## The REFLEX Project:

# Risk evaluation of potential environmental hazards from low energy electromagnetic fields (EMF) exposure using sensitive *in vitro* methods

*The range of frequencies classified as extremely low frequency (ELF) is not large, stretching from zero only as far as 300 Hz. Electricity supply grids over the entire world operate within this range and give rise to ELF electromagnetic fields (ELF-EMFs). So, sources of ELF-EMFs are widespread inside and outside the home and workplace. Many experimental and epidemiological studies have investigated the biological effects of these fields on humans. A large number have found no detrimental influence, but controversy still clings to the issue. EMFs classified as radio frequency (RF-EMF) cover a much broader range, extending from low to extremely high frequencies, 30 kHz to 300 GHz. They too are all around us.*

### Objectives

- The REFLEX project sought to clarify the issue of whether extremely low frequency electromagnetic fields influence human health through an *in vitro* study at the level of individual cells. This involved exposing a wide range of human and animal cell lines to EMFs at intensities within current safety limits and analysing the outcomes;
- In ELF-EMF exposure systems, selected human cell lines were irradiated. Among these were lymphocytes, fibroblasts, muscle cells and animal cell lines like granulosa cells from rats. Similar experiments were performed in RF-EMF exposure systems on cell lines that included HL-60, a human cell line used as a model of early bone-marrow precursor cells; granulosa cells from rats; AND human lymphocytes, fibroblasts and brain cells;
- After exposure the cells were analysed for cellular changes indicative of genotoxicity – for example DNA breakages, micronuclei left outside the nucleus during cell division, and chromosomal aberrations;
- Changes in the expression of genes and proteins in the exposed cells were monitored – expression is the process where the genetic information encoded in a gene is converted into the structure and function of a cell.

### Key findings and conclusions

- Intermittent exposure to ELF-EMF at 50Hz, a common electrical mains frequency, had genotoxic effects on human fibroblasts, human melanocytes and some animal cells. Lymphocytes and other cell lines, meanwhile, remained unaffected;
- In fibroblasts, a direct correspondence between the intensity and duration of ELF-EMF exposure and the number of DNA breakages or micronuclei, both markers of genotoxicity, was discovered. Obtained by two of the REFLEX laboratories, these results were validated by two laboratories outside the project;

- In cells exposed to RF-EMF the researchers also identified genotoxic effects – marked by, among other things, DNA breakages, chromosomal aberrations and the formation of micronuclei – in human fibroblasts, HL-60 cells and granulosa cells in rats, but not in lymphocytes. Once more, the degree of damage depended on the duration of exposure and on the type of signal used;
- The REFLEX team also obtained evidence that in some cell cultures both ELF-EMFs and RF-EMFs may affect the expression of genes and proteins involved in such activities as cell division, proliferation and differentiation.

### Relevance and contribution to EU policy

The findings are a valuable addition to our understanding of the effects ELF-EMFs and RF-EMFs on human and animal cells cultured in the laboratory. From a scientific point of view, it has to be stated very clearly that the REFLEX data do not prove a causal link between EMF exposure and any adverse health effects. The genotoxic and phenotypic effects, which have been reported within REFLEX, clearly require further research. As a consequence, before any conclusions can be drawn regarding the risks to human health, the results will have to be complemented by whole animal studies.

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