

Electromagnetic Fields (EMF), Special Issue

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EMF EFFECTS ON DNA

Electromagnetic fields stress living organisms. Blank, M and R. Goodman. pp 71-78.

Abstract

Electromagnetic fields (EMF), in both ELF (extremely low frequency) and radio frequency (RF) ranges, activate the cellular stress response, a protective mechanism that induces the expression of stress response genes, e.g., HSP70, and increased levels of stress proteins, e.g., hsp70. The 20 different stress protein families are evolutionarily conserved and act as 'chaperones' in the cell when they 'help' repair and refold damaged proteins and transport them across cell membranes. Induction of the stress response involves activation of DNA, and despite the large difference in energy between ELF and RF, the same cellular pathways respond in both frequency ranges. Specific DNA sequences on the promoter of the HSP70 stress gene are responsive to EMF, and studies with model biochemical systems suggest that EMF could interact directly with electrons in DNA. While low energy EMF interacts with DNA to induce the stress response, increasing EMF energy in the RF range can lead to breaks in DNA strands. It is clear that in order to protect living cells, EMF safety limits must be changed from the current thermal standard, based on energy, to one based on biological responses that occur long before the threshold for thermal changes.

Electromagnetic fields and DNA damage. Phillips, JL, NP Singh, H Lai. pp 79-88.

Abstract

A major concern of the adverse effects of exposure to non-ionizing electromagnetic field (EMF) is cancer induction. Since the majority of cancers are initiated by damage to a cell's genome, studies have been carried out to investigate the effects of electromagnetic fields on DNA and chromosomal structure. Additionally, DNA damage can lead to changes in cellular functions and cell death. Single cell gel electrophoresis, also known as the 'comet assay', has been widely used in EMF research to determine DNA damage, reflected as single-strand breaks, double-strand breaks, and crosslinks. Studies have also been carried out to investigate chromosomal conformational changes and micronucleus formation in cells after exposure to EMF. This review describes the comet assay and its utility to qualitatively and quantitatively assess DNA damage, reviews studies that have investigated DNA strand breaks and other changes in DNA structure, and then discusses important lessons learned from our work in this area.

Genotoxic effects of radiofrequency electromagnetic fields. Ruedinger, HW. pp 89-102

Abstract

101 publications are exploited which have studied genotoxicity of radiofrequency

electromagnetic fields (RF-EMF) *in vivo* and *in vitro*. Of these 49 report a genotoxic effect and 42 do not. In addition, 8 studies failed to detect an influence on the genetic material, but showed that RF-EMF enhanced the genotoxic action of other chemical or physical agents. The controversial results may in part be explained by the different cellular systems. Moreover, inconsistencies may depend from the variety of analytical methods being used, which differ considerably with respect to sensitivity and specificity. Taking altogether there is ample evidence that RF-EMF can alter the genetic material of exposed cells *in vivo* and *in vitro* and in more than one way. This genotoxic action may be mediated by microthermal effects in cellular structures, formation of free radicals, or an interaction with DNA-repair mechanisms.

EMF EFFECTS ON THE BRAIN

Increased blood-brain barrier permeability in mammalian brain 7 days after exposure to the radiation from a GSM-900 mobile phone. Nittby, H. et al. pp 103-112.

Abstract

Microwaves were for the first time produced by humans in 1886 when radio waves were broadcasted and received. Until then microwaves had only existed as a part of the cosmic background radiation since the birth of universe. By the following utilization of microwaves in telegraph communication, radars, television and above all, in the modern mobile phone technology, mankind is today exposed to microwaves at a level up to 10^{20} times the original background radiation since the birth of universe.

Our group has earlier shown that the electromagnetic radiation emitted by mobile phones alters the permeability of the blood–brain barrier (BBB), resulting in albumin extravasation immediately and 14 days after 2 h of exposure.

In the background section of this report, we present a thorough review of the literature on the demonstrated effects (or lack of effects) of microwave exposure upon the BBB. Furthermore, we have continued our own studies by investigating the effects of GSM mobile phone radiation upon the blood–brain barrier permeability of rats 7 days after one occasion of 2 h of exposure. Forty-eight rats were exposed in TEM-cells for 2 h at non-thermal specific absorption rates (SARs) of 0 mW/kg, 0.12 mW/kg, 1.2 mW/kg, 12 mW/kg and 120 mW/kg. Albumin extravasation over the BBB, neuronal albumin uptake and neuronal damage were assessed.

Albumin extravasation was enhanced in the mobile phone exposed rats as compared to sham controls after this 7-day recovery period (Fisher's exact probability test, $p = 0.04$ and Kruskal–Wallis, $p = 0.012$), at the SAR-value of 12 mW/kg (Mann–Whitney, $p = 0.007$) and with a trend of increased albumin extravasation also at the SAR-values of 0.12 mW/kg and 120 mW/kg. There was a low, but significant correlation between the exposure level (SAR-value) and occurrence of focal albumin extravasation ($r_s = 0.33$; $p = 0.04$).

The present findings are in agreement with our earlier studies where we have seen increased BBB permeability immediately and 14 days after exposure. We here discuss the present

findings as well as the previous results of altered BBB permeability from our and other laboratories.

Epidemiological evidence for an association between use of wireless phones and tumor diseases. Hardell, L, M Carlber, KH Mild. pp 113-122.

Abstract

During recent years there has been increasing public concern on potential cancer risks from microwave emissions from wireless phones. We evaluated the scientific evidence for long-term mobile phone use and the association with certain tumors in case-control studies, mostly from the Hardell group in Sweden and the Interphone study group. Regarding brain tumors the meta-analysis yielded for glioma odds ratio (OR) = 1.0, 95% confidence interval (CI) = 0.9–1.1. OR increased to 1.3, 95% CI = 1.1–1.6 with 10 year latency period, with highest risk for ipsilateral exposure (same side as the tumor localisation), OR = 1.9, 95% CI = 1.4–2.4, lower for contralateral exposure (opposite side) OR = 1.2, 95% CI = 0.9–1.7. Regarding acoustic neuroma OR = 1.0, 95% CI = 0.8–1.1 was calculated increasing to OR = 1.3, 95% CI = 0.97–1.9 with 10 year latency period. For ipsilateral exposure OR = 1.6, 95% CI = 1.1–2.4, and for contralateral exposure OR = 1.2, 95% CI = 0.8–1.9 were found. Regarding meningioma no consistent pattern of an increased risk was found. Concerning age, highest risk was found in the age group <20 years at time of first use of wireless phones in the studies from the Hardell group. For salivary gland tumors, non-Hodgkin lymphoma and testicular cancer no consistent pattern of an association with use of wireless phones was found. One study on uveal melanoma yielded for probable/certain mobile phone use OR = 4.2, 95% CI = 1.2–14.5. One study on intratemporal facial nerve tumor was not possible to evaluate due to methodological shortcomings. In summary our review yielded a consistent pattern of an increased risk for glioma and acoustic neuroma after >10 year mobile phone use. We conclude that current standard for exposure to microwaves during mobile phone use is not safe for long-term exposure and needs to be revised.

Mobile phone base stations-Effects on wellbeing and health. Kundi, M. and H-P Hutter. pp 123-135.

Abstract

Studying effects of mobile phone base station signals on health have been discouraged by authoritative bodies like WHO International EMF Project and COST 281. WHO recommended studies around base stations in 2003 but again stated in 2006 that studies on cancer in relation to base station exposure are of low priority. As a result only few investigations of effects of base station exposure on health and wellbeing exist. Cross-sectional investigations of subjective health as a function of distance or measured field strength, despite differences in methods and robustness of study design, found indications for an effect of exposure that is likely independent of concerns and attributions. Experimental studies applying short-term exposure to base station signals gave various results, but there is weak evidence that UMTS and to a lesser degree GSM signals reduce wellbeing in persons that report to be sensitive to such exposures. Two ecological studies of cancer in the vicinity of base stations report both a strong increase of incidence within a radius of 350 and 400 m respectively. Due to the limitations inherent in this design no firm conclusions can be drawn, but the results underline the urgent need for a

comprehensive investigation of this issue. Animal and in vitro studies are inconclusive to date. An increased incidence of DMBA induced mammary tumors in rats at a SAR of 1.4 W/kg in one experiment could not be replicated in a second trial. Indications of oxidative stress after low-level in vivo exposure of rats could not be supported by in vitro studies of human fibroblasts and glioblastoma cells.

From available evidence it is impossible to delineate a threshold below which no effect occurs, however, given the fact that studies reporting low exposure were invariably negative it is suggested that power densities around 0.5–1 mW/m² must be exceeded in order to observe an effect. The meager data base must be extended in the coming years. The difficulties of investigating long-term effects of base station exposure have been exaggerated, considering that base station and handset exposure have almost nothing in common both needs to be studied independently. It cannot be accepted that studying base stations is postponed until there is firm evidence for mobile phones.

Estimating the risk of brain tumors from cellphone use: Published case-control studies.
Morgan, L. pp 137-147.

Abstract

This paper reviews the results of early cellphone studies, where exposure duration was too short to expect tumorigenesis, as well as two sets of more recent studies with longer exposure duration: the Interphone studies and the Swedish studies led by Dr. Lennart Hardell. The recent studies reach very different conclusions. With four exceptions the industry-funded Interphone studies found no increased risk of brain tumors from cellphone use, while the Swedish studies, independent of industry funding, reported numerous findings of significant increased brain tumor risk from cellphone and cordless phone use. An analysis of the data from the Interphone studies suggests that either the use of a cellphone *protects* the user from a brain tumor, or the studies had serious design flaws. Eleven flaws are identified: (1) selection bias, (2) insufficient latency time, (3) definition of 'regular' cellphone user, (4) exclusion of young adults and children, (5) brain tumor risk from cellphones radiating higher power levels in rural areas were not investigated, (6) exposure to other transmitting sources are excluded, (7) exclusion of brain tumor types, (8) tumors outside the cellphone radiation plume are treated as exposed, (9) exclusion of brain tumor cases because of death or illness, (10) recall accuracy of cellphone use, and (11) funding bias. The Interphone studies have all 11 flaws, and the Swedish studies have 3 flaws (8, 9 and 10). The data from the Swedish studies are consistent with what would be expected if cellphone use were a risk for brain tumors, while the Interphone studies data are incredulous. If a risk does exist, the public health cost will be large. These are the circumstances where application of the Precautionary Principle is indicated, especially if low-cost options could reduce the absorbed cellphone radiation by several orders of magnitude.

EMF IN THE ENVIRONMENT

Long-term exposure to magnetic fields and the risks of Alzheimer's disease and breast cancer: Further biological research. Davanipour, Z and E. Sobel. pp 149-156.

Abstract

Objective: Extremely low frequency (ELF) and radio frequency (RF) magnetic fields (MFs) pervade our environment. Whether or not these magnetic fields are associated with increased risk of serious diseases, e.g., cancers and Alzheimer's disease, is thus important when developing a rational public policy. The Bioinitiative Report was an effort by internationally recognized scientists who have spent significant time investigating the biological consequences of exposures to these magnetic fields to address this question. Our objective was to provide an unbiased review of the current knowledge and to provide our general and specific conclusions.

Results: The evidence indicates that long-term significant occupational exposure to ELF MF may certainly increase the risk of both Alzheimer's disease and breast cancer. There is now evidence that two relevant biological processes (increased production of amyloid beta and decreased production of melatonin) are influenced by high long-term ELF MF exposure that may lead to Alzheimer's disease. There is further evidence that one of these biological processes (decreased melatonin production) may also lead to breast cancer. Finally, there is evidence that exposures to RF MF and ELF MF have similar biological consequences. **Conclusion:** It is important to mitigate ELF and RF MF exposures through equipment design changes and environmental placement of electrical equipment, e.g., AC/DC transformers. Further research related to these proposed and other biological processes is required.

Disturbances of the immune system by electromagnetic fields-A potentially underlying cause for cellular damage and tissue repair reduction which could lead to disease and impairment. Johansson, O. pp 157-177.

Abstract

A number of papers dealing with the effects of modern, man-made electromagnetic fields (EMFs) on the immune system are summarized in the present review. EMFs disturb immune function through stimulation of various allergic and inflammatory responses, as well as effects on tissue repair processes. Such disturbances increase the risks for various diseases, including cancer. These and the EMF effects on other biological processes (e.g. DNA damage, neurological effects, etc.) are now widely reported to occur at exposure levels significantly below most current national and international safety limits. Obviously, biologically based exposure standards are needed to prevent disruption of normal body processes and potential adverse health effects of chronic exposure.

Based on this review, as well as the reviews in the recent Bioinitiative Report [<http://www.bioinitiative.org/>] [C.F. Blackman, M. Blank, M. Kundi, C. Sage, D.O. Carpenter, Z. Davanipour, D. Gee, L. Hardell, O. Johansson, H. Lai, K.H. Mild, A. Sage, E.L. Sobel, Z. Xu, G. Chen, The Bioinitiative Report—A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF), 2007)], it must be concluded that the existing public safety limits are inadequate to protect public health, and that new public safety limits, as well as limits on further deployment of untested technologies, are warranted.

Reproductive and developmental effects of EMF in vertebrate animal models. Pourtis, AF. pp 179-189.

Abstract

This paper reviews the literature data on the effects of electromagnetic fields (EMF), in the reproductive organs as well as in prenatal and postnatal development of vertebrate animals. Review articles which have been published till 2001, regarding the reproductive and developmental effects of the entire range of frequency of electromagnetic fields, were surveyed. Experimental studies which were published from 2001 onwards were summarized. Special focus on the effects of radiofrequencies related to mobile communication in the above mentioned topics has been made. According to the majority of the investigations, no strong effects resulted regarding the exposure to EMF of mobile telephony in the animal reproduction and development. However further research should be done in order to clarify many unknown aspects of the impact of EMF in the living organisms.

Electromagnetic pollution from phone masts. Effects on wildlife. Balmori, A. pp 191-199.

Abstract

A review on the impact of radiofrequency radiation from wireless telecommunications on wildlife is presented. Electromagnetic radiation is a form of environmental pollution which may hurt wildlife. Phone masts located in their living areas are irradiating continuously some species that could suffer long-term effects, like reduction of their natural defenses, deterioration of their health, problems in reproduction and reduction of their useful territory through habitat deterioration. Electromagnetic radiation can exert an aversive behavioral response in rats, bats and birds such as sparrows. Therefore microwave and radiofrequency pollution constitutes a potential cause for the decline of animal populations and deterioration of health of plants living near phone masts. To measure these effects urgent specific studies are necessary.

FM-radio and TV tower signals can cause spontaneous hand movements near moving RF reflector. Huttunen, P., O. Hanninen, and R. Myllyla. pp 201-204.

Abstract

For testing human sensitivity to radio frequency (RF) standing waves a movable reflecting wall was constructed. Radio waves from the radio-TV tower reflected back and formed a standing wave near the reflector. When the reflector was moved, the position of the maximums of the standing waves changed and the electromagnetic intensity changed in the body of the standing test subject. The computer with an AD-converter registered the signals of the hand movement transducer and the RF-meter with 100 MHz dipole antennas. A total of 29 adults of different ages were tested. There were 9 persons whose hand movement graphs included features like the RF-meter. Six showed responses that did not correlate with the RF-meter. There were also 14 persons who did not react at all. Sensitive persons seem to react to crossing standing waves of the FM-radio or TV broadcasting signals.

Cell phone radiation: Evidence from ELF and RF studies supporting more inclusive risk identification and assessment. Blackman, C. pp 205-216.

Abstract

Many national and international exposure standards for maximum radiation exposure from the use of cell phone and other similar portable devices are ultimately based on the production of heat particularly in regions of the head, that is, thermal effects (TE). The recent elevation in

some countries of the allowable exposure, that is, averaging the exposure that occurs in a 6 min period over 10 g of tissue rather than over 1 g allows for greater heating in small portions of the 10-g volume compared to the exposure that would be allowed averaged over 1-g volume. There is concern that ‘hot’ spots, that is, momentary higher intensities, could occur in portions of the 10-g tissue piece, might have adverse consequences, particularly in brain tissue.

There is another concern about exposure to cell phone radiation that has been virtually ignored except for the National Council of Radiation Protection and Measurements (NCRP) advice given in a publication in 1986 [National Council for Radiation Protection and Measurements, Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields, National Council for Radiation Protection and Measurements, 1986, 400 pp.]. This NCRP review and guidance explicitly acknowledge the existence of non-thermal effects (NTE), and included provisions for reduced maximum-allowable limits should certain radiation characteristics occur during the exposure.

If we are to take most current national and international exposure standards as completely protective of thermal injury for acute exposure only (6 min time period) then the recent evidence from epidemiological studies associating increases in brain and head cancers with increased cell phone use per day and per year over 8–12 years, raises concerns about the possible health consequences on NTE first acknowledged in the NCRP 1986 report [National Council for Radiation Protection and Measurements, Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields, National Council for Radiation Protection and Measurements, 1986, 400 pp.].

This paper will review some of the salient evidence that demonstrates the existence of NTE and the exposure complexities that must be considered and understood to provide appropriate, more thorough evaluation and guidance for future studies and for assessment of potential health consequences. Unfortunately, this paper is necessary because most national and international reviews of the research area since the 1986 report [National Council for Radiation Protection and Measurements, Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields, National Council for Radiation Protection and Measurements, 1986, 400 pp.] have not included scientists with expertise in NTE, or given appropriate attention to their requests to include NTE in the establishment of public-health-based radiation exposure standards. Thus, those standards are limited because they are not comprehensive.

SCIENCE AS A GUIDE TO PUBLIC POLICY

Late Lessons from Early Warnings: Towards realism and precaution with EMF? Gee, D. pp 217-231

Abstract

The histories of some well-known public and environmental hazards, from the first scientifically based early warnings about potential harm, to the subsequent precautionary and preventive measures, have been reviewed by the European Environment Agency in their report “Late Lessons from Early Warnings: The Precautionary Principle 1896–2000”. This paper summarises some of the definitional and other issues that arise from the report and subsequent

debates, such as the contingent nature of knowledge; the definitions of precaution, prevention, risk, uncertainty, and ignorance; the use of different strengths of evidence for different purposes; the nature and main direction of the methodological and cultural biases within the environmental health sciences; the need for transparency in evaluating risks; and public participation in risk analysis. These issues are relevant to the risk assessment of electromagnetic fields (EMF). Some implications of these issues and of the “late lessons” for the evaluation and reduction of risks from EMF are indicated.

Public Health implications of wireless technologies. Sage, C., and DO Carpenter. pp 23-246.

Abstract

Global exposures to emerging wireless technologies from applications including mobile phones, cordless phones, DECT phones, WI-FI, WLAN, WiMAX, wireless internet, baby monitors, and others may present serious public health consequences. Evidence supporting a public health risk is documented in the BioInitiative Report. New, biologically based public exposure standards for chronic exposure to low-intensity exposures are warranted. Existing safety standards are obsolete because they are based solely on thermal effects from acute exposures. The rapidly expanding development of new wireless technologies and the long latency for the development of such serious diseases as brain cancers means that failure to take immediate action to reduce risks may result in an epidemic of potentially fatal diseases in the future. Regardless of whether or not the associations are causal, the strengths of the associations are sufficiently strong that in the opinion of the authors, taking action to reduce exposures is imperative, especially for the fetus and children. Such action is fully compatible with the precautionary principle, as enunciated by the Rio Declaration, the European Constitution Principle on Health (Section 3.1) and the European Union Treaties Article 174.