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**Effects of Radiofrequency Fields on the Genome:
Genotoxicity and Gene Regulation**

Statement by the German Commission on Radiological Protection

Adopted at the 213th session of the Commission on Radiological Protection on 5/6 December, 2006

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**Wirkung hochfrequenter Felder auf das Genom:
Genotoxizität und Genregulation**

Stellungnahme der Strahlenschutzkommission
und wissenschaftliche Begründung

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In the event of any doubts about the meaning, the German original as published shall prevail.

Table of contents

| | |
|--|----------|
| Initial position and course of action | 4 |
| Exposure systems | 5 |
| Genotoxicity | 5 |
| Gene regulation | 5 |
| Summary | 6 |
| References | 6 |

Initial position and course of action

The possibility that radiofrequency electromagnetic fields (RF fields) may cause negative health effects has been controversially discussed. Taking into account the increased use of technologies involving RF fields, e.g. the mobile telephone system, this issue gains even more significance. Exposure restrictions recommended by international committees, on which national regulations are based, serve to protect the population against proven adverse health effects. These limits are based on scientific research on the interaction of RF fields with biological systems and are periodically reviewed. In 2001, the German Commission on Radiological Protection (SSK) evaluated the relevant scientific literature and published a recommendation on “Exposure Restrictions and Preventive Measures to Protect the Public from Electromagnetic Fields” [SSK 2001]. The SSK’s conclusion at that time was “that, even after examining new scientific literature, no new scientific findings are available to either prove that such adverse health effects exist or to raise doubts on the scientific evaluation used by the ICNIRP and EU Council in making their recommendations”. In this statement, a distinction is made between scientific “proof”¹, “scientifically based suspicion”² and “hint”³.

Since 2001 many publications appeared, which made a new assessment of the SSK necessary. In some of them effects on the genome are reported even below existing RF exposure restrictions. These publications have found great interest in the media and thus caused public concern. The present statement re-evaluates the current status of science in this field. The evaluation is largely based on the critical assessment of literature in peer reviewed scientific journals. However, in few cases and for reason of topicality, other documented sources are also considered. In particular, this concerns research reports on the REFLEX and PERFORM B studies, which have only been partially published in scientific journals.

This statement is dealing with the question whether radiofrequency electromagnetic fields from wireless applications, e.g. radio broadcast or mobile communications, can induce changes in the genome and/or in gene expression (gene regulation) when field intensities are below exposure restrictions. The available scientific literature since 2000 has been considered. The evaluation of older studies was based on reviews and the SSK’s 2001 Recommendation, in which genotoxicity and gene expression were discussed. The SSK’s evaluation at that time stated, “In summary, the studies of cancer-relevant proteins, carcinogenesis and the development of cancer display a very inconsistent picture. To what extent individual and non-reproduced indications have an impact on health should be clarified by further research.” More recent papers addressing this topic are referred to in the attached scientific annex and are summarised in the following sections.

¹ **Scientific proof** would show a connection between electromagnetic fields and adverse health effects if scientific studies are able to reproduce findings in independent research groups, thereby supporting a causal connection in the overall scientific picture.

² A **scientifically based suspicion** would suggest that there is a connection between adverse health effects and electromagnetic fields if the results of confirmed scientific investigations point to such a connection even though the total sum of scientific investigations does not sufficiently support a causal connection. The extent of scientific suspicion depends on the number and consistency of available scientific papers.

³ **Scientific hints** exist in cases where indications of individual studies on the connection between adverse health effects and electromagnetic fields are not independently confirmed and not supported by the overall scientific picture.

Exposure systems

In recent years there has been great technical progress in exposure systems and dosimetric procedures. As compared to earlier experiments, improved dosimetric designs lead to better defined and more homogenous exposure of the samples. Most exposure systems used today are waveguides. Using waveguides with standing waves, it is possible to produce field intensities within the range of exposure restrictions with little technical effort. Improvements have reduced the risk of artefacts so that most of the recent studies operate with better defined and reproducible field characteristics.

Genotoxicity

Apart from classical cytogenetic techniques to study biological effects at the cellular level such as analysis of chromosomal aberrations or micronuclei, the comet assay is increasingly being used. It is, however, much more prone to artefacts. Mutation tests well established in toxicology are rarely used to investigate the effects of RF fields. There is a general lack of consistency in study design (even in newer studies) and, in no case the whole range of the established and required tests in toxicology has been used.

A comprehensive assessment of publications on the induction of DNA damage by RF fields is difficult because of the variety of test objects and methods used. In most studies, no genotoxic effects were found. The few positive findings are contradictory in part and do not conform to a systematic overall picture. Because of the ambiguity of these scientific findings independent replications are particularly important. In the few cases where they have been carried out the original positive findings have not been confirmed. Therefore, it can be stated that there is no scientifically based suspicion that RF fields are able to induce DNA damage.

Further clarification and confirmation would only be possible if different cell types and various parameters were systematically studied in carefully planned programmes by several competent laboratories working in parallel. As a general rule, the practice to date has not fulfilled these requirements.

Gene regulation

The number of studies on gene regulation has increased noticeably since 2000. Positive findings reported in the literature before 2000 on the activation of ornithine decarboxylase, a marker used in cell division, have recently been disproved. In addition, processes previously not in the centre of interest have been studied now, such as induction of heat shock proteins and programmed cell death (apoptosis). An evaluation of the available literature shows that the vast majority of results on the induction of heat shock proteins is negative. Replications of the few positive findings have not confirmed the original results. Also studies on apoptosis yielded, almost without exception, negative findings. The few positive results are inconsistent. There is, therefore, no scientifically based suspicion that RF fields below exposure restrictions induce heat shock proteins or apoptosis.

Established standard techniques used to investigate individual genes are usually employed to study gene regulation. More modern methods for studying RNA at the genome scale by microarrays and proteome studies, were only rarely used to investigate RF effects. The results of these studies are flawed in part by methodical defects and deficiencies in statistical analysis and do, therefore, not provide clear evidence. Thus they play only a secondary role in this evaluation.

Although these techniques hold great potential for studying the effects of RF fields on the genome, it must be noted that the possibility of false-positive results is particularly high here due to the large number of variables. Therefore, additional time and effort using other methods is needed to confirm such results.

Summary

Based on an evaluation of scientific literature, the SSK has concluded that even considering the recently published results until October 2006

- there is no scientifically based suspicion that RF fields have a genotoxic effect, and
- there is no scientifically based suspicion that RF fields have an influence on gene regulation.

The results of available studies give no indication that there is an adverse health effect on the genome by radiofrequency electromagnetic fields questioning existing exposure restrictions.

References

Strahlenschutzkommission (SSK): Grenzwerte und Vorsorgemaßnahmen zum Schutz der Bevölkerung vor elektromagnetischen Feldern, Empfehlung der Strahlenschutzkommission mit wissenschaftlicher Begründung, Berichte der SSK, Heft 29, Urban & Fischer, München / Jena 2001