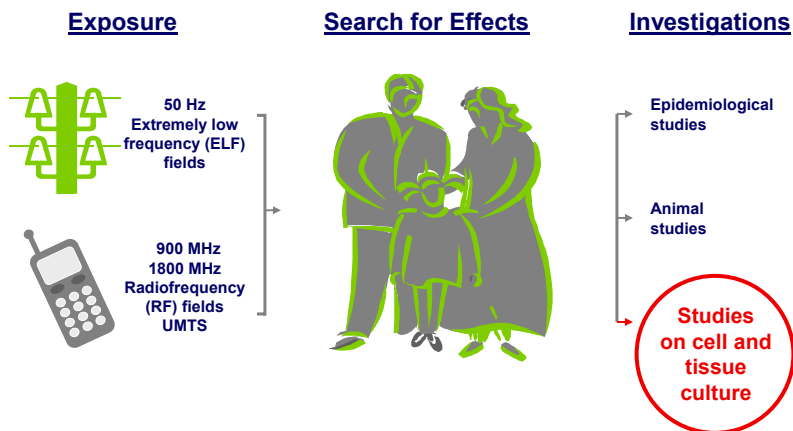


# Proof of principle tests confirm genotoxic potential of RF-EMF

Franz Adlkofer

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Munich, Germany

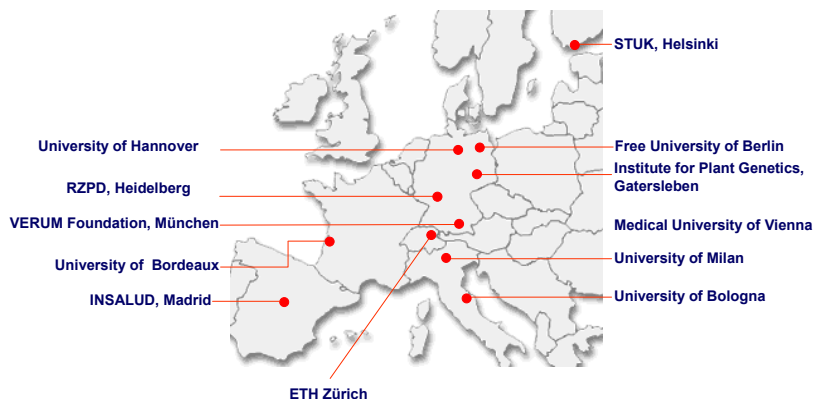
## Scientific approach



# **Risk Evaluation of Potential Environmental Hazards From Low Energy Electromagnetic Field Exposure Using Sensitive *in vitro* Methods**



A project funded by the European Union under the programme "Quality of Life and Management of Living Resources",  
Key Action 4 "Environment and Health": QLK4-CT-1999-01574



## **State of the art in 1999**

Even though the biological effects of EMF exposure have been studied for the past 80 years, no consensus has been reached with respect to either findings or their interpretation.

The reasons for this are numerous:

- difficulties in measuring EMF exposure at the putative sites of action
- vast differences in exposure and experimental conditions
- the complete lack of agreement on biological endpoints appropriate for study

## Assumption and aim of the study

- REFLEX was based on the assumption that a health risk due to EMF below the current safety limits can only exist if scientific proof of biological effects, relevant for the development of diseases, is obtained.
- The aim of REFLEX was to find out whether or not EMF below the current safety limits cause cellular, sub-cellular or molecular alterations in isolated mammalian cells that are relevant for the development of diseases.

## Pathogenesis of chronic diseases

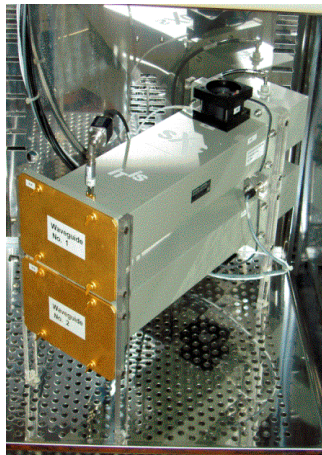
All chronic diseases such as cancer and neurodegenerative disorders are of extremely diverse and heterogeneous origin and this variability is generated by alterations of the structure and function of genes, leading to changes in gene and protein expression. This may result in a number of critical cellular events for example deregulated cell proliferation or cell differentiation and suppressed or exaggerated programmed cell death (apoptosis).

Their convergence is required for the development of chronic diseases.

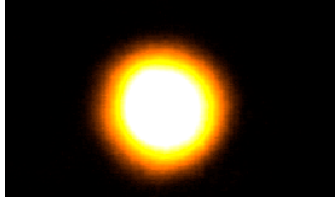
## Working hypothesis

- The hypothesis that was to be tested in the REFLEX project assumed that no biological effects of relevance for the pathogenesis of chronic diseases will be detected and that the present safety limits reliably protect EMF-exposed people from any health risk.

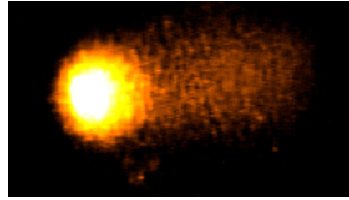
## Exposure chamber



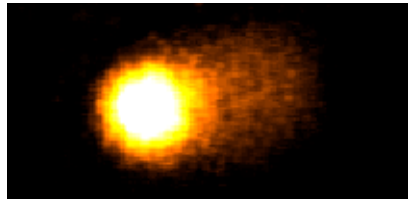
## Comet assay



sham exposition



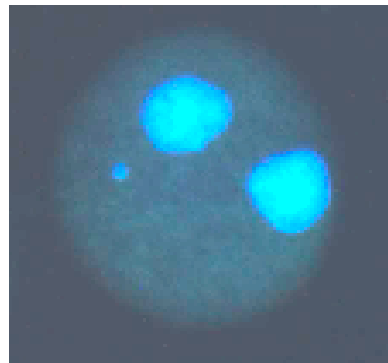
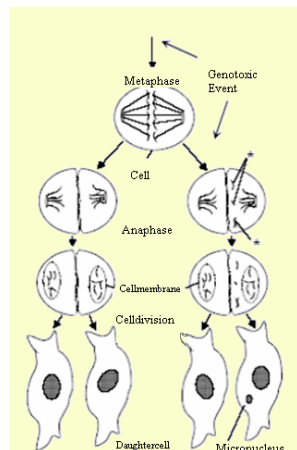
gamma-radiation; 0,5 Gy



RF-EMF: 1800 MHz continuously; SAR 1.3 W/kg; 24h

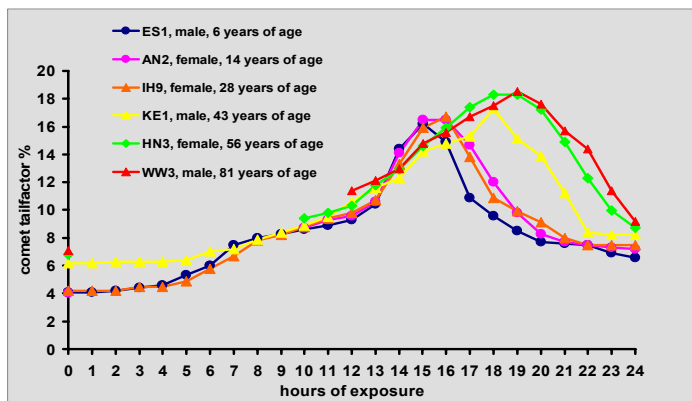
© Clinical Chemistry, Free University of Berlin

## Micronucleus test



## ELF-EMF \_ Age-dependent increase of DNA strand breaks in human fibroblasts

50 Hz sinus; 1000  $\mu$ T; 5 min on / 10 min off



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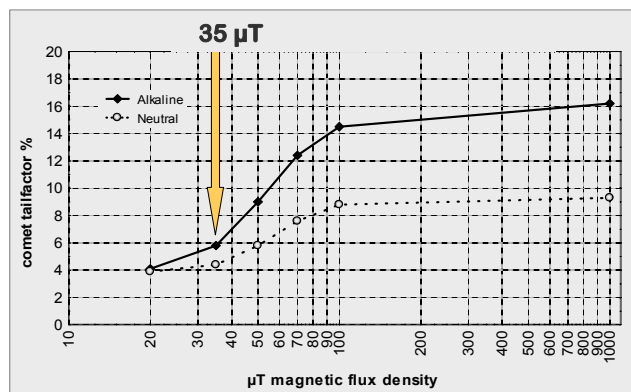


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## ELF-EMF \_ Flux density-dependent increase of DNA strand breaks in human fibroblasts

50 Hz sinus; 15 h; 5 min on / 10 min off



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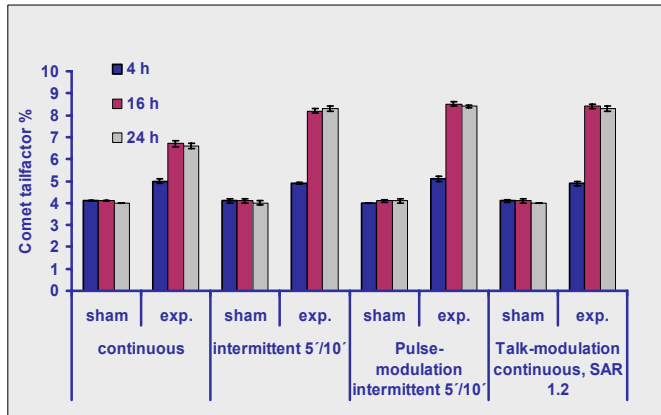


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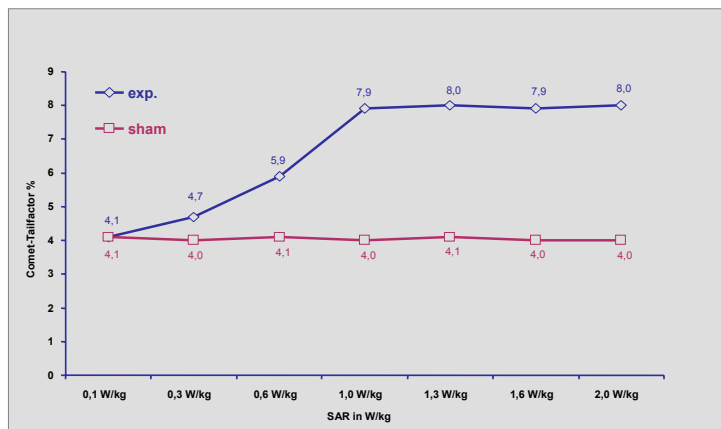
## GSM \_ Exposure- and signal pattern-dependent increase of DNA strand breaks in human fibroblasts

1800 MHz; SAR 2 W/kg



## GSM-RF-EMF \_ Dose-dependent increase of DNA strand breaks

GSM Basic; 1950 MHz; 24 h; 5 min on / 10 min off



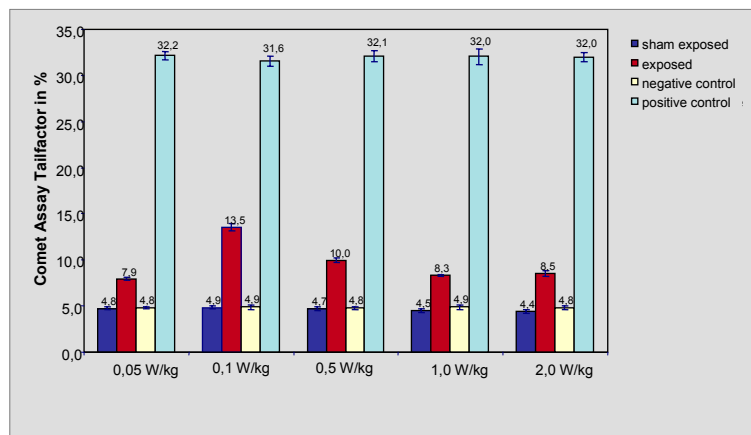
## UMTS \_ Dose-dependency

- UMTS 1950 MHz
- normal human fibroblasts (cell line ES-1)
- exposure duration: 24 hours
- exposure pattern: continuous
- SAR values: 0.05 W/kg, 0.1 W/kg, 0.5 W/kg, 1.0 W/kg and 2.0 W/kg
- endpoints: comet assay, micronucleus test

positive controls in the comet assay: UV light, 254 nm, 3 min, 800  $\mu\text{W}/\text{cm}^2$

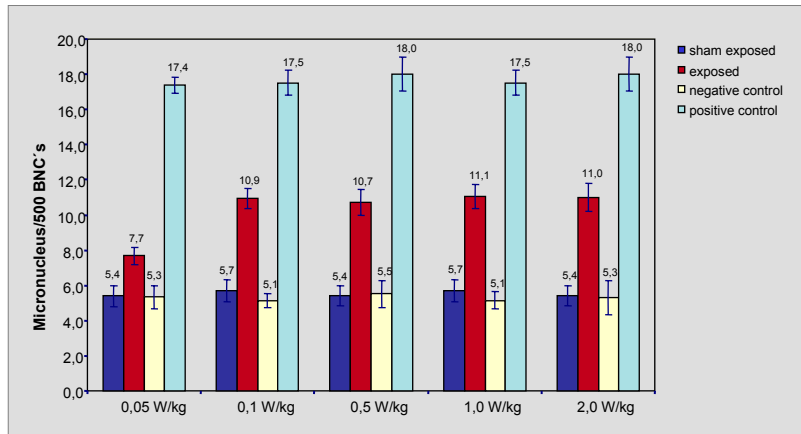
positive control in the micronucleus test: 25 nM Vincristin

## Dose-dependent increase in DNA strand breaks after UMTS exposure





## Dose-dependent increase of micronuclei after UMTS exposure



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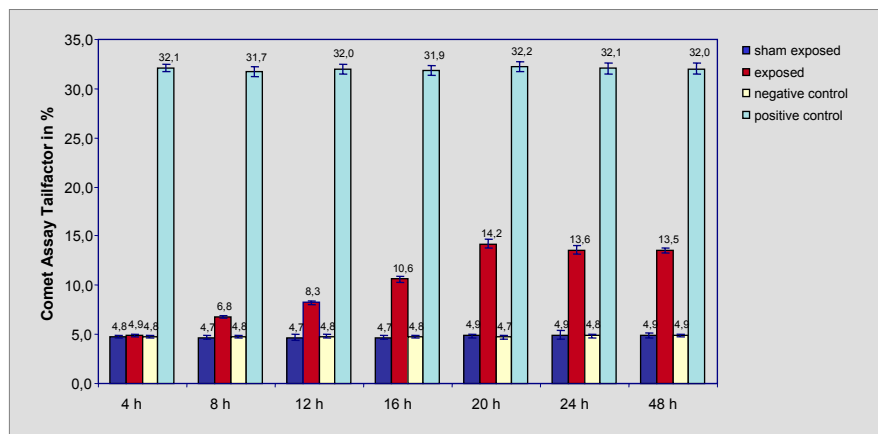
## UMTS \_ Time-dependency

- UMTS 1950 MHz
- normal human fibroblasts (cell line ES-1)
- SAR value: 0.1 W/kg
- exposure pattern: continuous
- exposure duration: 4, 8, 12, 16, 20, 24 and 48 hours
- endpoints: comet assay, micronucleus test

positive controls in the comet assay: UV light, 254 nm, 3 min, 800 µW/cm²

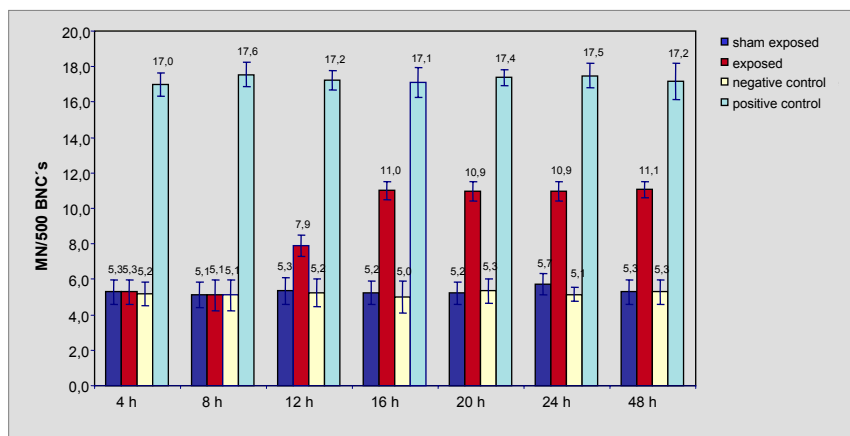
positive control in the micronucleus test: 25 nM Vincristin

## Time-dependent increase of DNA strand breaks after UMTS exposure



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## Time-dependent increase of micronuclei after UMTS exposure

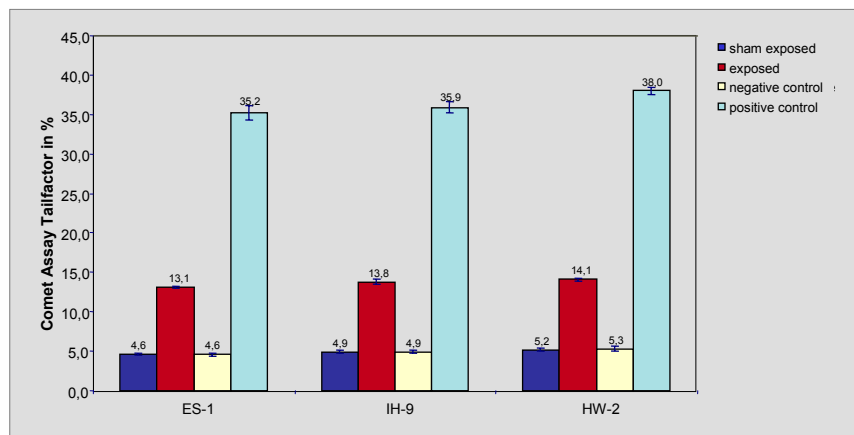


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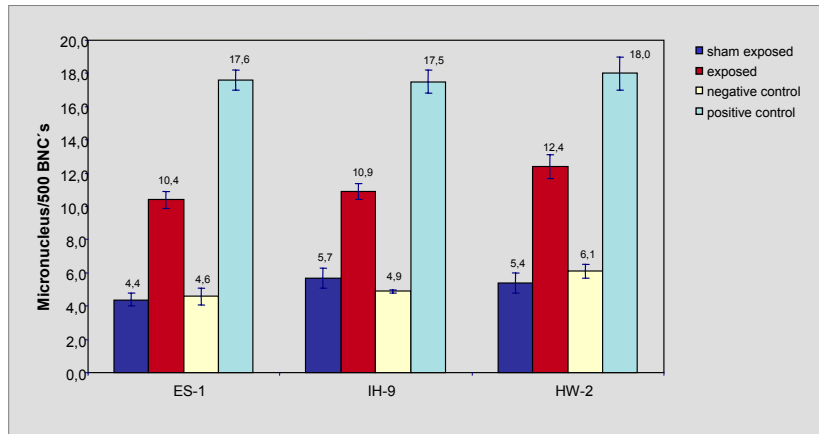
## UMTS \_ Repetition with 3 different cell lines

- UMTS 1950 MHz
- SAR value: 0.1 W/kg
- exposure duration: 16 hours
- exposure pattern: 5 min on / 10 min off
- cells: 3 different cell lines from human fibroblasts

## Increase of DNA strand breaks in fibroblasts from three different persons after UMTS exposure



## Increase of micronuclei in fibroblasts from three different persons after UMTS exposure



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## RF-EMF \_ Effects on gene and protein expression

GSM; 900 MHz; SAR 2 W/kg; 1h

### RF-EMF activates

- gene expression (MAPK p38, PKC)
- protein expression (HSP27)
- metabolism (phosphorylation of HSP27)

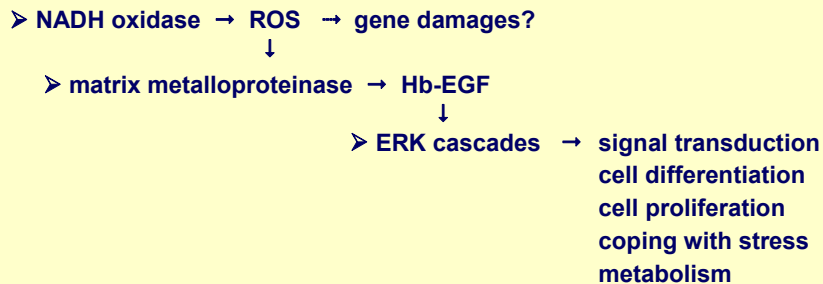
**Cells react to exposure with RF-EMF with stress the physiological relevance of which has not been sufficiently investigated yet.**

from: Dariusz Leszczynski, Radiation and Nuclear Safety Authority (STUK), Finland

## RF-EMF \_ Contribution to pathogenesis

875 MHz; SAR < 2 W/kg; minutes

### RF-EMF activates



Friedman et al. (2007) Mechanisms of short-term ERK activation by electromagnetic fields at mobile phone frequencies. *Biochem J* 405: 559-568 (The Weizman Institute of Science, Israel)

## Summary of the REFLEX results

The results of the REFLEX study did not confirm our hypothesis which assumed that no biological effects of relevance for the pathogenesis of chronic diseases will be found below the existing safety limits. However, ELF-EMF below 100  $\mu$ T and RF-EMF below 2 W/kg alter the structure and function of genes in different animal and human cells. We saw an

- increase of single and double DNA strand breaks in human fibroblasts, HL60 cells and granulosa cells of rats, but not in human lymphocytes
- an increase of micronuclei and chromosome aberrations in human fibroblasts
- alterations in gene and protein expression of several cell types, especially in human fibroblasts, human endothelial cells and embryonic stem cells from mice

A significant increase of DNA strand breaks was observed in human fibroblasts after GSM exposure at a SAR of 0.3 W/kg and after UMTS exposure at a SAR of 0.05 W/kg.

## Swisscom patent

on the "reduction of electrosmog in wireless local networks":

"Thus it has been possible to show that mobile radio radiation can cause damage to genetic material, in particular in human white blood cells, whereby both the DNA itself is damaged and the number of chromosomes changed. This mutation can consequently lead to increased cancer risk. In particular, it could also be shown that this destruction is not dependent upon temperature increases, i.e. is non-thermal. ..."

International Publication Number: WO 2004/075583 A1

## A risk to our health?

None of the single approaches in basic research, animal experiments and epidemiological studies is at present in the position to provide proof of a health risk caused by EMF with sufficient certainty. However, as the results from the three approaches complement each other, they strongly speak in favour of the assumption that a health risk could arise from ELF-EMF as well as from RF-EMF.

## Worst case scenario

Genotoxic effects caused by mobile phone radiation in living cells in vitro speak in favour of a causality between the long-term use of mobile phones and the increase of a brain tumour risk.

This in mind, we have to consider:

- The Interphone study, although not published yet in a final report, found a significantly increased risk for brain tumours in long-term users of mobile phones.

**Causal or not? We do not know yet**

- Lennard Hardell recently reported in young people below 20 years of age a more than 5-fold increase in the risk for brain tumours at the side of the head at which they used the mobile phone.

**Causal or not? We do not know yet**

## Conclusions

- Available scientific data clearly demonstrate that biological effects of electromagnetic fields below the current safety limits are athermal by nature. Since current safety limits are based upon the assumption that athermal biological effects do not exist at all, the only possible conclusion is that they are invalid and do not protect people.
- Lowering the safety limits by a factor between  $10^{-1}$  and  $10^{-5}$  may be a first and easily to accomplish step to adjust the radiation intensity to the conditions of living organisms. In the long range, the development of adequate safety limits away from physical EMF effects towards biological EMF effects by independent researchers is a top priority.
- All-clear signals by the industry and their scientific advisers that deny possible health risks of people exposed to RF-EMF below the current safety limits do not have a sound basis. Therefore, national governments which are responsible for the health protection of their citizens are badly advised, if they back the safety limits and the all-clear signals.