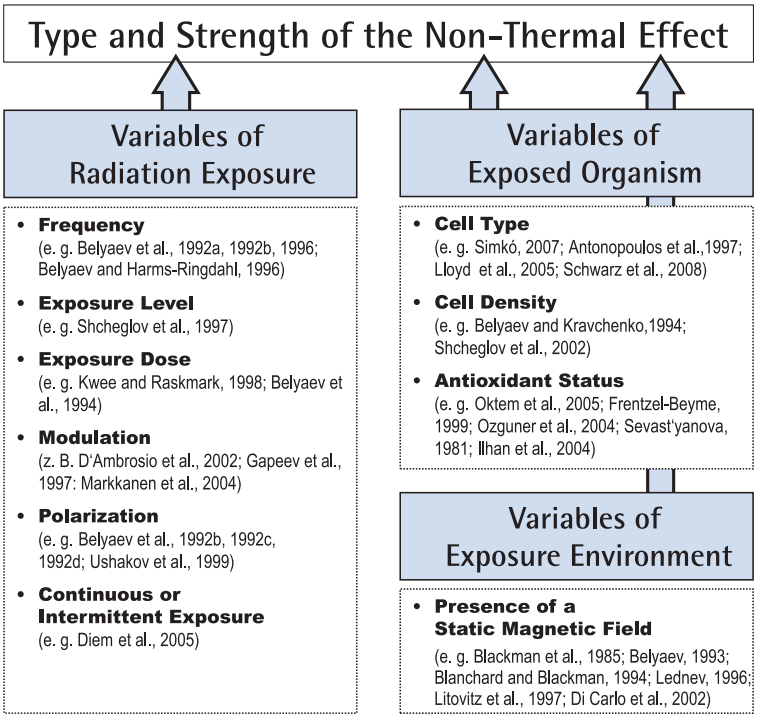


Fig. 1: Dependence of Type and Strength of an RF-EMF Induced Non-Thermal Effect on Different Variables

viii) Cell Type

That not every tissue or cell type responds in the same way to RF-EMF exposures is a fact that has been demonstrated in many studies. Primarily, this is the responsibility of the *redox homeostasis* (Simkó, 2007), which—depending on the cell type—is developed to different degrees. Redox homeostasis can be understood as the cell's

desire to keep its redox status, which can be referred to as the ratio of glutathione (GSH) to glutathione disulfide (GSSG) (Rahman et al., 2005), within a range where oxidative processes do not get out of control. A very strong desire to maintain the physiological redox status can be demonstrated in e. g. *lymphocytes*, which indeed in many studies were found to show no response to RF-EMF exposures (Antonopoulos et al., 1997; Lloyd et al., 2005; Schwarz et al., 2008). Other types of cells, however, are much more susceptible to an external modulation of the redox homeostasis, which explains their greater susceptibility to EMF exposures (Simkó, 2007).

ix) Cell Density

If the cell density of a solution with *E. coli.* cells is changed and exposed to microwave radiation at 51.755 GHz, an increased change in the chromatin conformation of the cells can be observed as a function of their cell density (Belyaev und Kravchenko, 1994). If the cell density is increased from 4 x 107 to 4 x 108 cells/ml, the effect is amplified by a factor of 4.7 (± 0.5). This dependence of the effect level on cell density was also found for the resonance frequencies at 51.672 GHz and 51.688 GHz (Shcheglov et al., 2002). Above a cell density of 5 x 10^8 cells/ml, no further increase of the effect level could be observed, which may be explained by the fact that at this density the distance between the cells is equivalent to the wavelength of microwave radiation at 10^{12} – 10^{13} Hz and that at these measurements a type of "saturation effect" occurs. Interestingly enough, H. Fröhlich postulated the existence of coherent oscillations in biological systems in the frequency range from 10^{11} to 10^{12} Hz (Fröhlich, 1968).

x) Antioxidant Status

The microwave radiation exposure from a GSM900 mobile phone causes an increased MDA (malondialdehyde) value (biomarker for lipid peroxidation) in rats and, at the same time, reduces antioxidant biomarkers such as superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px). When melatonin is administered, these effects can be prevented (Oktem et al., 2005). Melatonin is an antioxidant that neutralizes free radicals by changing electric charges via "internal conversion", which, in turn, results in the formation of radical pairs that neutralize each other. If this process is disturbed, many more free radicals will impact the organism because fewer of them will be neutralized and thus their life span will be extended (Frentzel-Beyme, 1999). When Wister albino rats are exposed to GSM900 signals, this type of radiation causes pathological changes in the skin (e.g. epidermal atrophy), which can be prevented by administering melatonin (Ozguner et al., 2004). In another study, it was found that the antioxidant levels of CAT, SOD, and GSH-Px decreased in the skin of rats after the exposure to the microwave radiation of a GSM1900 mobile phone. Again, it could be demonstrated that the administration of melatonin prevents this effect (Sevast'yanova, 1981). That the administration of the antioxidant Ginkgo biloba (Gb) can prevent damage induced by the microwave exposure to a GSM900 signal could be shown in rat brain tissue: While the exposure without Gb results in an increase in MDA and nitric oxide (NO) and a decrease in SOD and GSH-Px in the rat brain tissue, the administration of Gb prevents these effects (Ilhan et al., 2004).

xi) Latency Period

If and which non-thermal effect is demonstrated when an organism is exposed to RF-EMFs also depends to a large extent on the point in time at which the analysis is performed after the exposure. For example, chromosome damage of RF-EMF exposure could be demonstrated in rat thymocytes after a latency period of only 30 to 60 min, but after 80 min chromosome damage could no longer be detected (Belyaev and Kravchenko, 1994).

2 DNA and Chromosome Damage Caused by RF-EMF Exposure: On the State of the Research

The favorite answer of mobile phone providers to the question of whether RF-EMF exposures can result in DNA and chromosome damage often reads as follows, e.g. in information brochures by the Information Center of Mobile Telephony (IZMF):

> *"Mobile phone frequencies belong to the non-ionizing portion of the electromagnetic spectrum. The energy of this type of radiation is one million times lower than the energy level required for breaking chemical bonds (e. g. nucleic acid). Unlike UV radiation or x-rays, mobile phone radiation is therefore not energetic enough to damage genes directly and thus to initiate a tumor." (Otto and von Mühlendahl, 2005, p. 11).*

This statement is correct insofar as the energy of mobile phone radiation, indeed, is not sufficient to cause direct damage to the DNA (e. g. single- and double-strand breaks). The reasons for this lie in the fact that the energy of electromagnetic waves in the microwave range

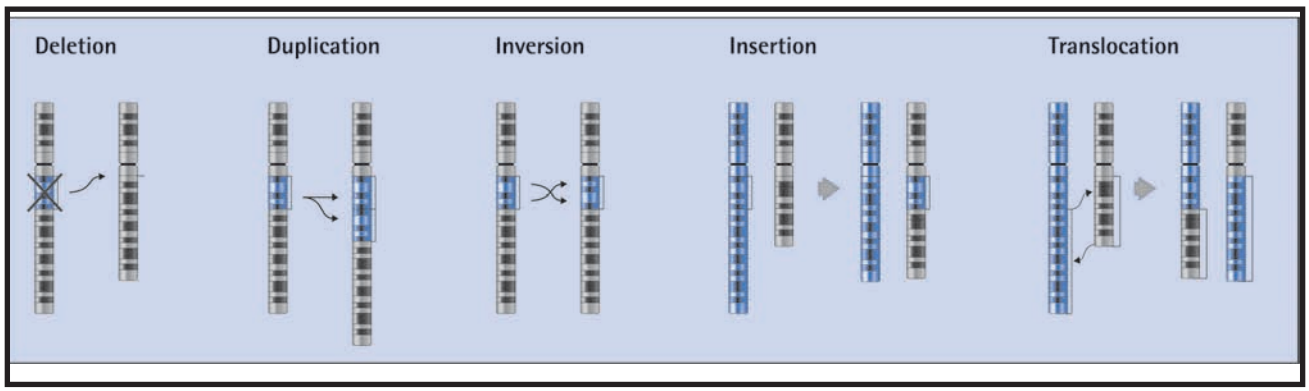


Fig. 2: Selected Types of Chromosome Mutations (Image: based on Wikipedia)

is too small: In order to dissociate molecules of the DNA, the radiation energy absorbed would have to be greater than the intramolecular bonding forces.

While phosphate and deoxyribose within a single DNA strand are bonded through a covalent bond (bonding energy: ca. 1^{-10} eV), in-between single strands or the nucleic bases, respectively, hydrogen bonds are formed (bonding energy: ca. 0.2-0.5 eV). The quantum energy of a microwave at 1 GHz is calculated as follows:

$$E = hf = 6.626 \times 10^{-34}\ Js^{-1} \cdot 1 \times 10^{9}\ Hz \approx 6.6 \times 10^{-25}\ J;$$

Or the relationship:

$$1\ eV = 1.9 \times 10^{-19}\ J \text{ to } E = 3.4 \times 10^{-6}\ eV = 3.4\ \mu eV.$$

The energy is by a factor of 10^6 (=1,000,000) too low to be able to break a covalent bond directly, and about 10^5 (=100,000) times too low to destroy a hydrogen bond. Yet, this does not mean—and this is crucial—that low-level microwave exposure in principle could not have any impact on the DNA. On the contrary, a large number of studies demonstrate that RF-EMF exposures can result in genotoxic effects (single- and double-strand breaks, chromosome aberrations, etc.). These studies use established methods of analysis such as the comet assay (test of DNA primary damage) or the micronuclei test (test of chromosome aberration) (Heddle et al., 1991; Klaude et al, 1996).

2.1 Overview of Studies

Examples of studies, in which increased single- and double-strand DNA breaks were demonstrated after RF-EMF exposure:

- Aitken et al. (2005) (900 MHz, SAR: 90 mW/kg, exposure duration: 12 h/day for 7 days, exposed system: male germ cells of mice)
- Diem et al. (2005) (1.8 GHz, SAR: 1.2 or 2 W/kg, exposure duration: 16 h, exposed system: human fibroblasts and rat granulosa cells)
- Lai and Singh (1995, 1996, 1997a, 1997b, 2004, 2005), Lai and Carino (1997) (2.45 GHz), SAR: 0.6-1.2 W/kg, exposure duration: 2 h, exposed system: rat brain cells)
- Lixia et al. (2006) (1.8 GHz, SAR: 3 W/kg, exposure duration: 2 h, exposed system: human lens epithelial cells)
- Markova et al. (2005) (GSM, 905-915 MHz, SAR: 37 mW/kg, exposure duration: 1 h, exposed system: human lymphocytes)
- Narasimhan and Huh (1991) (2.45 GHz, exposure duration: 2, 4, 8, 12, 16, and 20 s, exposed system: λ-phage DNA)
- Nikolova et al. (2005) (1.71 GHz, SAR: 1.5 W/kg, exposure duration: intermittent, 5 min on/30 min off, for 6 h or 48 h, exposed system: mouse stem cells)
- Paulraj and Behari (2006) (2.45 GHz or 16.5 GHz, SAR: 1 or 2.01 W/kg, exposed system: rat brain cells)
- Phillips et al. (1998) (813.5625 MHz, SAR: 24 µW/g, exposure duration: 2 or 24 h, exposed system: lymphoblastoid cells)
- Sagripanti et al. (1987) (8.75 GHz, SAR: 10 mW/g, exposure duration: 20 min, exposed system: plasmid DNA)
- Schwarz et al. (2008) (1.95 GHz UMTS signal, SAR: 0.05 W/kg, exposure duration: 24 h, exposed system: human fibroblasts)
- Sun et al. (2006) (1.8 GHz, SAR: 3 or 4 W/kg, exposure duration: 2 h, exposed system: human lens epithelial cells)
- Zhang et al. (2006) (1.8 GHz, SAR: 3 W/kg, exposure duration: 24 h, exposed system: hamster lung cells)

Radical Reactive Oxygen Species (ROS)

Name	*Alternate Name*	*Formula*
Hyperoxide anion radical	Superoxide	$O_2^{\cdot -}$
Hydroxyl radical	-	$HO^{\cdot}$
Perhydroxyl radical	Perhydroxyl	$HOO^{\cdot}$
Peroxyl radical	Alkyldioxal, Hyperoxyl	$ROO^{\cdot}$
Alkyl radical	-	$RO^{\cdot}$

DNA segment, which was released from the chromosome by a double strand break, is reversed and re-inserted), and *translocation* (broken chromosome segments translocate to the chromatid of another chromosome). We speak of genome mutations when the number of chromosomes change, which is a result of errors that occur during the process of cell division.

Chromosome aberrations caused by RF-EMF exposures could be demonstrated in e. g. the following studies (the variables, at which an effect showed, are given in brackets):

- Busljeta et al. (2004) (2.45 GHz, 5-10 mW/cm², exposure duration: 2, 8, 15, and 30 days for 2 h, exposed system: rats)
- D'Ambrosio et al. (2002) (1.748 GHz, phase modulated (GMSK), 5 W/kg, exposure duration: 15 min, exposed system: human peripheral blood)
- Fucic et al. (1992) (1.25-1.35 GHz, 0.1-200 W/m², occupational exposure, exposed system: lymphocytes in vivo)
- Garaj-Vrhovac et al. (1990) (7.7 GHz, 30 mW/cm², exposure duration: 15, 30, or 60 min, cell type: hamster fibroblasts)
- Mashevich et al. (2003) (830 MHz, SAR: 1.6-8.8 W/kg, exposure duration: 72 h, exposed system: human lymphocytes in vitro)
- Sarimov et al. (2004) (895-915 MHz, SAR: 5.4 mW/kg, exposure duration: 30 min – 1 h, exposed system: human lymphocytes in vitro)
- Sarkar et al. (1994) (2.45 GHz, 1 mW/cm², exposure duration: 2h/day for 120, 150, or 200 days, exposed system: rats)
- Tice et al. (2002) (837 MHz, 1.9098 GHz, SAR: 5-10 W/Kg, exposure duration: 24 h, exposed system: human lymphocytes in vitro)
- Trosic et al. (2002) (2.45 GHz, 5-10 mW/cm², exposure duration: 2, 8, 15 days for 2 h, exposed system: rats)
- Zotti-Martelli et al. (2000) (2.45 GHz, 7.7 GHz, 30 mW/cm², exposure duration: 30-60 min, exposed system: human lymphocytes in vitro)

2.2 Effect Mechanism

The above-listed studies show that RF-EMF exposures can cause genotoxic effects. This is astounding insofar as it must be *non-thermal effects* since the quantum energy of this radiation—as explained earlier—is not sufficient to cause direct damage to the DNA or chromosomes, respectively. How then do these genotoxic effects come about?

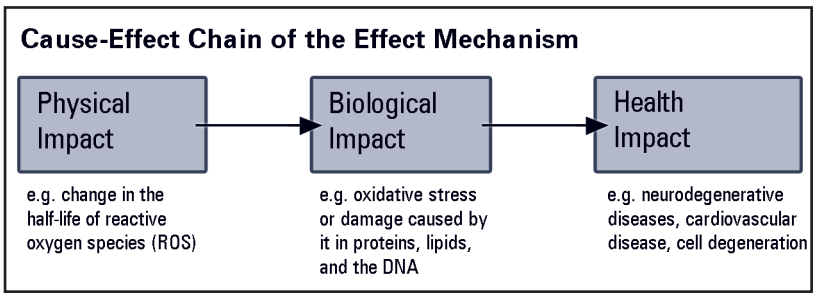


Fig. 3: Cause-Effect Chain of the Effect Mechanism

The answer to this question is still the object of research. As of today, there is no unifying model of explanation yet. However, there are models for individual steps or aspects of the effect mechanism, which explain the impact of RF-EMFs on biological systems in great detail and depth. The term "effect mechanism" refers to the cause-and-effect chain of events, starting from the (i) *physical impacts* of RF-EMF exposure through to the (ii) *biological impacts* up to the (iii) *health impacts* (Glaser, 2008) (compare *figure 3*).

A particularly successful model of explaining genotoxic effects of low-level RF-EMFs is based on the insight that EMF exposures impact the formation and stability of certain reduced forms of oxygen in a given organism (Lai and Singh, 1997a, 1997b, 2004; Oral et al., 2006; Simkó, 2007). These are referred to as *reactive oxygen species* or ROS (Jamieson et al., 1986), and we distinguish between radical and non-radical ROS (compare *table 1*). While oxygen radicals (radical ROS) such as $O2^{\cdot -}$, $HO^{\cdot}$, or $HOO^{\cdot}$ contain one electron or several unpaired electrons that react among each other or with non-radical molecules, non-radical ROS such as H_2O_2, O_3, or $^1O_2$, cannot

Non-Radical Reactive Oxygen Species (ROS)		Reactive Nitrogen Species (RNS)	
Name	*Formula*	*Name*	*Formula*
Ozone	O_3	Peroxynitrite	$ONOO^-$
Singlet oxygen	$^1O_2$	Nitric oxide	$NO^{\cdot}$
Hydrogen peroxide	H_2O_2	Nitric dioxide	N_2O_2
Hydroperoxide	ROOH	Nitric trioxide	N_2O_3

Table 1: Classification of ROS and RNS

easily be converted into radicals. In a living organism, ROS are generated through both endogenous and exogenous factors. In aerobic organisms, the endogenous formation of ROS occurs during mitochondrial respiration when electrons and protons are transferred to oxygen molecules (Joenje et al., 1989). Ca. 2 % of the total oxygen inhaled by a human is converted into ROS (especially superoxide anion radicals) (Halliwell, 1994). The immune response of phagocytic cells is another source of the endogenous formation of ROS (Curnutte, 2004). Exogenous factors include e.g. tobacco smoke (Frei et al., 1991), UV radiation (Epe, 1991), or certain environmental toxins, which contain ROS or from which ROS are generated during metabolism (Nuhn, 2001, Simkhovich et al., 2008).

Superoxide anion radicals ($O_2^{\cdot -}$) can react with the nitric oxide (NO) present in an organism, thereby forming highly reactive peroxide nitrite ($ONOO^-$). NO occurs naturally in living organisms and plays a crucial role in regulating important physiological functions (e. g. respiration, circulation, metabolism, immune response) (Stuehr and Marletta, 1985; Wu and Morris, 1998; Pfeiffer et al., 1999; Ralt, 2008). In the process of synthesizing NO, NADPH is used up through NO synthases—of which there are four: iNOS, eNOS, nNOS, mtNOS (Ghafourifar and Richter, 1997; Alderton et al., 2001; Li et al., 2002; Lowenstein and Padalko, 2004)—from oxygen and the amino acid L-arginine. In analogy to the term ROS, both NO and $ONOO^-$ are combined under the term *reactive nitrogen species* (RNS).

ROS and RNS (referred to as ROS/RNS below) have the potential of being hazardous to the organism since they are highly reactive molecules, which react with proteins, lipids, and the DNA and can actually damage any of these. Since the formation of ROS/RNS in the cell is inevitable, throughout evolution an efficient protective system has been established that is based on (i) the provision of specific molecules (antioxidants), which are capable of neutralizing ROS/RNS. It also provides (ii) mechanisms for repairing the cell structures (e. g. DNA) that become damaged by ROS/RNS (Dröge, 2002; Kuklinski and van Lunteren, 2005). Antioxidants are subdivided into enzymatic (e. g. glutathione peroxidase, superoxide dismutase, hydroxyperoxidase) and non-enzymatic (e. g. vitamin E, vitamin C, flavonoids, polyphenols) antioxidants (Nuhn, 2001).

Under physiological conditions, there is a balance in the organism between the presence of ROS/RNS and their removal through antioxidants. This balance, however, can be disturbed by an excessive production of ROS/RNS or a lack of antioxidants, respectively. An excess of *ROS* results in a condition referred to as *oxidative stress* (Halliwell, 1994; Dröge, 2002; Kuklinski and van Lunteren, 2005; Döll, 2008). In the event of excessive RNS, we speak of *nitrosative stress* (Hausladen et al., 1996, 1998). Since both oxidative stress and nitrosative stress are closely linked, and oxidative stress usually leads to nitrosative stress, the term *oxidative/nitrosative stress* was coined (Kremer, 2002; Warnke, 2005; Kuklinski and van Lunteren, 2005; Yücel, 2006).

During oxidative/nitrosative stress, specific transcription factors such as NF-kappa B are activated (Kratsovnik et al., 2005, Bar-Shai and Reznick, 2006; Vile et al., 2008), resulting in reactions between ROS/RNS and proteins, lipids, and the DNA.

i) Impact of ROS/RNS on Proteins

When ROS/RNS come into contact with proteins, the latter will become oxidized, resulting in the modification and degeneration of amino acids (e.g. formation of new functional groups such as hydroxyl and carbonyl groups), which in the end cause the protein to loose its function (Dean et al., 1997; Kirsch et al., 2002, 2003). The brain tissue of Alzheimer's patients, for example, shows high levels of protein oxidation (Aksenov et al., 2001; Butterfield and Lauderback, 2002). Frequently, oxidized proteins accumulate in the cell as "waste," of which, however, only a part can be metabolized by proteases. The remaining fragments form complexes that, for instance, show as age spots on the skin (Kuklinski and van Lunteren, 2005).

ii) Impact of ROS/RNS on Lipids

The process by which ROS/RNS cause oxidation in lipids is referred to as lipid peroxidation. Polyunsaturated fatty acids in the cell membrane (due to the highly reactive methyl groups present) are particularly susceptible to it, resulting in structural and functional changes to its membrane (Esterbauer et al., 1992). During lipid peroxidation, waste products such as hydroxyl radicals are generated, which can cause damage to the DNA (Joenje, 1989; Hruszkewycz, 1992). Lipid peroxidation plays a crucial role in degenerative diseases (Dix and Aitkens, 1993) and in the aging process in general (Ames et al., 1993; Halliwell, 1994; Praticò, 2002). DNA damages (as a result of the concomitant ROS/RNS), therefore, can already be caused by lipid peroxidation alone. This process is started when the mitochondrial transmembrane potential is lost through severe lipid peroxidation (Quillet et al., 1997). In addition, apoptogenic factors (factors that induce apoptosis) such as cytochrome c and AIF (apoptosis-inducing factor) are released (Liu et al., 1996). A chain reaction is triggered that leads to the opening of permeability transition pores (PTP) of other mitochondria so that, in turn, even more ROS and apoptogenic factors are re-

leased. AIFs induce DNA fragmentation in the cell nucleus (Susin et al., 1999). This shows how lipid peroxidation and the resulting release of ROS/RNS as well as AIFs can cause DNA damage.

iii) Impact of ROS/RNS on the DNA

Hyperoxide anion radicals ($O_2^{\cdot -}$) that are generated during respiration and formed by phagocytic cells are relatively weak radicals whose potential for causing direct damage to the DNA is rather limited (Brawn and Fridovich, 1981; Imlay and Linn, 1988; Keyer, 1995). After all, $O_2^{\cdot -}$ immediately reacts with protons and is dismutated into hydrogen peroxide (H_2O_2) and molecular oxygen (O_2), which, on the one hand, proceeds slowly and spontaneously and, on the other hand, more quickly by the catalytic effect of superoxide dismutase (SOD) (Fridovich, 1975, 1995): $2\ O_2^{\cdot -} + 2\ H+ \rightarrow H_2O_2 + O_2$. The resulting hydrogen peroxide is then reduced (Fenton reaction) by metal ions (Fe_2+ or Cu+) so that hydroxyl ions (HO^-) and hydroxyl radicals ($HO^{\cdot}$) are formed: $Fe_2+/Cu+ + H_2O_2 \rightarrow Fe_3+/Cu_2+ + OH- + OH^{\cdot}$. Hydroxyl radicals are highly reactive and long-lasting (ca. 10-9 s), which is why they react with almost all organic compounds and cause severe damage (Pryor, 1986). Hydrogen peroxide is capable of passing through cell membranes (Halliwell and Gutteridge, 1985) so that it can cause direct damage to the DNA. The metal ion complexes present in the DNA (or released by oxidative stress from transport proteins) react with the hydrogen peroxide, resulting in the formation of highly reactive hydroxyl radicals directly at the DNA and in the damage of the sugar-phosphate skeleton (Aruoma and Halliwell, 1998), which in the end causes the sugar-phosphate skeleton to fragment, single and double DNA strands to break, and bases to be modified (Halliwell and Aruoma, 1991). This type of DNA damage can also be caused by hydrogen peroxide (Demple et al., 1986) and singlet oxygen (Epe, 1991). The most frequent damage is the modification of DNA bases (Sies, 1991), whereby more than 100 different oxidative DNA modifications are known (Epe, 1995). Since the base pyridine has the lowest oxidation potential of all bases of the DNA (Hüttermann, 1982), changes occur most frequently in guanine (Nackerdien et al., 1992). In this process, a hydroxyl radical bonds to the C8 atom of guanine and forms 8-oxo-Gua (specifically: 7,8-dihydro-8-oxoguanine) (Halliwell and Aruoma, 1991). ROS also cause changes in the methylation patterns of the DNA, which can lead to changes in gene expression (epigenetic effects) (Cerda and Weitzman, 1997). Cells react to oxidative damage of their DNA with an increased activation of their antioxidant protective mechanisms and DNA repair mechanisms. Single-strand DNA breaks are removed by nucleotide excision repair (NER), DNA base damage

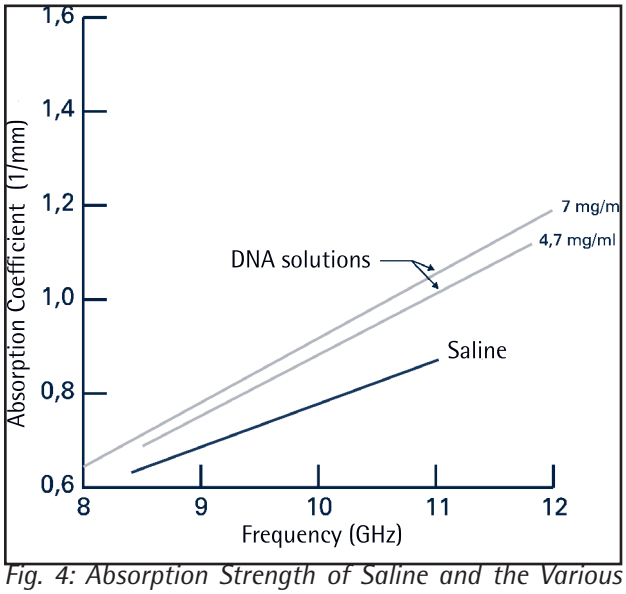


Fig. 4: Absorption Strength of Saline and the Various Concentrations of DNA Dissolved in It (7 mg/ml, 4.7 mg/ml). It is obvious that the DNA solution shows a stronger absorption than the solution alone. (Image: Edwards et al., 1985, graph from original paper).

by base excision repair (BER) (Speit and Dennog, 2000). The process of reverse transcription also plays an important role in DNA repair (Temin and Baltimore, 1972; Temin, 1985; Varmus, 1987; Shin et al., 2004; Scholkmann, 2007).

If there are not enough antioxidants available or if the rate of DNA damage exceeds the rate of repair, genetic regulation processes or protein expression become impaired, leading to diverse pathogenic ramifications. Thus, the likelihood of cancer formation increases (Trush and Kensler, 1991; Wiseman and Halliwell, 1996) because the processes of initiation and promotion of carcinogenesis are promoted by DNA damage mediated by ROS/RNS (Totter, 1980; Goldstein et al., 1981; Guerrero et al., 1984; Ames, 1989; Janssen et al., 1993; Takabe et al., 2001). Oncogenes are also activated in this process (Shibutani et al., 1991; Cheng et al., 1992). Damage to the DNA in mitochondria is particularly fatal (mtDNA, mitochondrial DNA) because mtDNA is ten times more susceptible to oxidative stress than DNA in the cell nucleus (nDNA). This has to do with the fact that mtDNA is not protected by histone proteins and does not possess any effective repair mechanism (Hruszkewycz and Bergtold, 1988; Druzhyna et al., 2008). Mitochondria can be damaged so severely by damage to their mtDNA that (i) the various steps of respiration can no longer proceed as usual, but even more ROS are generated and (ii) the energy production will fall below a critical threshold, as a result of which the cell will die (apoptosis) (Kremer, 2002; Kuklinski and van Lunteren, 2005). In case the mechanisms of

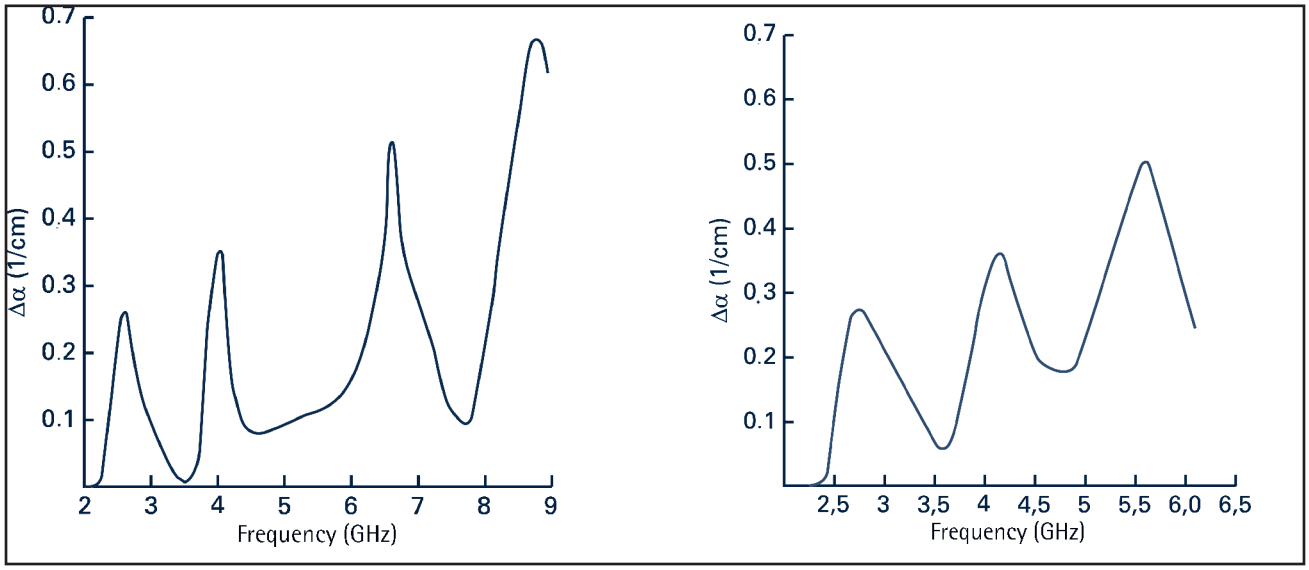


Fig. 5: Dependence of Absorption Strength of Circular DNA (left graph) and Linear DNA (right graph) on the Frequency of Microwave Radiation (Image: Edwards et al., 1985, graph from original paper).

apoptosis are blocked, the cell will become transformed into a cancer cell (Kremer, 2002) and, at the same time, its energy production process will be converted as well: from an oxygen dependent ATP production in the mitochondria to a non-oxygen enzymatic ATP production in the cell plasma (Warburg et al., 1924; Warburg, 1956; Gatenby and Gillies, 2004). This physiological switch of energy production is a counterregulation by the cell because during anaerobic glycolysis far fewer ROS/RNS are generated and, thus, the oxidative stress situation is defused (Brand and Hermfiess, 1997; Kremer, 2002). In healthy cells, energy production is also switched periodically (during late-stage cell division) in order to protect exposed chromosomes from ROS/RNS. This reaction is regulated by the mitochondrial permeability transition pore whose activity, in turn, is controlled by NO and $O2^{\cdot-}$ (Kremer, 2002). mtDNA damage mediated by ROS/RNS plays a significant role in the formation of cancer (Carew and Huang, 2002; Copeland et al., 2002). The decisive factor of whether a cell is transformed into a cancer cell depends on the redox status of the mitochondria or the mitochondrial membrane potential, respectively (Chen, 1988; Kremer, 2002). This fact explains the observation that cells may also be transformed into cancer cells when the DNA of the nucleus (nDNA) is not damaged (Lijinsky, 1973, 1992; Weaver and Gilbert, 2004; Maffini et al., 2004). Why an increased ROS/RNS production has an adverse health impact can then be easily understood: The resulting damage to proteins, lipids, and the DNA lead to adverse health effects, which may cause cancer and degenerative diseases.

While the association between ROS/RNS and their effects on health are thus resolved, the crucial question *how* RF-EMFs impact ROS/RNS processes still remains. There is much to be said for finding relevant explanations in the realm of physical effect mechanisms based on quantum mechanical/physicochemical models and the physics of non-linear as well as non-equilibrium systems (Fröhlich, 1968, 1982; Popp and Strauß, 1979; Popp, 1984, 200 6; Edwards et al., 1985; Adey, 1993; Scaiano et al., 1994; Kaiser, 1995; Ho, 1995; Brocklehurst and McLauchlan, 1996; Galvanovskis and Sandblom, 1997; Scott, 1999; Adair, 1999, 2002; Hyland, 2000, 2008; Panagopoulos et al., 2000, 2002; Binhi and Savin, 2002; Pokorny, 2004; Warnke, 2004a, 2004b, 2005; Binhi and Rubin, 2007; Warnke, 2008). The research by Edwards et al. shall serve as an example. Based on the fact that water strongly absorbs RF-EMFs in the microwave range, this research team investigated how the absorption capacity of water is changed when small amounts of isolated DNA of E. coli are added. Surprisingly, it was observed that the absorption increases depended on the RF-EMF frequency (Swicord and Davis, 1982; Swicord and Davis, 1983) (compare *figure 4*). Further studies directly investigating the DNA showed that the absorption strength depends on the length of the DNA fragments and the DNA conformation (linear, circular). For example, circular DNA with a length of 2740 base pairs (bp) caused absorption maxima at 2.55, 4.00, 6.00, and 8.75 GHz. A solution of linear DNA with a length of 948-1792 bp showed absorption maxima at around 2.65, 4.10, and 5.6 GHz (compare figure 5). These frequency-dependent absorption maxima of the DNA, the research team explains with resonance coupling between the microwave field and the oscillation modes of the DNA (Edwards et al., 1985). Experiments with static magnetic fields of varying

field strength showed that magnetic fields increase the half-life of free radicals or ROS/RNS (Batchelor et al., 1992; Harkins and Grissom, 1994; Roy et al., 1995; Scaiano et al., 1995a, 1995b; Santana et al., 1996; Suri et al., 1996; Zmyslony and Jajte, 1998; Warnke, 2008), which is associated with an increased probability of pathogenic oxidative processes. Unfortunately, there are only a very few studies available today that investigate the impact of RF-EMFs on free radicals or ROS/RNS in biological systems. The studies available to date, however, demonstrate already that:

1. Human exposure to 900 MHz for 4 h leads to an increase in lipid peroxidation in the plasma and a decrease in antioxidants (SOD, GSH-Px, catalase) in erythrocytes (Moustafa et al., 2001); 2. Rats exposed to 900 MHz RF-EMFs (SAR: 0.52 W/kg, 20 min/day, 7 days/week, 1 month) showed increased malondialdehyde (MDA) values (MDA: marker for lipid peroxidation) in their brains (Dasdag, 2004), which has been confirmed by another study (Ilhan, 2004); 3. An increased level of ROS in rat lymphocytes can be shown when the rats are exposed with 930 MHz RF-EMFs (SAR: 1.5 W/kg) for 5 or 15 min (Zmyslony, 2004); 4. The kidney tissue of exposed rats (900 MHz, 30 min/day, 1 month, SAR: 4 W/kg) shows an increased level of ROS and a decreased level of antioxidant enzymes (Ozguner, 2005); 5. Brain tissue of pigs exposed to GSM mobile phone signals (890-915 MHz, 12 h/day, 30 days) shows an increased level of MDA and a decreased level of GSH (glutathione) (Meral, 2007); 6. Exposed human monocytes and lymphocytes (GSM signal, 1.8 GHz, 2 W/kg, 30 or 45 min) show higher levels of ROS than non-exposed ones (Lantow et al., 2006).

It is also highly significant that researchers discovered that an exposure of HeLa and Rat2 cells with RF-EMFs (800, 865, and 950 MHz, 0.005-0.3 mW/cm²) leads to an immediate activation of the cell membrane component NADH oxidase, which causes an increased production of ROS (Friedman et al., 2007). As a result, the MPA kinase signaling cascade is activated, which among other things is involved in the regulation of cell differentiation, apoptosis, and cell growth (Pearson and Robinson, 2001; Seger and Krebs, 1995). That an EMF exposure also results in increased NO synthesis could be demonstrated in several studies (Miura et al., 1993; Seaman et al., 1999; Diniz et al., 2002; Hirohisa et al., 2006; Schnoke and Midura, 2007; Fitzsimmons et al., 2008). These results are exceptional in that a disturbance of the NO system in a given organism may not only lead to nitrosative stress—followed by DNA damage (Burney et al, 1999)—, but may also have impacts on major regulation processes. An increased synthesis of NO, for example, increases the permeability of the blood-brain barrier (Mayhan, 1996, 2000; Mayhan and Didion, 1999; Yamauchi et al., 2007), which encourages the formation of neurodegenerative diseases (James, 1992; Khan, 2006; Kuklinski, 2006).

3 Summary and Outlook

As is shown above, there are many studies that prove that the exposure of living organisms to low-level RF-EMFs may lead to DNA and chromosome damage. The genotoxic effect depends on many variables (e.g. frequency, dose, modulation, cell type, cell density, polarization, latency period), which require highly sophisticated research methods to investigate. Seemingly conflicting study results are traced back to the fact that even the smallest variation in one of these variables can lead to a completely different behavior of the system under study.

As to the effect mechanism of RF-EMF induced genotoxic effects, two of the three aspects of the cause-effect chain of events (physical impact → biological impact → health impact) are resolved. Thus, oxidative/nitrosative stress is the biological consequence of an increased production of reactive oxygen species (ROS) and reactive nitrogen species (RNS) while at the same time antioxidant protective mechanisms are reduced all of which, in turn, may trigger pathogenic processes such as neurodegenerative diseases (health impact). Regarding the physical effects caused by RF-EMF exposure, there are currently various models of explanation that explain the observed effects by direct impacts on (i) the DNA or on (II) the half-life of radicals, respectively. It is very important that further research looks into this aspect of the cause-effect chain so that a uniform model of the effect mechanism can be found.

In view of the well-documented effects of DNA and chromosome damage caused by low-level RF-EMFs, it is imperative that RF electromagnetic fields utilized in wireless communication technologies are optimized in such a way that those frequencies, modulations, and intensity levels are selected which minimize potential pathogenic effects. This approach is of utmost importance because the parameters selected for RF electromagnetic fields currently in use do not take those considerations into account and are not optimized to trigger as few biological effects as possible. As was shown by the most recent research (Yao et al., 2008), the risk could probably already be minimized by, for example, the superposition

of additional electromagnetic noise in the form of a fluctuating magnetic field (2 µT, 30-90 Hz, white noise) because, in this experiment, it was demonstrated that the latter prevented the formation of DNA and chromosome damage. Although the impact of an RF-EMF exposure on the DNA/chromosomes plays a crucial role in the health impact of this type of radiation, it is important to realize that the described genotoxic effects represent only a single aspect of the effects caused by RF-EMFs in living systems. A multitude of other effects is also documented, among others, impacts on ATP synthesis (Blank and Soo, 1993, 1996, 2001, Blank 2005; Kuzmanova et al., 1994) and gene expression (Lupke et al., 2006; Nylund and Leszczynski, 2006; Zhao et al., 2007; Leszczynski, 2007; Karinen et al., 2008).

As long as wireless communication technologies are not switched to non-pathogenic field parameters, everybody is urgently advised to avoid using mobile phones, Wi-Fi networks for prolonged periods, and to avoid spending time in the vicinity of mobile phone base stations.

Literature

Adair, R. K. (1999). Effects of very weak magnetic fields on radical pair reformation. *Bioelectromagnetics*, 20 (4), 255-263.

Adair, R. K. (2002). Vibrational resonances in biological systems at microwave frequencies. *Biophysical Journal*, 82, 1147-1152.

Adey, W. R. (1993). Biological Effects of Electromagnetic Fields. *Journal of Cellular Biochemistry*, 51, 410-416.

Aitken, R. J., Bennetts, L. E., Sawyer, D., Wiklendt, A. M. & King, B. V. (2005). Impact of radio frequency electromagnetic radiation on DNA integrity in the male germline. *International Journal of Andrology*, 28, 171-179.

Aksenov, M. Y., Butterfield, D. A., Geddes, J. W. & Markesbery, W. R. (2001). Protein oxidation in the brain in Alzheimer's disease. *Neuroscience*, 103 (2), 373-383.

Alderton, W. K., Cooper, C. E., Knowles, R. G. (2001). Nitric oxide synthases: structure, function and inhibition. *Biochemical Journal*, 357, 593-615.

Ames, B. N. (1989). Endogenous oxidative DNA damage, aging, and cancer. *Free Radical Research Communications*, 7 (3-6), 121-128.

Ames, B. N., Shigenaga, M. K., Hagan, T. M. (1993). Oxidants, antioxidants and the degenerative disease of aging. *Proceedings of the National Academy of Sciences USA*, 90, 7915-7922.

Antonopoulos, A., Eisenbrandt, H. & Obe, G. (1997). Effects of high-frequency electromagnetic fields on human lymphocytes in vitro. *Mutation Research*, 395 (2-3), 209-214.

Aruoma, O. I. & Halliwell, B. (Hrsg) (1998). *Molecular Biology of free radicals in human diseases.* Santa Lucia, London: OICA International.

Bar-Shai, M. & Reznick, A. Z. (2006). Reactive nitrogen species induce nuclear factor-κB-mediated protein degradation in skeletal muscle cells. *Free Radical Biology & Medicine*, 40 (12), 2112-2125.

Batchelor, S. N., McLauchlan, K. A. & Shkrob, I. A. (1992). Reaction yield detected magnetic resonance and magnetic field effect studies of radical pairs containing electronically excited organic radicals. *Molecular Physics*, 77, 75-110

Belyaev, I. Y. & Harms-Ringdahl, M. (1996). Effects of gamma rays in the 0.5-50-cGy range on the conformation of chromatin in mammalian cells. *Radiation Research*, 145 (6), 687-693.

Belyaev, I. Y., Alipov, Y. D. & Shcheglov, V. S. (1992b). Chromosome DNA as a target of resonant interaction between Escherichia coli cells and low-intensity millimeter waves. *Electro- and Magnetobiology*, 11 (2), 97-108.

Belyaev, I. Y., Alipov, Y. D., Shcheglov, V. S. & Lystsov, V. N. (1992a). Resonance effect of microwaves on the genome conformational state of E. coli cells. *Zeitschrift für Naturforschung*, 47 (7-8), 621-627.

Belyaev, I. Y. (2005). Non-thermal Biological Effects of Microwaves. *Microwave Review*, 13-29.

Belyaev, I. Y. & Kravchenko, V. G. (1994). Resonance effect of low-intensity millimeter waves on the chromatin conformational state of rat thymocytes. *Zeitschrift für Naturforschung*, 49, 352-358.

Belyaev, I. Y., Alipov, Y. D., Shcheglov, V. S., Polunin, V. A. & Aizenberg, O. A. (1994). Cooperative response of Escherichia Coli cells to the resonance effect of millimeter waves at super low intensity. *Electro- and Magnetobiology*, 13 (1), 53-66.

Belyaev, I. Y., Shcheglov, V. S. & Alipov, Y. D. (1992c). Existence of selection rules on helicity during discrete transitions of the genome conformational state of E.coli cells exposed to lowlevel millimeter radiation. *Bioelectrochemistry and Bioenergetics*, 27 (3), 405-411.

Belyaev, I. Y., Shcheglov, V. S. & Alipov, Y. D. (1992d). Selection rules on helicity during discrete transitions of the genome conformational state in intact and X-rayed cells of E.coli in millimeter range of electromagnetic field, in Charge and Field Effects in Biosystems, 3, D. D. Shillady, Ed.:Birkhauser, 1992, pp. 115-126.

Belyaev, I. Y., Shcheglov, V. S., Alipov, Y. D. & Radko, S. P. (1993). Regularities of separate and combined effects of circularly polarized millimeter waves on E. coli cells at different phases of culture growth. *Bioelectrochemistry and Bioenergetics*, 31 (1), 49-63.

Belyaev, I. Y., Shcheglov, V. S., Alipov, Y. D. & Polunin, V. A. (1996). Resonance effect of millimeter waves in the power range from 10(-19) to 3 x 10(-3) W/cm2 on Escherichia coli cells at different concentrations. *Bioelectromagnetics*, 17 (4), 312-321.

Binhi, V. N. & Rubin, A. B. (2007). Magnetobiology: the kT paradox and possible solutions. *Electromagnetic Biology and Medicine*, 26 (1), 45-62.

Binhi, V. N. & Savin, A. V. (2002). Molecular gyroscopes and biological effects of weak extremely low-frequency magnetic fields. *Physical Review. E, Statistical, nonlinear, and soft matter physics*, 65 (5), 051912.

Blackman, C. F., Benane, S. G., Rabinovits, J. R., House, D. E. & Joines, W. T. (1985). A role for the magnetic field in the radiationinduced efflux of calcium ions from brain tissue, in vitro. *Bioelectromagnetics*, 6 (4), 1–11.

Blanchard, J. P., Blackman, C. F. (1994). Clarification and application of an ion parametric resonance model for magnetic field interaction with biological systems. *Bioelectromagnetics*, 15, 217–238.

Blank, M. (2005). Biological effects of environmental electromagnetic fields: molecular mechanisms. *Biosystems*, 35 (2-3), 175-178.

Blank, M. & Soo, L. (1993). The Na,K-ATPase as a model for electromagnetic field effects on cells. *Bioelectrochemistry and Bioenergetics*, 30, 85-92.

Blank, M. & Soo, L. (1996). The threshold for Na,K-ATPase stimulation by electromagnetic fields. *Bioelectrochemistry and Bioenergetics*, 40 (1), 63-65.

Blank, M. & Soo, L. (2001). Optimal frequencies for magnetic acceleration of cytochrome oxidase and Na,K-ATPase reactions. *Bioelectrochemistry*, 53 (2), 171-174.

Brand, K. A. & Hermfiess, U. (1997). Aerobic glycolysis by proliferating cells: a protective strategy against reactive oxygen species. *The FASEB Journal*, 11, 388–395.

Brawn, K. & Fridovich, I. (1981). DNA strand scission by enzymically generated oxygen radicals. *Archives of biochemistry and biophysics*, 206 (2), 414-419.

Brocklehurst, B. & McLauchlan, K. A. (1996). Free radical mechanism for the effects of environmental electromagnetic fields on biological systems. *International Journal of Radiation Biology*, 69 (1), 3-24.

Burney, S., Caulfield, J. L., Niles, J. C., Wishnok, J. S. & Tannenbaum, S. R. (1999). The chemistry of DNA damage from nitric oxide and peroxynitrite. *Mutation Research*, 424, 37–49.

Busljeta, I., Trosic, I. & Milkovic-Kraus, S. (2004). Erythropoietic changes in rats after 2.45 GHz nonthermal irradiation. *International Journal of Hygiene and Environmental Health*, 207 (6), 549-554.

Butterfield, D. A. & Lauderback, C. M. (2002). Lipid peroxidation and protein oxidation in Alzheimer's disease brain: Potential causes and consequences involving amyloid β-peptide-associated free radical oxidative stress. *Free radical biology & medicine*, 32 (11), 1050-1060.

Carew, J. S. & Huang, P. (2002). Mitochondrial defects in cancer. *Molecular Cancer*, 1 (9), http://www.molecular-cancer.com/content/pdf/1476-4598-1-9.pdf

Cerda, S. & Weitzman, S. A. (1997). Influence of oxygen radical injury on DNA methylation. *Mutation Research/Reviews in Mutation Research*, 386 (2), 141-152.

Chen, L. B. (1988). Mitochondrial Membrane Potential in Living Cells. *Annual Review of Cell Biology*, 4, 155-181.

Cheng, K. C., Cahill, D. S., Kasai, H., Nishimura, S. & Loeb, L. A. (1992). 8-Hydroxyguanine, an abundant form of oxidative DNA damage, causes G>T and A>C substitutions. *The Journal of biological chemistry*, 267 (1), 166-172.

Copeland, W. C, Wachsman, J. T., Johnson, F. M. & Penta, J. S (2002). Mitochondrial DNA alterations in cancer. *Cancer investigation*, 20 (4), 557-569.

Curnutte, J. T. (2004). Superoxide production by phagocytic leukocytes: the scientific legacy of Bernard Babior. *Journal of Clinical Investigation*, 114 (8), 1054-1057.

D'Ambrosio, G., Massa, R., Scarfi, M. R. & Zeni, O. (2002). Cytogenetic damage in human lymphocytes following GMSK phase modulated microwave exposure. *Bioelectromagnetics*, 23 (1), 7-13.

Dasdag, S., Akdag, M. Z., Aksen, F., Bashan, M, et al. (2004). Does 900 MHz GSM mobile phone exposure affect rat brain? *Electromagnetic Biology and Medicine*, 23, 201-214.

Dean, R.T., Fu, S.-L. Stocker, R. & Davies, M. J. (1997). Biochemistry and pathology of radical mediated protein oxidation. *Biochemical Journal*, 324, 1-18.

Demple, B., Johnson. A. W. & Fung, D. (1986). Exonuclease III and endonuclease IV remove 3' blocks from DNA synthesis primers in H_2O_2-damaged Escherichia coli. Proceedings of the National Academy of Sciences USA, 83, 7731-7735.

Di Carlo, A., White, N., Guo, F., Garrett, P. & Litovitz, T. (2002). Chronic electromagnetic field exposure decreases HSP70 levels and lowers cytoprotection. Journal of Cell Biochemistry, 84 (3), 447-454.

Diem, E., Schwarz, C., Adlkofer, F., Jahn, O. & Rüdiger, H. (2005). Non-thermal DNA breakage by mobile-phone radiation (1800 MHz) in human fibroblasts and in transformed GFSHR17 rat granulosa cells in vitro. *Mutation Research*, 583 (2), 178-183.

Diniz, P., Soejima, K. & Ito, G. (2002). Nitric oxide mediates the effects of pulsed electromagnetic field stimulation on the osteoblast proliferation and differentiation. *Nitric Oxide*, 7 (1), 18-23.

Dix, T. A. & Aitkens, J. (1993). Mechanisms and biological relevance of lipid peroxidation. *Chemical research in Toxicology*, 6, 2-18.

Döll. M. (2008). *Die Kraft der Antioxidantien*. München: Goldmann Verlag

Dröge, W. (2002). Free Radicals in the Physiological Control of Cell Function. *Physiological Review*, 82, 47–95.

Druzhyna, N. M., Wilson, G. L. & LeDoux, S. P. (2008). Mitochondrial DNA repair in aging and disease. *Mechanisms of Ageing and Development*, 129 (7-8), 383-390.

Edwards, G. S., Davis, C. C., Saffer, J. D. & Swicord, M. L. (1985). Microwave-field-driven acoustic modes in DNA. *Biophysical Journal*, 47, 799-807.

Eichwald, E. & Walleczek, J. (1996). Model for magnetic field effects on radical pair recombination in enzyme kinetics. *Biophysical Journal*, 71 (2), 623–631.

Epe, B. (1991). Genotoxicity of singlet oxygen. *Chemico-biological interactions*, 80 (3), 239-260.

Epe, B. (1995). DNA damage profiles induced by oxidizing agents. *Reviews of Physiology, Biochemistry and Pharmacology*, 127, 223-249.

Esterbauer, H., Gebiki, J., Puhl, H. & Jurgens, G. (1992). The role of lipid peroxidation and antioxidants on oxidative modification of LDL. *Free radical biology & medicine*, 13, 341-390.

Fitzsimmons, R. J., Gordon, S.L., Kronberg, J., Ganey, T. & Pilla, A. A. (2008). A pulsing electric field (PEF) increases human chondrocyte proliferation through a transduction pathway involving nitric oxide signaling. *Journal of Orthopaedic Research*, 26 (6), 854- 859.

Frei, B., Forte, T. M., Ames, B. N. & Cross, C. E. (1991). Gas phase oxidants of cigarette smoke induce lipid peroxidation and changes in lipoprotein properties in human blood plasma. *Biochemical Journal*, 277, 133-138.

Frentzel-Beyme, R. (1999). Krebs als Folge von Einwirkungen elektromagnetischer Felder. In: Mersch-Sundermann, V & Böse-O'Reilly (Hrsg). Beiträge zur Umweltmedizin. Frankfurt: Mabuse-Verlag, S. 103-132.

Fridovich, I. (1975). Superoxide Dismutases. *Annual Review of Biochemistry*, 44, 147-159.

Fridovich, I. (1995). Superoxide Radical and Superoxide Dismutases. *Annual Review of Biochemistry*, 64, 97-112.

Friedman, J., Kraus, S., Hauptman, Y., Schiff, Y. & Seger, R. (2007). Mechanism of short-term ERK activation by electromagnetic fields at mobile phone frequencies. *Biochemical Journal*, 405, 559–568.

Fröhlich, H. (1968). Long-range coherence and energy storage in biological systems. *International Journal of Quantum Chemistry*, 2, 641-652.

Fröhlich, H. (1982). What are non-thermal electric biological effects? *Bioelectromagnetics*, 3 (1), 45-46.

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

Galvanovskis, J. & Sandblom, J. (1997). Amplification of electromagnetic signals by ion channels. *Biophysical Journal*, 73, 3056-3065.

Gapeev, A. B., Iakushina, V. S., Chemeris, N. K. & Fesenko, E. E. (1997). Modulated extremely high frequency electromagnetic radiation of low intensity activates or inhibits respiratory burst in neutrophils depending on modulation frequency [in Russian]. *Biofizika*, 42, 1125-1134.

Garaj-Vrhovac, V., Horvat, D. & Koren, Z. (1990). The effect of microwave radiation on the cell genome. *Mutation Research*, 243 (2), 87-93.

Gatenby, R. A. & Gillies, R. J. (2004). Why do cancers have high aerobic glycolysis? *Nature Reviews Cancer*, 4, 891–899.

Ghafourifar, P. & Richter, C. (1997). Nitric oxide synthase activity in mi-

tochondria. *FEBS Letters*, 418, 291-296.

Glaser, R. (2008). Biophysikalische Primärreaktionen hochfrequenter elektromagnetischer Felder. In: Forschungsgemeinschaft Funk (Herausgeber). Gepulste Felder – eine besondere Gefahr für die Gesundheit?, 59-66.

Goldstein, B. D., Witz, G., Amoruso, M., Stone, D. S. & Troll W. (1981). Stimulation of human polymorphonuclear leukocyte superoxide anion radical production by tumor promoters. *Cancer Letters*, 11 (3), 257-262.

Guerrero, I., Villasante, A., Corcer, V. & Pellicer, A. (1984). Activation a c-k-ras oncogene by somatic mutations in mouse lymphomas induced by γ-radiation. *Science*, 225, 1159-1162.

Halliwell, B. (1994). Free radicals, antioxidants and human disease: curiosity, cause or consequence? *The Lancet*, 344, 721-724.

Halliwell, B. & Aruoma, O. (1991). DNA damage by oxygen-derived species. Its mechanism and measurement in mammalian systems. *FEBS Letters*, 281 (1-2), 9-19.

Halliwell, B. & Gutteridge, J. M. C. (1985). *Free radicals in biology and medicine*. Oxford: Clarendon Press.

Harkins, T. T. & Grissom, C. B. (1994). Magnetic field effects on B12 ethanolamine ammonia lyase: evidence for a radical mechanism. *Science*, 263 (5149), 958-960.

Hausladen, A., Gow, A. J. & Stamler, J. S. (1998). Nitrosative stress: Metabolic pathway involving the flavohemoglobin. *PNAS*, 95 (24), 14100-14105.

Hausladen, A., Privalle, C. T., Keng, T., DeAngelo, J. & Stamler, J. S. (1996). Nitrosative stress: activation of the transcription factor OxyR. *Cell*, 86 (5), 719-29.

Heddle, J. A., Cimino, M. C., Hayashi, M., Romagna, F., Shelby, M. D., Tucker, J. D., Vanparys, P. & MacGregor, J. T. (1991). Micronuclei as an index of cytogenetic damage: past, present, and future. *Environmental and molecular mutagenesis*, 18 (4), 277–291.

Hirohisa, N., Ryoichi, O., Miki, K., Kazuhiro, F., Norinaga, U., Akira, K. & Hisamitsu, B. (2006). Effects of Electromagnetic Waves from a Cellular Phone on Levels of Serum Nitric Oxide and Cerebral iNOS mRNA in Mice [Language: Japanese]. *Campus Health*, 43 (2), 127-132.

Ho, M.-W. (1995). Bioenergetics and the coherence of organisms. *Neural Network World*, 5, 733-750.

Hruszkewycz, A. M. (1992). Lipid peroxidation and mtDNA degeneration. A hypothesis. *Mutation Research*, 275 (3-6), 243-248.

Hruszkewycz, A. M. & Bergtold, D. S. (1988). Oxygen radicals, lipid peroxidation and DNA damage in mitochondria. *Basic Life Sciences*, 49, 449-456.

Hüttermann, J. (1982). Solid-state radiation chemistry of DNA and its costituents. *Journal of Ultramicroscopy*, 10, 25-40.

Hyland, G J. (2008). Physical basis of adverse and therapeutic effects of low intensity microwave radiation. *Indian Journal of Experimental Biology*, 46 (5), 403-419.

Hyland, G. (2000). Physics and biology of mobile telephony. *The Lancet*, 356 (9244), 1833-1836.

Ilhan, A., Gurel, A., Armutcu, F., Kamisli, S., Iraz, M., Akyol, O. & Ozen, S. (2004). Ginkgo biloba prevents mobile phone induced oxidative stress in rat brain. *Clinica Chimica Acta*, 340, 153-162.

Imlay, J. & Linn, S. (1988). DNA damage and oxygen radical toxicity. *Science*, 240, 1302-1309.

James, P. B. (1992). Pathogenesis of multiple sclerosis: a blood-brain barrier disease. *Journal of the Royal Society of Medicine*, 85 (11), 713-714.

Jamieson, D., Chance, B., Cadenas & E., Boveris, A. (1986). The relation of free radical production to hyperoxia. *Annual Review of Physiology*, 48, 703-719.

Janssen, Y., Van Houten, B., Borm, P. & Mossman, B. (1993). Biology of disease. Cell and tissue responses to oxidative damage. *Laboratory Investigation*, 69, 261-274.

Joenje, H. (1989). Genetic toxicology of oxygen. *Mutation Research*, 219, 193-208.

Kaiser, F. (1995). Coherent oscillations - their role in the interaction of weak ELM-fields with cellular systems. *Neural Network World*, 5, 751-762.

Karinen, A., Heinävaara, S., Nylund, R. & Leszczynski, D. (2008). Mobile phone radiation might alter protein expression in human skin. *BMC Genomics*, 9, 77, http://www.pubmedcentral.nih.gov/picrender.fcgi?artid=2258283&blobtype=pdf

Keyer, K., Gort, A. S. & Imlay, J. A. (1995). Superoxide and the production of oxidative DNA damage. *Journal of Bacteriology*, 177 (23), 6782-6790.

Khan, E. (2006). The blood–brain barrier: Its implications in neurological disease and treatment. *British Journal of Neuroscience Nursing*, 2 (1), 18-25.

Kirsch, M., Fuchs, A. & de Groot, H. (2003). Regiospecific nitrosation of N-(terminal) blocked tryptophan derivatives by N_2O_3 at physiological pH. *Journal of Biological Chemistry*, 278, 11931-11936.

Kirsch, M., Korth, H.-G., Sustmann, R. & de Groot, H. (2002). The pathobiochemistry of nitrogen dioxide. *Journal of Biological Chemistry*, 383, 389-399.

Klaude, M., Eriksson, S., Nygren, J. & Ahnstrom, G. (1996). The comet assay: mechanisms and technical considerations. *Mutation Research*, 363 (2), 89-96.

Kratsovnik, E., Bromberg, Y., Sperling, O. & Zoref-Shani, E. (2005). Oxidative stress activates transcription factor NF-κB-mediated protective signaling in primary rat neuronal cultures. *Journal of Molecular Neuroscience*, 26 (1), 27-32.

Kremer, H. (2002). *Die stille Revolution der Krebs- und Aidsmedizin*. Wolfratshausen: Ehlers Verlag.

Kuklinski, B. (2006). *Das HWS-Trauma*. Bielefeld: Aurum Verlag.

Kuklinski, B. & van Lunteren, I. (2005). *Neue Chancen zur natürlichen Vorbeugung und Behandlung von umweltbedingten Krankheiten*. Bielefeld: J. Kamphausen Verlag.

Kuzmanova, M., Ivanov, S., Nankova, V. & Markov, M. (1994). Effects of extremely high frequency electromagnetic fields on electrophoretic mobility and ATP content in rat erythrocytes. *Bioelectrochemistry and Bioenergetics*, 35 (1-2), 53-56.

Kwee, S. & Raskmark, P. (1998). Changes in cell proliferation due to environmental non-ionizing radiation. 2. Microwave radiation. *Bioelectrochemistry and Bioenergetics*, 44 (2), 251-255.

Lai, H. & Carino, M. A. (1997). Singh NP, Naltrexone blocks RFR-induced DNA double strand breaks in rat brain cells. *Wireless Networks*, 3, 471-476.

Lai, H. & Singh, N. P. (1995). Acute low-intensity microwave exposure increases DNA single-strand breaks in rat brain cells. *Bioelectromagnetics*, 16 (3), 207-210.

Lai, H. & Singh, N. P. (1996). Single- and double-strand DNA breaks in rat brain cells after acute exposure to radiofrequency electromagnetic radiation. *International Journal of Radiation Biology*, 69 (4), 513-521.

Lai, H. & Singh, N. P. (1997a). Melatonin and a spin-trap compound block radiofrequency electromagnetic radiation-induced DNA strand breaks in rat brain cells. *Bioelectromagnetics*, 18 (6), 446-454.

Lai, H. & Singh, N. P. (1997b). Melatonin and N-tert-butyl-alpha-phenylnitrone block 60-Hz magnetic field-induced DNA single and double strand breaks in rat brain cells. *Journal of Pineal Research*, 22 (3), 152-162.

Lai, H. & Singh, N. P. (2004). Magnetic-field-induced DNA strand breaks in brain cells of the rat. *Environmental Health Perspectives*, 112 (6), 687-694.

Lai, H. & Singh, N. P. (2005). Interaction of microwaves and a temporally incoherent magnetic field on single and double DNA strand breaks in rat brain cells. *Electromagnetic Biology and Medicine*, 24, 23-29.

Lai, H., Carino, M. A. & Singh, N. P. (1997). **Naltrexone blocks RFR-in**duced DNA double strand breaks in rat brain cells. *Wireless Networks*, 3, 471-476.

Lantow, M., Lupke, M., Frahm, J., Mattsson, O., Kuster, N., Simko, M. (2006). ROS release and Hsp70 expression after exposure to 1,800 MHz radiofrequency electromagnetic fields in primary human monocytes and lymphocytes. Radiation and *Environmental Biophysics*, 45, 55-62.

Lednev, V. V. (1996). Bioeffects of weak combined, static and alternating magnetic fields. *Biofizika*, 41, 224–232.

Leszczynski, D. (2007). Mobile phone radiation and gene expression. *Radiation Research*, 167 (1), 121.

Li, H., Wallerath, T. & Forstermann, U. (2002). Physiological mechanisms regulating the expression of endothelial-type NO synthase. *Nitric Oxide*, 7, 132-147.

Lijinsky, W. (1992). *Chemistry and Biology of N-Nitrosocompounds*. Cambridge: University Press.

Lijinsky, W., Taylor, H. W., Snyder, C. & Nettersheirn, C. (1973). Malignant tumours of liver and lung in rats fed aminopyrin of heptamethyleneimine together with nitrite, *Nature*, 244, 176-178.

Litovitz, T. A., Penafiel, L. M., Farrel, J. M., Krause, D., Meister, R. & Mullins, J. M. (1997). Bioeffects induced by exposure to microwaves are mitigated by superposition of ELF noise. *Bioelectromagnetics*, 18 (6), 422-430.

Liu, B., Kim, C. N., Yang, J., Jemmerson, R. & Wang, X. (1996). Induction of apoptotic program in cell-free extracts: requirement for dATP and cytocrome c. *Cell*, 86, 147-157.

Lixia, S., Yao, K., Kaijun, W., Deqiang, L., Huajun, H., Xiangwei, G., Baohong, W., Wei, Z., Jianling, L. & Wei, W. (2006). Effects of 1.8 GHz radiofrequency field on DNA damage and expression of heat shock protein 70 in human lens epithelial cells. *Mutation Research*, 602, 135-142.

Lloyd, D. C., Saunders, R. D., Moquet, J. E. & Kowalczuk, C. I. (2005). Absence of chromosomal damage in human lymphocytes exposed to microwave radiation with hyperthermia. *Bioelectromagnetics*, 7 (2), 235-237.

Lowenstein, C. J. & Padalko, E. (2004). iNOS (NOS2) at a glance. *Journal of Cell Science*, 117, 2865-2867.

Lupke, M., Frahm, J., Lantow, M., Maercker, C., Remondini, C., Bersani, F. & Simkó, M. (2006). Gene expression analysis of ELF-MF exposed human monocytes indicating the involvement of the alternative activation pathway. *Biochimica et Biophysica Acta (BBA) - Molecular Cell Research*, 1763 (4), 402-412.

Maffini, M. V., Soto, A. M., Calabro, J. M., Ucci, A. A. & Sonnenschein, C. (2004). The stroma as a crucial target in rat mammary gland carcinogenesis. *Journal of Cell Science*, 117, 1495-1502.

Markkanen, A., Penttinen, P., Naarala, J., Pelkonen, J., Sihvonen, A. P. & Juutilainen, J. (2004). Apoptosis induced by ultraviolet radiation is enhanced by amplitude modulated radiofrequency radiation in mutant yeast cells. *Bioelectromagnetics*, 25 (2), 127-133.

Markova, E., Hillert, L., Malmgren, L., Persson, B. R. & Belyaev, I. Y. (2005). Microwaves from GSM Mobile Telephones Affect 53BP1 and gamma-H2AX Foci in Human Lymphocytes from Hypersensitive and Healthy Persons. *Environmental Health Perspectives*, 113 (9), 1172-1177.

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

Mayhan, W. G. (1996). Role of nitric oxide in histamine-induced increases in permeability of the blood-brain barrier. *Brain Research*, 743 (1-2), 70-76.

Mayhan, W. G. (2000). Nitric oxide donor-induced increase in permeability of the blood-brain barrier. *Brain Research*, 866 (1-2), 101-108.

Mayhan, W. G. & Didion, S. P. (1996). Glutamate-induced disruption of the blood-brain barrier in rats. Role of nitric oxide. *Stroke*, 27 (5), 965-969.

Meral, I., Mert, H., Mert, N., Deger, Y., Yorukc, I., Yetkind, A: & Keskin, S. (2007). Effects of 900 MHz electromagnetic field emitted from cellular phone on brain oxidative stress and some vitamin levels. *Brain Research*, 1169, 120-124.

Miura, M., Takayama, K. & Okada, J. (1993). Increase in nitric oxide and cyclic GMP of rat cerebellum by radio frequency burst-type electromagnetic field radiation. *Journal of Physiology*, 461, 513-524.

Moustafa, Y. M., Moustafa, R. M., Belacy, A., Abou-El-Ela, S. H. & Ali, F. M. (2001). Effects of acute exposure to the radiofrequency fields of cellular phones on plasma lipid peroxide and antioxidase activities in human erythrocytes. *Journal of pharmaceutical and biomedical analysis*, 26 (4), 605-608.

Nackerdien, Z., Olinski, R. & Dizdaroglu, M. (1992). DNA base damage in chromatin of gammairradiated cultured human cells. *Free radical research communications*, 16, 259-273.

Narasimhan, V. & Huh, W. K. (1991). Altered restriction patterns of microwave irradiated lambda-phage DNA. *Biochemistry International*, 25 (2), 363-370.

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

Nuhn P. (2001). Wie sich der Organismus gegen aggressive Moleküle schützt. *Pharmazeutische Zeitung*, 44, 10-15.

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

Oktem, F., Ozguner, F., Mollaoglu, H., Koyu, A. & Uz, E. (2005). Oxidative Damage in the Kidney Induced by 900-MHz-Emitted Mobile Phone: Protection by Melatonin. *Archives of Medical Research*, 36, 350-355.

Oral, B., Guney, M., Ozguner, F., Karahan, N., Mungan, T., Comlekci, S. & Cesur, G. (2006). Endometrial apoptosis induced by a 900-MHz mobile phone: preventive effects of vitamins E and C. *Advances Therapies*. 23 (6), 957-973.

Otto, M. & von Mühlendahl, K. E. (2005). *Mobilfunk und Gesundheit - Eine Information für Ärzte*. Kinderumwelt gemeinnützige GmbH der Deutschen Akademie für Kinderund Jugendmedizin e.V., Informationszentrum Mobilfunk e. V.

Ozguner, F., Aydin, G., Mollaoglu, H., Gokalp, H., Koyu, A. & Cesur, G. (2004). Prevention of mobile phone induced skin tissue changes by melatonin in rat: an experimental study. *Toxicology and Industrial Health*, 20, 133-139.

Ozguner, F., Oktem, F., Ayata, A., Koyu, A., et al. (2005). A novel antioxidant agent caffeic acid phenetyl ester prevents long-term mobile phone exposure-induced renal impairment in the rat. *Molecular and cellular biochemistry*, 277, 73-80.

Panagopoulos, D. J., Karabarbounis, A. & Margaritis, L. H. (2002). Mechanism for action of electromagnetic fields on cells. *Biochemical and Biophysical Research Communications*, 298, 95-102.

Panagopoulos, D. J., Messini, N., Karabarbounis, A., Philippetis, A. L., Margaritis, L. H. (2000). A mechanism for action of oscillating electric fields on cells. *Biochemical and biophysical Research Communications*, 272, 634-640.

Paulraj, R. & Behari, J. (2006). Single strand DNA breaks in rat brain cells exposed to microwave radiation. *Mutation Research*, 596, 76-80.

Pearson, G. & Robinson, F. (2001). Mitogen-Activated Protein (MAP) Kinase Pathways: Regulation and Physiological Functions. *Endocrine Reviews*, 22 (2), 153-183.

Pfeiffer, S., Mayer, B. & Hemmens, B. (1999).Stickstoffmonoxid: die rätselhafte Chemie eines biologischen Botenstoffes. *Angewandte*

Chemie, 111 (12), 1824-1844.

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

Pokorny, J. (2004). Excitation of vibrations in microtubules in living cells. *Bioelectrochemistry*, 63 (1-2), 321-326.

Popp, F.-A. (1984). *Biologie des Lichts*. Berlin/Hamburg: Verlag Paul Paray

Popp, F.-A. (2006). *Biophotonen – Neue Horizonte in der Medizin* (3. Auflage). Stuttgart: Haug Verlag

Popp, F.-A. & Strauß, V. E. (1979). *So könnte Krebs entstehen*. Frankfurt a. M.: Fischer Verlag

Praticò, D. (2002). Lipid Peroxidation and the Aging Process. *Science of Aging Knowledge Environment*, 50, 5.

Pryor, W. (1986). Oxy-radicals and related species: their formation, lifetimes, and reactions. *Annual Review of Physiology*, 48, 657-667.

Quillet, M. A., Jaffrezou, J. P., Mansat, V., Bordier, C., Naval, J. & Laurant, G. (1997). Implication of mitochondrial hydrogen peroxide generation in ceramide-induced apoptosis. *Journal of Biological Chemistry*, 272, 21388-21395.

Rahman, I., Biswas, S. K., Jimenez, L. A., Torres, M. & Forman, H.J. (2005). Glutathione, stress responses, and redox signaling in lung inflammation. *Antioxidants & redox signaling*, 7 (1-2), 42-59.

Ralt, D. (2008). NO netting, health and stress – Studying wellness from a net perspective. *Medical Hypothesis*, 70, 85-91.

Roy, S., Noda, Y., Eckert, V., Traber, M. G., Mori, A., Liburdy, R. & Packer, L. (1995). The phorbol 12-myristate 13-acetate (PMA)-induced oxidative burst in rat peritoneal neutrophils is increased by a 0,1 mT (60 Hz) magnetic field. *FEBS Letters*, 376, 164-166.

Sagripanti, J.-L., Swicord, M. L. & Davis, C. C. (1987). Microwave Effects on Plasmid DNA. *Radiation Research*, 110, 219-231.

Santana, P., Pena, L. A., Haimovitz-Friedman, A., Martin, S., Green, D., McLoughlin, M., Cordon-Cardo, C., Schuchman, E. H., Fuks, Z. & Kolesnick, R. N. (1996). Acid sphingomyelinase deficient human lymphoblasts and mice are defective in radiation-induced apoptosis. *Cell*, 86 (2), 189-199.

Sarimov, R., Malmgren, L. O. G., Markova, E., Persson, B. R. R. & Belyaev, I. Y. (2004). Nonthermal GSM microwaves affect chromatin conformation in human lymphocytes similar to heat shock. *IEEE Transactions, Plasma Science*, 32, 1600-1608.

Sarkar, S., Ali, S. & Behari, J. (1994). Effect of low power microwave on the mouse genome: a direct DNA analysis. *Mutation Research*, 320 (1-2), 141-147.

Scaiano, J. C, Cozens, F. L. & Mohtat, N. (1995a). Influence of combined AC-DC magnetic fields on free radicals in organized and biological systems. Development of a model and application of the radical pair mechanism to radicals in micelles. *Photochemistry an photobiology*, 62 (5), 818-829.

Scaiano, J. C., Cozens, F. L. & McLean, J. (1994). Model for the rationalization of magnetic field effects in vivo. Application of the radical-pair mechanism to biological systems. *Photochemistry an photobiology*, 59 (6), 585-589.

Scaiano, J. C., Mohtat, N., Cozens, F. L., McLean, J. & Thansandote, A. (1995b). Application of the radical pair mechanism to free radicals in organized systems: Can the effects of 60 Hz be predicted from studies under static fields? *Bioelectromagnetics*, 15 (6), 549-554.

Schnoke, M. & Midura, R. J. (2007). Pulsed Electromagnetic Fields Rapidly Modulate Intracellular Signalling Events in Osteoblastic Cells: Comparison to Parathyroid Hormone and Insulin. *Journal of Orthopaedic Research*, 25 (7), 933-940.

Scholkmann, F. (2007). Die Probleme mit dem zentralen Dogma der Molekularbiologie und die wahre Bedeutung der reversen Transkription. Teil 3 der Artikelserie «Irrtümer und Halbwahrheiten in der Genetik». *ZeitGeist*, 2, 52-54.

Schwarz, C., Kratochvil, E., Pilger, A., Kuster, N., Adlkofer, F. & Rüdiger, H. W. (2008). Radiofrequency electromagnetic fields (UMTS, 1,950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes. *International archives of occupational and environmental health*, 81 (6), 755-767.

Scott, A. (1999). *Nonlinear Science: Emergence and Dynamics of Coherent Structures*. Oxford: Oxford University Press.

Seaman, R. L., Belt, M. L., Doyle, J. M. & Mathur, S. P. (1999). Hyperactivity caused by a nitric oxide synthase inhibitor is countered by ultra-wideband pulses. *Bioelectromagnetics*, 20 (7), 431-439.

Seger, R, & Krebs, E. (1995): The MAPK signaling cascade. *The FASEB Journal*, 9, 726-735.

Sevast'yanova, L. A. (1981). *Nonthermal effects of millimeter radiation* (in Russian), N. D. Devyatkov, Ed. Moscow: Institute of Radioelctronics of USSR Academy of Science, 86-109.

Shcheglov, V. S., Alipov, E. D. & Belyaev, I. Y. (2002). Cell-to cell communication in response of E. coli cells at different phases of growth to low-intensity microwaves. *Biochimica et Biophysica Acta*, 1572, 101-106.

Shcheglov, V. S., Belyaev, I. Y., Alipov, Y. D. & Ushakov, V. L. (1997). Power-dependent rearrangement in the spectrum of resonance effect of millimeter waves on the genome conformational state of E. coli cells. *Electro- and Magnetobiology*, 16 (1), 69-82.

Shibutani, S., Takeshita, M. & Grollman, A. P. (1991). Insertion of specific bases during DNA synthesis past the oxidation-damaged base 8-oxodG. *Nature*, 349, 431-434.

Shin, K.-H., Kang, M. K., Dicterow, E., Kameta, A., Baluda, M. A. & Park, N.-H. (2004). Introduction of human telomerase reverse transcriptase to normal human fibroblasts enhances DNA repair capacity. *Clinical Cancer Research*, 10 (7), 2551-2560.

Sies, H. (Hrsg) (1991). *Oxidative stress. Oxidants and Antioxidants*. London: Academic Press.

Simkhovich, B. Z., Kleinman, M. T. & Kloner, R. A. (2008). Air Pollution and Cardiovascular Injury. *Journal of the American College of Cardiology*, 52 (9), 719-726.

Simkó, M. (2007). Cell Type specific Redox Status is Responsible for Diverse Electromagnetic Field Effects. *Current Medicinal Chemistry*, 14 (10), 1141-1152.

Speit, G. & Dennog, C. (2000). Untersuchungen zur genotoxischen Wirkung von oxidativem Streß. *Forschungsbericht FZKA-BWPLUS.*

Stuehr, D. J. & Marletta, M. A. (1985). Mammalian nitrate biosynthesis: mouse macrophages produce nitrite and nitrate in response to Escheria coli lipopolysaccharide. *Proceedigs of the National Academy of Sciences (USA)*, 82, 7738-7742.

Sun, L. X., Yao, K., He, J. L., Lu, D. Q., Wang, K. J. & Li, H. W. (2006). Effect of acute exposure to microwave from mobile phone on DNA damage and repair of cultured human lens epithelial cells in vitro [Article in Chinese]. *Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi*, 24 (8), 465-467.

Suri, A., deBoer, J., Kusser, W. & Glickman, B. W. (1996). A 3 milliTesla 60 Hz magnetic field is neither mutagenic nor co-mutagenic in the presence of menadione and MNU in a transgenic rat cell line. *Mutation Research*, 372, 23–31.

Susin, S. A., Lorenzo, H. K., Zamzami, N., Marzo, I., Snow, B. E., Brothers, G. M., Mangion, J., Jacotot, E., Costantini, P., Loeffler, M., Larochette, N., Goodlett, D. R., Aebersold, R., Siderovski, D. R., Penninger, J. M. & Kroemer, G. (1999). Molecular characterisation of mitochondrial apoptosis-inducing factor. *Nature*, 397, 441-446.

Swicord, M. L. & Davis, C. C. (1982). Microwave absorption of DNA between 8 and 12 GHz. *Biopolymers*, 21, 2453-2460.

Swicord, M. L.& Davis, C. C. (1983). An optical method for investigating the microwave absorption characteristics of DNA and other biomolecules. *Bioelectromagnetics*, 4, 21-42.

Takabe, W., Niki, E., Uchida, K., Satoh, K. & Noguchi, N. (2001). Oxidative stress promotes the development of transformation: involvement of a potent mutagenic lipid peroxidation product, acrolein. *Carcinogenesis*, 22, 935-941.

Temin, H. M. (1985). Reverse transcription in the eucaryotic genome: Retroviruses, pararetroviruses and retrotranscripts. *Molecular Biology and Evolution*, 2, 455-468.

Temin, H. M. & Baltimore, D. (1972). RNA-directed DNA synthesis and RNA tumor viruses. *Advances in Virus Research*, 17, 129-186.

Tice, R. R., Hook, G. G., Donner, M., McRee, D. I. & Guy, A. W. (2002). Genotoxicity of radiofrequency signals. I. Investigation of DNA damage and micronuclei induction in cultured human blood cells. *Bioelectromagnetics*, 23, 113-126.

Tkalec, M., Malaric, K. & Pevalek-Kozlina, B. (2005). Influence of 400, 900, and 1900 MHz electromagnetic fields on Lemna minor growth and peroxidase activity. *Bioelectromagnetics*, 26 (3), 185-193.

Totter, J. R. (1980). Spontaneous cancer and its possible relationship to oxygen metabolism. *PNAS USA*, 77 (4), 1763-1767.

Trosic, I., Busljeta, I., Kasuba, V. & Rozgaj, R.. (2002). Micronucleus induction after whole-body microwave irradiation of rats. *Mutation Research*, 521 (1-2), 73-79.

Trush, M. & Kensler, T. (1991). Role of free radicals in carcinogen activation. In: Sies, H. (Hrsg): *Oxidative stress. Oxidants and antioxidants*, S. 277-317. London: Academic Press.

Ushakov, V. L., Shcheglov, V. S., Belyaev, I. Y. & Harms-Ringdahl, M. (1999). Combined effects of circularly polarized microwaves and ethidium bromide on E . coli cells. *Electromagnetic Biology and Medicine*, 18 (3), 233-242.

Varmus, H. (1987). Reverse Transcription. *Scientific American*, 257, 56-59, 62-64.

Vile, G. F., Tanew-Iliitschew, A. & Tyrrell, R. M. (2008). Activation of NF-κB in human skin fibroblasts by the oxidative stress generated by UVA radiation. *Photochemistry and Photobiology*, 62 (3), 463-468.

Warburg, 0., Poesener, K. & Negelein, E. (1924). Über den Stoffwechsel der Carcinomzelle. *Naturwissenschaften*, 12 (50), 1131-1137.

Warburg, O. (1956). On the origin of cancer cells. *Science*, 123, 309-314.

Warnke, U. (2004a). Warum können kleinste Leistungsflussdichten elektromagnetischer Energie große Effekte am Menschen auslösen? www.hese-project.de

Warnke, U. (2004b). In der Mobil- und Kommunikationsfunk-Problematik bisher unbeachtet: Elektrostatische Longitudinalschwingungen und ihre Plasma-Vakuum-Interaktion. www.hese-project.de

Warnke, U. (2005). Pathologische Wirkungsmechanismen der Schädigung durch Hochfrequenzsender – ein plausibles Modell. *Umwelt, Medizin, Gesellschaft*, 18 (2), 107-118

Warnke, U. (2008). Sensible Bereiche der biologischen Wirkung. In: Richter, K. & Zimmer, G. (Hrsg.). Die Gefährdung und Schädigung von Kindern durch Mobilfunk, S. 16-28. Kompetenzinitiative zum Schutz von Menschen, Umwelt und Demokratie e. V.

Weaver, V. M. & Gilbert, P. (2004). Watch thy neighbor: cancer is a communal affair. *Journal of Cell Science*, 117, 1287-1290.

Wiseman, H. & Halliwell, B. (1996). Damage to DNA by reactive oxygen and nitrogen species: role in inflammatory disease and progression to cancer. *Biochemical Journal*, 313, 17-29.

Wu, G. & Morris, S. M. (1998). Arginine Metabolism: Nitric Oxide and Beyond. *Biochemical Journal*, 336, 1-17.

Yamauchi, A., Dohgu, S., Nishioku, T., Shuto, H., Naito, M., Tsuruo, T., Sawada, Y. & Kataoka, Y. (2007). An inhibitory role of nitric oxide in the dynamic regulation of the blood-brain barrier function. *Cellular and Molecular Neurobiology*, 27 (3), 263-270.

Yao, K., Wu, W., Yu, Y., Zeng, Q., He, J., Lu, D., & Wang, K. (2008). Effect of Superposed Electromagnetic Noise on DNA Damage of Lens Epithelial Cells Induced by Microwave Radiation. *Investigative Ophthalmology and Visual Science*, 49, 2009-2015.

Yücel, D., Şeneş, M., Topkaya, B. Ç. & Zengi, O. (2006). Oxidative / Nitrosative Stress in Chronic Heart Failure: A Critical Review. *Turkish Journal of Biochemistry*, 31 (2), 86-95.

Zhang, D. Y., Xu, Z. P., Chiang, H., Lu, D. Q. & Zeng, Q. L. (2006). Effects of GSM 1800 MHz DNA Damage and Genotoxicity radiofrequency electromagnetic fields on DNA damage in Chinese hamster lung cells [Article in Chinese]. *Zhonghua Yu Fang Yi Xue Za Zhi,* 40 (3), 149-152.

Zhao, R., Zhang, S., Xu, Z., Ju, L., Lu, D. & Ya, G. (2007). Studying gene expression profile of rat neuron exposed to 1800 MHz radiofrequency electromagnetic fields with cDNA microassay. *Toxicology*, 235 (3), 167-175.

Zmyslony, M. & Jajte, J. M. (1998). The role of free radicals in mechanisms of biological function exposed to weak, constant and net magnetic fields [Article in Polish]. *Medycyna pracy*, 49 (2), 177-186.

Zmyslony, M., Politanski, P., Rajkowska, E., Szymczak, W. & Jajte, J. (2004). Acute exposure to 930 MHz CW electromagnetic radiation in vitro affects reactive oxygen species level in rat lymphocytes treated by iron ions. *Bioelectromagnetics*, 25, 324-328.

Zotti-Martelli, L., Peccatori, M., Scarpato, R. & Migliore, L. (2000). Induction of micronuclei in human lymphocytes exposed in vitro to microwave radiation. *Mutation Research*, 472 (1-2), 51-58.

Possible Health Effects of Mobile Phone Radiation in Children and Youth: The MOPHORAD Project

Franz Adlkofer

1. EU Grant Application

The Munich-based VERUM Foundation for Behaviour and Environment organized and coordinated the REFLEX project from 2000 to 2004. In February 2008, it submitted—together with nine international partners (Switzerland 3, Germany 1, Austria 1, Finland 1, Spain 1, Israel 1, China 1)—a grant application for a follow-up research project (MOPHORAD = Mobile Phone Radiation) to the EU Commission, requesting its support. The cost of this project is estimated to be around 4.7 million euro, of which 1.2 million euro can be put up by the research partners. Despite an excellent evaluation by the international reviewers of the EU Commission, the project funding was not granted. One of the main reasons for this decision may be attributed to the fact that the timing of the project review coincided with the beginning of the "Vienna Scandal." The research results of the Vienna research group, which has been falsely accused of fraud, form an important, though not crucial, basis for the research grant application.

2. Project Summary

In spite of decade-long research efforts, there is still uncertainty about the nature and extent of possible health risks caused by radiofrequency electromagnetic fields (RF-EMF). With the rapidly growing use of mobile phones by children and adolescents, the respective concerns are also increasing. Epidemiological research data on the long-term use of mobile phones indicate an increased incidence of brain tumors while experimental studies demonstrate biological RF-EMF effects that may be relevant to human health. This raises the question of whether epidemiological and experimental research results can be reconciled with each other. If electromagnetic fields (EMF) accelerated cell aging, which would result in the early onset of age-related diseases like cancer and Alzheimer's, this would hold true.

MOPHORAD, an interdisciplinary research project, is dedicated to investigating potential short- and long-term effects of mobile phone radiation on neuronal tissue and its functions, especially in children and adolescents. For these experiments, human, animal, and cell models will be used. The research project is subdivided into seven work packages: 1) Application of numerical and experimental methods to gain a comprehensive exposure analysis of mobile phone radiation in human tissue depending on anatomy and age; 2) Application of current genomic and proteomic methods to study the effect of mobile phone radiation on gene and protein expression, on protein structure and activity, as well as on gene integrity in adolescent and adult volunteers; 3) Investigation of cellular, molecular, morphological, and functional effects of mobile phone radiation on the brains of long-term exposed rats of different ages; 4) Characterization of genotoxic and enzymatic reactions in human cells after mobile phone radiation exposure in relation to the donor's age; 5) Examining whether there is a causal relationship between short- and long-term exposures to mobile phone radiation and their effects on genetic stability, gene expression, and intracellular signal transduction, all this with the objective, to clarify the mechanisms these radiation effects are based on and to reveal the markers responsible for the tissue defects induced by mobile phone radiation. The sixth work package provides the exposure chambers and oversees the technical quality control while the seventh work package is responsible for the project management.

3. Background of the Research Project

Following the introduction of mobile phones, the exposure of the general public to EMFs has greatly increased over the past 15 years. In close proximity to the mobile handset, its antenna emits amplitude modulated RF-EMFs and the circuitry supplying it with power gives off extremely low frequency electromagnetic fields (ELF-EMF). Since wireless communication among children and adolescents has greatly increased over the past years, and since a growing organism may be particularly susceptible to health implications due to long-term exposures, the concerns about an increased risk of additional health problems in this population group have also continued to grow–and rightly so.

As a consequence of the fact that a mobile phone is held next to the brain when in use, the inevitable question arises as to whether the still developing central nervous system could be affected in such a way that neurological damage may occur. Data from epidemiological studies indicate that brain tumors may occur more often in users who use a mobile phone for over 10 or more years. Due to the rapidly changing technologies and their applications, and due to the long latency period until the onset of chronic diseases, results from epidemiological studies cannot reliably prove any such association—at least not for as long as the fundamental mechanisms that would explain the dose-effect relationship are unknown. The results of experimental studies show that EMFs can induce DNA damage, impact gene expression, change the structure and activity of proteins, form oxygen radicals, and affect intracellular signal transduction.

Even though doubts continue to be expressed about some of these observations, it can hardly be disputed that, after EMF exposure, cells show molecular characteristics that are observed in premature aging or senescence. Under these circumstances, another question arises: Can the available epidemiological and experimental study results be reconciled with each other? The assumption that EMFs accelerate the aging of cells would implicate that the early onset of age-related diseases such as neurodegenerative diseases and cancer are to be expected.

4. Research Project Goal

MOPHORAD is dedicated to studying the impact of UMTS and ELF-EMF on the central nervous system and tissue homeostasis (self-regulation). In interdisciplinary cooperation by 10 research groups from seven countries, cellular, molecular, and functional aspects relevant to the risk assessment shall be investigated. The research project is designed to help solve fundamental problems that are important for risk assessment. Currently, this task represents a great challenge to public health policy because of public pressure. Accordingly, the reaction of cells and organs of different origins and ages is studied after UMTS exposure in vivo and in vitro. The biological consequences are shown at the molecular and functional level in relation to their developmental stage with special attention to brain cells. The results will provide new insights into the possible differences of EMF susceptibility in children, adolescents, and adults. The information gained from human, animal, and laboratory studies will be used to generate hypotheses and to test in what way the demonstrated molecular mechanisms explain the EMF induced effects. The clarification and characterization of cell processes will, in all likelihood, lead to identifying biomarkers, which are urgently needed for conducting and evaluating future epidemiological studies.

5. Expected Results of the Research Project

MOPHORAD is a project with a multifaceted and multidisciplinary research approach that is designed to help solve a series of questions about the possible health hazards of mobile phone radiation. Its main goal is to generate results that provide information about whether it is plausible to assume a health risk especially in children and adolescents but also adults. The research project is not only meant to considerably improve our current knowledge base in the area of in vitro research, but the schedule of planned activities goes far beyond that:

- The research project is designed in such a way that for children and adolescents using mobile phones biological responses relevant to the central nervous system are collected, which may contribute to the formation of brain tumors or neurodegenerative diseases later in life.
- The research project is designed in such a way that stress responses (i.e. oxidative stress, defects in signal transduction, defects in DNA repair, etc.) are monitored, which play an important role in the formation of neurodegenerative diseases and cancer

when occurring already at a young age. Several epidemiological studies about long-term users of mobile phones do indicate such a risk.

- The research project is designed in such a way that it can determine whether cytogenetic, cellular, and molecular findings—which raise the suspicion that mobile phone radiation may contribute to accelerating the aging process (DNA damage, formation of oxygen radicals, modification of gene expression and intracellular signal transduction)—are sufficiently verified and, as a result, may justifiably be associated with age-related diseases like neurodegenerative diseases or cancer.
- In summary, the research consortium studies UMTS impacts on tissue homeostasis whereby the above-mentioned consequences would result from the expected results. In view of the sensitivity of the methods used, the findings of the research project—whether positive ones, in case health relevant effects and their mechanisms of formation are discovered, or negative ones—will make it possible to base the development of relevant and urgently needed health recommendations on a scientific footing.

6. Impacts of the Research Project

The duration of the MOPHORAD project is scheduled for four years. Its successful implementation will answer the question of whether mobile phone radiation poses a potential health risk for children and adolescents but also for adults. The main goal is to clarify whether RF-EMFs and pulsed magnetic fields can trigger biological effects in the central nervous system at a functional, cellular, and molecular level that are relevant to disease formation or individual symptoms. We assume that MOPHORAD will provide us with valuable insights into the interaction between RF-EMF exposures and the human body. This knowledge is essential both for risk assessment as well as for risk reduction or risk avoidance when developing future wireless technologies. All in all, MOPHORAD will expand our knowledge through innovative research; and what is more, the project will greatly contribute to clarifying a public issue with far-reaching consequences.

Innovation: By collecting and taking into account data on age-related anatomical, morphological, and dielectric characteristics that determine the penetration of sensitive tissues such as in the brain or bone marrow, the dosimetric evaluation of the radiation exposure in children and adolescents can be improved. It will provide a foundation for new safety standards in telecommunications. Identifying changes that are observed at a molecular level after RF-EMF exposure will lead to markers that can be used for estimating the biologically effective radiation dose. This type of markers is urgently needed for a reliable assessment of epidemiological data. Animal experiments in combination with human studies will answer the question of whether RF-EMF exposure causes DNA damage and premature cell aging as a result of releasing radicals and abnormal signal transduction, which, in turn, impair the proper maintenance and function of especially the nervous system. The standard of in vitro testing for isolated cell systems, especially for cells of the central nervous system, will be greatly improved so that the newly developed testing systems can be used for compatibility studies prior to the introduction of new wireless technologies. Taken as a whole, the results of the suggested studies will help to recognize the necessity for precautionary measures. Thus, it should be possible to avoid potential long-term health consequences from mobile phone radiation in the general population of Europe, and in particular in children and adolescents with a high life expectancy. What really matters here is that these results—in contrast to those from epidemiological research—could be available within just a few years.

Contribution to Clarifying a Public Issue: Mobile phones are an integral part of any modern society. This applies even though public concerns regarding the safety of this technology are rather strong. The reason for this uncertainty lies in the fact that scientific risk assessment lags hopelessly behind technical progress, which has been made easier than ever by the official line of risk communication that propagates reassurances of safety. There is only one solution at this point: We have to search for and rule out RF-EMF induced biological effects that may cause health effects in humans and, thus, may also contribute to the formation of chronic diseases like cancer or neurodegenerative diseases.

MOPHORAD has the potential to show the way for this particular strategy. Should the testing methods used lead to results that indicate potential health risks especially for children and adolescents, it can be assumed that the knowledge gained by this research will provide a reliable foundation for scientifically verifiable health policies as well as the prerequisites for the development of safe wireless technologies. If we wish to eliminate the possibility of epidemiological research proving beyond any doubt that those health risks we only worry about currently are real some decades down the road, then we must find a solution to the pressing problems now. There is not much time left.

Self-Help in a Time of Systematic Mental Corruption

Karl Richter

Summary

The following documentary account of the controversy surrounding the results of the Reflex Study and its findings of the still greater genetic toxicity of UMTS radiation reveals not that any fraud has to date been proven, but rather that scholars seeking the truth, and the truth itself, have been handled in a very questionable manner. The entire affair clearly served the endeavours of the mobile phone industry to contradict – in a scientifically unusual manner – increasingly reliable findings concerning the particular dangers of UMTS radiation. With the example of Prof. Alexander Lerchl – at once the initiator of the affair and a leading German "radiation protector" and political advisor – a standard of "radiation protection" will be documented that ignores significant international findings, that is permanently occupied with the confirmation of accepted levels and the minimising of potential danger and that finds nothing unusual about advocating antennas for the roofs of kindergartens and schools. An alliance of political interests, capital and such "experts" as Prof. Lerchl has laid claim to the right to define the truth as well as the tolerability of human health not according to the available findings of scientific research, but rather from the perspective of economic opportunity. This alliance is seeking with increasing arrogance to impose this perspective on others. The present account comes to the frank conclusion that effective protection from the effects of electro magnetic fields is not presently to be found with the government, but in opposition to the government's conception of public health and environmental protection and, furthermore, that such protection may best be realized in projects of self-help.

1 Mobile Telephone Research and Mobile Telephone Intrigues – A Documentary Record of a Scandal

1.1 Background

The sale of UMTS licenses earned the German government 100 billion DM, but also made it the purchaser of UMTS technology. In this process, technological and financial advantages were considered; research into the risks, however, was left to the future – a dangerous course of events still prevalent in the auction of new radio frequency technology.

Since then, the particular risks of UMTS technology have become increasingly more apparent. In the course of negotiations between industry and the government, it would appear that matters pertaining to the health of the population and environment were also decided. It may appear understandable that both sides should allow suitable "experts" to certify the harmlessness of UMTS radiation. And yet, the articles in this brochure indicate that this is anything but a responsible approach.

The discrepancy between the state of scientific knowledge and the minimisation of risk by both industry and the government has been apparent for some time, as the following chronology of events indicates:

- In 2003, a study commissioned by three Dutch departments of government (TNO Study) confirmed tinnitus, head-aches and nausea, among others, as possible immediate effects of the new technology.
- In 2005, a Swedish-Russian research team comprised of I. Belyaev, E. Markova and other scientists revealed that UMTS microwave radiation could have a significantly greater cell-damaging biological effect than GSM radiation because of the nature of the signal it emits.
- In 2006, Professors H.W. Rüdiger and F. Adlkofer confirmed the veracity of such comparisons with the finding that UMTS radiation, even at a rate of intensity reduced by a factor of ten (SAR), is as genotoxic as GSM radiation according to the Reflex Study.
- In 2008, a study by the Fraunhofer Institute for Toxicology and Experimental Medicine in Hannover documented the tumor causing effects of UMTS on mice.

Why studies which have found nothing are unable to refute well documented risks is repeatedly shown in the articles in this brochure. This applies doubly where supposed "replications" are not intended to find anything. After the release of the Dutch TNO Study, the mobile

telephone industry commissioned a UMTS Study by the ETH Zurich, but changed the project design (in the selection of test persons, among other things) in such a way that different results had to emerge. In December 2006, as Prof. Adlkofer presented the German Federal Ministry of the Environment with the results of the new UMTS Study, Prof. Alexander Lerchl of the private Jacobs University Bremen felt himself compelled for the first time to invalidate the thesis of particular UMTS risks with his own experiments on mice. Furthermore, as Prof. Adlkofer sought to continue and to verify UMTS research in an international context, Prof. Lerchl attempted to reestablish trust in UMTS technology by other means.

1.2 The Documentary Record: Part I

The UMTS Study by Professors Rüdiger, Adlkofer and their colleagues, who had demonstrated the increased potential for risk of UMTS radiation, has been available in a scholarly journal since the beginning of 2008.[1] On February 25, 2008, Prof. Adlkofer submitted a proposal to the EU which would verify on an international basis previous, fundamental findings according to the – once again improved – format of the Reflex Study and which would transfer them from the test tube to humans. In the interests of health protection, the project offered the opportunity to provide dependable clarification as to how biologically active UMTS radiation actually is – an important finding for public health, though potentially dangerous for mobile telephone policy as it is now practiced.

Accusations that the disquieting findings were fraudulent were intended to achieve four results:

1. to cast doubts upon the reputations of the relevant researchers;
2. to alleviate the contradiction between the minimising of risk by the German Mobile Telecommunication Research Programme and the state of international research;
3. to question the legitimacy of an EU application which is dangerous to industrial, government and personal interests;
4. if possible, to "dispose" of the Reflex Study of 2005.

The first stage of this process, including the opposing claims of Professors Rüdiger and Adlkofer, is by now well documented; thus, a short summary here will suffice.[2] Once again, Alexander Lerchl was clearly the instigator of the campaign. Most certainly after a confidential vote (for which there is strong evidence), he wrote first the Rector of the university and then the editors of two scholarly journals and claimed that the data of the two studies concerning genotoxicity from GSM and UMTS radiation had been falsified.

Indeed, in May 2008 Prof. Rüdiger's successor reported to the Rectorate of the Medical University of Vienna that a laboratory assistant in occupational medicine had falsified data. The assistant, who had worked in the laboratory of occupational medicine for close to 10 years and who was acknowledged as highly qualified, admitted to instances of carelessness that were dated to April 2008. She emphasised, however, that these instances had absolutely nothing to do with the earlier projects to which she had contributed.

Nonetheless, against the protestations of the laboratory assistant and without consulting her previous supervisor, Prof. H. W. Rüdiger, or even reviewing the raw data of the studies themselves, a three-member university Council for Scientific Ethics came to the conclusion that publications to which the assistant had contributed would have to be withdrawn due to the suspicion of data manipulation. Admitedly, this was specifically requested only for the two studies concerning the effects of mobile telephone radiation, GSM and UMTS. Six other studies to which the assistant had contributed have remained unaffected for the time being. Prof. Rüdiger's objection that the results were legitimately obtained and confirmed elsewhere numerous times was met by the Rector of the University with the argument that Prof. Rüdiger was to accept the vote of an independent Council for Scientific Ethics and to withdraw the results of the UMTS Study published in 2008 and those of the Reflex Study of 2005. Unexpectedly, however, two days later it emerged that the Chairperson of the three-member Council for Scientific Ethics established by the Rector was employed as a lawyer for a company of the mobile telephone industry. Regardless of the fact that others considered the independence of the commission irreparably compromised, the Rector of the University – without Profs. Rüdiger and Adlkofer – issued a press release which, in reference to a confession of wrongdoing that was never given, raised the suspicion that the studies concerning the genetic effects of mobile telephone fields had been falsified.

The *Spiegel* editor Manfred Dworschak immediately announced to the public that "two much discussed studies have become practically worthless after a confession of wrongdoing."[3]

1 "Radiofrequency electromagnetic fields (UMTS 1950 MHz) induce genotoxic effects in vitro in human fibroblasts, but not in lymphocytes," International Archives of Occupational and Environmental Health 81 (2008): 755-67.

2 www.diagnose-funk.ch/gesundheit/00000097f40ae101b/033ea29ab01004701.html

3 Manfred Dworschak, "Beim Tricksen ertappt" ("Caught Cheating"), Der Spiegel 2008, No. 22. Also reported in Spiegel online from 26 May 2008.

1.3 Documentary Record: Part II

Despite these developments, the accused nonetheless managed to have the commission renew negotiations under a new and neutral Chairperson. Given the weak case, about which the instigators were also aware, the Rector sought to salvage a compromise before a meeting of the commission. This compromise was more concerned with "saving face" than uncovering the truth: the Reflex Study was to remain unaffected. In response, Prof. H.W. Rüdiger was to declare himself prepared to distance himself from the UMTS Study because of mistakes which, for *formal* reasons, could not be excluded with certainty.

Hardly had H.W. Rüdiger agreed to this dubious horse-trading when the Rector renewed in full scope the old claims of fraud in a public statement. Prof. Rüdiger defended himself and in his response made clear that the compromise was arrived at under pressures which those privy to the events frankly characterized as "extortionist." The *Spiegel*, however, once again hastened to bring the tidings of the confirmed fraud to the public with a sensational story, *The Darling of the Professor*.[4] Manfred Dworschak served the mobile telephone industry yet again with a form of partisan, tendentious journalism which in effect limited reporting to the self-representation of the Viennese Rectorate.

The extent to which the versions of the facts diverge is revealed when the Rector's more recent statements are compared with those of Profs. Rüdiger and Adlkofer – as the following selections will indicate.

From the Press Release of the Rector of the Medical University of Vienna on July 29, 2008

"Prof. Hugo Rüdiger withdraws obviously incorrect study concerning mobile telephone radiation:

The corresponding author admits mistakes and withdraws the study which appeared earlier this year.

Vienna (OTS) – Following a hearing before the Council for Scientific Ethics (a body established four years ago at the Medical University of Vienna to assess cases of scientific misconduct), Dr. Hugo Rüdiger, the former Head of the Division of Occupational Medicine and since 2007 retired as Professor Emiritus, withdrew at least one of two disputed publications – one published in March of this year – concerning the alleged DNA damaging effect of mobile telephone radiation. Suspicion that the data published there had been manipulated was reported in a release from the Medical University of Vienna on May 23, 2008.

In the wake of further investigations conducted by the Council, it has been established that the employee who conducted the experiments had known the blinding code since August 2005. [...] As previously reported, the said employee was commissioned to conduct test trials in the context of an internal quality control in April of this year which were also used in both publications; she also supplied data without first undertaking microscopic examinations and relevant evaluations. Upon being found guilty of misconduct, she immediately confessed and immediately terminated her employment with the Medical Univesity of Vienna. [...]

The Rector of the Medical University of Vienna thereupon informed the editors of the two journals where the studies had appeared that, with high probability, the said publications were based on scientific misconduct.

The Rector of the Medical University of Vienna now sees the case as closed: 'We responded quickly and decisively, which is what we owe the reputation of our university, its researchers, teachers and students. Methods which do not comply with the scholarly standards and ethos of proper science are not to be tolerated. I am very pleased that Prof. Rüdiger has also shown understanding.'"

(1) E Diem, C Schwarz, F Adlkofer, O Jahn, HW Rüdiger (2005): Non-thermal DNA breakage by mobile-phone radiation (1800 MHz) inhuman fibroblasts and in GFSH R17 rat granulosa cells in vitro. Mutation Research 583, 178-183. C Schwarz, E Kratochvil, A Pilger, N Kuster, F Adlkofer, HW Rüdiger (2008) Radiofrequency electromagnetic fields (UMTS, 1950 MHz) induce genotoxic effects in vitro in human fibroblasts but not in lymphocytes. International Archives of Occupational and Environmental Health 81, 755-767."

Concluding synopsis from the statement by Professor H.W. Rüdiger

"That the Rector should ignore the compromise he himself had previously lauded and with a second press release on July 29, 2008 confirm the validity of his first one from May 23, 2008 speaks for itself. In particular, the following points must be properly clarified:

1. My mobile telephone study was not withdrawn because it was 'obviously incorrect' but for purely formal reasons.
2. The withdrawal was the result of an internal agreement (compromise) to which the Rector had agreed and which he is no longer honouring.
3. The studies which have been on-going for months did not lead to findings which prove the falsification of published data. A written request from June 3, 2008 by the Editor-in-Chief of the *Inter-*

4 Manfred Dworschak, Die Favoritin des Professors, in: Der Spiegel 2008 / No. 35, pp. 148-150.

national Archive of Occupational and Environmental Health concerning this matter has still not been answered by the Rector.

4. It has *not been proven* that the blinding code of the exposition chamber was known to the employee who conducted the experiments since August 2005.
5. By his reference to a suspicion of data manipulation expressed on May 23rd, 2008 (though in the meantime unproven by the Council for Scientific Ethics), the Rector is at least indirectly unjustifiably confirming a suspicion of fraud.
6. Reference to the publication E. Diem, D. Schwary. F. Adlkofer, O. Jahn, H.W. Rüdiger (2005): "Non-thermal DNA breakage by mobile-phone radiation (1800 MHz) in human fibroblasts and in GFSH R17 rat granulosa cells in vitro," Mutation Research 583: 178-83 is confusing as this study was not withdrawn."

In the course of further verifications, the suspicion publicly expressed by the Rector of the Medical University of Vienna on May 23rd, 2008 that publications regarding genotoxic effects of mobile telephone radiation had been falsified could not be proven in either of the studies. Regardless of this fact, the Rector intensified the hunt for possible fraud and demanded "the withdrawal of all other publications which included the same test procedures by the same employee and then to advise the responsible editors to retract these publications as well."

Prof. Rüdiger comments:

"Concretely, this means that after it has not been possible to demonstrate falsification in two publications, this evidence is now not to be required at all and studies are to be withdrawn without any examination at all. In this context, the following must be clearly observed:

- The blanket withdrawal of scholarly publications in the absence of evidence of wrongdoing in these works is internationally *unprecedented*.
- The groundless destruction of scholarly findings that have been compiled after years of effort by usually young employees is *irresponsible* because it opens to question the personal integrity and career development of those involved.
- It is also *irresponsible* with respect to the state and other institutions which have provided substantial funding over years for these studies.
- It is *irresponsible* with respect to society as a whole as the here procured and now devalued findings are of critical importance to the health of many people."

After review of the confidential minutes from the protocol which documents the progress and findings of the second meeting of the Council for Scientific Ethics, Prof. Adlkofer summarized the history of the scandal from its beginnings to the present in a press release of September 8th:

Press release from Prof. Dr. Franz Adlkofer from September 8, 2008

"Science and the truth in mobile telecommunication research: Status and background of a controversy

The German Mobile Telecommunication Research Programme (DMF) was carried out within the last six years and the costs of 17 million Euro have been borne equally by the Government and the telecommunication industry. Based on the results it was concluded that there is no reason to doubt the protective effect of the present safety limits against health risks from mobile phone radiation.

The overwhelming echo in the media reaching far beyond Germany was in line with the significance of this statement. However, regarding its truthfulness it is in stark contradiction to the current status of international research, and it is not even covered by the results of the own research programme. The DMF can give no answer on the central issue of long-term effects of mobile phone radiation and on the special risk for children. In view of this limitation, the all clear signal is close to irresponsibility, and since the existence of athermic effects well below the valid safety limits has been entirely ignored, it is not far away from being unconscionable. To realize this in time thus preventing a wrong decision by the Federal Government would have been the task of an governmental advisory committee, the so-called German Radiation Protection Board (SSK) consisting exclusively of scientists. But we experience exactly the opposite: It is the SSK's recommendation that made the Government's all clear signal even possible.

A major role in this advisory committee plays Prof. Alexander Lerchl from the private Jacobs University Bremen, whose scientific work enjoys special support from the telecommunication industry. For quite a while he objects the results from the international research indicating possible harmful effects of mobile phone radiation, and especially of the UMTS radiation. In the Rector of the Medical University Vienna (MUV) and the editors of the German weekly *Der Spiegel* he did apparently find partners who support his activities without any reservation.

A few months ago the Rector of MUV claimed solely on the basis of suspicions and misleading information, which came among others from Alexander Lerchl, that two important studies on possible genotoxic effects of mobile phone radiation from the Division of Occupational Health in his university have been fabricated. By demanding from the authors and the editors of the scientific journals where the studies had been published the retraction of both, he followed the recommendation of his Council of Ethics in Science. But surprisingly it turned out that the composition of this Council did not even stick to ethical principles of the MUV in so far as its chairman was a representative of the Austrian telecommunication industry!

After the disclosure of this scandal another meeting of the Council was fixed, this time with a neutral chairman. The minutes of this meeting which are treated as a secret document not foreseen for publication, but which we could view being co-author of the published studies, show convincingly that the allegations against the concerned research team are with a high probability unfounded. Remaining uncertainties could be easily clarified if this is actually wanted. But what does the Rector do? Regardless of the content of the minutes he repeats his allegations in public announcements. These accusations were considered important enough to be dealt with in major journals like *Science*, and *Der Spiegel* brought them out into the open in a sensational presentation.

On his homepage the Rector of the MUV comments on science and truth in general and in particular in the field of mobile phone radiation research. Following his understanding, he considers it obviously justified to destroy scientific results obtained in many years of research as well as reputation of the involved researchers, based solely on his suspicion of wrong-doing, although none of his allegations is proven yet. A campaign like this, although not new in mobile phone radiation research, contradicts all demands on scientific and journalistic honesty. Even worse, the denial of possible risks to the health of people due to mobile phone radiation which are well documented decisively contradicts the mission of any medical university!

At present, one can only speculate on the background of these activities which inevitably lead to the destruction of scientific data and aim at the manipulation of the public opinion. Doing so, one can try to find an explanation on the basis of available hints. The consequence of getting the Vienna research results out of the scientific literature would be that one important reason speaking against the irresponsible DMF statement and the claimed reliability of the current safety limits would at least be weakened, if not removed at all. And if the planned continuation of research on the same topics as followed in Vienna could be prevented for some years, the telecommunication industry would have no reason to complain.

The VERUM Foundation which organized and coordinated the largely EU-funded REFLEX project (QLK4-CT-1999-01574) running from 2000 to 2004, did in the meantime submit a grant application for a follow-up research project including 9 international partners. The REFLEX project with a considerable contribution by the Vienna team showed that mobile radiation can alter the structure and function of genes in isolated human cells. With the new project it is intended to find out if similar alterations in cells can be found also in humans, and especially in children and adolescents. Should that be the case, there would be a strong indication that mobile phone radiation is a health risk for man, although the extent of it would still lie in the dark.

The follow-up project received an excellent evaluation by the reviewers of the EU Commission but still has not been funded yet. How far the events in Vienna did influence the Commission to hesitate can hardly be found out. But once more the question arises who will profit most from preventing this kind of research and with it the further clarification of possible health risks due to mobile phone radiation. Of course, not Alexander Lerchl from the private Jacobs University Bremen who enjoys the special support of the telecommunication industry and not the actors in Vienna and Hamburg who support him. It is the telecommunication industry that obviously makes use of willing straw men. That truthfulness and reliability in the science of mobile phone radiation research must not be hindered in this way, for that we have to take care now.

Prof. Dr. Med. Franz Adlkofer"

It is quite apparent that the Rector was not in agreement with the results of the meeting of the three-member ethics council he had appointed or the protocol of the new – and now actually neutral – Chairperson. According to his office, he has the right in such situations to place himself above the protocol and to act at his own discretion – a right he has made plentiful use of. At the cost of the truth and against the practice of all democratic countries regarding treatment of the accused, with his decision to hold the protocol in confidentiality, he has suppressed not only the truth but also the objectifying and protective function of public disclosure.

1.4 Assessment

For various reasons, the agreed upon compromise between the Rector of the Medical University, Prof. Wolfgang Schütz, and the recently retired Prof. Hugo W. Rüdiger was "rotten". Questions of scientific truth are not decided by compromise, and certainly not before the meeting which is supposed to clarify the truth. The desire to save face and consideration of business interests dominated over the responsibility of medicine and science for the health of people. The manner in which the Rector of the Medical University of Vienna ignored his own agreed upon compromise, and the protocol of the ethics council which considered the case, was not only rotten, but irresponsible and slanderous. Ultimately, Prof. Rüdiger committed a terrible mistake when, for "formal" reasons, he agreed to a compromise with his Rector, a man who, on the basis of subsequent experience, ought not to have been trusted and who transformed the compromise into an admission of guilt.

The dissemination of falsities, the refusal to disclose the protocol as well as the willingness to damage uninvolved third parties render claims to a rigorous pursuit of the truth unreliable and veil the serious problems inherent in the very approach to resolving the issue. This begins with questions concerning what actually happened in April 2008 in the laboratory of the Medical University of Vienna. No one wishes to see acts of carelessness by a laboratory assistant glossed over. According to our inquiries, however, they occurred in a climate of failed personal relations and mistrust that, after Prof. Rüdiger's release from his duties, had increasingly determined the working environment within the laboratory between the Prof. Rüdiger's appointed successor and K, his former assistant. Still other questions concerning what transpired in Vienna have been left unanswered:

- Of what relevance was it that Prof. Wolf is also the deputy Chair of the Wissenschaftliche Beirat Funk / the Scientific Advisory Board Funk (WBF)?
- The Rector's precipitous and tendentious press release emphasizes the apparent goal of serving the mobile telephone industry. Of what relevance is it that Nina Hoppe, the Head of the Dept. of Public Relations and Sponsoring at the Medical University of Vienna, was observed at the signing of the press release – a not unproblematic mixing of public relations and sponsoring within the university.
- Or were there other payments by the mobile telephone industry apart from the not unusual sponsorship of universities by the mobile telephone industry – as has been documented in a related context of dispute from 2005?[5]

As long as the Rector of the University continues to disseminate untruths, holds an important protocol in confidentiality and questions such as these are left unanswered, it seems appropriate to intervene on behalf of an employee who is unable to defend herself against administrative force and a questionable understanding of problem resolution.

As a result of our own inquiries and after comparison of the above cited documents, the following is apparent:

1. The Rector's press releases show no contact to the truth which was determined by his university's Council for Scientific Ethics in their second sitting under a neutral Chairperson.
2. The holding in confidentiality of the protocol contradicts all notions of problem resolution and democracy and continues previous practices involving the arbitrary treatment of information and university employees.
3. The Rector, Prof. A. Lerchl and M. Dworschak have conducted their pursuit of falsifiers with falsifications. Their publically disseminated condemnations of the work of two respected professors and an assistant have been deemed a lie in everyday language and, in legal terminology, character assassination clearly detrimental to future career development – a matter currently occupying the attentions of a lawyer.
4. Where one would expect to feel the spirit of the Hippocratic oath, a form of corporate service has

5 That it is difficult to gain clear answers to questions concerning the possible flow of money is unsurprising. Nonetheless, for some time the contents have been known of a letter from April 13, 2005 in which the Austrian Vice-Chancellor and Federal Minister for Roads, Innovation and Technology, Hubert Gorbach responded to 15 questions by the Austrian Member of Parliament Dr. Gabriela Moser. Questions 2 and 3 are concerned with, among other matters, the issue whether there was a possible connection between the observed minimizing of risks according to the TNO and REFLEX studies and financial payments by the industry. The Minister referred to a range of numbers. And yet he too was hesitant to provide much information: "Direct payment from mobile telephone companies to members of the WBF did not occur. [...] In cooperation with ARC (Austrian Research Centers Ltd.), the mobile telephone companies have contributed 100,000 Euros. Division into the individual companies and sums is only partially possible and subject to administrative confidentiality. A full response is thus not possible." To the 15th and final question regarding whether members of the WBF "were directly remunerated for their voluntary work by mobile telephone companies" the Minister chose to repeat the following: "See my answer to questions 2 and 3." In explanation of the acronyms: The Wissenschaftliche Beirat Funk / Scientific Advisory Board Funk is under the control of the ARC, the Austrian Research Centers Ltd., "Austria's largest non-university research organization" (cited from the internet) which belongs 50.46% to the government and 49.54% to insurance, manufacturing and electrical power corporations. In this instance, the government proves helpful not in the creation of transparency but in the veiling of financial transfers which are then declared "administratively confidential" – not unlike the Rector of the Medical University of Vienna with the protocol of the meeting of the Council for Scientific Ethics.

been granted which, in its rendering, is reminiscent of a medieval witch-hunt or a tribunal of the inquisition.
5. Together, not only has the reputation of the Medical University of Vienna been damaged but also an appropriate standard of health and environmental protection.
6. The German-Austrian grotesque initiated by Alexander Lerchl is increasingly proving itself to be nothing more than an anachronistic attempt to distract from the internationally recognized risks of mobile telephone radiation at levels far beneath those currently accepted and to return to radiation the innocence it has forfeited in a variety of ways.

With Manfred Dworschak's reports, the *Spiegel* magazine not for the first time presented examples of highly tendentious reportage in the interests of the mobile telephone industry. The two articles covering events in Vienna brought the fairy tale about fraud into circulation as quickly as possible. The German Press Agency (Deutsche Presseagentur) carried the unconfirmed reports into the broad media landscape. In the meantime, on the basis of this information, radio and television programs have offered such scandalous examples of unserious journalism that we wish to respond by unusual means.

The following short statement will suffice to indicate the character of Dworschak's journalism:

1. Both articles are not only poorly researched: the manipulation and avoidance of easily available information confirm the attempt to bring as quickly as possible, into as broad a forum as possible, a partisan depiction of things which all but glorifies Lerchl's activities.
2. Tendencies of this sort are repeated in the response to research concerning the risks of radiation. In this regard, the article reveals itself to be not only poorly informed. With apparent intention, he also passes over what is well confirmed and known regarding the health risks posed by radiation.
3. Allusions to a possible relationship between a professor and his assistant are without any foundation and serve the market's desire for sensationalism.

Both articles offer examples of unprofessional journalism; they are paradigms of the kind of tendentious journalism which coarsens the exploitation of journalism and complements the exploitation of the media. The honoraria and advertising revenue generated in this manner are purchased with defamation, threats and damage to third parties. Such practices contradict all journalistic claims to independence and critical practice.

2. Misunderstood "Radiation Protection" in Self Testimonials A Documentary Record

2.1 The Truth of Coincidence

A German journalist asked the Rector of the Medical University of Vienna, how it could come about that a representative of the telecommunications industry could become the Chairperson of the three-member ethics council that he had instituted. The Rector answered that this had occurred entirely "coincidentally," a not entirely satisfying response. It appears that this was not the only "coincidence" of this sort – something which seems to betray a measure of intentionality.

Professors Lerchl and Schütz and the journalist Manfred Dworschak have attempted to convey to the public the image of a more or less coincidentally formed action group which was united solely by their uncompromising search for truth and transparency in science. Yet much speaks against both coincidence and the guiding function of a search for the truth. Is it really a coincidence that, on Alexander Lerchl's part, connecting ties extend to the Research Group Funk while, on the part of the Medical University of Vienna, they lead to the Scientific Advisory Board Funk (WBF)?

Coincidences occasionally betray something of a concealed law; predetermined truths serve to veil another truth which rests hidden beneath the surface of talk and action. In the present instance, the hidden truth lies in the simple fact that the global evidence of the damaging genetic effects of mobile telephone radiation – at rates far beneath currently accepted levels – has become a persistent problem for the industry and politicians. In reality, the trio Lerchl, Schütz and Dworschak seem active in helping to dispose of such problems. In this respect, it is no coincidence that the minimising of concerns of danger constitutes a motif in the activities of Alexander Lerchl – as will be revealed in the following, primarily through reference to self testimonials.

2.2 The Minimising of Danger and the Confirmation of Accepted Levels: A Portrait of a "Radiation Protector"

Prof. Dr. Alexander Lerchl of the private Jacobs University Bremen is the unquestioned instigator behind the German-Austrian science grotesque. He is known to the independent scholars, doctors and technicians of our in-

itiative as a contributing figure in workshops on environmental medicine which have been organised and financed by the mobile telephone industry's lobby group (IZMF). Workshops of this type have been, and are, held in the most varied German regions – including in 2007 at the Jacobs University.[6] The central message of such workshops is repeatedly delivered by the Managing Director of the IZMF but also by attending scientists and doctors: "Doctors confirm minimal risk."[7]

Confirmations of minimal risk are in general a conspicuous feature of Lerchl's activities, something not entirely to be expected. For if one delves deep enough into the past, one discovers that he was once a non-dogmatic promoter of a critical approach to mobile telephone radiation. In 1999 – 2001, he played a decisive role in a project that demonstrated the harmful effects of pulsating, high-frequency radiation on one-year-old seedlings of three types of coniferous tree. The observation that the tree with the highest proportion of upright needles, Pinus pumila, also showed the highest rate of damage seemed to suggest that the causal effect proceeded directly through the needles.[8] The report from this project, which was supported with public funding, has never been released and was made available to us only in summary after various complicated attempts to retrieve it.

Alexander Lerchl now has a surprising explanation for the minimised topicality of his previous findings: in reality the damage was caused "by thermal effects on the growing soil" perhaps as a result of "water stress" or "insufficient nutrients." In no way is it to be assumed "that the experiments on seedlings under the described conditions permit relevant expositions concerning tree damage or causal relationships."[9] Are all biological effects, also in plants, exclusively due to thermal effects, as the current accepted limits suggest?

In December 2006, as Franz Adlkofer presented the German Federal Department of the Environment with the findings of his UMTS study – which concluded that UMTS radiation is potentially far more genetically damaging than GSM radiation – a press release from the Jacobs University Bremen was quick to follow. On June 29, 2007, Lerchl was able to report to the public that in "long-term experiments" conducted on mice "no evidence of damage due to UMTS radiation" was found.[10] "Scientists from the Jacobs University [...] under the direction of Alexander Lerchl, Professor of Biology, in cooperation with scientists from the University of Wuppertal [...] have now confirmed the minimal risk" was to be read in one of the many public marketings of the calming information.[11] Talk of "long-term experiments," which would seem to suggest consideration of long term risks, is in fact a reference to the life-span of mice. The justifications for this putative confirmation of minimal risk are questionable in many ways. Among the usual, standard arguments of those in Germany who would minimise the potential for risk is the claim that effects observed in animals are not carried over to humans. Here the minimising of risk is justified with such transference in reverse. And upon closer observation, one also discovers that the radiation of the UMTS mice was concluded four weeks earlier than that of the GSM mice.[12]

In his brochure of 2007, *Macht Mobilfunk krank? Daten, Fakten, Hintergründe* (*Do Mobile Telephones Cause Sickness? Dates, Facts, Background Information*), Lerchl summarizes the totality of his own findings and those known to him under the heading "Critical Insights": "The results of scientific studies to date document no suspicion of a connection between mobile telephone radiation within the legally accepted limits and risks to health, whether in cell or animal experiments according to available epidemiological studies."[13] Confirmation of accepted limits and the minimising of risk are complementarily served with this claim. A review of the book, however, indicates that "Dates, Facts, Background Information" is "one-sided, incompletely documented" and that undesired findings – for example concerning electro sensitivity – were "ignored." For its part, the review refers to the background of a privately funded university at which Vodafone scholarships (Vodafone – a provider of mobile telephone services) are already providing for future generations of appropriately amenable scientists.[14]

Lerchl is one of the most important contractors of the German Mobile Telecommunication Research Programme. Peter Neitzke, who has also contributed to the programme, has clearly distanced himself from the number of projects Lerchl has participated in. Lerchl has "un-

6 The title of the workshop held on the 20th and 21st of June 2007 from the Program of Events: "Mobile Telephone Radiation - Real Danger or Irreal Discussion?" Organizer: Jacobs University Bremen; Welcoming Statement: Prof. Lerchl; Opening Address: Dagmar Wiebusch (IZMF).

7 See the add-hoc news from November 7, 2007: www.ad-hoc-news.de/Aktuelle-Nachrichten/de/14074992/Mediziner-geben-Entwarnung

8 D. Lerchl, A. Lerchl, P. Hantsch, A. Bitz, J. Streckert, V. Hansen (2000): "Studies on the Effects of Radio Frequency Fields on Conifers," Summarized report from the conference of the Bioelectriomagnetics Society in Munich (to date unpublished as a complete article).

9 A. Lerchl on January 9, 2007 in a letter to Dr. E. Vogel of the Bavarian Ministry of the Environment, Health and Consumer Protection.

10 Similar in numerous newspapers.

11 www.golem.de/0707/53206.html; signed: ad - powered by golem.

12 This is a finding established by scientists from our initiative upon reviewing the documentation to the experiments.

13 See page 72 of the cited brochure.

14 See Electrosmog-Report November 2007.

15 See EMF-Monitor March 2008: 4.

dertaken the most projects in the context of the German Mobile Telecommunication Research Programme." And yet his project reports show a degree of uniformity which clearly distinguishes them from the reports of other researchers. From each of his projects assurance is derived that there is no reason to reduce the accepted limits: "Thus, out of these experiments, arise no findings that could justify a reduction of the current accepted levels for a whole-full body exposure" – this, or a similar outcome is the result to be derived from each of his projects. Neitzke makes the critical observation "that the necessity of establishing a new accepted level is certainly not provided by the results of a single experiment."[15]

The practice of radiation protection appropriate to regular minimisings of risk and confirmations of accepted level was expressed by Alexander Lerchl in an interview given at the conclusion of a lecture held in Ritterhude. He made an "urgent appeal" to the communities not to waste "further tax revenues on mobile telephone studies" and advocated "the erection of towers on public buildings in the middle of communities: on schools, kindergartens and other public buildings frequented by the public."[16] His promotion of antennas on kindergartens and schools complements his promotion of Wi-Fi in schools. In the context of disputes concerning the introduction of Wi-Fi in the comprehensive school Osterholz-Scharmbeck, he declared Wi-Fi completely harmless and the health risks as little proven as the existence of people sensitive to electricity. Against the resistence of concerned parents and indignant citizens he thus supported the organization "n-21: Schools in Lower Saxony online" which would like to supply schools in Lower Saxony with Wi-Fi and whose approximately 70 members also belong to Telekom, Siemens, EWE, Intel and Microsoft. Although Bavaria, the German Federal Office for Radiation Protection (BfS) and the German Federal Government have recommended against having Wi-Fi in schools, numerous classrooms in primary and secondary schools in Osterholz-Scharmbeck and the surrounding region are being provided with notebooks and Wi-Fi.[17]

On the basis of Lerchl's reported observations and personal testimonials, it is clear that:

1. The minimising of risk and the confirmation of accepted levels are the most prominent features of his activity.
2. In both instances, he has proven himself an exemplary representative of a form of science which has been co-opted for the mobile telephone industry and the government.
3. Whatever contradicts his claims to minimised danger is systematically ignored, mired in spurious argumentation or simply denied – according to the book *Die Fälscher* (The Falsifiers), one of the most common and influential strategies of scientific fraud.[18]
4. The recommendation of antennas on kindergartens and Wi-Fi in schools from one of the currently most influential "radiation protectors" is expression of a perverted understanding of "radiation protection" but also of the perverse system of health and environmental protection which 80 million people are subjected to.

2.3 The Paths, Detours and Mistaken Paths of Financing

Lerchl is a member of the private Jacobs University Bremen, an institution funded primarily with the capital of sponsors. That this could also represent a danger for the independence of science is denied with statements which betray a total absence of awareness of a problem. As Lerchl's university, together with the telecommunications firm Huawei, joined the Association for Radio Applications (Forschungsgemeinschaft Funk/ FGF), an organization with close ties to industry, the public was proudly informed of the new partnerships as well as the particular independence of research: "Since September 12th, 2007 both organizations have been members of the Research Community Funk. [...] Huawei Technologies is a leading producer of telecommunications networks of the next generation and serves telecommunications providers with over a billion users worldwide. The Jacobs University Bremen is a private independent institution of post-secondary education with the highest standards of research and education."[19]

Amongst independent scientists, Lerchl has acquired a somewhat dubious reputation, not least because of his commitment to IZMF financed workshops for doctors. The extent of his remuneration from these sources is unknown. When asked about the financing of his activities, he refers to two further contractors and emphasizes that he has never taken "direct research projects" from the mobile telephone industry. His contractors are the German Federal Office for Radiation Protection (BfS) and the Research Community Funk (FGF). The extent to which the Research Community Funk represents the interests of the industry is not mentioned. And yet the very composition of the *board of directors* is most informative: Karl-

16 See the Osterholzer Kreisblatt of June 16, 2007 under the headline "Professor Lerchl appeals to all communities: don't spend tax revenues for further mobile telephone studies."

17 This information according to the protocols of a local community initiative.

18 Die Fälscher (The Falsifers), edited by the Society for the Protection of the Population from Electrosmog, Stuttgart 2008.

19 www.huawei.com/; http://www.jacobs-university.de

Wilhelm Siebert (Chairman), Vodafone D2 Ltd.; Dr. Fritz Lauer, T-Mobile Deutschland Ltd.; Dr. Karsten Menzel, E-plus Mobilfunk Ltd.; Herbert Tillmann, Bayerischer Rundfunk; Matthias Meier, Motorola Ltd.; Christer Törnevik, Ericsson Ltd.; Luo Shudong, Huawei; Albrecht Gundlach, German Federal Ministry of the Economy and Technology. *Personal representatives*: Dr. Michael Schüller, Vodafone D2 Ltd.; Joe Wiart, France Telekom; Dieter Vorbeck, O2 Germany Ltd.; Helwin Lesch, Bayerischer Rundfunk; Reinhart Wählen, Motorola Ltd.; Slavko Kutija, Ericsson Ltd.; Maximilian Maier, Forum Mobilkommunikation; Dieter Garvert, German Federal Ministry of the Economy and Technology.[20] Asked about the unsatisfactory nature of these scientific assignments, Lerchl, in his response, noted the urgent need for such a network of contacts and cooperation. And indeed, the fact that such contacts exist is perhaps of less importance than the results of their activity.[21] But when it emerges that the minimising of risks is given great prominence in government policy and that the Bavarian Broadcasting Corporation broadcasts programmes of at times exceptional one-sidedness[22], then it is perhaps time to ask whether good contacts do not in fact lead to bad results. Moreover, the other principal referred to, the state Federal Office for Radiation Protection, needs to be asked by both scientists and citizens whether recommendations for antennas on kindergartens and schools is the type of radiation protection that tax-payers ought to be asked to finance.

2.4. Advisor or Traitor

The type of scientist exemplified by Alexander Lerchl is not a rare phenomenon. "Exemplary States of Mobile Communication" and paradises of everything wireless are being created with his help[23], although the problem of dealing with the risks is being left to future generations. Despite the large number of such "culprits," who show little concern for their potentially numerous "victims," Alexander Lerchl is of particular importance in their circles. Among all those who minimise risk, he is not only one of the most consequent but also one of the most influential. As a contractor for numerous projects of the German Mobile Telecommunication Research Programme, he has contributed to making his minimising of risk into the foundation of technocratically indifferent health and environmental policy. As a member of the radiation protection commission, he has become the buttress of a system of protection which has made the minimising of risk the foundation of the German government's policy. As the German federal Minister of the Environment Gabriel sold the results of the German Mobile Telecommunication Research Programme (DMF) to the German public as a comprehensive minimising of risk, his words rang as a politically simplified echo of Lerchl.

The experiences of Dr. Birgit Stöcker, the Chairperson of the Federal Association Electrosmog, indicate the extension of such echos as far as into the Federal Chancellory. In response to her devastating critique of German Mobile Telecommunication Research Programme and its organizer, Dr. W. Weiss (Federal Office for Radiation Protection) informed her Minister of the Environment, Gabriel, that initially apparent "evidence of possible risk" could not be "confirmed" during the course of the programme, and thus any reduction to the maximum accepted levels was completely without "scientific foundation." For her part, Dr. W. Weiss offered assurance that "there was no scientific evidence of particular danger to children and adolescents due to high frequency fields" and thus there was also no need to legally restrict the use of mobile telephones by children. Given the current state of scientific knowledge, he could not support the demands of particularly sensitive people and those suffering developmental disabilities who requested "radiation free zones and 'living-space oases.'" In the German Federal Chancellory, Ms. Pia Beyer once again summarized in paraphrase this line of argument: According to the results of the German Mobile Telecommunication Research Programme, there were no findings "that from a scientific perspective would support questioning the current accepted levels" nor could "evidence of possible risks [...] be confirmed."[24] When such statements – more or less identical in tone – are regularly issued by representatives of the mobile communications industry, one knows how to interpret them. When, however, they are formulated in the name of the government, which is responsible for the country's health and environment, then one ought to be allowed to expect a different type of information and recommendation!

Alone for the introduction of UMTS technology, the German government garnered 50 billion Euros in licensing fees. Now it is attempting to impress the public with the fact that 17 million is being spent on the protection of the population, a total which amounts to a full 0.003% of the monies received for UMTS technology. Of this, the

20 Hans Drexler and Karl Heinz Schaller: Commentary to A. Lerchl "Umgang mit kritischen Kommentaren zu veröffentlichten Daten" ("Response to Critical Commentary Regarding Published Data"), Umweltmed. Forsch. Prax. 13 (4): 261-64. Citation from p. 262.

21 Alexander Lerchl: Reply to the Commentary by H. Drexler and K.H. Schaller, ibid.: 263.

22 See for example the program of January 24, 2008 Der gefühlte Mobilfunk in the series of broadcasts Faszination Wissen.

23 Two favoured projects by the government of the Saarland were named by the former Minister of Finance Georgi: "Musterland des Mobilfunks" ("Exemplary State of Mobile Communication") and Saarland Unwired."

24 Citations are taken from letters to Ms. Stöcker which were dated September 1, August 6, and August 18, 2008.

mobile telephone industry paid half of the costs, reducing government expenditures to 0.0015%. Given that, according to reliable sources, the financial participation of industry resulted in their inclusion in the assignment of projects, the dependence of the investigation of risks is shrunken still further. And then, when a significant portion of the projects and funding in the context of such arrangements goes to professional minimisers of risk, then it is clear why the minimising of risk is preprogrammed. The above cited words of the German Minister of the Environment, Gabriel, for the German Mobile Telecommunication Research Programme were exposed against his will. At the beginning of the programme, there was evidence of risk; afterwards they were cleared away. Between the two lies the work of those who seek to minimise awareness of risk!

As of yet, neither the government nor its helpers have been capable of the truthfulness necessary to admit to themselves or the public the contradictions which result from so deceitful and scientifically ineffectual a system of protection. Scientists who are active in conspicuous proximity to the industry and who play down the risk of industry products are at the same time called upon to serve in commissions which are supposed to protect the public from the risks of these very products. They themselves have no problem with combining both functions within themselves and allowing themselves to be paid for both. In terms of their social effect, however, a new form of scientific double agent has emerged whereby the more powerful and better situated are served and the others betrayed. As "radiation protectors" and political advisers, such servants – with their two incompatible functions – have created a standard of supposed state legitimacy which, de facto, justifies physical harm as a result of negligence as well as the victimization and eviction of the public. Industry-friendly "experts" and poorly advised politicians have, under the influence of industrial capital, created a system of thinking and acting in which even public health and the environment have been transformed into purchasable and tradable commodities.

What is grandiosely presented to the public as an act of generous and prudent political care and protection in reality reveals the limitless subordination of public health to the economy – examples of flippancy which are not even to be justified in economic terms. A book, edited by the European Environmental Agency and translated by the German Federal Department of the Environment, examines the political observance of the precautionary principal over the course of a century. Its title is *Late Lessons from Early Warnings: The Precautionary Principal 1896-2000*. In a broad, historical panorama and with a multitude of examples, it analyses a century of political failure to meet the responsibilities of precaution. This failure took a horrendous toll in life and resulted in the loss of economic gain which far exceeded all profit otherwise achieved. Those responsible for the mobile telecommunications industry of the present seem not to have heard of the 12 lessons which are to be derived from this and which, among other things, urge serious consideration of early warnings. Perhaps this is because it is no longer a question merely of heeding warnings but of taking notice of the mechanisms of effect which constitute evidence! From this perspective, this type of irresponsibility may be characterized as a crime against public health.

3. Consequences Derived from the Experience of a Democratic State

The currently accepted levels of radiation permit rates of technically produced electromagnetic fields into our living space which are allowed to exceed amounts of magnetic and electromagnetic fields found in the natural order by a factor of 1: 10 billion.[25] As Ulrich Warnke has shown in the first brochure from this series on bees, birds and humans, it is shortsighted to assume that such incursions into the natural order which, via evolution, has become a constituent element of our organization and our functioning can continue indefinitely. Verifiable indicators of damage encourage the prognosis that those responsible for all groupings will destroy, within a few decades, that which the evolutionary process has built up over millions of years.

Numerous publications of national and international renown confirm the necessity of a change. The BioInitiative Working Group has called for such a change with a monumental research report issued as a consensus among the most renowned international scientists. The BUND has made the demand for such a change the basis of its new *Position 2008*:

> "The human organism, and that of other living beings, is dependent upon a bioelectrical system that is capable of functioning and is as unhindered as possible. Due to technical developments, various electro-mag-

25 See Ulrich Wanke: Bienen, Vögel und Menschen. Die Zerstörung der Natur durch ‚Elektrosmog' (Bees, Birds and Humans: The Destruction of the Natural Environment by 'Elektrosmog') Kempten, 2007: 11.

netic fields are impinging upon these living systems in ways ranging from the disruptive to the damaging. The present findings, experiences and observations unmistakeably show that adequate protection and effective prevention of damaging electromagnetic fields must be achieved for humans, animals and plants. [...] Changes to mobile communications technology is thus imperative and will be outlined with this position."[26]

In our publication *Die Gefährdung und Schädigung von Kindern durch Mobilfunk* (*The Endangering and Damaging of Children by Mobile Telephones, 2008*), we documented a worldwide spectrum of such voices and their scientific justifications; we also showed what a bizarre and provincial effect the German minimisings of danger evoke in this context. How can a leading politician allow himself to announce something that, according to the here documented state of international findings, makes the damaging of health and genes the standard of everyday policy?

The answer is "a wide range." It begins with the question how politicians inform themselves or receive advice. And it continues with the question what has been accomplished by the recipients of sums of money in the billions and the numerous ties connecting the mobile telephone industry to the political arena. It leads still further, however, deep into the sphere of the psychology of power. In his book *Höhenrausch* (*Intoxication of the Heights*), the journalist Jürgen Leinemann has impressively shown how the exercise of power is regularly accompanied by a clouding of a sense of reality, if for no other reason than that the holders of such power are unable to bear the weight of an intact conscience.

The easing of the burden of conscience along with the simultaneous justification of power as well as the extensive foreshortening of a sense of reality assume, in the present case, the standards of an ideology of mobile communication known to all. Their central articles of faith are as follows: i) there is no evidence of damage; ii) particular sensitivity with regard to electromagnetic fields does not exist; iii) in addition, we are adequately protected by established limits and expensive projects designed to secure their observance. The actual experience of reality ignored by this has been described in this publication; it reveals that German mobile telephone policy is being pursued on the basis of fanciful thinking and in denial of the language of scientific fact. Placed in the context of the research reports contained in our series of publications, the cited stereotypes of mobile telephone policy are proven to be the canon of as many lies. And were politicians actually to take their assurances of concern for the public to those who have been affected by their actions, they would have ample opportunity to test their sense of reality. Yet, instead of this, they choose to close their eyes to the extent to which they, with what amounts to forced radiation, are causing the imposed degradation of values and the creation of a growing group of "alienated" people who are suspicious of the assurances of a democratic government.

The German constitution obliges our leaders, among other things, to assure protection of human dignity (Article 1 of the Constitution), appropriate prevention of risk (Article 2.2 of the Constitution) and the protection of property (Article 14 of the Constitution). It also obliges them to assure the protection of the weaker and more susceptible – particularly such vulnerable groups as children, the elderly and the sick – something which is an indicator of the quality of any democracy. A system of "radiation protection" that levels the differences all but erases the right to individuality which has distinguished modern political culture since the Enlightenment.

Under current mobile telephone and telecommunications policy, a dubious alliance of governmental power, capital and instrumentalized experts have, with unprecedented arrogance, lain claim to the right to determine according to economic needs what is "true" and what a human is capable of tolerating. This alliance transforms lies into public awareness and injustice into state technical "care," and gross negligence and damage into governmental "radiation protection." Moreover, it is ever more consequential in eradicating the independent spheres of authority which are constitutive of every functioning democracy. The infiltration of capital and, as a consequence thereof, the reduction in independence of politics, science but also the media and justice in contrast to industry and its needs has presented society with a new form of conformity in the face of commercial interests. They have advanced the divorce of morality from politics, truth from responsibility, leading to a resurgence of the Machiavellianism of past centuries, now in economic form. What has emerged is naked capitalism in its purest form where profit is purchased with the exploitation of the health and enonomic well-being of those affected. It has made of citizens – those who ought to be the subjects of democracy – the objects of commercial interest. Those affected experience democracy not as the rule of the people but as the dictatorship of industry aided with state support.

In his book *Die grosse Gier. Korruption, Kartelle, Lustreisen: Warum unsere Wirtschaft eine neue Moral braucht (Great Greed. Corruption, Cartels and Pleasure Junkets: Why Our Economy Needs a New Sense of Morality)*, the journalist Hans Leyendecker has shown with impressive

26 Cited according to the Conference Publication of the BUND Mobile Communication Symposium held in Mainz in 2008.

examples how, and with what sums, international companies today engage in the transference of funds and bribery.[27] Moreover, with reference to the German situation, he makes it clear that the hollowing out of a sense of morality damages, in the long term, the reputation of German business and even profits. The conclusion derived from his research is that our economy needs nothing as much as a "new sense of morality." With reference to our own research, we can only confirm this assessment, though we would not like to limit reference to the economy. Politics, science, the media and occasionally even the churches[28] require a new sense of morality!

And we are being very moderate in our judgment. The Section Head of the European Anti-Fraud Office (OLAF), Wolfgang Hetzer, is no longer certain where the border between politics and organized crime currently runs: "Perhaps it is already no longer possible to distinguish to what extent and at what time congruency exists between (still) legal companies and organized crime. The financial needs of the parties involved, the power interests of politician and the profit motif of companies seem to be growing ever closer together in an unholy manner. Money clears all obstacles without a sound."[29]

Corruption comes from the Latin word corrumpere, "spoil," "bribe," "seduce" and "falsifiy." The German Brockhaus Encyclopedia characterizes it both scholarly and colloquially as a sphere of "morally reprehensible affairs which extend from the abuse of administrative power to general social and political moral degeneration".[30] Citizens of Stuttgart, in their publication *The Falsifiers*[31], have documented the extent of the lies and corruption already demonstrated in the spheres influenced by mobile telephone and mobile communication technologies; and all are aware that what they documented is only the tip of the iceberg.

This chapter was only concerned with the mental, spiritual-moral form of corruption which merely provides the more well-known form of material corruption with a convenient context. And yet the effects of this "mental corruption" exceed those of material corruption by far. They adversely affect the level of health care, the future potential of society and, to a large degree, contemporary political culture.

4. An Appeal for Self-Help and for Support of the MOPHORAD Project

By overburdening our living space with electromagnetic fields, the government has driven ever more citizens into despair, impotent resignation or latent resistance. Furthermore, as scientists, doctors and technicians who are guided by their sense of professionalism, their consciences and consciousness of social responsibility, we can not ask anyone to place their trust in the idea of protection as understood by this government. As scientists and citizens, we are coming to the realization that realistic health and environmental protection from the effects of electromagnetic fields is not currently to be sought through the understanding of protection offered by the government but, indeed, against them in a process of self-help. Thus, we see all those who have come to this conclusion called upon to counteract the forced sale of our health, property and environmental rights in a spirit of mutually supportive community.

Even our series of publications *Wirkungen des Mobil- und Kommunikationsfunks* (*Effects of Wireless Communication Technologies*), which we are here continuing with this third brochure, is to be understood as a project of self-help. We want to make available the very state of knowledge which is being ignored, denied or withheld from the public.

Our espousal of the project presented by Prof. Franz Adlkofer *Mögliche gesundheitliche Auswirkungen der Mobilfundstrahlung bei Kindern und Jugendlichen (MOPHORAD-Projekt) (Potential Health Consequences of Mobile Telephone Radiation on Children and Adolescents*) is also to be understood as further support of a model project of this form of self-help. The project was

27 Hans Leyendecker, *Die grosse Gier. Korruption, Kartelle, Lustreisen: Warum unsere Wirtschaft eine neue Moral braucht* (Great Greed. Corruption, Cartels and Pleasure Junkets: Why Our Economy Needs a New Sense of Morality), Berlin: 2007.

28 See, among others, the penetrating review of Heike-Solweig Bleuel's edited book *Generation Handy ... grenzenlos im Netz verführt* (Generation Mobile Phone ... Without Limits Seduced on the Net) in which Werner Thiede not only refers to such signs of the times as antennas on church towers and the uncritical portal www.kirchenhandy.de, which have become an irritant to many churchgoers, but also concludes: "That not least of all creation ought to be something protected from a surfeit of electromagnetic freighting still has to be discovered by theological ethics." Materialdienst der Evang. Zentralstelle für Weltanschauungsfragen 8 (2008): 136.

29 Wolfgang Hetzer, *Theorie und Praxis der Organisierten Kriminalität in Europa* (The Theory and Practice of Organized Crime in Europe), Dokumentation 4 Offene Akademie: Gelsenkirchen, 2007: p. 24.

30 *Brockhaus-Enzyklopädie*, volume 12, Leipzig, 2001: p. 406.

31 *Die Fälscher* (The Falsifers), edited by the Society for the Protection of the Population from Electrosmog, Stuttgart 2008.

more closely described above. The research proposal was submitted in February 2008 to the European Union Commission for support in the context of the 7th Research Programme (FP7). Due to the very good assessments provided by a commission of independent reviewers called by the European Union Commission, the research proposal has been accepted into the list of projects worthy of support. Thus far, however, there has been no evidence that it will in fact be funded. The extent to which the German-Austrian machinations have contributed to this ambivalent situation is difficult to assess. Irrespective of this question, however, there are excellent scientific as well as social-civil reasons to promote this project.

With the present publication, we are promoting this project because we are convinced of its high degree of scientific dignity. It is exceptionally well conceived and, according to the plan, to be funded in a broad international context. Situated in the continuity of international research, it is of great meaning for the present and future of the population. It will be supported by the most well-qualified scientists derived from international teams and will be undertaken within the FP7 of the European Union Commission, even if the commission were to participate only partially or not at all – assuming the acceptance of the commission. Within a few years, it promises significant growth in reliable estimates of risks, precisely in those areas where they have been ignored by the German Mobile Telecommunication Research Programme.

We are also supporting this project, however, as an act of self-help and of resistance to a policy which is not fulfilling its responsibility to ensure the protection of health, the environment and the future. We do not want to see life and the environment left to the type of scientist described above who has overly close ties to industry and too little to their consciences and to the state of biological knowledge. Nor do we want to entrust our health, environment and quality of life to politicians who seem to have satisfied their responsibility to obtain unbiased information with resort to both convenient and one-sided advice.

To begin with, we appeal to the European Commission and to the European Parliament to support realistic study of the risks and also to provide financing to project such as the one represented here. We appeal to the governments of Europe to contribute to the provision of the necessary funding. We are also going to support the initiators of the project in the search for non-government funding and, in the case of insufficient financial support, turn to all European citizens with a call for financial contributions. Seventeen million Euros have been allocated alone for the German Mobile Telecommunication Research Programme. Can we allow a project which promises dependable protection fail because of a shortfall of 3.5 million.

Carlo Schmid, one of the fathers of the German constitution, once said that "Democracy is the chance to make the state more human." Democratic resistance could be a useful opportunity to tell the state when it has become inhuman. Still more pertinently, Hermann Hesse described the task which many more people with similar experiences currently see themselves confronted:

> "[...] apparently contemporary political rationality no longer resides with political power and a confluence of intelligence and intuition from unofficial sources must take place if catastrophes are to be prevented or mitigated."[32]

32 From a letter of February 1960. Hermann Hesse, *Ausgewählte Briefe*, Expanded Edition, Frankfurt: 1974.

About the Authors

Prof. Dr. med. Franz Adlkofer (Berlin/Munich) earned his doctoral degree from the Max Planck Institute of Biochemistry in Munich. He was awarded his habilitation in internal medicine from the Free University of Berlin. Prof. Adlkofer worked in the industry for 20 years before he took over the management of the Munich-based VERUM Foundation for Behaviour and Environment in 1992. Since 2002, he has also been a member of the foundation's board of directors. Between 1999 and 2004, Prof. Adlkofer organized and coordinated the EU Commission funded REFLEX research project, in which 11 scientific institutions from 7 European countries collaborated.

Prof. Dr. Igor Y. Belyaev (Stockholm/Moscow), PhD from the Institute of Biophysics at the USSR Academy of Sciences, Pushchino; D.Sc. of Genetics at Saint Petersburg University. Since 2004, Belyaev has been an associate professor at the Department for Genetics, Microbiology and Toxicology of Stockholm University; also a professor at the Russian Academy of Sciences in Moscow. He is a member of the Russian National Committee on Non-Ionizing Radiation Protection (RCNIRP).

Prof. Dr. phil. Karl Richter (St. Ingbert / Saarbrücken) earned his doctoral and postdoctoral degrees in Munich; a retired professor of Modern German Literary Studies of Saarland University. Interdisciplinary papers on the relationship of the humanities and natural sciences and their respective history constituted one of his more significant research areas over the past decades. He is the initiator of the Competence Initiative and currently serves as its first president.

Vladislav M. Shiroff is an engineering scientist. As an extremely knowledgeable researcher, he is actively involved in the areas of medical engineering and biophysics. Out of consideration for his family's livelihood, he publishes his pertinent insights under the pseudonym "Shiroff." We should not blame him for his split identity but rather our society's poor handling of truth.

About the Competence Initiative for the Protection of Humanity, Environment and Democracy e. V.

The Competence Initiative for the Protection of Humanity, Environment and Democracy e.V. is a registered non-profit society whose work has met with great approval far beyond Germany. The founding program *Health Is Not a Commodity!* and the statute describe its goals. Both documents can be downloaded from the Initiative's web site at www.kompetenzinitiative.net where also important results of recently initiated or completed projects can be found.

The Initiative, whose work is managed from three different offices in St. Ingbert, Kempten, and Dornach (Switzerland), regards itself as an international, interdisciplinary, and non-partisan society. It is committed to the change necessary in public health and environmental policy, especially with regard to mobile phone and wireless communication technologies. The brochure series *Effects of Wireless Communication Technologies* (also see www.broschuerenreihe.net) addresses the same issue. If you would like to support this program, you may become an active or supporting member, or support our work with a donation. The Initiative's banking information: Raiffeisenbank Kempten, Account No. 1020-102, Bank Routing No. 733 699 02, Keyword: „Kompetenzinitiative".

For more information about the Initiative and cooperation opportunities, please contact us at info@kompetenzinitiative.net or via the member office in Kempten:

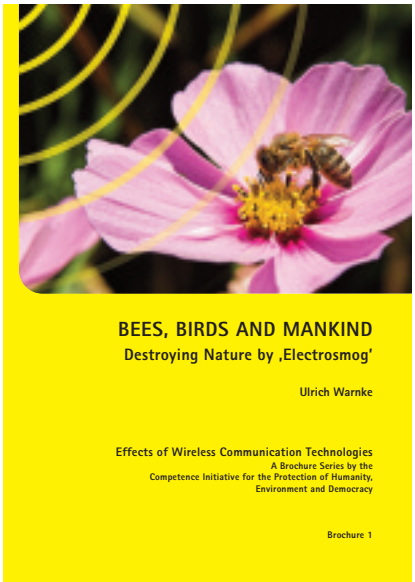
Competence Initiative for the Protection of Humanity, Environment and Democracy e. V.

(www.kompetenzinitiative.net)

Now Brochure 1 of the Series Effects of Wireless Communication Technologies is also available in English:

Bees, Birds and Mankind

Destroying Nature by 'Electrosmog'
Ulrich Warnke, 2007



About this Brochure

The bioscientist Ulrich Warnke knows the electromagnetic workings of nature better than most. In this brochure, which opens a new science series by independent scientists, medical doctors, and technicians, he shows how nature uses much wisdom and sensitivity in employing electric as well as magnetic fields in the creation of life. But, therefore, he is also in a position to convincingly criticize how foolish and irresponsible we are as we interfere with this delicate natural balance today. According to the findings of this brochure, we are currently in the process of destroying in less than a few decades what nature took to create over millions of years.

The outlook is all the more worrisome because it is not based on hypotheses and probabilities but the work of verifiable and reproducible effect mechanisms. We think that the protective provisions of the German Constitution obligate the responsible elected officials to draw the necessary conclusions. Anybody who still relies on downplaying the risk, the most convenient of all strategies used most frequently to pretend that there were no known serious risks, only signals that short-term economic interests are more important to this person than the future of the coming generations.

Ulrich Warnke summarizes the findings of his brochure as follows:

"Today, unprecedented exposure levels and intensities of magnetic, electric, and electromagnetic fields from numerous wireless technologies interfere with the natural information system and functioning of humans, animals, and plants. The consequences of this development, which have already been predicted by critics for many decades, cannot be ignored anymore. Bees and other insects vanish; birds avoid certain places and become disorientated at others. Humans suffer from functional impairments and diseases. And insofar as the latter are hereditary, they will be passed on to next generations as pre-existing defects."

Prof. Dr. K. Hecht, Dr. med. M. Kern, Prof. Dr. K. Richter, Dr. med. H.-Chr. Scheiner

About the Author

The main research areas of Dr. rer. nat. Ulrich Warnke, an internationally renowned bioscientist at Saarland University, include biomedicine, environmental medicine, and biophysics. For decades his research interest centered especially on the effects of electromagnetic fields.

The brochure can be downloaded for free from www.broschuerenreihe.net

We ask for your donations to assist us in publishing more translations:

Kompetenzinitiative
Raiffeisenbank Kempten (73369902)
Bank Account: 1020-102
IBAN: DE42733699020001020102
BIC: GENODEF1KM1

Contact and Correspondence:
Competence Initiative
Postfach 15 04 48
70076 Stuttgart
Germany

englishcontact@kompetenzinitiative.net

www.competence-initiative.net

More information about the German print editions of the brochures of the series and how to order them can be found at www.broschuerenreihe.net.

About this Brochure

"In this document *How susceptible are genes to mobile phone radiation? State of the Research* - Endorsements of Safety and Controversies - *Self-Help Recommendations*, Franz Adlkofer considers the endorsement of safety by the German Mobile Telecommunication Research Programme the result of wishful thinking, which ignores the scientific facts. Experts in biomedicine and biosciences, Prof. F. Adlkofer, Prof. I. Y. Belyaev, and V. M. Shiroff share in their respective articles what is known about biological effects in the international literature. Furthermore, they also explain what may make UMTS radiation especially dangerous. And all of them are in agreement that the issue is about long-term and non-thermal effects. Both of these parameters, however, were not considered in the setting of the current exposure guidelines." (Foreword by the Editors)