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David Vela, Superintendent
Grand Teton National Park
John D. Rockefeller, Jr. Memorial Parkway

Re: Telecommunications Infrastructure Plan EA

Dear Mr. Vela & National Park Staff,

Environmental Health Trust (EHT) is a nonprofit Think Tank and policy organization dedicated to identifying and reducing environmental health hazards. EHT provides independent scientific research and advice on controllable environmental hazards to local, state and national governments. Today, we write to advise you of scientific grounds for major health and environmental concerns about the proposal for the installation of wireless telecommunications facilities and associated infrastructure at nine developed areas in the park and to express our grave concerns about this planned expansion of mobile communications in Grand Teton National Park. You may recall your discussions last year with me about the need to limit exposures to wildlife and fauna from wireless radiation that took place when we met as part of the City Kids final ascent of the Grand.

We fully recognize there is a need for communication for emergency purposes. We further recognize that the Park plays a unique role in our country and in our lives by providing a wilderness that is apart from the normal hectic life that many Americans lead today. We are deeply concerned that by expanding wireless communications this proposal will irrevocably impair the wilderness experience and that there are wired solutions that would be far less damaging.

The transmissions to and from these proposed microwave wireless installations will be emissions that are an environmental pollutant known to cause cancer (in both experimental animals and humans) and other adverse health and environmental effects (e.g., on birds, bees, trees) according to internationally recognized authoritative research, including studies conducted by the U.S. National Toxicology Program, which is the nation's premiere testing program.

In light of the scientific documentation showing harmful effects, EHT writes today to advise regarding technical scientific information on impacts to human health, wildlife and the environment, explaining why more than 240 expert scientists are calling for immediate reductions in exposures to microwave wireless radiation.

Documented Impacts to Wildlife and the Environment

We would like to make you aware that there is growing literature showing the adverse impacts of microwave radiation on animal and bird behavior and physiology, as well as plants and trees. As the Natural Resources Defense Council and the Public Employees for Environmental Responsibility have argued, an environmental impact assessment should be performed before building these networks. Peer-reviewed research links EMF emissions to

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myriad adverse environmental and health effects. Environmental effects include disruptions to reproduction, development, orientation, and migration of animals,[1], and damage to plants and crops.[2]

Albert Manville, former U.S. Fish and Wildlife Service agency lead on avian-structural impacts, wrote "A BRIEFING MEMORANDUM: What We Know, Can Infer, and Don't Yet Know about Impacts from Thermal and Non-thermal Non-ionizing Radiation to Birds and Other Wildlife" [3] documenting the body of research and concluding:

> "There is an increasing body of published laboratory research that finds DNA damage at low intensity exposures — well below levels of thermal heating — which may be comparable to far field exposures from cell antennas. This body of work would apply to all species, including migratory birds, since DNA is DNA, whether single-strand or double helix. The first study to find such effects was conducted by H. Lai and N.P. Singh in 1995 (Lai and Singh 1995). Their work has since been replicated (e.g., Lai and Singh 1996, as well as in hundreds of other more recent published studies), performed in at least 14 laboratories worldwide. The take-home message: low level transmission of EMF from cell towers and other sources probably causes DNA damage. The laboratory research findings strongly infer this relationship. Since DNA is the primary building block and genetic "map" for the very growth, production, replication and survival of all living organisms, deleterious effects can be critical."

Please note the following published research studies.

- "A review of the ecological effects of RF-EMF" 2013 review of 113 published studies found in 65% of the studies (50% of the animal studies and about 75% of the plant studies) RF-EMF had a significant effect on birds, insects, other vertebrates, other organisms and plants (Cucurachi 2013). The review paper cites development and reproduction in birds and insects as the most strongly affected endpoints.[4]

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[1] See, e.g., Kimmel, Stefan, et al. "Electromagnetic radiation: influences on honeybees (Apis mellifera)." *IIAS-InterSymp Conference*, 2007 (finding that 39.7% of the non-irradiated bees had returned to their hives compared to only 7.3% of the irradiated bees); Cucurachi, C., et al. "A review of the ecological effects of radiofrequency electromagnetic fields (RF-EME)." *Environment International*, vol. 51, 2013, pp. 116–40; "Briefing Paper on the Need for Research into the Cumulative Impacts of Communication Towers on Migratory Birds and Other Wildlife in the United States." *Division of Migratory Bird Management (DMBM)*, U.S. Fish & Wildlife Service, 2009; Balmori, A. "Mobile phone mast effects on common frog (Rana temporaria) tadpoles." *Electromagnetic Biology and Medicine*, vol. 29, no. 1-2, 2010, pp. 31-5; Harkless, Ryan, Muntather Al-Quraishi and Mary C. Vagula. "Radiation hazards of radio frequency waves on the early embryonic development of Zebrafish." *SPIE Proceedings*, vol. 9112, 2014.

[2] See, e.g., Waldmann-Selsam, C., et al. "Radiofrequency radiation injures trees around mobile phone base stations." Science of the Total Environment, vol. 572, 2016, pp. 554-69; Halgamuge, M.N. "Weak radiofrequency radiation exposure from mobile phone radiation on plants." Electromagnetic Biology and Medicine, vol. 36, no. 2, 2017, pp. 213-235; Halgamuge, Malka N., See Kye Yak and Jacob L. Eberhardt. "Reduced growth of soybean seedlings after exposure to weak microwave radiation from GSM 900 mobile phone and base station." *Bioelectromagnetics*, vol. 36, no. 2, 2015, pp. 87-95; Haggerty, Katie. "Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings." International Journal of Forestry Research, vol 2010, no. 836278, 2010.

[3] Manville, Albert M. "A BRIEFING MEMORANDUM: What We Know, Can Infer, and Don't Yet Know about Impacts from Thermal and Non-thermal Non-ionizing Radiation to Birds and Other Wildlife." *Wildlife and Habitat Conservation Solutions*, 2014.

[4] S. Cucurachi, W.L.M. Tamis, M.G. Vijver, W.J.G.M. Peijnenburg, J.F.B. Bolte, G.R. de Snoo, A review of the ecological effects of radiofrequency electromagnetic fields (RF-EMF), Environment International, Volume 51, 2013, Pages 116-140, ISSN 0160-4120, doi.org/10.1016/j.envint.2012.10.009.

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- A 2012 Review "Impacts of radio-frequency electromagnetic field (RF-EMF) from cell phone towers and wireless devices on biosystem and ecosystem – A Review" on 919 research papers found 593 showed impacts, 180 showed no impacts, and 196 were inconclusive studies."[5]
- Studies on bees have found behavioral effects (Kumar 2011[6], Favre 2011[7]), disrupted navigation Goldsworthy 2009[8], Sainudeen 2011[9], Kimmel et al. 2007[10]), decreasing egg-laying rate (Sharma and Kumar, 2010[11]) and reduced colony strength after RF exposures (Sharma and Kumar, 2010, Harst et al. 2006[12]).
- A study focusing on RF from cellular antennas found increased sperm abnormalities in mice exposed to RF from GSM antennas (Otitoloju 2010).[13]
- "Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz" published in Scientific Reports is the first study to investigate how insects (including the Western honeybee) absorb the higher frequencies (2 GHz to 120 GHz) to be used in the 4G/5G rollout. The scientific simulations showed increases in absorbed power between 3% to 370% when the insects were exposed to the frequencies. Researchers concluded, "This could lead to changes in insect behavior, physiology, and morphology over time…."[14]
- Researchers published a study on frogs in Electromagnetic Biology and Medicine exposing eggs and tadpoles to electromagnetic radiation from cell phone antennas for two months, from the egg phase until an advanced phase of tadpole and found low coordination of movements, an asynchronous growth, resulting in both big and small tadpoles, and a high mortality rate. The authors conclude, "these results indicate that radiation emitted by phone masts in a real situation may affect the development and may cause an increase in mortality of exposed tadpoles."[15]

We also want to bring your attention to the growing body of literature showing the impacts on trees and plants. Here again, experimental literature has found that rhizomes, nitrification and other critical processes to plant growth and health are affected by cell phone like radiation under controlled conditions. There have been over one hundred studies that have shown this and most recently a field study[16] that showed under controlled conditions, trees that are

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[5] S Sivani*, D Sudarsanam, Impacts of radio-frequency electromagnetic field (RF-EMF) from cell phone towers and wireless devices on biosystem and ecosystem – a review, Biology and Medicine, 4 (4): 202–216, 2012.
[6] Kumar, N. R., Sangwan, S., & Badotra, P. (2011). Exposure to cell phone radiations produces biochemical changes in worker honey bees. *Toxicology international*, *18*(1), 70–72. doi:10.4103/0971-6580.75869.
[7] Favre, D. Apidologie, Mobile phone-induced honeybee worker piping, (2011) 42: 270. doi.org/10.1007/s13592-011-0016-x.
[8] Dr. Andrew Goldsworthy, The Birds, the Bees and Electromagnetic Pollution, May 2009.
[9] Sainudeen Sahib.S, Electromagnetic Radiation (EMR) Clashes with Honey Bees, *International Journal of Environmental Sciences*, Volume 1, No 5, 2011.
[10] Kimmel, Stefan, et. al, Electromagnetic Radiation: Influences on Honeybees (Apis mellifera), 2007.
[11] Ved Parkash Sharma, Neelima R. Kumar, Changes in honeybee behaviour and biology under the influence of cellphone radiations, *Current Science*, Vol. 98, No. 10, 25 May 2010.
[12] Wolfgang Harst, Jochen Kuhn, & Hermann Stever, Can Electromagnetic Exposure Cause a Change in Behaviour? Studying Possible Non-Thermal Influences on Honey Bees – An Approach within the Framework of Educational Informatics, 2006.
[13] Otitoloju, A.A., Obe, I.A., Adewale, O.A. et al., Preliminary study on the induction of sperm head abnormalities in mice, Mus musculus, exposed to radiofrequency radiations from global system for mobile communication base stations. Bull Environ Contam Toxicol (2010) 84: 51. doi.org/10.1007/s00128-009-9894-2.
[14] Thielens, A., Bell, D., Mortimore, D. B., Greco, M. K., Martens, L., & Joseph, W. (2018). Exposure of Insects to Radio-Frequency Electromagnetic Fields from 2 to 120 GHz. *Scientific Reports*, *8*(1), 3924. https://doi.org/10.1038/s41598-018-22271-3.
[15] Balmori A. Mobile phone mast effects on common frog (Rana temporaria) tadpoles: the city turned into a laboratory. Electromagn Biol Med. 2010 Jun;29(1-2) 31-35. doi:10.3109/15368371003685363. PMID: 20560769.
[16] Cornelia Waldmann-Selsam, Alfonso Balmori-de la Puente, Helmut Breunig, Alfonso Balmori,

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closer to cell phone towers start to die more readily; and this can be seen if one looks at the branches of the trees closest to the antennae of the cell phone tower with the fake tree at the Stilson parking lot off Hwy 390.

Please note these published studies:

- A field monitoring study spanning 9 years involving over 100 trees (Waldmann-Selsam 2016)[17] found trees sustained significantly more damage on the side of the tree facing the antenna, leaving the entire tree system prone to degradation over time. Documentation of tree damage from base stations is made visible in the Report "Tree Damage Caused by Mobile phone base stations" (Breunig, 2017).[18]
- A study on Aspen trees near Lyons, Colorado entitled "Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings " published in the *International Journal of Forestry* found adverse effects on growth rate and fall anthocyanin production concluding that, "results of this preliminary experiment indicate that the RF background may be adversely affecting leaf and shoot growth and inhibiting fall production of anthocyanins associated with leaf senescence in trembling aspen seedlings. These effects suggest that exposure to the RF background may be an underlying factor in the recent rapid decline of aspen populations. Further studies are underway to test this hypothesis in a more rigorous way."[19]
- An analysis of 45 peer-reviewed scientific publications (1996-2016) on changes in plants due to the non-thermal RF-EMF effects from mobile phone radiation entitled "Weak radiofrequency radiation exposure from mobile phone radiation on plants concludes, "Our analysis demonstrates that the data from a substantial amount of the studies on RF-EMFs from mobile phones show physiological and/or morphological effects (89.9%, $p < 0.001$). Additionally, our analysis of the results from these reported studies demonstrates that the maize, roselle, pea, fenugreek, duckweeds, tomato, onions and mungbean plants seem to be very sensitive to RF-EMFs. Our findings also suggest that plants seem to be more responsive to certain frequencies…"[20]

Electromagnetic Fields Alter Animal and Insect Orientation

Science of the Total Environment published environmental scientist Alforso Balmori's "Anthropogenic radiofrequency electromagnetic fields as an emerging threat to wildlife orientation," which states, "Current evidence indicates that exposure at levels that are found in the environment (in urban areas and near base stations) may particularly alter the receptor organs to orient in the magnetic field of the earth. These results could have important implications for migratory birds and insects, especially in urban areas, but could also apply to birds and insects in

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Radiofrequency radiation injures trees around mobile phone base stations, Science of The Total Environment, Volume 572, 2016, Pages 554-569, ISSN 0048-9697, doi.org/10.1016/j.scitotenv.2016.08.045.

[17] Cornelia Waldmann-Selsam, Alfonso Balmori-de la Puente, Helmut Breunig, Alfonso Balmori, Radiofrequency radiation injures trees around mobile phone base stations, *Science of The Total Environment*, Volume 572, 2016, Pages 554-569, ISSN 0048-9697, doi.org/10.1016/j.scitotenv.2016.08.045.

[18] Breunig, Helmut,Tree damage caused by mobile phone base stations An observation guide, 2017.

[19] Katie Haggerty, "Adverse Influence of Radio Frequency Background on Trembling Aspen Seedlings: Preliminary Observations," *International Journal of Forestry Research*, vol. 2010, Article ID 836278, 7 pages, 2010. doi.org/10.1155/2010/836278.

[20] Malka N. Halgamuge (2017) Review: Weak radiofrequency radiation exposure from mobile phone radiation on plants, *Electromagnetic Biology and Medicine*, 36:2, 213-235, DOI: 10.1080/15368378.2016.1220389.

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natural and protected areas where there are powerful base station emitters of radiofrequencies. Therefore, more research on the effects of electromagnetic radiation in nature is needed to investigate this emerging threat." [21]

Multiple research studies have documented how animals magnetoreception can be disrupted by external electromagnetic fields from mice[22] to cows to dogs to birds.[23] Electromagnetic exposure is especially disruptive to migratory birds.[24] Electromagnetic fields have been shown to disrupt the magnetic compass orientation used by birds to navigate.[25,26] Researchers have suggested this disruption of magnetoreception is due to cryptochrome photoreceptors that allow birds to use built-in receptors as a biological compass.

In 2012 the government of India's Ministry of the Environment and Forest issued a report on the potential impacts of communication towers on wildlife, citing hundreds of research studies that found adverse effects. Recommendations from the Ministry include, "Introduce a law for protection of urban flora and fauna from emerging threats like ERM/EMF as conservation issues in urban areas are different from forested or wildlife habitats."[27]

A 2017 report to UNESCO[28] by botanist Mark Broomhall details the association between increasing amounts of electromagnetic radiation from cellular antennas on the Mt. Nardi tower complex and species disappearance and exodus from the Mt. Nardi area of the Nightcap National Park World Heritage Area during a 15-year period (2000-2015). He estimates "in both volume and species that from 70 to 90 % of the wildlife has become rare or has disappeared from the Nightcap National Park within a radius of the Mt. Nardi tower complex. This statement can be summarised with concrete data: 3 bat species once common have become rare or gone, 11 threatened and endangered bird species are gone, 11 migratory bird species are gone, 86 bird species are demonstrating unnatural behaviours, 66 once common bird species are now rare or gone." The Report concludes, "With these short explanations of events we can appreciate that the effects of this technology and its application on Mt. Nardi over the last fifteen years, affect not only the top of the life chain species but they are devastating the fabric of the continuity of the World Heritage, causing genetic deterioration in an insidious, massive and ever escalating scale. To truly understand what these studies reveal is to stare into the abyss."

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[21] Alfonso Balmori, Anthropogenic radiofrequency electromagnetic fields as an emerging threat to wildlife orientation, *Science of The Total Environment*, Volumes 518–519, 2015, Pages 58-60, ISSN 0048-9697, doi.org/10.1016/j.scitotenv.2015.02.077.

[22] Malkemper, E.P., et al. "Magnetoreception in the wood mouse (Apodemus sylvaticus): influence of weak frequency-modulated radio frequency fields." *Scientific Reports*, vol. 4, no. 9917, 2015.

[23] Wiltschko Roswitha, Thalau Peter, Gehring Dennis, Nießner Christine, Ritz Thorsten, Wiltschko Wolfgang. Magnetoreception in birds: the effect of radio-frequency fields.12. *Journal of The Royal Society Interface*.

[24] Engels, Svenja, et al. "Anthropogenic electromagnetic noise disrupts magnetic compass orientation in a migratory bird." *Nature* 509.7500 (2014): 353-356.

[25] Wiltschko, Roswitha, et al. "Magnetoreception in birds: the effect of radio-frequency fields." *Journal of The Royal Society Interface* 12.103 (2015): 20141103.

[26] Schwarze, S.,, et al. "Weak Broadband Electromagnetic Fields are More Disruptive to Magnetic Compass Orientation in a Night-Migratory Songbird (Erithacus rubecula) than Strong Narrow-Band Fields." *Front Behav Neurosci*. 10.55 (2016).

[27] Expert Committee, Ministry of Environment and Forest, Government of India, Report on Possible Impacts of Communication Towers on Wildlife Including Birds and Bees, Constituted on 30th August, 2010.

[28] Broomhall, Mark. "Report detailing the exodus of species from the Mt. Nardi area of the Nightcap National Park World Heritage Area during a 15-year period (2000-2015.)" United Nations Scientific and Cultural Organization (2017).

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It is very important that in considering antenna placement, there be a full environmental assessment on migratory animal patterns (from the smallest to the largest) and not simply on birds and mammals like the pronghorn but also on impacts to amphibians and insects.

Wireless Radiation is Known to Harm Humans and Wildlife

Human health effects include impaired reproduction, increased incidence of brain cancer, DNA breaks, oxidative stress and immune dysfunction, altered brain development, sleep changes, hyperactivity, and memory and cognitive problems.[29] Since the WHO/IARC classified EMF as a Group 2B Possible Carcinogen in 2011, the peer-reviewed research connecting wireless exposure to cancer has significantly strengthened and several scientists have published documentation that the weight of current peer-reviewed evidence supports the conclusion that radiofrequency radiation should be regarded as a human carcinogen.[30,31,32]

- The 10 year $30 million National Institute of Environmental Health Sciences National Toxicology Program's (NTP) Studies of the Toxicology and Carcinogenicity of Cell Phone Radiation[33,34] found that RFR was associated with "clear evidence" of cancer due to the increased malignant schwannomas found in RFR-exposed male rats. The brain (glioma) cancers and tumors in the adrenal glands were also considered evidence of an association with cancer. In addition, exposed animals had significantly more DNA damage, heart damage, and low birth weight.
- The Ramazzini Institute published its findings[35] that animals exposed to very low-level RFR developed the same types of cancers as reported by the NTP.
- Long-term research on humans who have used cell phones has found increased tumors—schwannomas and glioblastomas—the same cell type as found in the NTP and Ramazzini Institute studies. Persons who started using cell phones under age 20 had the highest risk.[36]
- A 2015 Jacobs University study (replicating a 2010 study) found that weak cell phone signals significantly promote the growth of tumors in mice and that combining a toxic chemical exposure with RF more than doubled the tumor response.[37,38]

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[29] For more information on acute health symptoms, see, e.g., Martin Pall, Microwave Frequency Electromagnetic Fields (EMFs) Produce Widespread Neuropsychiatric Effects Including Depression, 75 *J. Chemical Neuroanatomy* 43-51 (Sept. 2016); Response of residents living in the vicinity of a cellular phone base station in France ; Electromagnetic Fields: A Hazard to Your Health?, Healthy Children.

[30] Adams, Jessica A., et al. "Effect of mobile telephones on sperm quality: a systematic review and meta-analysis." *Environment International,* 70, 2014, pp. 106-112.

[31] Deshmukh, P.S., et al. "Cognitive impairment and neurogenotoxic effects in rats exposed to low-intensity microwave radiation." *International Journal of Toxicology*, vol. 34, no. 3, 2015, pp. 284-90.

[32] Aldad, T.S., et al. "Fetal Radiofrequency Radiation Exposure From 800-1900 MHz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice." *Scientific Reports,* vol. 2, no. 312, 2012.

[33] National Toxicology Program, Cell Phone Radio Frequency Radiation

[34] High exposure to radio frequency radiation associated with cancer in male rats

[35] L. Falcioni, L. Bua, E. Tibaldi, M. Lauriola, L. De Angelis, F. Gnudi, D. Mandrioli, M. Manservigi, F. Manservisi, I. Manzoli, I. Menghetti, R. Montella, S. Panzacchi, D. Sgargi, V. Strollo, A. Vornoli, F. Belpoggi, Report of final results regarding brain and heart tumors in Sprague-Dawley rats exposed from prenatal life until natural death to mobile phone radiofrequency field representative of a 1.8 GHz GSM base station environmental emission, *Environmental Research*, Volume 165, 2018, Pages 496-503, ISSN 0013-9351, doi.org/10.1016/j.envres.2018.01.037.

[36] https://www.pathophysiologyjournal.com/article/S0928-4680(14)00064-9/fulltext

[37] Lerchl, Alexander, et al. "Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans." *Biochemical and Biophysical Research Communications,* vol. 459, no. 4, 2015, pp. 585-90.

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- "5G wireless telecommunications expansion: Public health and environmental implications," is a research review published in Environmental Research, which documents the range of adverse effects reported in the published literature from cancer to bacteria growth changes to DNA damage and concludes that "a moratorium on the deployment of 5G is warranted" and "the addition of this added high-frequency 5G radiation to an already complex mix of lower frequencies, will contribute to a negative public health outcome both from both physical and mental health perspectives."[39]
- A study published in Electromagnetic Biology and Medicine, "Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base station," compared people living close and far from a cell antennas and found that people living closer to cellular antennas had higher radiation levels in the homes and several significant changes in their blood predictive of cancer development."[40]
- A 2019 study of students in schools near cell towers found their higher RF exposure was associated with impacts on motor skills, memory and attention (Meo 2019).[41] Examples of other effects linked to cell towers in research studies include neuropsychiatric problems[42], elevated diabetes[43], headaches[44], sleep problems[45] and genetic damage[46]. Such research continues to accumulate after the 2010 landmark review study on 56 studies that reported biological effects found at very low intensities, including impacts on reproduction, permeability of the blood-brain barrier, behavior, cellular and metabolic changes, and increases in cancer risk (Lai and Levitt 2010).[47]
- Published research has found impacts from wireless radiation exposure to reproduction and brain development in addition to a myriad of other adverse effects.[48,49,50,51] Although renowned institutions, such

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[38] Tillmann, Thomas, et al. "Indication of cocarcinogenic potential of chronic UMTS-modulated radiofrequency exposure in an ethylnitrosourea mouse model." *International Journal of Radiation Biology,* vol. 86, no. 7, 2010, pp. 529-41.

[39] https://doi.org/10.1016/j.envres.2018.01.016

[40] Zothansiama & Zosangzuali, Mary & Lalramdinpuii, Miriam & Jagetia, Ganesh & Siama, Zothan. (2017). Impact of radiofrequency radiation on DNA damage and antioxidants in peripheral blood lymphocytes of humans residing in the vicinity of mobile phone base stations. Electromagnetic Biology and Medicine. 36. 1-11. 10.1080/15368378.2017.1350584.

[41] Meo, S. A., Almahmoud, M., Alsultan, Q., Alotaibi, N., Alnajashi, I., & Hajjar, W. M. (2019). Mobile Phone Base Station Tower Settings Adjacent to School Buildings: Impact on Students' Cognitive Health. *American Journal of Men's Health*. doi.org/10.1177/1557988318816914.

[42] G. Abdel-Rassoul, O. Abou El-Fateh, M. Abou Salem, A. Michael, F. Farahat, M. El-Batanouny, E. Salem, Neurobehavioral effects among inhabitants around mobile phone base stations, NeuroToxicology, Volume 28, Issue 2, 2007, Pages 434-440, ISSN 0161-813X, doi.org/10.1016/j.neuro.2006.07.012.

[43] SA, Meo & Alsubaie, Yazeed & Almubarak, Zaid & Almutawa, Hisham & AlQasem, Yazeed & Hasanato, Rana. (2015). Association of Exposure to Radio-Frequency Electromagnetic Field Radiation (RF-EMFR) Generated by Mobile Phone Base Stations with Glycated Hemoglobin (HbA1c) and Risk of Type 2 Diabetes Mellitus. International Journal of Environmental Research and Public Health. 12. 14519-14528;. 10.3390/ijerph121114519.

[44] Hutter, H. P., Moshammer, H., Wallner, P., & Kundi, M. (2006). Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. *Occupational and environmental medicine*, *63*(5), 307–313. doi:10.1136/oem.2005.020784.

[45] R. Santini, P. Santini, J.M. Danze, P. Le Ruz, M. Seigne, Enquête sur la santé de riverains de stations relais de téléphonie mobile: I/Incidences de la distance et du sexe, Pathologie Biologie, Volume 50, Issue 6, 2002, Pages 369-373, ISSN 0369-8114, doi.org/10.1016/S0369-8114(02)00311-5.

[46] Gursatej Gandhi, Gurpreet Kaur & Uzma Nisar (2015) A cross-sectional case control study on genetic damage in individuals residing in the vicinity of a mobile phone base station, Electromagnetic Biology and Medicine, 34:4,344-354, DOI: 10.3109/15368378.2014.933349.

[47] B. Blake Levitt and Henry Lai, Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays, Environ. Rev. Downloaded from www.nrcresearchpress.com by 172.58.41.200 on 04/10/19

[48] Adams, Jessica A., et al. "Effect of mobile telephones on sperm quality: a systematic review and meta-analysis." *Environment International,* 70, 2014, pp. 106-112.

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as the Cleveland Clinic, advise men to keep phones and wireless devices away from their reproductive organs, the public remains largely unaware.

Once the towers are erected they will be upgraded over time with new antennas and soon 5G technology. 5G would use today's wireless frequencies while adding new, higher frequencies to transmit data at faster speeds. These higher frequency millimeter waves uniquely penetrate the eyes and skin,[52,20,21,22] and have been shown to accelerate bacterial and viral cell growth.[53] Millimeter waves were originally developed as a military weapon to create the sensation that the skin is burning.[54] Currently accepted standards are not sophisticated enough to measure effects on sweat glands or quantify the risks of cumulative exposure.[55,56]Any future applications of these technologies must consider the biological effect of cumulative exposures to these frequencies.

Radiofrequency radiation exposure is increasing at a rapid pace.

A 2018 article published in *The Lancet Planetary Health* points to unprecedented increasing RF exposures, and the abstract concludes, "due to the exponential increase in the use of wireless personal communication devices (eg, mobile or cordless phones and WiFi or Bluetooth-enabled devices) and the infrastructure facilitating them, levels of exposure to radiofrequency electromagnetic radiation around the 1 GHz frequency band, which is mostly used for modern wireless communications, have increased from extremely low natural levels by about 1018 times…"(Bandara and Carpenter 2018).[57]

Another key finding from Zothansiama 2017 was that homes closer to antennas had measurably higher radiation levels—adding to the documentation that antennas increase RF levels. An Australian study also found that children in kindergartens with nearby antenna installations had nearly three-and-a-half times higher RF exposures than children with installations further away (more than 300 meters (Bhatt 2016).[58]

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[49] Deshmukh, P.S., et al. "Cognitive impairment and neurogenotoxic effects in rats exposed to low-intensity microwave radiation." *International Journal of Toxicology*, vol. 34, no. 3, 2015, pp. 284-90.
[50] Aldad, T.S., et al. "Fetal Radiofrequency Radiation Exposure From 800-1900 MHz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice." *Scientific Reports,* vol. 2, no. 312, 2012.
[51] Sonmez, O.F., et al. "Purkinje cell number decreases in the adult female rat cerebellum following exposure to 900 MHz electromagnetic field." *Brain Research,* vol. 1356, 2010, pp. 95-101.
[52] A lecture by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the 2017 IIAS Conference website. Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." *Conference on Wireless and Health*, 2017.
[53] Cindy L. Russell, 5G Wireless Telecommunications Expansion: Public Health and Environmental Implications, 165 Envt'l Res. 484 (2018).
[54] For information on Active Denial Systems, see, e.g., Vehicle-Mounted Active Denial System (V-MADS) ; Active Denial System FAQs.
[55] A lecture by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the 2017 IIAS Conference website. Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." *Conference on Wireless and Health*, 2017.
[56] Hayut, Itai, Paul Ben Ishai, Aharon J. Agranat and Yuri Feldman. "Circular polarization induced by the three-dimensional chiral structure of human sweat ducts." *Physical Review E*, vol. 89, no. 042715, 2014.
[57] Priyanka Bandara, David O Carpenter, Planetary electromagnetic pollution: it is time to assess its impact, *The Lancet Planetary Health*, Volume 2, Issue 12, 2018, Pages e512-e514,ISSN 2542-5196, doi.org/10.1016/S2542-5196(18)30221-3.
[58] Bhatt, C. R., Redmayne, M., Billah, B., Abramson, M. J., & Benke, G. (2016). Radiofrequency-electromagnetic field exposures in kindergarten children. *Journal Of Exposure Science And Environmental Epidemiology*, *27*, 497. Retrieved from https://doi.org/10.1038/jes.2016.55.

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A 2018 multi-country study that measured RF in several countries found that cell phone tower radiation is the dominant contributor to RF exposure in most outdoor areas exposure in urban areas was higher and that exposure has drastically increased. As an example, the measurements the researchers took in Los Angeles, USA was 70 times higher than the US EPA estimate 40 years ago.[59]

FCC limits are non-protective

FCC limits are based only on thermal heating and do not account for biological impacts at levels far lower than FCC limits. The Department of Interior wrote a 2014 letter on the impact of cell towers on migratory birds documenting several studies that found adverse effects and concludes that "The electromagnetic radiation standards used by the Federal Communications Commission (FCC) continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today."[60]

In the United States, RFR radiation regulatory limits were set by the FCC more than two decades ago in 1996. However, the FCC limits are not safety standards. Although the EPA was actively researching this issue and tasked to develop proper safety limits,[61,62] the EPA was abruptly defunded in 1996 and the FCC adopted guidelines developed by industry-connected non-independent groups (ANSI/IEEE C95.1-1992, NCRP's 1986 Report)[63] Experts from U.S. government agencies (including the EPA and NIOSH) have repeatedly documented issues concerning the inadequacy of these limits but their letters have gone unanswered.[64,65] The EPA has clarified that the FCC limits do not protect against effects from long-term low-level exposures.[66] In 2008, the National Academy of Sciences released a Report on research needs that included recommending research on the impacts to brain development and exposures to children and pregnant women.[67]

In 2012, the Government Accountability Office issued a Report calling for RFR standards to be updated with current research recommending that the FCC formally reassess the current RF energy exposure limit, including its effects on

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[59] Sanjay Sagar, Seid M. Adem, Benjamin Struchen, Sarah P. Loughran, Michael E. Brunjes, Lisa Arangua, Mohamed Aqiel Dalvie, Rodney J. Croft, Michael Jerrett, Joel M. Moskowitz, Tony Kuo, Martin Röösli, Comparison of radiofrequency electromagnetic field exposure levels in different everyday microenvironments in an international context, Environment International, Volume 114, 2018, Pages 297-306, ISSN 0160-4120, doi.org/10.1016/j.envint.2018.02.036.

[60] W.R.Taylor, February 7, 2014, United States Department of the Interior, Letter In Reply Refer To: (ER 14/0001) (ER 14/0004).

[61] A lecture by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the 2017 IIAS Conference website. Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." *Conference on Wireless and Health*, 2017.

[62] Hayut, Itai, Paul Ben Ishai, Aharon J. Agranat and Yuri Feldman. "Circular polarization induced by the three-dimensional chiral structure of human sweat ducts." *Physical Review E*, vol. 89, no. 042715, 2014.

[63] https://www.fcc.gov/general/fcc-policy-human-exposure#block-menu-block-4

[64] A lecture by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the 2017 IIAS Conference website. Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." *Conference on Wireless and Health*, 2017.

[65] Hayut, Itai, Paul Ben Ishai, Aharon J. Agranat and Yuri Feldman. "Circular polarization induced by the three-dimensional chiral structure of human sweat ducts." *Physical Review E*, vol. 89, no. 042715, 2014.

[66] https://ehtrust.org/wp-content/uploads/4c0f61dc30c3d6bb27d90f53a57c616e.pdf

[67] Consensus Study Report, Identification of Research Needs Relating to Potential Biological or Adverse Health Effects of Wireless Communication Devices, 2008.

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human health, the costs, and benefits associated with keeping the current limit, and the opinions of relevant health and safety agencies, and change the limit if determined appropriate. In response to the 2012 GAO Report, the FCC opened proceedings (ET Docket No. 13-84 Reassessment of FCC Radiofrequency Exposure Limits and ET Docket No. 03-137 Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields) to explore whether it should modify its radiofrequency exposure standards. The FCC also noted, "we specifically seek comment as to whether our current limits are appropriate as they relate to device use by children." To date, the FCC has failed to act. Over 900 comments have been filed since the FCC opened these dockets these dockets, but no US health agency has submitted any opinion or scientific documentation to either docket.

Due to the FCC's inaction, the GAO has updated the status[68] as "Closed - Not Implemented" with these comments: "despite many years of consideration, FCC still has no specific plans to take any actions that would satisfy our recommendations. Accordingly, we are closing the recommendations as not implemented."

Children are more vulnerable.

Children's skulls are thinner, their heads are smaller, and the radiation penetrates deeper into their brain. Research has found that a child's head's absorption can be over two times greater, and absorption of the skull's bone marrow can be ten times greater, than adults.[69,70] The American Academy of Pediatrics, which is the largest organization of U.S. pediatricians, has repeatedly written to the U.S. government documenting children's vulnerabilities and recommends reducing children's and pregnant women's exposure.[71]

The California Department of Health, the Connecticut Department of Health, many international health organizations and medical associations, and more than 20 governments are recommending wireless exposure reduction, especially for children.[72]

Several countries have allowable public exposure limits lower than ICNIRP levels with limits that are even more protective for kindergartens, schools and hospitals. In addition, some governments' regulatory actions include banning cell phones or removing Wi-Fi and cell towers in or near schools.[73] For example:

- Belgium and France have banned the sale of cell phones designed for young children and made it illegal to market cell phones to children less than 14 years of age.

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[68] Exposure and Testing Requirements for Mobile Phones Should Be Reassessed GAO-12-771: Published: Jul 24, 2012. Publicly Released: Aug 7, 2012.

[69] A lecture by Paul Ben-Ishai, PhD at the Israel Institute for Advanced Studies on this finding can be found on the 2017 IIAS Conference website. Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." *Conference on Wireless and Health*, 2017.

[70] Hayut, Itai, Paul Ben Ishai, Aharon J. Agranat and Yuri Feldman. "Circular polarization induced by the three-dimensional chiral structure of human sweat ducts." *Physical Review E*, vol. 89, no. 042715, 2014.

[71] https://ehtrust.org/wp-content/uploads/American-Academy-of-Pediatrics-Letters-.pdf

[72] For more on international policy actions, see our online briefing. "International Policy Briefing: Cautionary Policy on Radiofrequency Radiation Actions by Governments, Health Authorities and Schools Worldwide." Environmental Health Trust, 2017.

[73] See Database of Worldwide Policies on Cell Phones, Wireless and Health, Environmental Health Trust.

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- France has banned cell phones in elementary and middle schools, and playgrounds.[74]
- The Supreme Court of India upheld the High Court of the State of Rajasthan's decision to remove all cell towers from the vicinity of schools, hospitals and playgrounds because this radiation is "hazardous" and causes cancer, brain tumour, digestive disorder and tachycardia.[75]
- The Environment Minister of Italy has decreed to reduce as much as possible indoor exposure to both ELF-EMF and RF-EMF.
- Cyprus has banned Wi-Fi from kindergartens and elementary classrooms.
- In Chile, the 2012 "Antenna Law" prohibits cell antennas/towers in "sensitive areas" such as "educational institutions, nurseries, kindergartens, hospitals, clinics, nursing homes or other institutions of similar nature."[76]

Children will have a lifetime of exposure to wireless radiation; in order to protect their healthy future, public health authorities must limit this exposure as much as possible.

Moreover, recent cell phone radiation tests released by the French government found that nine out of ten cell phones exceed regulatory limits for radiofrequency radiation when tested in body contact positions (simulating a phone in pants pocket, bra or resting on chest). Despite this documentation, U.S. radiation limits have still not been revised. To this date, there has been no public record of an independent systematic review of the research by any U.S. health agency in order to set proper safety standards. The current outdated regulations are inadequate to protect public health.

Since 1997, insurance companies have refused to insure wireless companies and "electromagnetic field exclusions" in insurance policies are an industry standard. EMFs are deemed as "high-risk" in insurance white papers, and EMFs are defined as a "pollutant" by many insurance companies alongside smoke, chemicals, and asbestos. Some companies will only cover liability from EMFs under additional "Pollution Liability" policy enhancement coverage. Some policies not only exclude damages from EMFs but also exclude paying for the defense of "*any supervision, instruction, recommendation, warning or advice given or which should have been given in connection with bodily injury, property damage, abatement and/or mitigation etc.*"

Wireless companies warn their shareholders—in mandated annual 10k filings—that they may incur financial losses from lawsuits related to EMF radiation emissions of their products. For example:

- AT&T states, *"We may incur significant expenses defending such suits or government charges and may be required to pay amounts or otherwise change our operations in ways that could materially adversely affect our operations or financial results."*
- Crown Castle's 2016 10-K ANNUAL REPORT states, *"If radio frequency emissions from wireless handsets or equipment on our wireless infrastructure are demonstrated to cause negative health effects, potential future claims could adversely affect our operations, costs or revenues. The potential connection between radio frequency emissions and certain negative health effects, including some forms of cancer, has*

[74] « Plus de téléphones portables dans les écoles et collèges à la rentrée 2018 », annonce Jean-Michel Blanquer, Le Monde (Dec. 10, 2017).
[75] Abhinav Sharma, Rajasthan HC orders relocation of mobile towers from schools, hospitals, Economic Times (Nov. 28, 2012).
[76] New communications antenna law in Chile, 20 Communications Law: Newsletter of the International Bar Association Legal Practice Division 14-16 (2013).

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been the subject of substantial study by the scientific community in recent years. We cannot guarantee that claims relating to radio frequency emissions will not arise in the future or that the results of such studies will not be adverse to us...If a connection between radio frequency emissions and possible negative health effects were established, our operations, costs, or revenues may be materially and adversely affected. We currently do not maintain any significant insurance with respect to these matters."

Most wireless companies—from AT&T to Nokia to T Mobile to Verizon Wireless—have issued similar warnings to their shareholders.[77]

Will the visiting public to the National Parks also be warned of the risk?

Scientists Worldwide: Reduce Exposure

An increasing number of experts around the world are calling for reduced exposure—due to the unprecedented threat to public health and the environment—to stop the installation of radiation-emitting equipment placed within meters of homes, playgrounds, and schools.

- In 2015, the International EMF Scientist Appeal, now signed by over 225 scientists from 41 nations, urging the development of more protective guidelines for EMF (including RF-EMF), encouraging precautionary measures, and calling for education of the public about health risks, particularly risks to children and fetal development, was submitted to the Secretary-General of the United Nations, the Director-General of the World Health Organization, and U.N. Member Nations.[78]
- In June 2017, EMF Scientists submitted Comments to the U.S. FCC, asking the FCC to critically consider the potential impact of the 5th generation wireless infrastructure on the health and safety of the U.S. population before proceeding to deploy this infrastructure.
- In September 2017, I joined over 180 experts from 35 countries who sent a declaration to the European Union calling for a moratorium on 5G until hazards have been fully investigated by independent scientists, citing potential neurological impacts, infertility, and cancer.[79]

The tobacco and asbestos crises demonstrate that failing to act on public health hazards when they arise can lead to irreversible damage later. EHT thus strongly opposes building out 5G infrastructure—which would place thousands of new sources of microwave radiation emissions in close proximity to workers, families, and local wildlife—at least until more testing has been conducted.

Cell Towers Create Additional Safety Hazards

Another area of concern with the proposed expansion of the wireless infrastructure is fires. Cell towers are known to catch fire such as the 150-foot tower in Washington that experienced an electrical malfunction at a lighted beacon on top of the tower which caught an Osprey's nest on fire. Many birds, particularly raptors, choose to nest on or near cell towers because of the heat they provide, the clear view, and high vantage point that they favor for their nesting

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[77] Corporate Company Investor Warnings In Annual Reports 10k Filings Cell Phone Radiation Risks
[78] Blank, M., et al. "International Appeal: Scientists call for protection from non-ionizing electromagnetic field exposure." *European Journal of Oncology,* vol. 20, no. 3/4, 2015, pp. 180-2.
[79] "Appeal to the European Union: Scientists warn of potential serious health effects of 5G." 13 September 2017.

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sites. There are many more examples of these towers catching fire, such as a 125-foot tower in Maryland. A church in South Africa that housed antennas caught fire this month, and news reports state authorities are investigating if it was a short circuit from the equipment that started the fire.

Towers have also been known to attract lightning strikes. The higher the tower the higher the probability that lightning will strike the tower, presenting another type of fire hazard.[80]

We at the Environmental Health Trust urge you, as stewards of our national parks and along with your mission, "The **National Park Service** preserves unimpaired the **natural** and cultural resources and values of the **national park** system for the enjoyment, education, and inspiration of this and future generations," to seek out the research and information about the health effects on both humans and the flora and fauna of the parks in order to protect and preserve. Taking all information into consideration you are also following the National Park Service's own statement, "by caring for the parks and conveying the park ethic, we care for ourselves and act on behalf of the future. The larger purpose of this mission is to build a citizenry that is committed to conserving its heritage and its home on earth."[81]

Respectfully submitted,

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Associate Editor, Frontiers in Radiation and Health

[80] Witman, S. (2017), Antenna towers attract additional lightning strikes, *Eos, 98,* doi.org/10.1029/2017EO074341. Published on 26 May 2017.
[81] NPS Entering the 21st Century, Changes in Mission, Changes in the Future, 2016.

SPECIAL ARTICLE

The Sensitivity of Children to Electromagnetic Fields

Leeka Kheifets, PhD*; Michael Repacholi, PhD‡; Rick Saunders, PhD‡; and Emilie van Deventer, PhD‡

ABSTRACT. In today's world, technologic developments bring social and economic benefits to large sections of society; however, the health consequences of these developments can be difficult to predict and manage. With rapid advances in electromagnetic field (EMF) technologies and communications, children are increasingly exposed to EMFs at earlier and earlier ages. Consistent epidemiologic evidence of an association between childhood leukemia and exposure to extremely low frequency (ELF) magnetic fields has led to their classification by the International Agency for Research on Cancer as a "possible human carcinogen." Concerns about the potential vulnerability of children to radio frequency (RF) fields have been raised because of the potentially greater susceptibility of their developing nervous systems; in addition, their brain tissue is more conductive, RF penetration is greater relative to head size, and they will have a longer lifetime of exposure than adults. To evaluate information relevant to children's sensitivity to both ELF and RF EMFs and to identify research needs, the World Health Organization held an expert workshop in Istanbul, Turkey, in June 2004. This article is based on discussions from the workshop and provides background information on the development of the embryo, fetus, and child, with particular attention to the developing brain; an outline of childhood susceptibility to environmental toxicants and childhood diseases implicated in EMF studies; and a review of childhood exposure to EMFs. It also includes an assessment of the potential susceptibility of children to EMFs and concludes with a recommendation for additional research and the development of precautionary policies in the face of scientific uncertainty. *Pediatrics* **2005;116:e303–e313. URL: www.pediatrics.org/cgi/doi/10.1542/peds.2004-2541;** ***children, environmental risk, policies, sensitive periods, mobile phones, electromagnetic fields, power lines.***

ABBREVIATIONS. ELF, extremely low frequency; IARC, International Agency for Research on Cancer; RF, radio frequency; EMF, electromagnetic field; WHO, World Health Organization; CNS, central nervous system; ALL, acute lymphoblastic leukemia; AML, acute myeloblastic leukemia; SAR, specific absorption rate.

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The opinions in this paper are the sole responsibility of the authors and do not represent the position of the World Health Organization.

Conflict of interest: Dr Kheifets worked and consulted for Electric Power Research Institute and Utilities (Palo Alto, CA), and Dr Saunders worked for the National Radiation Protection Board (Oxfordshire, United Kingdom).

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Children in both industrialized and developing countries are exposed to a large variety of environmental agents including indoor and outdoor air pollution, water and food contaminants, chemicals (eg, pesticides, lead, mercury), and physical agents such as ultraviolet radiation and excessive noise. Changes in exposure to these agents are being linked to real or perceived increases in the incidence of certain childhood diseases, such as asthma, leukemia, and brain cancer, and in some behavioral and learning disabilities. Environmental exposures can be particularly harmful to children because of their special vulnerability during periods of development before and after birth.

Exposure to electric and magnetic fields from 0 to 300 GHz has been increasing greatly as countries increase their capacity to generate and distribute electricity and take advantage of the many new technologies, such as telecommunications, to improve lifestyle and work efficiency (Fig 1). Evidence of an association between childhood leukemia and exposure to extremely low frequency (ELF) magnetic fields has led to their classification by the International Agency for Research on Cancer (IARC) as a "possible human carcinogen"[1] based on consistent epidemiologic data and lack of support by laboratory studies in animals and cells. The reason why the results of the childhood leukemia studies are consistent is still being investigated, but one possibility is that children may be more sensitive to radiation in some or all parts of the electromagnetic spectrum.

Concerns about the potential vulnerability of children to radio frequency (RF) fields from mobile telephony were first raised by an expert group in the United Kingdom[2] on the grounds that children have a longer lifetime of exposure than adults, and from a physiologic point of view, they have a developing nervous system, their brain tissue is more conductive than that of adults because it has a higher water content and ion concentration, and they have greater absorption of RF energy in the tissues of the head at mobile telephone frequencies. This topic was discussed further at a European Cooperation in the Field of Scientific and Technical Research (COST) 281 workshop,[3] in a report of the Health Council of the Netherlands,[4] and in a recent report from the United Kingdom's National Radiological Protection Board.[5]

To evaluate the available information relevant to children's sensitivity to electromagnetic fields (EMFs) and to identify research needs, the World Health Organization (WHO) held an expert workshop in Istanbul, Turkey, in June 2004. This article is based on discussions and recommendations from the workshop and provides background information on

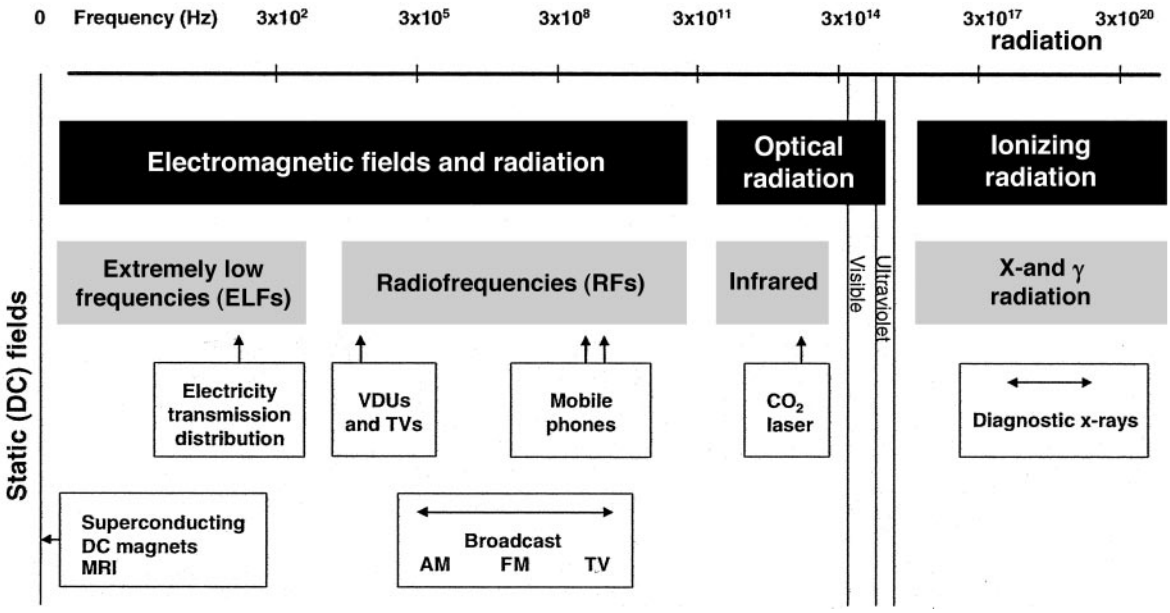

Fig 1. Electromagnetic spectrum. VDUs indicates video display units.

the development of the embryo, fetus, and child, with particular attention to the developing brain; an outline of childhood susceptibility to environmental toxicants, childhood diseases implicated in EMF studies, and exposure to ELF and RF fields, with a focus on children. After a brief presentation of the EMF science most pertinent to effects on children and a review of several proposed mechanisms, the potential sensitivity of children to EMFs is discussed. Finally, recommendations are outlined on the protection of children through the development of precautionary approaches in the face of scientific uncertainty.

FROM EMBRYO TO ADOLESCENCE

Embryo, Fetal, and Childhood Development

Development proceeds from conception to adulthood through a number of different stages in which the developmental processes are markedly different, and their susceptibility to environmental teratogens varies. The prenatal period of development is divided roughly into 3 periods: the preimplantation period, extending from fertilization to the settling of the embryo into the uterine wall; a period of organogenesis, characterized by the formation of the main body structures; and the fetal period, during which growth of the structures already formed takes place. Additional developmental changes take place after birth. Postnatal changes are characterized by slower growth and maturation of existing organ systems, notably the central nervous system (CNS), the hemopoietic and immune systems, the endocrine and reproductive systems, and the skeletal system. The completion of sexual development at the end of the second or the beginning of the third decade of human life marks the completion of this period of growth and maturation. Essentially, however, the nature of the toxicant and the timing and magnitude of exposure determine the risk of any adverse effects in terms of both severity and occurrence. Vulnerability can vary quite rapidly during the prenatal period, whereas slower changes occur postnatally.[6]

During the first 2 weeks of embryonic development (known as the "all-or-none period"), the embryo is very sensitive to the lethal effects of toxic agents and much less sensitive to the induction of malformation. Many of the cells are still omnipotential stem cells, and if the embryo survives a toxic exposure it can recuperate without an increased risk of birth defects or growth retardation. During the next 6 to 8 weeks of development, major organogenic events occur and toxic agents with teratogenic potential can cause major malformations of the visceral organs, the CNS, the face, and the limbs. From the 8th to the 15th week, neuron proliferation, differentiation, and migration in the CNS are particularly vulnerable.[7] Genitourinary and other malformations, gonad cell depletion, and neurodevelopmental problems may occur if the thresholds for these effects are exceeded. During the late fetal period, effects on growth of the fetus and susceptible organs such as the CNS diminish, but vulnerability to deleterious effects remains high compared with adults.

Development continues after birth, but now this process largely entails the maturation of existing organ systems, although growth is still occurring. Neurobiologists long believed that neurogenesis in the human ends during the first months of postnatal life, but recent rodent and primate studies demonstrate that there is lifelong neuron production in some parts of the CNS.[8] However, with some particular exceptions, most adult neurons are already produced by birth. The number of connections (synapses) between neurons in the human brain peaks at ~2 years and decreases by 40% to the adult number during adolescence[8] as experience is acquired and "redundant" connections lost. This reflects the balance between the formation of new synapses (synaptogenesis) and synapse elimination, a "pruning" back of excess synapses between neurons, which are key

processes in the development of the postnatal "hard-wiring" of the brain. Another important neurologic event that occurs postnatally is myelination, which facilitates the transmission of information within the CNS and occurs most rapidly from birth to 24 months but may also continue into the second decade. Unfortunately, the susceptibility of these processes to environmental agents has not been studied extensively and thus is not well understood. However, because developmental processes are vulnerable to disruption by agents that may not be toxic to mature systems, it is reasonable to expect that the later stages of brain development present special risks.[8]

Other threshold effects that can result from postnatal exposures include interference with fertility and endocrine function, alterations in sexual maturation, and interference with the development of the immune system. Endocrine disrupters, exogenous substances that mimic the action of hormones (particularly steroids), may alter the function of the developing endocrine system and have adverse effects on the reproductive organs, liver, kidney, adrenal glands, CNS, immune system, cardiovascular system, and bones.[9]

Exposure to toxic agents with mutagenic and carcinogenic potential, such as ionizing radiation, cancer chemotherapeutic drugs, and some chemicals, poses theoretical, stochastic risks for the induction or progression of cancer during embryonic and childhood development. However, although many agents have been alleged to be responsible for cancer and genetic disease, such effects will only result from agents that have either mutagenic properties or the ability to produce more subtle effects on carcinogenic processes, such as the stimulation of excessive cell proliferation or an influence on cell-to-cell communication, apoptosis, or DNA repair.

Children's Susceptibility to Environmental Exposures

Several aspects of exposure and susceptibility warrant a focus on children. In some exposure scenarios, children may receive higher doses than adults, resulting from higher intake and accumulation or differences in behavior. Greater susceptibility to some toxicants and physical agents has been demonstrated in children. Because the period from embryonic life to adolescence is characterized by growth and development, deleterious effects can occur at lower levels and be more severe or lead to effects that do not occur in adults; on the other hand, children can be more resilient because of better recuperative capacities.

Toxic exposures in utero have produced effects that are quite surprising, given the period or level of exposure. Cassidy et al[10] reported that exposure to the persistent organochlorine chlordane in utero at quite low levels causes significant long-term alterations in sexual behavior. These effects were evident at levels of exposure very similar to those experienced in homes in the United States when chlordane and heptachlor were universally applied as termiticides. Both of these chemicals produced marked changes in sexually dimorphic functions in rats; females exposed in utero developed masculine behaviors, and males showed exaggerated male mating behaviors. These observations suggest that these chemicals masculinized by mimicking steroid hormones or by changing hormone levels.

Of perhaps more specific interest are toxic exposures that affect the nervous system of the fetus, infant, and child. Because development of the nervous system is very specific in pattern and timing, exposure to various agents at critical periods of development can cause long-lasting or permanent injury. For instance, exposure to ethanol or methylmercury has been shown to affect neuronal proliferation in rodents and in other experimental models. Some agents such as ethanol, lead, methylmercury, and some pesticides seem to affect synaptogenesis. Each of the multiple processes of neural development has been shown to be affected by specific toxic agents, often at low doses but at critical periods of development.

The timing of exposure might be critical as well: for ionizing radiation, excess risk for leukemias and brain and thyroid cancer is higher for exposures that occur in childhood; the risk of breast cancer was highest for Japanese women exposed to ionizing radiation from the atomic bomb during puberty, although the risk also increased in women who were <10 years old (an age at which girls have little or no breast tissue) at the time of the explosion.[11] Similarly, sunburns in childhood seem to be particularly potent in increasing the risk of skin cancer later in life.[12] Exposure in childhood may also increase the risk of disease later in life simply because the duration of exposure can be much longer if it starts early. There is evidence, for instance, that the younger a person is when starting smoking, the higher the risk of lung cancer.[13]

Childhood Diseases Relevant to EMF Exposure

Some diseases are limited to the embryo, child, or adolescent; other diseases that occur in children and adults manifest themselves differently in children. Of particular relevance to EMF exposure are childhood leukemia and brain cancer. There is consistent evidence from epidemiologic studies of a risk of childhood leukemia associated with exposure to environmentally high levels of ELF magnetic fields. There is no explanation for this effect from laboratory studies. An increased risk of brain cancer has been investigated in relation to ELF exposures and has been raised particularly in the context of mobile-phone use and the absorption of RF signals by the brain, although there is no convincing evidence suggesting an increased risk. To put potential EMF effects in perspective and determine how EMFs might be involved in the development of these diseases, we provide a brief overview of rates and risk factors for them.

Childhood Leukemia

Leukemias are the most common cancer to affect children, accounting for 25% to 35% of all childhood malignancies. The biological heterogeneity of childhood leukemia is well documented; the major mor-

phologic types are acute lymphoblastic leukemia (ALL) and acute myeloblastic leukemia (AML).

The rate of leukemia for children <15 years old has been estimated to be ~4 per 100 000 per year in the developed world and 2.5 per 100 000 per year in the developing world.[14] In developed countries, the incidence of leukemia rises rapidly after birth, peaking at ~3 years of age before declining and then rising steadily again throughout life. Thus, unlike many cancers, it has a short latency and a peak incidence early in life[15] that has resulted in many etiologic hypotheses, most notably those involving exposure to infections.[16]

Subtypes of AML and ALL are frequently characterized by genetic alterations, including changes in chromosome number (hyperdiploidy or hypodiploidy) and chromosomal translocations that may involve chimeric or fusion genes.[17,18] These genes include *MLL*, *TEL*, and *AML1*, all of which can fuse with many other genes and, in the case of *TEL* and *AML1*, with each other. There is strong evidence that this rearrangement may originate in utero, supported by data obtained from studies of identical twins or children with concordant ALL. Screening of newborn blood samples suggests that ~1% have the *TEL-AML1* gene fusion, 100 times the proportion of children that will develop ALL with a *TEL-AML1* gene fusion before the age of 15 years. This implies that the conversion of the preleukemic clone to overt disease is low and that development of childhood ALL is a multistep process requiring at least 1 prenatal event in combination with additional prenatal and/or postnatal events. Although the "first hit," the initiating in utero event, is believed to be common, the "second hit," possibly occurring postnatally, is rare and therefore acts as the rate-determining step in development of the disease.

As with most other cancers, the mechanism by which leukemia arises is likely to involve gene-environment interactions, the environmental exposures being derived from both endogenous and exogenous sources. Accordingly, it is important to identify exposures that either cause DNA damage and induce chromosome breaks that are repaired inadequately or act as promoters and/or progressers, ultimately leading to the overt expression of the disease. Exposures acting before birth and early in life have long been thought to be important determinants of leukemia; it is unfortunate that the evidence regarding the majority of suggested exposures is limited and often contradictory. Ionizing radiation given at large doses is one of the few known risk factors for leukemia.

Brain Cancer

CNS tumors account for ~20% of all malignancies in children <15 years old[19] but account for <2% of cancers in adults. CNS cancers in children occur in tissues of mesodermal or embryonic origin, but in adults they occur in epithelial tissues. Another difference between childhood and adult tumors is that adult tumors tend to occur in the cerebral hemispheres, whereas the majority of pediatric tumors are brainstem gliomas.

The international incidence rates of childhood CNS tumors (0–14 years) vary between developed and developing nations, with the higher rates observed in most Westernized countries reaching 3 per 100 000 per year compared with 1 to 2 per 100 000 in other parts of the world.[19] Over recent decades, steady rises in the incidence of childhood CNS tumors have been observed in several populations of the United Kingdom, the United States, Japan, and Australia. The debate continues over whether these increases are "real" or an artifact of improved diagnostic practice and case finding by cancer registries.

The causes of CNS cancers are largely unknown, although up to 5% may be explained by genetic predisposition, associated with disorders such as neurofibromatosis type I.[20,21] Having a parent or sibling with a CNS tumor also increases the risk. The identification of environmental risk factors for CNS tumors has generally been inconsistent.[20,21] Again, ionizing radiation given in therapeutic doses is one of the few known risk factors for CNS tumors.

CHILDREN'S EXPOSURE TO RF AND ELF FIELDS

In evaluating the potential role of environmental exposures in the development of childhood diseases, it is important to consider not only the fact that childhood exposures can be different from exposures during adulthood but also the fact that they can be highly age dependent. Exposures of interest during the preconception and gestation periods include residential and parental exposures to ELF and RF fields, including mothers' exposure from use of domestic appliances and mobile phones. Infants and toddlers are exposed mostly at home or at day care facilities. Among preteens, exposure sources expand to include mobile-phone use and sources at school, with an increased use of mobile phones in adolescence. Here we focus on 2 major exposure scenarios: residential ELF and RF exposures and exposure from mobile phones.

Residential Exposure

Everyone is exposed to ELF electric and magnetic fields at home.[22] High-voltage power lines are a major source of exposure for children who live near them; however, only ~ 1% of children live in close proximity to high-voltage lines. For most children, exposure to low-level fields from primary and secondary distribution wiring is continuous; short-duration and intermittent exposure to higher fields results from proximity to domestic appliances. ELF exposure also occurs at school, during transport, and even during mobile-phone use. Typical average magnetic fields in homes seem to be ~0.05 to 0.1 μT. Generally, magnetic fields in homes vary from country to country; geometric-mean fields are ~35 nT in the United Kingdom and 70 nT in the United States. This difference results from the supply voltage used in the United States (110 V) being approximately half that used in the United Kingdom (220 V), leading to approximately twice the electric current and magnetic field exposure. The fraction of homes with average fields above certain thresholds likewise varies; for example, 1% to 2% of homes in the United Kingdom and 10% in the United States have fields of >0.2

μT. Exposure to appliances has been estimated to be 30% of total exposure. Maximum fields experienced are typically in the tens of microtesla. There is evidence that younger children use appliances less (and spend less time outside the home), so their personal exposure is closer to and correlates better with the fields in the home.

RF fields are produced by radio and television broadcasts, mobile phones and base stations, and other communications infrastructure. Radio and television signals are broadcast to a large area from comparatively few sites. Mobile-phone base stations cover a smaller area and produce much lower emissions but are now much more common than radio and television stations (tens of thousands in many countries). Because of the width and angle of the RF signal beam and perturbation by the earth and building materials, there is little correlation between field strength and distance to the source. Typical power densities outdoors would be 0.01 to 1 $mW \cdot m^{-2}$ but could be orders of magnitude higher (ie, $\geq$100 $mW \cdot m^{-2}$). Depending on where the measurements are taken, base stations can be the largest individual source of RF fields, but other sources such as radio or television transmitters can result in comparable or greater exposures. Indoor levels are often lower by orders of magnitude, because buildings screen fields. A European median indoor power density of 0.005 $mW \cdot m^{-2}$ has been reported.

Background environmental levels are the primary source of RF exposure for very young children. Potential sources of residential RF exposure to children are wireless in-house communications (eg, wireless monitors used in children's cribs, cordless phones, Wi-Fi) and mobile-phone use by someone in close proximity to a child, creating passive exposure. Because children <5 years of age usually spend most of their time at home, residential exposure can be a sufficient predictor of individual exposure.[22,23] RF exposure may be estimated more easily for children than for adults, because the variety of exposure sources is smaller. When they reach adulthood, today's children will have a much higher cumulative exposure to RF fields than today's adults.

At present, population exposure to RF fields has been much less characterized than ELF fields, partly because of technical challenges (lack of adequate measuring equipment), the rapid evolution of mobile-phone technology (frequency, coding schemes), and new patterns of use (duration of calls, short-message services). However, the main reason ELF fields are better understood than RF fields is that they have been studied more.

Mobile-Phone Use

Modern children will experience a longer period of exposure to RF fields from mobile-phone use than adults, because they started using mobile phones at an early age and are likely to continue using them. Data from a multinational case-control study of potential causes of adult brain cancer show that both the prevalence of regular mobile-phone users and daily use are highest in the younger age groups (eg, 19% of younger subjects made calls for >30 minutes a day, compared with 10% of older subjects).[24,25] Moreover, several recent trends (such as increased popularity, reduced price, and advertising to children) have led to increased mobile-phone use among children.[26] A steep increase in mobile-phone ownership among children has been reported in several public-opinion surveys.[27] For example, in Australia >90% of 6- to 9-year-olds reported sometimes using their parents' mobile phones, and in Germany approximately one third of 9- to 10-year-olds reported owning a mobile phone. Clearly, mobile phones are the dominant source of RF exposure for teens and preteens.

HEALTH-RISK ASSESSMENT

The workshop addressed the potential sensitivity of children at all stages of development from conception through to sexual maturity. The nature of any adverse health effect that ensues from exposure to an environmental toxicant depends not only on the timing and magnitude of the exposure but also on the mechanisms by which the toxicant interacts with the developing tissue or organ. As a consequence, it is not possible to generalize about the possible health effects that might ensue from exposure to an agent posing unknown risks to health by drawing parallels with other toxic agents unless they have very similar mechanisms of interaction. Instead, it is necessary to examine the experimental and epidemiologic evidence by formulating and testing hypotheses on the basis of an examination of the known and possible interaction mechanisms.

Health Risks to Children From ELF Fields

Exposure to ELF EMFs induces electric fields and currents within the body; guidance on exposure is based on avoiding the risks to health that result from the interaction of the induced fields and currents with electrically excitable nerve tissue, particular that of the CNS (see, for example, refs [28] and [29]). Present guidance on occupational exposure is based on a basic restriction on induced current density in the CNS of 10 $mA \cdot m^{-2}$, which approximates an electric field in CNS tissue of ~100 $mV \cdot m^{-1}$. Guidance on public exposure incorporates an additional safety factor, reducing the basic restriction to 2 $mA \cdot m^{-2}$ (20 $mV \cdot m^{-1}$). The basic restrictions are linked to external field strengths (reference levels) through dosimetric calculation, which is based on realistic anatomic human models and measurements of the dielectric properties of human tissue. For general public exposure, the corresponding reference levels for power-frequency electric and magnetic fields are of the order of 5 kV/m and 100 μT, respectively.

Dosimetric calculations have not been conducted extensively for children and have not been undertaken for pregnant women and their unborn children. In general, adults exposed to ELF electric or magnetic fields have higher internal electric-field strengths and current densities than children because of size and shape differences. However, the distributions are different, and in children some tissues have higher field strengths and current densities for the same external field. Furthermore, children have sig-

nificantly higher internal field strengths and current densities from contact currents than do adults. Dose computations using anatomically correct models of children[30] reveal that modest, imperceptible current into the hand (10 μA) produces ~50 mV $\cdot$ m^{-1} averaged across the lower-arm marrow of a small child and approximately $\geq$130 mV $\cdot$ m^{-1} in 5% of that tissue. During pregnancy, the magnitude and distribution of induced electric fields and currents in the mother will be different because of changes in body shape and will not have been assessed in the embryo or fetus. These factors, along with differences in dielectric properties, need to be taken into account in assessing health risks to children from ELF EMFs.

The guidance cited above was based on a consideration of laboratory evidence, including evidence from volunteer studies of magnetic phosphenes, and more recently on evidence from voltage-gated ion channel and neural-network behavior.[29] Neurobehavioral studies in volunteers and in animals, mostly in adults, have not reported robust responses to ELF exposure[31]; overall, any changes seen have been subtle, transient, and reversible. Workshop participants thought that there is no reason to suppose a greater sensitivity of CNS neural networks and ion channels to induced electric fields in children or in the embryo or fetus. Reduced myelination seen in childhood and early adolescence was not thought likely to increase sensitivity either. It is not clear what the impact would be of an overabundance of synaptic connections seen in infants and early childhood, but any increased sensitivity was considered to be covered by the more restrictive guidance on public exposure.

The evidence that induced electric fields might affect development of the nervous system and other tissue was discussed at the workshop in some detail. Evidence was presented that endogenous direct-current electric fields of 10 to 100 V $\cdot$ m^{-1} played a role in prenatal development. There is little evidence regarding susceptibility to ELF electric fields, although it was thought that there is no reason to suppose greater sensitivity. It was noted that the direct-current electric fields were several orders of magnitude above present guidance values. However, the possible influence of such fields on synaptogenesis and/or synapse elimination is not known.

Results from several independent research groups suggest that exposure to ELF magnetic fields at microtesla levels may disturb early development of bird embryos. However, replication attempts have been unsuccessful in some laboratories. Results from experiments with other nonmammalian experimental models (fish, sea urchins, and insects) have also suggested subtle effects on developmental stability.[32] In mammals, prenatal exposure to ELF magnetic or electric fields does not result in strong adverse effects on development. Some effects of magnetic (or combined electric and magnetic) fields on postnatal development have been reported, but evaluation of the consistency of the findings is difficult because of the varying methods and approaches used in different studies.

Numerous epidemiologic studies of various pregnancy outcomes in relation to EMFs are available in the scientific literature. They include studies investigating the use of video display terminals, electric blankets, or heated waterbeds, as well as studies of parental occupational exposure. Most studies have found no effects, but these studies have been limited in exposure assessment and lacked the power to examine high exposure levels. Two studies have included personal measurements of ELF exposure and reported effects on spontaneous abortion in relation to maximum measured magnetic fields.[33,34] The possibility of exposure assessment bias in these studies has been discussed, and results need to be confirmed in additional studies before firm conclusions can be drawn.

The potential cancer risks to children of exposure to ELF EMF, estimated from residential proximity to power sources and from measured fields, have been investigated in relation to in utero and postnatal time periods and to paternal exposure. No consistent associations have been observed for childhood CNS tumors.[35] One recent study[36] found an increased risk of childhood leukemia with high maternal occupational exposure during pregnancy.

An increased risk of childhood leukemia has been found to be consistently associated with exposure to environmental levels of power-frequency magnetic fields at levels very much below present guidance. Initial studies used a surrogate for magnetic fields (known as wire codes) that was based on distance and thickness of power lines near the residence.[37] As instruments became available, the focus shifted to measured or calculated magnetic fields. Results of dozens of increasingly sophisticated studies and the 2 pooled analyses have reported a doubling of risk for children exposed to magnetic fields >0.3 to 0.4 μT compared with children exposed to fields <0.1 μT.[38,39] Although a number of factors, including socioeconomic status, have been evaluated as confounders, substantial confounding has not been identified. However, because of limited knowledge of the etiology of childhood leukemia, it is difficult to exclude the possibility of some yet-to-be-identified confounder or of confounding by a combination of factors. Nevertheless, substantial confounding of the observed association, it seems to us, is unlikely. Although these results are also not likely to be a result of chance, bias cannot be ruled out.[40] An epidemiologically detectable risk of leukemia for children, but not for adults, might result from either better exposure assessment for children or from greater susceptibility in children.

At present there is no experimental evidence that supports the view that this relationship is causal; however, few animal studies have been conducted using animal models of the predominant form of childhood leukemia, and most carcinogenesis bioassays begin when animals are sexually mature. In addition, there is no biophysical explanation for biologically significant interactions at these low field values, so if the association is causal, then there is currently no scientific explanation. Two hypotheses for such effects were discussed at the workshop.

One hypothesis discussed at the workshop proposed that the association of power-frequency mag-

netic fields with childhood leukemia may result from the flow of electric current through the bone marrow of children after contact with water fixtures or a water stream in which a small voltage difference exists as a result of the grounding of the residential electrical system to the water pipe.[41] Calculation shows that potentially significant electric fields (more than ~100 $mV \cdot m^{-1}$) may be induced in the bone marrow in these circumstances; this lends biological plausibility to the proposed mechanism. The effect of such weak electric fields in inducing effects in hematopoietic tissue that might increase the risk of ALL, possibly by affecting preleukemic clones (see above), has not been investigated.

A second hypothesis suggested that exposure to power-frequency magnetic fields increases the risk of childhood leukemia through disruption of the nocturnal production of melatonin in the pineal gland.[42] Although the International Commission on Non-ionizing Radiation Protection[43] concluded that there is no convincing evidence of an effect, subtle effects on melatonin physiology are not easily excluded, and such studies have not been conducted specifically on children.

Recommendations were made for additional research regarding the association between exposure to power-frequency magnetic fields and childhood leukemia; it is clear that this issue is unresolved. Although such scientific uncertainty remains, the WHO recommends the adoption of precautionary measures for the protection of children (see below).

Health Risks to Children From RF Fields

Exposure to RF radiation induces heating in body tissues and imposes a heat load on the whole body; guidance on exposure is based on avoiding the risks to health that result from localized rises in tissue temperature and from the physiologic stress engendered by excessive whole-body heat loads.[28,29] Present guidance on occupational exposure is based on restricting the RF-induced whole-body specific absorption rate (SAR) to $<0.4\ W \cdot kg^{-1}$, a heat load sufficiently small that its contribution to other possible heat loads, generated from hard physical work and/or imposed by high ambient temperatures, can be neglected. Basic restrictions on localized SARs, averaged over any 10 g of contiguous tissue, are 10 $W \cdot kg^{-1}$ in the head and trunk and 20 $W \cdot kg^{-1}$ in the limbs.[28] These are intended to restrict local tissue temperature rises to acceptable levels. Guidance on public exposure incorporates an additional safety factor of 5, reducing the basic restrictions to 0.08 $W \cdot kg^{-1}$ to the whole body and 2 $W \cdot kg^{-1}$ to the head. Temperatures are derived from dosimetric calculation and thermal modeling; SARs are also related to external field values via dosimetric calculation. The corresponding reference levels, which for RF fields are power densities, are frequency dependent and are of the order of 10 $W \cdot m^{-2}$ at 1800 MHz for general public exposure.

Dosimetric calculation has for more than a decade allowed for differences in body size between children and adults, and these differences have been factored into guidance. Despite large differences in the size, shape, and tissue distribution of heads, the SAR values and exposure variations for child models are similar to those for adults, although somewhat higher. In addition, the relative depth of penetration is larger for children, a logical consequence of smaller head diameter. Dielectric studies encompassing several tissue types, including brain, obtained from newborn to fully grown rats, mice, and rabbits exposed to RF EMF in the frequency ranges of 130 MHz to 10 GHz and 300 kHz to 300 MHz report large, age-related variations in the permittivity and conductivity of brain tissue and even larger variations for skin and skull tissue.[44–46] Thus, there is a need for dosimetric modeling of the distribution of SAR and temperature in children and also a requirement for appropriate age-related values for the dielectric properties of tissue.

In addition, the distribution of SAR and temperature should be addressed in pregnancy, taking into account the fact that the circulation of blood in the fetus is separate from maternal blood flow. The heat produced by fetal metabolism is dissipated to the mother mostly at the placenta, but this is less efficient than expected and the temperature of the fetus is usually ~0.5°C above that of the mother.[47]

The difference between the ability of children and that of adults to dissipate whole-body heat loads is small. During exercise in thermally neutral or warm environments, children thermoregulate as effectively as adults. When ambient temperatures exceed body temperature, however, children are more liable to have a higher rate of heat absorption compared with adults. Also, although neither children nor adults replace fluid loss sufficiently during exercise in the heat, dehydration may have a more detrimental effect on children because of their greater reliance on elevated skin blood flow to dissipate heat.

Hyperthermia during pregnancy can cause embryonic death, abortion, growth retardation, and developmental defects; animal studies indicate that the development of the CNS is especially susceptible.[47] In humans, epidemiologic studies suggest that an elevation of maternal body temperature by 2°C for at least 24 hours during fever can cause a range of developmental defects, although a causal relationship has not been established. In addition, young infants aged 2 to 3 months are even more vulnerable than neonates because of their higher metabolic rate, better tissue insulation, and slightly lower surface area/mass ratio. However, serious health effects are associated only with greatly elevated body temperatures (>40°C), and such temperature rises are well above the maximum allowable for public RF exposure.

Many different nonthermal mechanisms for RF interaction with tissue have been considered in recent studies.[48–50] These are not particular to children, but if any were confirmed at levels below current guidance, then questions might also be raised about potential childhood susceptibility. Possible RF electric-field interactions[51] include (1) changes in the conformation of proteins, including ATPases associated with ion channels, resulting in functional changes in the proteins, (2) changes in the binding of

ligands such as Ca^{2+} to cell receptor proteins, also resulting in changed receptor function, (3) absorption of RF energy by the vibrational states of biological components such as microtubules, (4) enhanced attraction between cells (the pearl-chain effect), and (5) demodulation of a modulated RF signal, producing ELF electric fields. Generally, it was considered that such interactions are unlikely to be biologically significant at RF levels below guidance values.

In addition, there is evidence concerning RF interactions with magnetite affecting nearby ion channel function by exerting a torque. Possible RF magnetic field effects include (1) interaction with magnetite particles in biological tissue and (2) radical pair interactions, potentially increasing free-radical concentrations, thereby leading to an increased risk of oxidative damage. Although these interaction mechanisms are also considered unlikely to be of biological significance at RF levels below guidance values, given the link between free radicals and disease, RF effects on free-radical concentrations via radical-pair interactions are considered worth exploring.

For infant, childhood, and adolescent exposure, the maturation of the CNS has been raised as potentially susceptible. In this context, the major changes to the CNS during this period comprise a maturation of the hard-wiring (namely, increased myelination), facilitating the transmission of information, which occurs rapidly over the first 2 years but extends into the second decade of life, and remodeling of the synaptic connections between neurons[8] after the first 2 years and into adolescence, mostly by synapse elimination as redundant connections are lost. With regard to synaptogenesis, spontaneous and stimulus-evoked electrical activity in the CNS is believed to play a crucial role in local competition between growing nerve axons and the distribution of their synaptic boutons on target cells.[52] Whether RF fields could affect these processes is not known. Neurobehavioral studies in volunteers and in animals, mostly adults, have not reported robust responses to RF exposure, particularly that associated with mobile phones.[31]

Numerous studies have evaluated developmental effects of RF fields on mammals, birds, and other nonmammalian species.[53,54] These studies have shown clearly that RF fields are teratogenic at exposure levels that are high enough to cause significant increases in temperature. There is no consistent evidence of effects at nonthermal exposure levels, although only a few studies have evaluated possible effects on postnatal development using sensitive end points such as behavioral effects.

Several studies of maternal occupational RF exposure, primarily to physiotherapists, have reported an increased risk of congenital malformations. However, no specific type of malformation has been consistently reported, and there is a potential for recall bias in these studies. Exposure to the fetus from a mobile phone kept in a pocket, handbag, or belt by the hip when a pregnant woman is using hands-free equipment has been mentioned. Thus far, no studies are available on pregnancy outcomes related to mobile telephony.

All the studies have reported negative results for carcinogenicity in normal animals at SARs compatible with mobile telephony,[55] although controversy still exists about the carcinogenic effects of RF radiation in a transgenic mouse model.[56] Two studies in particular reported the lack of an effect of perinatal RF exposure, continuing for 24 months, on spontaneous and chemically induced brain tumors in rats.[57,58]

Several ecological studies[59–66] have examined cancer risk, including risk of childhood leukemia, among populations living in proximity to radio and television broadcast towers. Often driven by a previously identified cluster, these analyses are based simply on distance from the source and often include an extremely small number of cases. Such studies have been uninformative. More rigorous investigations might be feasible with development of new instruments capable of capturing personal RF exposure.

Few relevant epidemiologic or laboratory studies have addressed the possible effects of RF exposure on children. Because of widespread use of mobile phones among children and adolescents and relatively high exposures to the brain, investigation of the potential effects of RF fields on the development of childhood brain tumors is warranted. The importance of longer lifetime exposure has been emphasized by a recent study[67] in which acoustic neuroma occurred only after 10-year use of mobile phones. The type of mobile-phone use among children (eg, text messaging), their potential biological vulnerability, and longer lifetime exposure make extrapolation from adult studies problematic. Such scientific uncertainty can be addressed through both the application of precautionary policies and through additional research.

DEVELOPING POLICY FOR CHILDREN AND PREGNANT WOMEN

In today's world, technologic developments bring both social and economic benefits to large sections of society; however, the health consequences of these developments can be difficult to predict and manage. Nevertheless, even if the effects are small, a widespread exposure can have large public health consequences. When risks are complex, an established cause-effect relationship is absent, or the scientific findings are not robustly quantifiable, the need for timely preventive action makes a precautionary approach an essential part of policy making. Many societies believe that this is particularly true regarding children (including the unborn child): they represent the future of the society, have the potential for longer exposure than adults, and yet are less able to manage their own risk.

International guidance on occupational and public exposure to EMFs, described above, is based on avoiding risks to health that are well understood and for which there is good scientific evidence. However, with regard to childhood exposure to EMFs (and exposure during pregnancy), several factors argue for the adoption of precautionary measures, including the possibility that EMFs might affect children;

the dread with which some of the diseases raised in this context, such as leukemia and brain cancer, are perceived; the involuntary nature of some of the exposure; its extensiveness; and its likely rapid growth in the future.

The WHO International EMF Project (www.who.int/emf) is finalizing a practical framework for guiding policy options in areas of scientific uncertainty that is based on the application of precaution.[68] In general terms, the draft WHO precautionary framework aims to develop a set of public health policy options that can be applied according to the degree of scientific uncertainty and the anticipated severity of the harm that might ensue from exposure, taking into account the size of the affected population and the cost of exposure reduction. These measures should not be seen as undermining science-based guidance on exposure; rather, they represent additional steps with application that may vary from country to country depending on social and economic considerations.

Precautionary measures may also be adopted at an individual level, depending on the degree of concern felt by the exposed person. In giving advice to their patients, physicians should weigh the strength of scientific evidence for the risk, if any, of an adverse outcome, the benefits of the technology, and the feasibility of reducing exposure, as well as the overall health of the patient, which includes freedom from worry and anxiety.

For ELF (power-frequency) fields, there is some evidence that exposure to environmental magnetic fields that are relatively high but well below guidance levels is associated with an increase in the risk of childhood leukemia, a very rare disease (even if the risk is doubled, it remains small at ~5–8 per 100 000 children per year). Although the evidence is regarded as insufficient to justify more restrictive limits on exposure, the possibility that exposure to ELF magnetic fields increases risk cannot be discounted. For the physician faced with questions from, for example, a couple planning a family and concerned about this issue, or from someone pregnant and occupationally exposed to relatively high ELF magnetic fields, standardized advice is not possible. Instead, physicians could inform their patients of possible risk and advise them to weigh all the advantages and disadvantages of the options available to them (of which EMF reduction is but one consideration). Some simple options include reducing exposure by minimizing the use of certain electrical appliances or changing work practices to increase distance from the source of exposure. People living near overhead power lines should be advised that such proximity is just an indicator of exposure and that homes far away from power lines can have similar or higher fields.

Regarding the long-term health effects of mobile-phone use, the paucity of data, particularly for children, suggests that low-cost precautionary measures are appropriate, especially because some of the exposures are close to guideline limits. Physicians could advise parents that their children's RF exposure can be reduced by restricting the length of calls or by using hands-free devices to keep mobile phones away from the head and body. On the other hand, exposure levels from mobile-phone base stations are extremely low, and therefore precautionary measures do not need to be recommended.

RESEARCH RECOMMENDATIONS

In addition to reviewing the available evidence summarized in this article, workshop participants developed a research agenda that identifies high-priority studies needed to fully assess the potential vulnerability of children to ELF and RF fields and outlines the rationale for these studies (see www.who.int/peh-emf/research/rf03/en for more details). Additional laboratory and epidemiologic studies relating to childhood leukemia and ELF magnetic field exposure were strongly recommended. In addition, because of widespread use of mobile phones and relatively high exposures to the brain among children and adolescents, investigation of the potential effects of RF fields on cognition and the development of childhood brain tumors was considered particularly urgent. Laboratory studies using children are, of course, subject to appropriate ethical design and approval.

APPENDIX: GLOSSARY

Absorption: dissipation of the energy of a radio wave (ie, conversion of its energy into another form, such as heat) into the surrounding medium.

Basic restriction: restriction on exposure to time-varying electric, magnetic, and electromagnetic fields that are based directly on established health effects. Depending on the frequency of the field, the physical quantities used to specify these restrictions are current density (J), SAR, and power density (S). Only power density in air, outside the body, can be readily measured in exposed individuals.

Contact current: current flowing through a person in contact with 2 surfaces that are at different potentials.

Current density: a vector of which the integral over a given surface is equal to the current flowing through the surface; the mean density in a linear conductor is equal to the current divided by the cross-sectional area of the conductor; expressed in ampere per square meter (A/m^2).

Dosimetry: measurement or determination by calculation of the internal electric-field strength or induced current density, or of the specific absorption (SA) or SAR distribution in humans or animals exposed to EMF.

Electric field or electric-field strength (E): the force (**E**) on a stationary unit positive charge at a point in an electric field; measured in volts per meter (V/m).

Electric and magnetic fields or electromagnetic fields (EMFs): the combination of time-varying electric and magnetic fields.

Extremely low frequency (ELF) EMFs: EMFs at frequencies of >0 Hz and <300 Hz.

Field strength: the magnitude of the electric or magnetic field, normally the root-mean-square value.

Frequency: the number of sinusoidal cycles completed by electromagnetic waves in 1 second; usually expressed in units of hertz (Hz).

Induced current: current induced in a human body exposed to EMF.
Magnetic field or magnetic field strength (H): an axial vector quantity, **H**, which, together with magnetic induction, specifies a magnetic field at any point in space; expressed in units of ampere per meter (A/m^2).
Magnetic flux density (B): a vector field quantity, **B**, that results in a force that acts on a moving charge or charges; expressed in tesla (T) or gauss (G).
Nonionizing radiation: includes all radiation and fields of the electromagnetic spectrum that do not normally have sufficient energy to produce ionization in matter; characterized by energy per photon less than ~12 eV, wavelengths >100 nm, and frequencies <3 × 10^{14} Hz.
Power density: the rate of electromagnetic energy flow crossing a unit area normal to the direction of wave propagation; expressed in watts per square meter ($W \cdot m^{-2}$).
Power frequency: the frequency at which alternating-current electricity is generated. For electric utilities, the power frequency is 60 Hz in North America, Brazil, and parts of Japan. Electric power is 50 Hz in much of the rest of the world. Isolated alternating-current electrical systems may have other power frequencies, eg, 440 Hz in commercial airliners and 16⅔ Hz in some railway systems.
Radiation (electromagnetic): the emission or transfer of energy through space in the form of electromagnetic waves.
Radio frequency (RF): any frequency at which electromagnetic radiation is useful for telecommunication. In this article, RF refers to the frequency range of 10 MHz to 300 GHz.
Reference level: EMF exposure level provided for practical exposure-assessment purposes to determine if basic restrictions are likely to be exceeded. Some reference levels are derived from relevant basic restrictions using measurement and/or computational techniques, and some address perception and adverse indirect effects of exposure to EMF.
Specific absorption: the energy absorbed per unit mass of biological tissue, expressed in joules per kilogram (J/kg); specific absorption is the time integral of the SAR.
Specific absorption rate (SAR): the rate at which energy is absorbed in body tissues; expressed in watts per kilogram (W/kg); SAR is the dosimetric measure that has been widely adopted at frequencies above ~100 kHz.

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The Sensitivity of Children to Electromagnetic Fields

Leeka Kheifets, Michael Repacholi, Rick Saunders and Emilie van Deventer

Pediatrics 2005;116;e303
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The Sensitivity of Children to Electromagnetic Fields

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Planetary electromagnetic pollution: it is time to assess its impact

As the Planetary Health Alliance moves forward after a productive second annual meeting, a discussion on the rapid global proliferation of artificial electromagnetic fields would now be apt. The most notable is the blanket of radiofrequency electromagnetic radiation, largely microwave radiation generated for wireless communication and surveillance technologies, as mounting scientific evidence suggests that prolonged exposure to radiofrequency electromagnetic radiation has serious biological and health effects. However, public exposure regulations in most countries continue to be based on the guidelines of the International Commission on Non-Ionizing Radiation Protection[1] and Institute of Electrical and Electronics Engineers,[2] which were established in the 1990s on the belief that only acute thermal effects are hazardous. Prevention of tissue heating by radiofrequency electromagnetic radiation is now proven to be ineffective in preventing biochemical and physiological interference. For example, acute non-thermal exposure has been shown to alter human brain metabolism by NIH scientists,[3] electrical activity in the brain,[4] and systemic immune responses.[5] Chronic exposure has been associated with increased oxidative stress and DNA damage[6,7] and cancer risk.[8] Laboratory studies, including large rodent studies by the US National Toxicology Program[9] and Ramazzini Institute of Italy,[10] confirm these biological and health effects in vivo. As we address the threats to human health from the changing environmental conditions due to human activity,[11] the increasing exposure to artificial electromagnetic radiation needs to be included in this discussion.

Due to the exponential increase in the use of wireless personal communication devices (eg, mobile or cordless phones and WiFi or Bluetooth-enabled devices) and the infrastructure facilitating them, levels of exposure to radiofrequency electromagnetic radiation around the 1 GHz frequency band, which is mostly used for modern wireless communications, have increased from extremely low natural levels by about 10^{18} times (figure). Radiofrequency electromagnetic radiation is also used for radar, security scanners, smart meters, and medical equipment (MRI, diathermy, and radiofrequency ablation). It is plausibly the most rapidly increasing anthropogenic environmental exposure since the mid-20th century, and levels will surge considerably again, as technologies like the Internet of Things and 5G add millions more radiofrequency transmitters around us.

Unprecedented human exposure to radiofrequency electromagnetic radiation from conception until death has been occurring in the past two decades. Evidence of its effects on the CNS, including altered neurodevelopment[14] and increased risk of some neurodegenerative diseases,[15] is a major concern considering the steady increase in their incidence. Evidence exists for an association between neurodevelopmental or

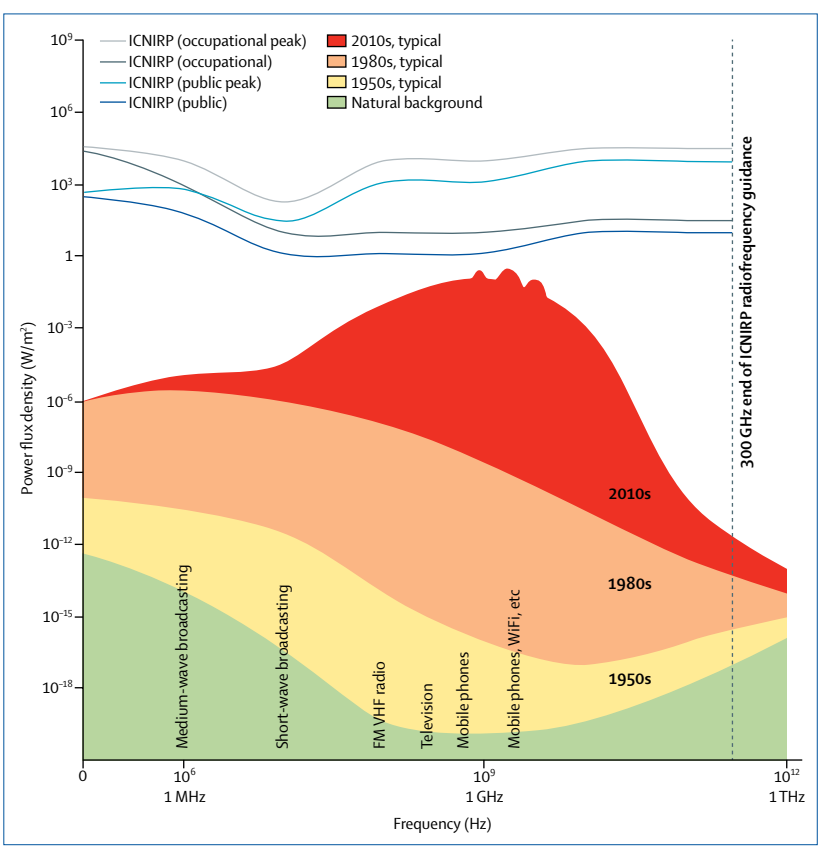

Figure: **Typical maximum daily exposure to radiofrequency electromagnetic radiation from man-made and natural power flux densities in comparison with International Commission on Non-Ionizing Radiation Protection safety guidelines[1]**

Anthropogenic radiofrequency electromagnetic radiation levels are illustrated for different periods in the evolution of wireless communication technologies. These exposure levels are frequently experienced daily by people using various wireless devices. The levels are instantaneous and not time-averaged over 6 minutes as specified by International Commission on Non-Ionizing Radiation Protection for thermal reasons. Figure modified from Philips and Lamburn[12] with permission. Natural levels of radiofrequency electromagnetic radiation were based on the NASA review report CR-166661.[13]

behavioural disorders in children and exposure to wireless devices,[14] and experimental evidence, such as the Yale finding, shows that prenatal exposure could cause structural and functional changes in the brain associated with ADHD-like behaviour.[16] These findings deserve urgent attention.

For the **Oceania Radiofrequency Scientific Advisory Association** see www.orsaa.org

At the Oceania Radiofrequency Scientific Advisory Association, an independent scientific organisation, volunteering scientists have constructed the world's largest categorised online database of peer-reviewed studies on radiofrequency electromagnetic radiation and other man-made electromagnetic fields of lower frequencies. A recent evaluation of 2266 studies (including in-vitro and in-vivo studies in human, animal, and plant experimental systems and population studies) found that most studies (n=1546, 68·2%) have demonstrated significant biological or health effects associated with exposure to anthropogenic electromagnetic fields. We have published our preliminary data on radiofrequency electromagnetic radiation, which shows that 89% (216 of 242) of experimental studies that investigated oxidative stress endpoints showed significant effects.[7] This weight of scientific evidence refutes the prominent claim that the deployment of wireless technologies poses no health risks at the currently permitted non-thermal radiofrequency exposure levels. Instead, the evidence supports the International EMF Scientist Appeal by 244 scientists from 41 countries who have published on the subject in peer-reviewed literature and collectively petitioned the WHO and the UN for immediate measures to reduce public exposure to artificial electromagnetic fields and radiation.

For the **International EMF Scientist Appeal** see www.emfscientist.org

Evidence also exists of the effects of radiofrequency electromagnetic radiation on flora and fauna. For example, the reported global reduction in bees and other insects is plausibly linked to the increased radiofrequency electromagnetic radiation in the environment.[17] Honeybees are among the species that use magnetoreception, which is sensitive to anthropogenic electromagnetic fields, for navigation.

Man-made electromagnetic fields range from extremely low frequency (associated with electricity supplies and electrical appliances) to low, medium, high, and extremely high frequency (mostly associated with wireless communication). The potential effects of these anthropogenic electromagnetic fields on natural electromagnetic fields, such as the Schumann Resonance that controls the weather and climate, have not been properly studied. Similarly, we do not adequately understand the effects of anthropogenic radiofrequency electromagnetic radiation on other natural and man-made atmospheric components or the ionosphere. It has been widely claimed that radiofrequency electromagnetic radiation, being non-ionising radiation, does not possess enough photon energy to cause DNA damage. This has now been proven wrong experimentally.[18,19] Radiofrequency electromagnetic radiation causes DNA damage apparently through oxidative stress,[7] similar to near-UV radiation, which was also long thought to be harmless.

At a time when environmental health scientists tackle serious global issues such as climate change and chemical toxicants in public health, there is an urgent need to address so-called electrosmog. A genuine evidence-based approach to the risk assessment and regulation of anthropogenic electromagnetic fields will help the health of us all, as well as that of our planetary home. Some government health authorities have recently taken steps to reduce public exposure to radiofrequency electromagnetic radiation by regulating use of wireless devices by children and recommending preferential use of wired communication devices in general, but this ought to be a coordinated international effort.

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Epidemiological Evidence for a Health Risk from Mobile Phone Base Stations

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Human populations are increasingly exposed to microwave/radiofrequency (RF) emissions from wireless communication technology, including mobile phones and their base stations. By searching PubMed, we identified a total of 10 epidemiological studies that assessed for putative health effects of mobile phone base stations. Seven of these studies explored the association between base station proximity and neurobehavioral effects and three investigated cancer. We found that eight of the 10 studies reported increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations. None of the studies reported exposure above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting the health of human populations. We believe that comprehensive epidemiological studies of long-term mobile phone base station exposure are urgently required to more definitively understand its health impact. *Key words*: base stations; electromagnetic field (EMF); epidemiology; health effects; mobile phone; radiofrequency (RF); electromagnetic radiation.

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INTRODUCTION

Mobile phone base stations are now found ubiquitously in communities worldwide. They are frequently found near or on shops, homes, schools, daycare centers, and hospitals (Figure 1). The radiofrequency (RF) electromagnetic radiation from these base stations is regarded as being low power; however, their output is continuous.[1] This raises the question as to whether the health of people residing or working in close proximity to base stations is at any risk.

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METHODS

By searching PubMed and using keywords such as base station, mast, electromagnetic field (EMF), radiofrequency (RF), epidemiology, health effects, mobile phone, and cell phone, and by searching the references of primary sources, we were able to find only 10 human population studies from seven countries that examined the health effects of mobile phone base stations. Seven of the studies explored the association between base station proximity and neurobehavioral symptoms via population-based questionnaires; the other three retrospectively explored the association between base station proximity and cancer via medical records. A meta-analysis based on this literature is not possible due to differences in study design, statistical measures/risk estimates, exposure categories, and endpoints/outcomes. The 10 studies are therefore summarized in chronological order (Table 1).

RESULTS AND DISCUSSION

We found epidemiological studies pertaining to the health effects of mobile phone base station RF emissions to be quite consistent in pointing to a possible adverse health impact. Eight of the 10 studies reported increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations. The studies by Navarro et al.,[2] Santini et al.,[3] Gadzicka et al.,[4] and Hutter et al.[5] reported differences in the distance-dependent prevalence of symptoms such as headache, impaired concentration, and irritability, while Abdel-Rassoul et al.[6] also found lower cognitive performance in individuals living ≤ 10 meters from base stations compared with the more distant control group. The studies by Eger et al.[7] and Wolf and Wolf[8] reported increased incidence of cancer in persons living for several years < 400 meters from base stations. By contrast, the large retrospective study by Meyer et al.[9] found no increased incidence of cancer near base stations in Bavaria. Blettner et al.[10] reported in Phase 1 of their study that more health problems were found closer to base stations, but in Phase 2[11] concluded that measured EMF emissions were not related to adverse health effects (Table 1).

Each of the 10 studies reviewed by us had various strengths and limitations as summarized in Table 1. Per-

Figure 1—Mobile phone base stations ("antennae" or "masts") in Australia. Upper left: Community shop roof showing plethora of flat panel antennae. Upper right: Hospital roof with flat panel antennae painted to blend in. Lower left: Top of a street light pole. Lower center: Mast erected next to a daycare center. Lower right: Antennae mounted on an office block top floor.

taining to those base station studies in which EMF measurements were not carried out,[3,4,7,9] it should be noted that distance is not the most suitable classifier for exposure to RF-EMF. Antennae numbers and configurations, as well as the absorption and reflection of their fields by houses, trees, or other geographic hindrances may influence the exposure level. Further, self-estimation of distance to nearest base station is not the best predictor of exposure since the location of the closest base station is not always known. Such exposure misclassification inevitably biases any association towards null. Multiple testing might also produce spurious results if not adjusted for,[3,5] as might failure to adjust for participant age and gender.[7] Latency is also an important consideration in the context of cancer incidence following or during a putative environmental exposure. In this regard, the study by Meyer et al.[9] found no association between mobile phone base station exposure and cancer incidence, but had a relatively limited observation period of only two years. On the other hand, the studies by Eger et al.[7] and Wolf and Wolf[8] found a significant association between mobile phone base station exposure and increased cancer incidence, although the approximate five-year latency between base station exposure and cancer diagnosis appears to be unexpectedly short in both of these studies.

Other problems in several population-based questionnaires are the potential for bias, especially selection[8] and participation[2,3,5,6,11] biases, and self-reporting of outcomes in combination with the exposure assessment methods used. For example, regarding limitations in exposure assessment, in a large two-phase base station study from Germany,[12,13]of the Phase 1 participants (n = 30,047), only 1326 (4.4%) participated with a single "spot" EMF measurement recorded in the bedroom for Phase 2. Further, health effect contributions from all relevant EMF sources and other non-EMF environmental sources need to be taken into account.[12] We acknowledge that participant concern instead of exposure could be the triggering factor of adverse health effects, however this "nocebo effect" does not appear to fully explain the findings.[4,5] Further, the biological relevance of the overall adverse findings (Table 1) is supported by the fact that some of the symptoms in these base-station studies have also been reported among mobile phone users, such as headaches, concentration difficulties, and sleep disorders.[13,14] Finally, none of the studies that found adverse health effects of base stations reported RF exposures above accepted international guidelines, the implication being that if such findings continue to be reproduced, current exposure standards are inadequate in protecting human populations.[15]

TABLE 1 Summary of Epidemiological Studies of Mobile Phone Base Station Health Effects

Publication (Year; Country)	Clinical Assessment	Study Design	Base Station Details	Participants	EMF Measured	Key Findings	Strengths	Limitations
Navarro[2] (2003; Spain)	Neuro-behavioral	Survey-questionnaire	GSM-DCS 1800 MHz	101	Yes	More symptoms with closer proximity to base station (< 150 m)	Detailed questionnaire, EMF measured, distances studied[a]	Low participation, self-estimated distances, subjects aware[b]
Santini[2] (2003; France)	Neuro-behavioral	Survey-questionnaire	n/s	530	No	More symptoms with closer proximity to base station (< 300 m)	Detailed questionnaire, distances & other EMF exposures assessed	As above, plus no EMF measurements, no base station details
Eger[7] (2004; Germany)	Cancer incidence	Retrospective case review	GSM 935 MHz	967	No	3 x risk of cancer after 5 yrs of exposure (< 400 m); early age of cancer diagnosis	Maximum beam intensity calculated, reliable cancer data collection	Other environmental risk factors not assessed; analysis not adjusted for age and sex.
Wolf & Wolf[8] (2004; Israel)	Cancer incidence	Retrospective case review	TDMA 850 MHz	1844	Yes	> 4 x risk of cancer after 3–7 yrs exposure (< 350 m); early age of cancer diagnosis	Reliable cancer & demographic data, no other major environmental pollutant identified	Not all environmental risk factors assessed; possible selection bias; no age, sex adjustment.
Gadzicka[4] (2006; Poland)	Neuro-behavioral	Survey-questionnaire	n/s	500	No	More headache with proximity < 150 m; nocebo unlikely[c]	Detailed questionnaire, distances & EMF studied, nocebo studied	Subjects aware, no base station details
Hutter[5] (2006; Austria)	Neuro-behavioral	Cross-sectional	900 MHz	336	Yes	Headaches & impaired concentration at higher power density; nocebo unlikely	Detailed questionnaire and testing, EMF measured, distances studied; nocebo effect studied	Subjects aware, low participation rate
Meyer[9] (2006; Germany)	Cancer incidence	Retrospective case review	n/s	177,428	No	No increased cancer incidence in municipalities with or without base stations	Wide population assessed (Bavaria)	Observation period only 2 years, vague definitions of exposure, exposure onset unknown, distance to base station unknown
Abdel-Rassoul[6] (2007; Egypt)	Neuro-behavioral	Cross-sectional	n/s	165	Yes	More symptoms & lower cognitive performance if living under or < 10 m from base station	Detailed questionnaire and testing, EMF measured, distances studied, subjects unaware	Exact base station details n/s, low number of participants
Blettner[10] (2009; Germany)	Neuro-behavioral	Cross-sectional	n/s	30,047	No	More health complaints closer to base station (< 500 m)	Wide population assessed, detailed survey, nocebo effect assessed	EMF measurements not carried out (see phase II in Berg-Beckhoff et al., 2009; below)
Berg-Beckhoff[11] (2009; Germany)	Neuro-behavioral	Cross-sectional	GSM 900 MHz GSM 1800 MHz UMTS 1920–1980 MHz	1326	Yes	Health effects probably caused by stress and not by RF-EMF	Measured EMF emissions, standardized questionnaires	Low participation, no detailed list of symptoms published, single "spot" measurement in one place in dwelling, no occupational exposure assessed, time lag from assessment of symptoms and EMF measurement

n / s = not specified.
[a]"Distance" refers to distance between base station and subjects' households.
[b]"Subjects aware" refers to study participants being aware of the nature of the study.
[c]"Nocebo" effect unlikely because the majority of subjects in the study reported little or no concern for base station proximity.

CONCLUSIONS

Despite variations in the design, size and quality of these studies as summarized in Table 1, it is the consistency of the base-station epidemiological literature from several countries that we find striking. In particular, the increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at distances < 500 meters from base stations found in 80% of the available studies. It should be pointed out that the overall findings of health problems associated with base stations might be based on methodological weaknesses, especially since exposure to RF electromagnetic radiation was not always measured.

There are some proposed mechanisms via which low-intensity EMF might affect animal and human health,[16,17] but full comprehensive mechanisms still remain to be determined.[18,19] Despite this, the accumulating epidemiological literature pertaining to the health effects of mobile phones[13,20] and their base stations (Table 1) suggests that previous exposure standards based on the thermal effects of EMF should no longer be regarded as tenable. In August 2007, an international working group of scientists, researchers, and public health policy professionals (the BioInitiative Working Group) released its report on EMF and health.[21] It raised evidence-based concerns about the safety of existing public limits that regulate how much EMF is allowable from power lines, cellular phones, base stations, and many other sources of EMF exposure in daily life. The BioInitiative Report[21] provided detailed scientific information on health impacts when people were exposed to electromagnetic radiation hundreds or even thousands of times below limits currently established by the FCC and International Commission for Non-Ionizing Radiation Protection in Europe (ICNIRP). The authors reviewed more than 2000 scientific studies and reviews, and have concluded that: (1) the existing public safety limits are inadequate to protect public health; and (2) from a public health policy standpoint, new public safety limits and limits on further deployment of risky technologies are warranted based on the total weight of evidence.[21] A precautionary limit of 1 mW/m^2 (0.1 $microW/cm^2$ or 0.614 V/m) was suggested in Section 17 of the BioInitiative Report to be adopted for outdoor, cumulative RF exposure.[21] This limit is a cautious approximation based on the results of several human RF-EMF studies in which no substantial adverse effects on well being were found at low exposures akin to power densities of less than 0.5 – 1 mW/m^2.[2,5,22–26] RF-EMF exposure at distances > 500 m from the types of mobile phone base stations reviewed herein should fall below the precautionary limit of 0.614 V/m.

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High radiofrequency radiation at Stockholm Old Town: An exposimeter study including the Royal Castle, Supreme Court, three major squares and the Swedish Parliament

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Abstract. Exposure to radiofrequency (RF) radiation was classified as a possible human carcinogen, Group 2B, by the International Agency for Research on Cancer at WHO in 2011. The exposure pattern is changing due to the rapid development of technology. Outdoor RF radiation level was measured during five tours in Stockholm Old Town in April, 2016 using the EME Spy 200 exposimeter with 20 predefined frequencies. The results were based on 10,437 samples in total. The mean level of the total RF radiation was 4,293 μW/m^2 (0.4293 μW/cm^2). The highest mean levels were obtained for global system for mobile communications (GSM) + universal mobile telecommunications system (UMTS) 900 downlink and long-term evolution (LTE) 2600 downlink (1,558 and 1,265 μW/m^2, respectively). The town squares displayed highest total mean levels, with the example of Järntorget square with 24,277 μW/m^2 (min 257, max 173,302 μW/m^2). These results were in large contrast to areas with lowest total exposure, such as the Supreme Court, with a mean level of 404 μW/m^2 (min 20.4, max 4,088 μW/m^2). In addition, measurements in the streets surrounding the Royal Castle were lower than the total for the Old Town, with a mean of 756 μW/m^2 (min 0.3, max 50,967 μW/m^2). The BioInitiative 2012 Report defined the scientific benchmark for possible health risks as 30-60 μW/m^2. Our results of outdoor RF radiation exposure at Stockholm Old Town are significantly above that level. The mean exposure level at Järntorget square was 405-fold higher than 60 μW/m^2. Our results were below the reference level on 10,000,000 μW/m^2 established by the International Commission on Non-Ionizing Radiation Protection (ICNIRP), which, however, are less credible, as they do not take non-thermal effects into consideration and are not based on sound scientific evaluation. Our highest measured mean level at Järntorget was 0.24% of the ICNIRP level. A number of studies have found adverse, non-thermal (no measurable temperature increase) health effects far below the ICNIRP guidelines.

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Introduction

The results of a study on public exposure to radiofrequency (RF) radiation at the Stockholm Central Railway Station in Sweden were recently published (1). The exposimeter EME Spy 200 that covers 20 different radiofrequency bands from 87 to 5,850 MHz was used. The results were based on 1,669 data points recorded in November, 2015. The median value for total exposure was 921 μW/m^2 (0.092 μW/cm^2), with certain outliers >95,544 μW/m^2 (6 V/m, which is the upper detection limit). One example of such very high measured power density was from a global system for mobile communications (GSM) + universal mobile telecommunications system (UMTS) 900 downlink band from a base station located at the Stockholm Central Station lower level (1). People standing at that area or passing by are involuntarily exposed to high RF radiation without their knowledge. It was concluded that this represented an improper location of a base station with an unnecessary high downlink level.

In European countries, the Old Town is a point of a national heritage, a place and source of cultural and historical development throughout centuries. Stockholm Old Town has already been retrofitted with several existing antennas to accommodate voice and data transmission. The aim of the present study was to characterize RF radiation already in place and its effect on the public. The antenna grid is expected to be further expanded to accommodate the rollout of 5G mobile networking as the next wave of mobile technology is implemented. As mobile base station antennas are placed on rooftops, outer walls of buildings and other places, visual perturbations appear in the form of antenna casings, cables and other peripheral devices. Not only does this damage the aesthetic appearance of the historic districts of the Old Town,

but it is associated with exposure of the public to invisible RF radiation. Even where hidden antennas have been architecturally camouflaged (stealth installations), the RF radiation exposure is still present and remains a growing concern for environmental health.

The most drastic change brought about by the mobile telephony network is the change in the electromagnetic climate. The streets of old towns are filled with visually imperceptible RF radiation. As modern mobile telephony and data networking provide services at several different bands, there are different frequencies that also require band-specific antennas, therefore multiplying the number of antennas.

One major concern regarding RF radiation exposure in Sweden, as well as in a number of other countries, is that various authorities base their guidelines for exposure on the International Commission on Non-Ionizing Radiation Protection's (ICNIRP) guidelines that are based on short-term (acute) exposure. Chronic, low-intensity cumulative exposure, possible long-term health risks and non-thermal biological effects are not taken into consideration. The ICNIRP safety limit was established in 1998 (2) and updated in 2009 (3), without any further changes, and it still recommends 10 W/m^2 (10,000,000 μW/m^2) as the reference level for limiting the public's exposure to RF radiation (2-300 GHz) (2). The Swedish Radiation Safety Authority (SSM) has adopted the ICNIRP guidelines. Several members of the SSM expert panel are also members of ICNIRP, which may entail a conflict of interest, since these members would rarely compromise the ICNIRP view so that critical opinions are not heard.

Our results on public RF radiation exposure at the Stockholm Central Station are orders of magnitude lower than the ICNIRP guidelines, where the median level of exposure was ~10,000 times lower. Wireless internet access in schools is also a concern (4), although measurements of levels are scanty.

In contrast to ICNIRP, the BioInitiative Reports from 2007 (5), updated in 2012 (6), also based their evaluation on the non-thermal effects of RF radiation. The BioInitiative 2012 Report assessed ~1,800 new peer-reviewed studies published between 2006 and 2012 that documented the new and lower scientific benchmark for health harm to be 30-60 μW/m^2 (0.003-0.006 μW/cm^2), which is 0.0003-0.0006% below ICNIRP's guidelines. Also considering chronic exposure and sensitivity among children, the precautionary target level was proposed to be one-tenth of this value, namely 3-6 μW/m^2 (6). This exposure target level is not acknowledged by SSM, thus making it possible to overlook results on exposure, such as those at the Stockholm Central Station, and not providing precautions against potential detrimental effects on public health.

Interestingly, scientific evidence on the carcinogenic potential of RF radiation in laboratory studies has long been accumulating, but has mostly been ignored or entirely overlooked by decision-makers.

In 1982, Szmigielski *et al* published a study on the co-carcinogenic effects of RF radiation exposure and benzopyrene in mice (7) and demonstrated that 2,450 MHz of RF radiation at either 50 or 150 W/m^2 promoted carcinogenesis. The authors concluded that the resulting acceleration of development of spontaneous and chemically induced cancers indicated the carcinogenic potential of RF radiation.

Two studies published in 1990 demonstrated that non-thermal 2,450 MHz continuous-wave RF radiation exerted a biphasic effect on glioma cells (8) and lymphocytes (9). Cell proliferation was found at a specific absorption rate (SAR) of ≤50 W/kg, whereas a higher SAR suppressed DNA and RNA synthesis. These effects were reported to be non-thermal.

In 1992, Chou *et al* published a study on 200 rats exposed to 2,450 MHz pulsed RF radiation for 21.5 h/day for 25 months and 200 controls (10). SAR ranged between 0.144 and 0.4 W/kg, depending on the rat's weight. A statistically significantly increased incidence of primary malignant diseases was found in exposed animals compared with sham exposure. It should be noted that malignant lymphoma and thyroid cancer were among the malignancies found in exposed rats. These findings are interesting in view of the low SAR values in that study compared with the ICNIRP safety limit of SAR 2 W/kg in the brain for use of mobile phones (2).

In 1997, a study on mice carrying a lymphomagenic oncogene exposed to RF radiation was published (11). A total of 100 mice were sham-exposed and 101 were exposed for two 30-min periods per day for up to 18 months to 900 MHz pulsed RF radiation with power densities of 2.6-13 W/m^2 (SAR 0.008-4.2 W/kg; mean, 0.13-1.4 W/kg). The lymphoma risk was found to be statistically significantly higher in the exposed mice compared with that in the controls.

Those results were not confirmed in the study by Utteridge *et al* (12), which has been criticized for not being a replication study. However, the findings on lymphoma risk by Repacholi *et al* (11) and Chou *et al* (10) are of relevance in terms of increased non-Hodgkin lymphoma (NHL) risk in epidemiological studies on humans associated with the use of wireless phones. Thus, a statistically significantly increased risk of T-cell NHL was found in a previous study [odds ratio (OR)=8.75] (13) and in a second study for all NHL cases among subjects with >6 years of mobile phone use (OR=4.4 in men) (14), although based on limited numbers. Furthermore, the finding of thyroid cancer risk in the Chou *et al* study (10) is interesting in view of the sharp increase in the incidence of thyroid cancer during recent years (15). The thyroid gland is among the organs with highest exposure to RF radiation during use of handheld wireless phones, particularly smartphones (16,17).

The effects on tumour susceptibility in mice exposed to a UMTS test signal from the fetal period for up to 24 months was studied by Tillman *et al* (18). Animals were exposed to UMTS fields with intensities of 0, 4.8 and 48 W/m^2. The low-dose group (4.8 W/m^2) was subjected to additional prenatal ethylnitrosourea (ENU) treatment. The group that was ENU-treated and UMTS-exposed at 4.8 W/m^2 exhibited an increased rate of lung tumours and an increased incidence of lung carcinomas as compared with the controls treated with ENU alone. The authors concluded that the study demonstrated a co-carcinogenic effect of lifelong UMTS exposure in female mice subjected to pretreatment with ENU (18).

A follow-up study of the Tillman *et al* investigation was published in 2015 (19). The exposure levels were 0 (sham), 0.04, 0.4 and 2 W/kg SAR. The numbers of lung and liver tumours in exposed animals were statistically significantly higher compared with those in sham-exposed controls, as were the numbers of malignant lymphoma. A tumour-promoting

effect of RF radiation was found at low to moderate levels (0.04 and 0.4 W/kg SAR), which were well below the exposure limits for users of mobile phones (19).

A report was released from The National Toxicology Program (NTP) under the National Institutes of Health (NIH) in USA on the largest ever animal study on cell phone RF radiation and cancer (20). An increased incidence of glioma in the brain and malignant schwannoma in the heart was found. Acoustic neuroma or vestibular schwannoma is a similar type of tumour as the one found in the heart, although benign. The use of mobile as well as cordless phones has been associated with increased risk for glioma and acoustic neuroma in humans, as described below.

The same RF radiation that led male rats to develop brain tumours in the NTP study also caused DNA breaks in their brains. Female rats, which did not have statistically significantly elevated tumour counts, had fewer DNA breaks (http://microwavenews.com/news-center/ntp-comet-assay). According to Ron Melnick, who led the team that designed the NTP study, the results provide 'strong evidence for the genotoxicity of cell phone radiation' and this 'should put to rest the old argument that RF radiation cannot cause DNA damage'. The study is currently under peer review.

These new NTP study results appear to corroborate the findings of the 1995 study by Lai and Singh regarding increased levels of DNA single-strand breaks in brain cells from rats acutely exposed to low-intensity 2,450 MHz microwaves (21). A dose-rate-dependent increase in DNA single-strand breaks was found in brain cells of rats at 4 h post-exposure to 0.6 and 1.2 W/kg whole-body SAR. In rats exposed for 2 h to continuous-wave 2,450 MHz microwaves (SAR 1.2 W/kg), increases in brain cell DNA single-strand breaks were observed immediately as well as at 4 h post-exposure (21).

Our research group published the first results on the increased risk for brain tumours associated with the use of mobile and cordless phones ~15 years ago (22-25). More results have been obtained from our subsequent studies, as well as from studies conducted in other countries. The International Agency for Research on Cancer (IARC) at WHO concluded in 2011 that RF radiation is a possible human carcinogen, Group 2B (26,27). The IARC decision was based on human Swedish studies by our group (28-30) and the IARC Interphone Study (31-33) giving evidence of increased risk for brain tumours, mainly glioma, and acoustic neuroma in subjects using mobile phones. These results have been replicated in our subsequent studies (34-37) and the French CERENAT study on glioma and meningioma (38). IARC concluded that there is limited evidence from experimental animal studies supporting the carcinogenicity of RF radiation. However, later published human and animal studies reported that there is sufficient evidence of the carcinogenicity of RF radiation. That conclusion is supported by our review (39) using the Bradford Hill viewpoints (40) on the association or causation on environment and disease. Mechanistic studies that support a causal inference are also currently available and discussed below.

As areas with high RF radiation were previously recorded at the Stockholm Central Station in Sweden (1), the aim of the present study was to continue with outdoor measurements in locations visited by numerous individuals in Stockholm. Stockholm Old Town is a popular place for tourists that is located in Stockholm City within walking distance from the Central Railway Station. Several people reside in the Old Town and a number of shops and restaurants are located within this area. In addition, certain government buildings, such as the Supreme Court and the Royal Castle and the nearby Swedish Parliament, are located in that region as well.

As this was a measurement study with no involvement of test subjects, no ethical permission was required.

Materials and methods

EME Spy 200 exposimeter. In this study, an EME Spy 200 exposimeter (Satimo, MVG Industries, Brest, France) with a valid calibration was used to collect the exposure data. The exposimeter measures 20 predefined frequency bands, as presented in Table I. These cover the frequencies of most public RF radiation emitting devices currently used in Sweden. The exposimeter covers frequencies of 87-5,850 MHz. For frequency modulation (FM), TV3, TETRA, TV4&5, Wi-Fi 2G and Wi-Fi 5G, the lower detection limit is 0.01 V/m (0.27 μW/m^2); for all other bands, the lower detection limit is 0.005 V/m (0.066 μW/m^2). For all bands, the upper detection limit is 6 V/m (95,544 μW/m^2; 9.5544 μW/cm^2). The sampling time used in this study was every 4th sec, which is the fastest for the given exposimeter.

The exposimeter measures different telecommunications protocols: FM radio broadcasting; TV broadcasting; TETRA emergency services (police, rescue, etc.); GSM second-generation mobile communications; UMTS third-generation mobile communications, 3G; long-term evolution (LTE) fourth-generation mobile communications standard, 4G; digital European cordless telecommunications (DECT) cordless telephone systems standard; Wi-Fi wireless local area network protocol; worldwide interoperability for microwave access (WiMAX) wireless communication standard for high-speed voice, data and internet.

EME SPY 200 utilizes 3-axis antennas to capture RF radiation from all possible directions. The exposimeter was held at a distance of ~0.4 m from the body. The unit reports the exposure in a conservative manner, since each reported value is the sampling outcome, where many samples are collected and statistically processed including minimum, mean, median and maximum values.

Study design. The study was performed during daytime in April 8, 9, 10, 11, 13 and 22, 2016. These were all business days, except for April 9 and 10 (Saturday and Sunday). The length of the measurement route was up to 2.5 h, depending on the investigation. All major streets were covered during the investigation rounds. A few very short and narrow streets were not included. In addition, special measurement rounds were made using the streets surrounding the Supreme Court and the Royal Castle. The Swedish Parliament was also measured using the streets surrounding the Parliament as well as the central street, Riksgatan. Special measurement rounds were made at three squares, Stortorget, Kornhamnstorg and Järntorget. All measurements were included in the total result for the Old Town, except for the Swedish Parliament, which is located on the island of Helgeandsholmen and is reported separately. The buildings were selected as they are important sites

for decision-makers in Sweden. The squares were included as they are frequented by numerous visitors sitting outdoors at the restaurants and cafés. The selected locations as major streets, squares and buildings were measured several times, whereas small streets were measured only once. It should be noted that the Old Town is located on an island surrounded by water and, thus, is geographically well-defined (Fig. 1).

Statistical methods. Means, medians, minimum and maximum values in $\mu W/m^2$ were calculated for all measured frequency bands and for total exposure, and box plots were constructed to illustrate the distribution of total exposure for all measurement rounds. Values below the lower detection limit were treated as null (0). Total exposure was calculated as the sum of all measured frequency bands at each measured data point. Stata/SE 12.1 for Windows (StataCorp., College Station, TX, USA) was used for all calculations.

Results

The results of the Old Town measurements were based on 10,437 measurements in total during five separate measurement rounds, with a total of 696 min of measurements (~12 h). The results are displayed in Table II. The mean total level of RF radiation was 4,292.7 $\mu W/m^2$. The highest mean values were obtained for GSM + UMTS 900 downlink and LTE 2600 downlink (1,558.2 and 1,264.9 $\mu W/m^2$, respectively). It should be noted that the highest maximum levels were from base stations (5 bands) varying from 24,384.7 (LTE 800 downlink) to 95,522.5 (LTE 2600 downlink) $\mu W/m^2$. The highest maximum uplink (from a mobile phone) was found for GSM 1800, yielding 19,136.9 $\mu W/m^2$.

In Fig. 2, the box plot shows the results for five old town measurements and all exposure (total). The total median level was 534.0 $\mu W/m^2$ with several outliers of >100,000 $\mu W/m^2$.

In Fig. 3. the RF exposure variation over time is displayed for one of the measurement rounds. There was a large variation over time during these >2 h measurements covering major parts of the Old Town (streets and squares). The mean level was 5,371.4 $\mu W/m^2$ (median, 701.8 $\mu W/m^2$; range, 4.2-83,348.8 $\mu W/m^2$). Only for few moments the exposure was <100 $\mu W/m^2$, whereas several measurements were >10,000 $\mu W/m^2$.

Royal castle. The Swedish Royal Castle was covered by measurement rounds on the surrounding streets and also the Castle Square (Yttre Borggården) during ~4 h measurement time in total. These measurements represent an area with among the lowest RF radiation in the Old Town. The results were also included in the total measurement of the Old Town. Rather low mean values were found for most downlink bands (Table III). The highest mean level was measured for UMTS 2100 downlink (306.2 $\mu W/m^2$). The total mean RF radiation level for the Royal Castle area was 755.6 $\mu W/m^2$, representing only 17.6 % of the total mean level for the Old Town. In addition, the total highest level (maximum) was lower than all (50,967.1 $\mu W/m^2$, or 29.4% of the total).

The box plot in Fig. 4 of the six measurement tours to the Royal Castle area and total clearly shows lower levels compared with those for all the Old Town. The total median level was 387.8 $\mu W/m^2$, without any significant variation between different tours.

Table I. Frequency ranges of predefined measurement frequency bands of EME Spy 200 exposimeter.

Frequency band	Frequency min (MHz)	Frequency max (MHz)
FM	87	107
TV3	174	223
TETRA I	380	400
TETRA II	410	430
TETRA III	450	470
TV4&5	470	770
LTE 800, 4G (DL)	791	821
LTE 800, 4G (UL)	832	862
GSM 900 + UMTS 900, 3G (UL)	880	915
GSM 900 + UMTS 900, 3G (DL)	925	960
GSM 1800 (UL)	1,710	1,785
GSM 1800 (DL)	1,805	1,880
DECT	1,880	1,900
UMTS 2100, 3G (UL)	1,920	1,980
UMTS 2100, 3G (DL)	2,110	2,170
Wi-Fi 2 GHz	2,400	2,483.5
LTE 2600, 4G (UL)	2,500	2,570
LTE 2600, 4G (DL)	2,620	2,690
WiMAX	3,300	3,900
Wi-Fi 5 GHz	5,150	5,850

FM, frequency modulation; TV, television; LTE, long-term evolution; DL, downlink (transmission from base station to mobile phone); UL, uplink (transmission from mobile phone to base station); GSM, global system for mobile communications; UMTS, universal mobile telecommunications system; DECT, digital European cordless telecommunications; WiMAX, worldwide interoperability for microwave access.

Fig. 5 shows the RF exposure variation over time during one of the measurement rounds around the Royal Castle, clearly indicating that most measurements were <1,000 $\mu W/m^2$, with few spikes exceeding 10,000 $\mu W/m^2$.

Supreme court. The results for the Supreme Court are displayed in Table IV. These measurements represent the lowest levels of RF radiation among all measurements. The total mean level was 403.6 $\mu W/m^2$ and the maximum level was 4,088.1 $\mu W/m^2$. Almost all exposure represented downlink bands from mobile telephony base stations.

Fig. 6 displays the box plot for the measurement tours around the Supreme Court and all exposure (total). The total median level was 274.5 $\mu W/m^2$. Total exposure over time during the tours exhibited little difference over time, mostly <1,000 $\mu W/m^2$. The time variation for one tour is shown in Fig. 7.

Old town squares. The mean values for three major squares in the Old Town are shown in Table V. Several shops, restaurants and cafés are located in this region, including outdoor sitting

Figure 1. Map of Stockholm Old Town and Helgeandsholmen. Specific measurement locations are shown as follows: 1, Royal Castle; 2, Supreme Court; 3, Stortorget; 4, Kornhamnstorg; 5, Järntorget and 6, Swedish Parliament. Map from Lantmäteriet, Sweden.

areas. The results represent the highest measurements in the Old Town.

The highest levels were measured at the Järntorget square, as presented in Table VI. Only at Järntorget some levels for FM radio were detected, which were comparatively low in other parts of the Old Town. Very high mean and maximum levels were found for all downlinks from mobile telephony base stations, except for GSM 1800. The mean level for GSM + UMTS 900 downlink was noteworthy (10,272.7 μW/m^2). An exceptionally high total maximum level of 95,522.5 μW/m^2 was measured for LTE 2600 downlink.

The box plot for the measurements in Järntorget is shown in Fig. 8 and variation over time during one tour is shown in Fig. 9. High levels were measured, with a total median of 19,990.0 μW/m^2.

Swedish parliament. The Swedish Parliament is located on a separate island, Helgeandsholmen, just outside the Old Town. The results of four measurement rounds of ~1.5 h measurement time in total are shown in Table VII. Significantly lower levels were found compared with total measurements for the Old Town. RF level dynamics for one measurement tour are seen in Fig. 10.

Old town summary. The box plot in Fig. 11 shows a large variation in total exposure across measured sites in Stockholm Old Town. Relatively low RF levels were measured at the Royal Castle and the Supreme Court, whereas the Stortorget, Kornhamnstorg and Järntorget squares had exposure levels of at least an order of magnitude higher.

Discussion

The Stockholm Old Town RF radiation levels were measured on five occasions, yielding a total of 10,437 readings for the Old Town. This study showed a large variation in outdoor RF radiation level in the Stockholm Old Town. Furthermore, it should be noted that the measurements mainly characterize downlink exposure, without considering personal use of wireless devices, such as mobile phones. Indoor RF levels are likely to be somewhat lower with respect to inbound radiation, since the walls and windows of buildings attenuate the signals. On the other hand, on the premises on the opposite side of the transmitter antennas, the exposure levels may be even an order of magnitude higher if the beam happens to be directed towards these premises. For accurate information it would be necessary to make measurements inside buildings such as the Royal Castle, the Supreme Court, restaurants, apartments and the Swedish Parliament. Several buildings contain Wi-Fi routers for wireless communication, which would increase exposure at Wi-Fi bands. Furthermore, personal use of wireless phones (mobile as well as cordless), use of tablets and wireless internet via computers, add to RF radiation exposure.

This study provides information on the passive RF radiation exposure in a popular area of Stockholm, which is a destination for a number of visitors, such as tourists, citizens contacting different authorities, employees and residents. The study determined low levels at the surroundings of the Royal Castle, with a mean level of 755.6 μW/m^2, which is 17.6% of the total mean level in the Old Town (4,292.7 μW/m^2). An even lower mean level was measured for the Supreme Court (403.6 μW/m), representing 9.4% of the total mean level for the Old Town. It should also be noted that certain hotspots had somewhat higher RF radiation levels, both for the Royal Castle and the Supreme Court (Figs. 5 and 7). This is also illustrated by the box plots (Figs. 4 and 6) with third quartiles of <1,000 μW/m^2, with the exception of one of the Royal Castle measurements.

The abovementioned results are in large contrast to the squares of the Old Town. The three major squares were

Table II. Stockholm Old Town levels of radiofrequency radiation in total for five different tours on 8, 9, 11, 13 and 22 April, 2016.

Frequency band	No. of readings	Mean	Median	Min	Max
FM	10,437	11.1	0.0	0.0	3,674.6
TV3	10,437	1.5	0.0	0.0	273.3
TETRA I	10,437	18.6	0.0	0.0	2,913.3
TETRA II	10,437	0.2	0.0	0.0	253.3
TETRA III	10,437	0.6	0.0	0.0	790.8
TV4&5	10,437	4.0	0.0	0.0	2,775.9
LTE 800 (DL)	10,437	473.6	9.5	0.0	24,384.7
LTE 800 (UL)	10,437	0.0	0.0	0.0	1.7
GSM + UMTS 900 (UL)	10,437	4.3	0.0	0.0	9,972.7
GSM + UMTS 900 (DL)	10,437	1,558.2	38.2	0.0	84,495.3
GSM 1800 (UL)	10,437	10.3	1.0	0.0	19,136.9
GSM 1800 (DL)	10,437	215.2	37.6	0.0	73,221.5
DECT	10,437	5.0	0.0	0.0	1,127.6
UMTS 2100 (UL)	10,437	0.0	0.0	0.0	51.2
UMTS 2100 (DL)	10,437	720.4	152.8	0.0	71,228.5
Wi-Fi 2G	10,437	0.4	0.0	0.0	288.9
LTE 2600 (UL)	10,437	4.6	0.0	0.0	3,832.4
LTE 2600 (DL)	10,437	1,264.9	84.0	0.0	95,522.5
WiMAX	10,437	0.0	0.0	0.0	3.1
Wi-Fi 5G	10,437	0.0	0.0	0.0	62.1
Total	10,437	4,292.7	534.0	0.0	173,301.8

Analysis of all data (μW/m^2) treating values at detection limit as 0. FM, frequency modulation; TV, television; LTE, long-term evolution; DL, downlink (transmission from base station to mobile phone); UL, uplink (transmission from mobile phone to base station); GSM, global system for mobile communications; UMTS, universal mobile telecommunications system; DECT, digital European cordless telecommunications; WiMAX, worldwide interoperability for microwave access.

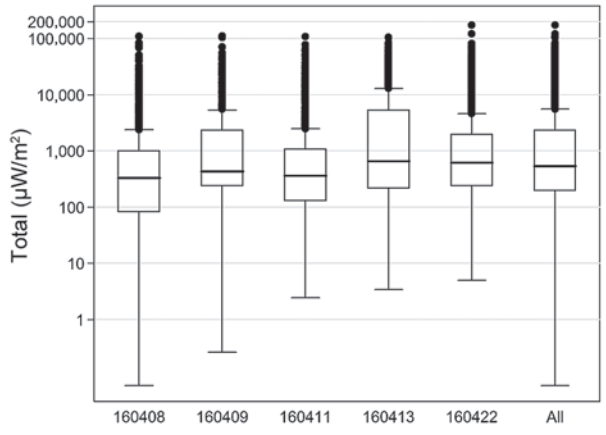

Figure 2. Stockholm Old Town. Box plot for exposure in μW/m^2, logarithmic scale, for the five measurement rounds and total exposure. The median is indicated by the black line inside each box; the bottom and top of the boxes represent the first and third quartiles; the end of the whiskers are calculated as 1.5 x interquartile range. The points represent the outliers.

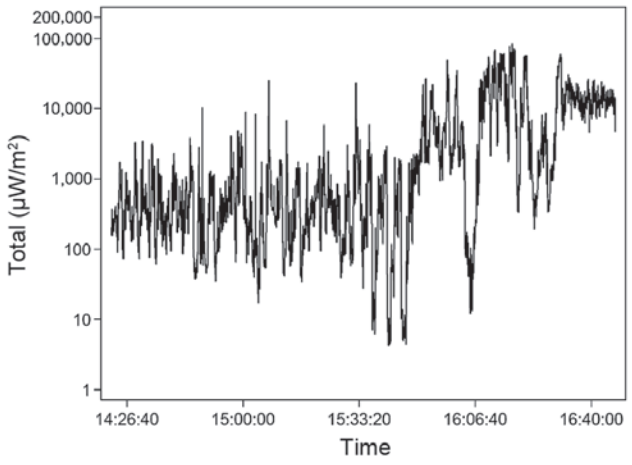

Figure 3. Stockholm Old Town. Total radiofrequency field exposure (mean exposure, 5,371.4 μW/m^2, logarithmic scale) over time of one typical exposure round (13 April, 2016; time, 14:22:14-16:46:58).

measured, namely Stortorget in the area of the Royal Castle, Kornhamnstorg and Järntorget at the other end of the Old Town. Particularly striking is the RF radiation level at Järntorget, although high mean levels were measured in all squares.

The mean RF radiation level at Järntorget was 24,277.1 μW/m^2, which is 60 times higher compared with that for the Supreme Court. It should also be noted that the maximum level for Järntorget was 173,301.8 μW/m^2, compared with 4,088.1 μW/m^2 for the Supreme Court, which is 42 times higher.

Table III. Stockholm Royal Castle levels of radiofrequency radiation in total as measured on 9, 11, 13 and 22 April, 2016.

Frequency band	No. of readings	Mean	Median	Min	Max
FM	3,385	3.7	0.9	0.0	140.3
TV3	3,385	1.8	0.0	0.0	85.9
TETRA I	3,385	51.6	1.7	0.0	2,913.3
TETRA II	3,385	0.3	0.0	0.0	74.9
TETRA III	3,385	0.8	0.0	0.0	655.2
TV4&5	3,385	1.4	0.0	0.0	133.1
LTE 800 (DL)	3,385	19.3	2.4	0.0	492.7
LTE 800 (UL)	3,385	0.0	0.0	0.0	0.3
GSM + UMTS 900 (UL)	3,385	9.7	0.0	0.0	9,972.7
GSM + UMTS 900 (DL)	3,385	51.2	6.6	0.0	3,961.0
GSM 1800 (UL)	3,385	14.4	1.2	0.0	19,136.9
GSM 1800 (DL)	3,385	172.4	42.1	0.0	44,198.2
DECT	3,385	1.4	0.0	0.0	234.0
UMTS 2100 (UL)	3,385	0.0	0.0	0.0	51.2
UMTS 2100 (DL)	3,385	306.2	126.1	0.1	32,530.5
Wi-Fi 2G	3,385	0.1	0.0	0.0	26.0
LTE 2600 (UL)	3,385	0.7	0.0	0.0	60.5
LTE 2600 (DL)	3,385	120.6	40.8	0.0	6,909.8
WiMAX	3,385	0.0	0.0	0.0	0.0
Wi-Fi 5G	3,385	0.0	0.0	0.0	1.4
Total	3,385	755.6	387.8	0.3	50,967.1

Analysis of all data ($\mu W/m^2$) treating values at detection limit as 0. FM, frequency modulation; TV, television; LTE, long-term evolution; DL, downlink (transmission from base station to mobile phone); UL, uplink (transmission from mobile phone to base station); GSM, global system for mobile communications; UMTS, universal mobile telecommunications system; DECT, digital European cordless telecommunications; WiMAX, worldwide interoperability for microwave access.

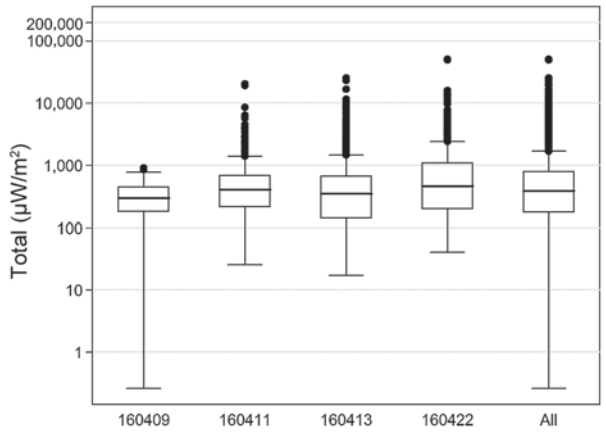

Figure 4. Stockholm Royal Castle. Box plot for exposure in $\mu W/m^2$, logarithmic scale, for four measurement rounds and total exposure. The median is indicated by the black line inside each box; the bottom and top of the boxes represent the first and third quartiles; the end of the whiskers are calculated as 1.5 x interquartile range. The points represent the outliers.

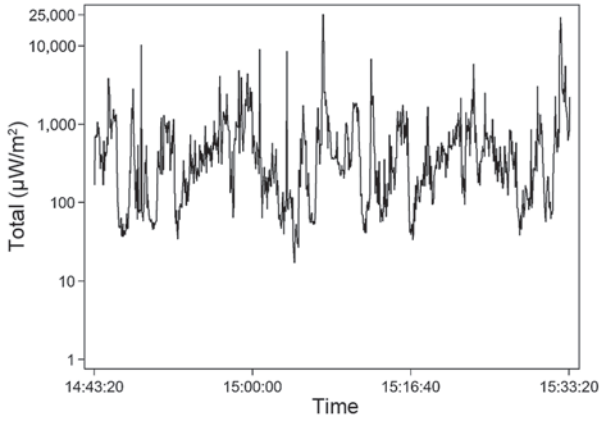

Figure 5. Stockholm Royal Castle. Total radiofrequency field exposure (mean exposure, 721.2 $\mu W/m^2$, logarithmic scale) over time of one typical exposure round (13 April, 2016; time, 14:43:22-15:33:26).

The high RF radiation exposure at the squares is of major concern due to the numerous shops, outdoor restaurants and cafés. The measured RF radiation is almost exclusively from mobile telephony base stations (e.g., see Table VI for Järntorget). Some of the base stations appear to be located in buildings of rather low height, with the radiation directed towards the sitting area of restaurants and coffee shops. The location of a base station at one of the measured squares is shown in Fig. 12; it was placed rather low, with the main emission directed towards an outdoor restaurant at a short distance.

Our results are significantly lower compared with the ICNIRP exposure guideline of 10,000,000 $\mu W/m^2$. However,

Table IV. Stockholm Supreme Court levels of radiofrequency radiation in total, as measured on 13 and 22 April, 2016.

Frequency band	No. of readings	Mean	Median	Min	Max
FM	715	0.6	0.0	0.0	29.2
TV3	715	1.2	0.0	0.0	35.7
TETRA I	715	0.3	0.0	0.0	58.9
TETRA II	715	0.3	0.0	0.0	12.6
TETRA III	715	0.1	0.0	0.0	26.0
TV4&5	715	0.1	0.0	0.0	19.2
LTE 800 (DL)	715	18.4	4.7	0.1	898.5
LTE 800 (UL)	715	0.0	0.0	0.0	0.0
GSM + UMTS 900 (UL)	715	6.1	0.0	0.0	2,874.5
GSM + UMTS 900 (DL)	715	32.7	11.2	0.2	578.5
GSM 1800 (UL)	715	4.7	2.5	0.0	65.4
GSM 1800 (DL)	715	104.6	54.2	3.4	2,196.6
DECT	715	0.0	0.0	0.0	1.1
UMTS 2100 (UL)	715	0.0	0.0	0.0	0.3
UMTS 2100 (DL)	715	82.0	46.2	0.4	1,966.4
Wi-Fi 2G	715	0.1	0.0	0.0	8.3
LTE 2600 (UL)	715	0.1	0.0	0.0	4.5
LTE 2600 (DL)	715	152.3	87.9	3.8	3,674.6
WiMAX	715	0.0	0.0	0.0	0.0
Wi-Fi 5G	715	0.0	0.0	0.0	0.9
Total	715	403.6	274.5	20.4	4,088.1

Analysis of all data (μW/m^2) treating values at detection limit as 0. FM, frequency modulation; TV, television; LTE, long-term evolution; DL, downlink (transmission from base station to mobile phone); UL, uplink (transmission from mobile phone to base station); GSM, global system for mobile communications; UMTS, universal mobile telecommunications system; DECT, digital European cordless telecommunications; WiMAX, worldwide interoperability for microwave access.

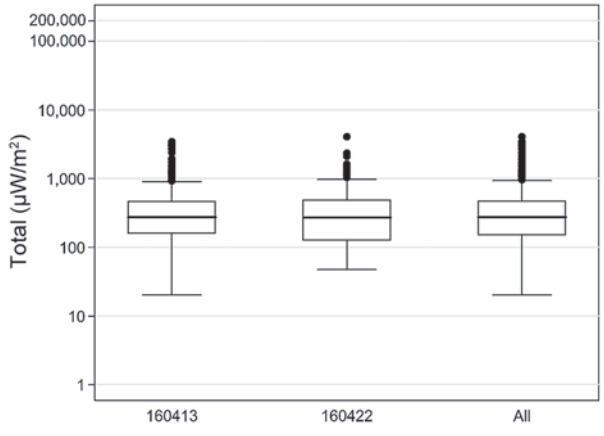

Figure 6. Stockholm Supreme Court. Box plot for exposure in μW/m^2, logarithmic scale, for two measurement rounds and total exposure. The median is indicated by the black line inside each box; the bottom and top of the boxes represent the first and third quartiles; the end of the whiskers are calculated as 1.5 x interquartile range. The points represent the outliers.

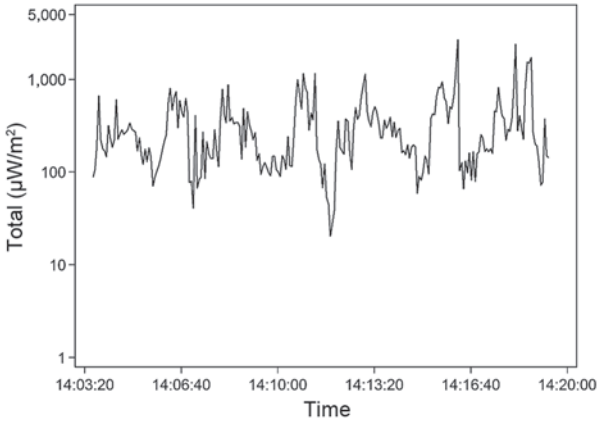

Figure 7. Stockholm Supreme Court. Total radiofrequency field exposure (mean exposure, 335.6 μW/m^2, logarithmic scale) over time of one typical exposure round (13 April, 2016; time, 14:03:37-14:19:21).

that guideline is outdated, since it does not include current scientific findings in humans and laboratory studies on RF radiation exposure. On the other hand, most measurements were higher than the scientific benchmark of 30-60 μW/m^2 that has been proposed to be the lowest observed effect level for RF radiation in Chapter 24 of the BioInitiative Report (6). Furthermore, our result on a total mean RF radiation level of 4,292.7 μW/m^2 in the Old Town (Table II) is of major concern, considering the oxidative effects on living cells from exposure to a level of RF radiation as low as 2,500 μW/m^2, as described by Yakymenko *et al* (41). This is also of

Table V. Stockholm Old Town mean levels of radiofrequency radiation ($\mu W/m^2$) for three squares, treating values at detection limit as 0.

	Stortorget, April 13 and 22, 2016		Kornhamnstorg, April 13 and 22, 2016		Järntorget, April 11, 13 and 22, 2016	
Frequency band	No.[a]	Mean	No.[a]	Mean	No.[a]	Mean
FM	527	2.8	1,191	24.4	574	67.9
TV3	527	0.0	1,191	0.4	574	0.7
TETRA I	527	0.6	1,191	0.0	574	0.9
TETRA II	527	0.0	1,191	0.3	574	0.0
TETRA III	527	0.1	1,191	0.0	574	0.4
TV4&5	527	4.3	1,191	3.4	574	30.8
LTE 800 (DL)	527	863.0	1,191	1,762.6	574	2,917.6
LTE 800 (UL)	527	0.0	1,191	0.0	574	0.0
GSM + UMTS 900 (UL)	527	0.0	1,191	0.0	574	0.0
GSM + UMTS 900 (DL)	527	2,721.9	1,191	5,222.3	574	10,272.7
GSM 1800 (UL)	527	10.8	1,191	7.5	574	0.1
GSM 1800 (DL)	527	194.4	1,191	590.8	574	12.1
DECT	527	0.0	1,191	39.2	574	0.0
UMTS 2100 (UL)	527	0.0	1,191	0.0	574	0.0
UMTS 2100 (DL)	527	1,811.0	1,191	672.2	574	4,049.7
Wi-Fi 2G	527	0.1	1,191	2.2	574	0.3
LTE 2600 (UL)	527	2.7	1,191	0.0	574	0.8
LTE 2600 (DL)	527	3,441.8	1,191	3,677.1	574	6,923.0
WiMAX	527	0.0	1,191	0.0	574	0.0
Wi-Fi 5G	527	0.0	1,191	0.1	574	0.0
Total	527	9,053.7	1,191	12,002.6	574	24,277.1

[a] Number of readings. FM, frequency modulation; TV, television; LTE, long-term evolution; DL, downlink (transmission from base station to mobile phone); UL, uplink (transmission from mobile phone to base station); GSM, global system for mobile communications; UMTS, universal mobile telecommunications system; DECT, digital European cordless telecommunications; WiMAX, worldwide interoperability for microwave access.

concern, since reactive oxidative species are crucial in carcinogenesis.

In Sweden, the dominating sources are currently exposure from mobile communication with UMTS, 3G and LTE, 4G with addition of Wi-Fi indoors, but also in certain outdoors locations. Our study from Stockholm Central Railway Station in 2015 yielded a mean total radiation level of 2,817-4,891 $\mu W/m^2$ for each measurement round and a median value of 921 $\mu W/m^2$ for all rounds. The mean for all rounds was 3,860 $\mu W/m^2$. In addition, hotspots were registered yielding >95,544 $\mu W/m^2$, which exceeded the exposimeter EME-Spy 200's upper detection limit. GSM+UMTS 900 downlink and UMTS 2100 downlink contributed the most, but LTE 800 downlink, GSM 1800 downlink and LTE 2600 downlink were also in the higher range of measurements (1). Thus, these results are similar to those of the present study.

The results of the present study show a large variation in passive outdoor RF radiation exposure in Stockholm Old Town. One explanation may be that there are no outdoor places with sitting areas to accommodate people during lunch or coffee breaks around the Royal Castle or the Supreme Court. This also applies to the Swedish Parliament, which is located on a separate island close to the Old Town. Thus, base stations are located around the squares to enable good network access. However, a lower level of radiation would still enable good network access (6). Comparatively low levels of RF radiation were measured for the Swedish Parliament compared with Järntorget. However, no indoor measurements were performed at the Swedish Parliament, where the RF radiation level would be quite different due to wireless internet access within the Parliament.

Unlike in other city districts, where mobile phone base station antennas are placed at a certain height, in the Old Town some antennas are located significantly closer to humans, sometimes only a few meters from the ground level. This creates areas of significantly high RF radiation, particularly in the immediate vicinity of such antennas. The exposure situation is worsened by the narrow streets and tall walls, which tend to trap the radio waves, hence creating reflections and increasing the exposure. The highest radiation zones may be proposed at buildings with windows facing the mobile base station antenna just across the street at the same height. The

Table VI. Järntorget mean levels of radiofrequency radiation (μW/m^2) on 11, 13 and 22 April, 2016, treating values at detection limit as 0.

Frequency band	No. of readings	Mean	Median	Min	Max
FM	574	67.9	0.4	0.0	3,674.6
TV3	574	0.7	0.0	0.0	69.6
TETRA I	574	0.9	0.0	0.0	41.4
TETRA II	574	0.0	0.0	0.0	0.7
TETRA III	574	0.4	0.0	0.0	27.1
TV4&5	574	30.8	0.0	0.0	2,775.9
LTE 800 (DL)	574	2,917.6	1,504.0	3.8	20,367.2
LTE 800 (UL)	574	0.0	0.0	0.0	0.0
GSM + UMTS 900 (UL)	574	0.0	0.0	0.0	4.9
GSM + UMTS 900 (DL)	574	10,272.7	6,140.5	29.8	65,440.6
GSM 1800 (UL)	574	0.1	0.0	0.0	8.9
GSM 1800 (DL)	574	12.1	4.5	0.6	590.9
DECT	574	0.0	0.0	0.0	0.0
UMTS 2100 (UL)	574	0.0	0.0	0.0	2.5
UMTS 2100 (DL)	574	4,049.7	2,716.7	38.2	21,078.9
WIFI 2G	574	0.3	0.0	0.0	25.5
LTE 2600 (UL)	574	0.8	0.0	0.0	35.1
LTE 2600 (DL)	574	6,923.0	4,157.8	30.4	95,522.5
WiMAX	574	0.0	0.0	0.0	3.1
Wi-Fi 5G	574	0.0	0.0	0.0	1.7
Total	574	24,277.1	19,990.0	257.0	173,301.8

FM, frequency modulation; TV, television; LTE, long-term evolution; DL, downlink (transmission from base station to mobile phone); UL, uplink (transmission from mobile phone to base station); GSM, global system for mobile communications; UMTS, universal mobile telecommunications system; DECT, digital European cordless telecommunications; WiMAX, worldwide interoperability for microwave access.

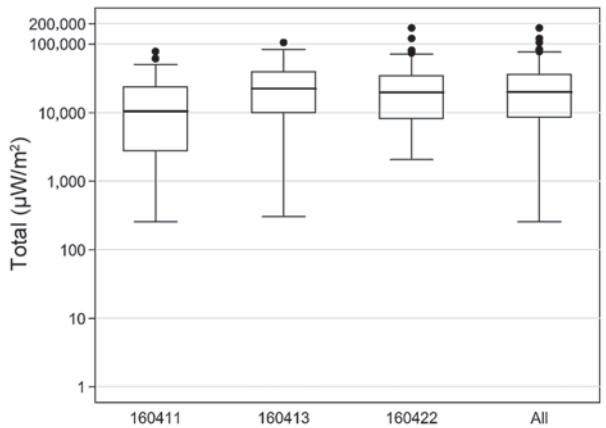

Figure 8. Stockholm Old Town, Järntorget. Box plot for exposure in μW/m^2, logarithmic scale, for three measurement rounds and total exposure. The median is indicated by the black line inside each box; the bottom and top of the boxes represent the first and third quartiles; the end of the whiskers are calculated as 1.5 x interquartile range. The points represent the outliers.

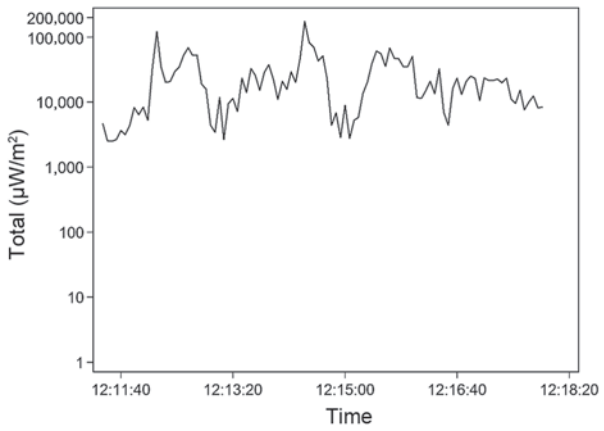

Figure 9. Stockholm Old Town, Järntorget. Total radiofrequency field exposure (mean exposure, 24,766.2 μW/m^2, logarithmic scale) over time of one typical exposure round (22 April, 2016; time, 12:11:24-12:17:56).

most affected are the individuals that have to stay longer in such places, also referred to as hotspots. Individuals whose living quarters, workstation or work area happen to be located in hotspots, are exposed to the heaviest RF load, whereas those who walk by hotspots only undergo momentary exposure and are less affected.

As the mobile telephony network is currently under development, the base station antennas are positioned following the current legal safety limits. However, the current limits only provide protection from short-term health effects (heating), but

Table VII. Stockholm Swedish Parliament mean levels of radiofrequency radiation ($\mu W/m^2$) on 8, 10, 11 and 22 April, 2016, treating values at detection limit as 0.

Frequency band	No. of readings	Mean	Median	Min	Max
FM	1,196	1.7	0.0	0.0	129.6
TV3	1,196	6.7	0.0	0.0	485.9
TETRA I	1,196	62.8	0.4	0.0	3,157.2
TETRA II	1,196	2.0	0.3	0.0	52.0
TETRA III	1,196	1.5	0.0	0.0	208.0
TV4&5	1,196	0.3	0.0	0.0	50.5
LTE 800 (DL)	1,196	99.7	5.9	0.0	5,623.2
LTE 800 (UL)	1,196	0.0	0.0	0.0	0.1
GSM + UMTS 900 (UL)	1,196	0.0	0.0	0.0	16.1
GSM + UMTS 900 (DL)	1,196	240.7	99.8	1.0	5,176.7
GSM 1800 (UL)	1,196	8.6	3.4	0.0	426.5
GSM 1800 (DL)	1,196	322.6	137.9	6.1	9,395.0
DECT	1,196	5.5	0.0	0.0	347.6
UMTS 2100 (UL)	1,196	0.0	0.0	0.0	1.5
UMTS 2100 (DL)	1,196	450.7	163.1	6.4	9,717.2
Wi-Fi 2G	1,196	0.1	0.0	0.0	8.9
LTE 2600 (UL)	1,196	7.1	1.1	0.0	313.9
LTE 2600 (DL)	1,196	293.9	129.6	5.1	9,385.0
WiMAX	1,196	0.0	0.0	0.0	0.0
Wi-Fi 5G	1,196	0.0	0.0	0.0	8.9
Total	1,196	1,503.9	957.4	99.6	16,781.9

FM, frequency modulation; TV, television; LTE, long-term evolution; DL, downlink (transmission from base station to mobile phone); UL, uplink (transmission from mobile phone to base station); GSM, global system for mobile communications; UMTS, universal mobile telecommunications system; DECT, digital European cordless telecommunications; WiMAX, worldwide interoperability for microwave access.

do not exclude possible long-term effects, which are currently under investigation. To grant better service coverage, the base station antennas are continuously placed in new locations, and the mobile telephony network becomes denser annually. Thus, the RF exposure of the population is increasing, particularly in densely populated areas.

As the research on long-term health hazards is ongoing, it is mostly focused on clearly identifiable biological effects. Knowledge on the effect of RF fields on mental health is of utmost importance, as in chronic exposure to RF radiation levels, such as those measured in hotspots in the Old Town. It should also be noted that long-term health effects, such as cancer, have not been investigated for this type of environmental contamination.

EME Spy 200 is a band-specific exposimeter and it enables identification and measurement of the majority of RF radiation bands currently used in Sweden. This study describes measurements mostly from far-field RF radiation and the exposure that the citizens may undergo without using personal wireless devices. Near-field exposure from personal mobile phones held near the ear or in the hand when on the internet will likely contribute considerably to an individual's total exposure.

The shielding effect from the body of a person carrying an exposimeter may be considerable, as shown by Bolte *et al* (42) when comparing a body-worn exposimeter with an exposimeter mounted on the roof of a car. This was partly compensated in our study by holding the exposimeter at a certain distance from the body.

Other studies have measured the exposure of RF radiation in public places. In 2012, Estenberg and Augustsson (43) used a car-mounted device to measure the frequency range 30-3,000 MHz in public places (rural, urban and large cities). The arithmetic mean measured exposure was 6,700 $\mu W/m^2$ in Stockholm, 1,500 $\mu W/m^2$ in 4 urban towns and 230 $\mu W/m^2$ in 2 rural areas. Similar to our study, the major sources were GSM and UMTS downlinks.

Earlier studies, prior to the use of smartphones, when 3G and 4G protocols became more common, reported lower exposure. Joseph *et al* (44) performed measurements with a personal exposimeter (EME-Spy 120-121) in different urban areas across Europe during 2007-2009. They found mean values for outdoor areas of 372-569 $\mu W/m^2$, mostly from mobile communications. In 2010, Bolte and Eikelboom (45) also performed measurements in The Netherlands with a personal exposimeter (EME-Spy 121) and found a mean value in outdoor activities of 208 $\mu W/m^2$. Visits to pubs, cafés, discos and snack bars yielded the highest mean value in their study (526 $\mu W/m^2$), mostly from mobile uplink at 1,800 MHz. Urbinello *et al* (46) used the same exposimeter in three different European cities (Basel, Ghent and Brussels), every month for 1 year (April, 2011-March, 2012). The

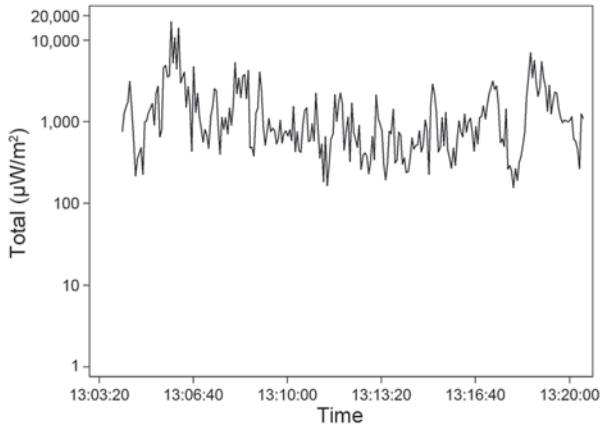

Figure 10. Stockholm, Swedish Parliament. Total radiofrequency field exposure (mean exposure, 1,460.2 μW/m^2, logarithmic scale) over time of one typical exposure round (11 April, 2016; time, 13:04:09-13:20:29).

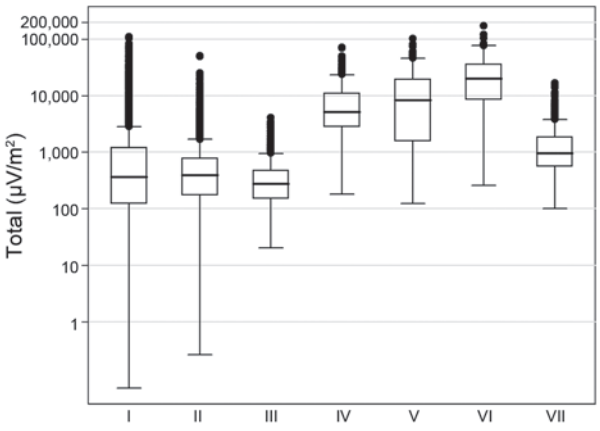

Figure 11. Box plot, total exposure (μW/m^2), all locations, logarithmic scale for the measurement rounds. The median is indicated by the black line inside each box; the bottom and top of the boxes represent the first and third quartiles; the end of the whiskers are calculated as 1.5 x interquartile range. The points represent the outliers. I=Stockholm Old Town; II=Royal Castle; III=Supreme Court; IV=Stortorget; V=Kornhamnstorg; VI=Järntorget; VII=Swedish Parliament.

total from all sources of RF radiation in downtown outdoor areas increased by 56% in Basel, 27% in Ghent and 25% in Brussels. The mean levels were 0.32-0.58 V/m (271-892 μW/m^2). In 2012, Aerts *et al* (47) conducted measurements in an urban/suburban area of Ghent, Belgium covering an area of 1 km^2. They selected 0.7 V/m (1,300 μW/m^2) as a threshold for a hotspot and found five hotspots in the area. GSM 900 base station signals contributed the most to all five hotspots with 45-100%, with GSM 1800 and 3G present in two of the hotspots.

Verlock *et al* (48) used a Narda NBM-550 in public places in Belgium during 2012-2013. The total average from all RF radiation sources between 100 kHz and 3 GHz was 0.62 V/m (1,020 μW/m^2), with a maximum of 2.4 V/m (15,287 μW/m^2).

Calvente *et al* (49) conducted measurements outside the homes of 123 families in Granada, Spain during 2012-2013. The arithmetic mean root square (RMS) for power density was 799 μW/m^2 and the median value was 285 μW/m^2. For the different homes, the median RMS ranged from 5 to 11,559 μW/m^2. In 2015, Gonzalez-Rubio *et al* (50) used an EME-Spy 140 located inside the plastic basket of a bicycle. With this bicycle they covered all 110 regions in the city of Albecete, Spain, performing measurements. The average for the 3 bands of mobile telephone antennas (GSM, Digital Combat Simulator and UMTS) in the different regions varied from 0.04 V/m (4.2 μW/m^2) to 0.89 V/m (2,102 μW/m^2).

The mean values for exposure to RF radiation from the earlier studies indicate a clear increase in the more recent exposimeter studies. It is clear from our present and previous (1) studies that the level of ambient RF radiation exposure is increasing. With the development of mobile communications technologies and the widespread use of wireless services, the exposure will continue to increase with higher exposure levels and also other frequency bands, despite the already proven adverse health effects.

Long-term studies with laboratory animals at or below the levels in the present study have shown the effects of RF radiation on several physiological parameters in the body of mammals. These are non-thermal effects and are discussed briefly below, including a few human studies.

Figure 12. Stockholm Old Town measurement location with a relatively high radiofrequency radiation level, due to a mobile telephony base station antenna positioned at a low height and targeted towards the square.

Several studies on rats have demonstrated that the blood-brain barrier (BBB) may open when exposed to RF radiation, resulting in pathological leakage of large molecules that may be toxic to the brain, with condensed dark neurons in the brain representing a sign of damage (51-54). The hippocampus, a center for memory and learning in the brain, appears to be particularly sensitive to neuronal damage from RF radiation and an opened BBB. Long-term exposure to 900 MHz RF radiation has been associated with extravasation of albumin in the hippocampus and cortex and impaired spatial memory in exposed rats (55-57).

A long-term study with exposure from GSM 900 MHz 3 h/day or DECT base station 8 h/day during 8 months reported a statistically significant downregulation or an overexpression for one-third of the 432 analyzed proteins from the brains of the RF-irradiated mice. Several neural function-related proteins, such as apolipoprotein E, heat shock proteins and cytoskeletal proteins, as well as proteins involved in brain metabolism, were altered (58).

Up to 12 months of exposure to Wi-Fi exerted an effect on microRNA in the brain (59) and in the testes, with head defects and DNA damage in sperm cells (60-62).

Yakymenko *et al* (41) published a review of 100 studies investigating the oxidative effects of low-intensity RF radiation in living cells, and demonstrated that exposure down to 2,500 μW/m^2 (63) with SAR values as low as 600 μW/kg (64,65) may increase oxidative stress in the cells. Long-term, low-intensity RF radiation exposure has also been associated with reduced levels of neurotransmitters, downregulation of microRNA, increase in pro-inflammatory cytokines and DNA damage with single-strand breaks in the hippocampus and cognitive impairments in learning and memory in exposed rats (65-67). An increase in frequency appears to exert more deleterious effect on several of the parameters (66).

Exposure levels in rats down to a SAR of 85 μW/kg, for 900 MHz during 2 h/day, 5 days/week for 30 days, increased the oxidative stress parameters in lipid peroxidation and protein oxidation. In addition, there was a statistically significant impairment in cognitive function in terms of spatial memory in the rats (68).

RF radiation has been shown to increase protein synthesis in proliferating human cells after 8 h of exposure, but not in quiescent white blood cells. This indicates a higher sensitivity of growing organisms (69). Furthermore, the capacity to repair DNA double-strand breaks was more affected by RF radiation in stem cells compared with differentiated cells, such as fibroblasts (70).

Epidemiological studies of mobile phone base stations have indicated health risks for humans. In particular, increased prevalence of adverse neurobehavioral symptoms or cancer in populations living at a distance of <500 m from base stations was found in 80% of the available studies in a review by Khurana *et al* (71). In another review, Levitt and Lai (72) included 56 studies. Exposure from base stations and other antenna arrays brought about changes in the immunological and reproductive systems of animals and humans, changes in biological material, DNA double-strand breaks, changes in calcium movement in the heart and increased proliferation rates in human astrocytoma cancer cells.

Long-term studies on low exposure to RF radiation of humans have demonstrated an effect on the neurotransmitters adrenaline, noradrenaline, dopamine and phenyletylamine when a GSM 900 MHz base station was installed in the village of Rimbach in Germany (73), as well as on cortisol and thyroid gland hormones in individuals living near base stations (74,75). Chronic dysregulation of psychobiological stress markers may contribute to health problems and chronic illnesses.

The results from these studies report levels of environmental exposure to RF radiation below the ICNIRP target level (2,3), but far above the BioInitiative Report level for biological effects (5,6). It has been argued that the BioInitiative Reports are not peer-reviewed. However, peer-reviewed and published studies also document health effects at low RF radiation levels (76,77). A recent article highlights the need for accurate information on the safety of exposure to RF radiation (78).

In conclusion, the aim of our study was to assess outdoor exposure to RF radiation at the Old Town and the nearby Parliament in Stockholm, Sweden. The Old Town is a part of Stockholm that is very popular among tourists, but also a destination for locals visiting the official buildings located in the area. In this study, real-time band-specific exposure measurements showed the highest contributors to the exposure to be download frequencies from the base stations of GSM + UMTS 900, UMTS 2100, LTE 800, LTE 2600 and GSM 1800 bands. The highest mean levels were found for GSM + UMTS 900 (3G) downlink and LTE 2600 (4G) downlink. The differences in exposure levels between the Supreme Court and Järntorget were striking, with the mean level 60 times higher at Järntorget. Unfortunately, studies on human risk from long-term environmental RF radiation based on personal exposure monitoring do not exist to the best of our knowledge. Future studies on cancer risk and other health effects from such exposure are imperative. The results of this study revealed unnecessarily high RF radiation areas in several parts of Stockholm Old Town. Using unnecessarily high power levels and placing mobile phone base station antennas too close to the ground and in heavily frequented areas pose an excess health risk to a significant part of the population.

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Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays

B. Blake Levitt and Henry Lai

Abstract: The siting of cellular phone base stations and other cellular infrastructure such as roof-mounted antenna arrays, especially in residential neighborhoods, is a contentious subject in land-use regulation. Local resistance from nearby residents and landowners is often based on fears of adverse health effects despite reassurances from telecommunications service providers that international exposure standards will be followed. Both anecdotal reports and some epidemiology studies have found headaches, skin rashes, sleep disturbances, depression, decreased libido, increased rates of suicide, concentration problems, dizziness, memory changes, increased risk of cancer, tremors, and other neurophysiological effects in populations near base stations. The objective of this paper is to review the existing studies of people living or working near cellular infrastructure and other pertinent studies that could apply to long-term, low-level radiofrequency radiation (RFR) exposures. While specific epidemiological research in this area is sparse and contradictory, and such exposures are difficult to quantify given the increasing background levels of RFR from myriad personal consumer products, some research does exist to warrant caution in infrastructure siting. Further epidemiology research that takes total ambient RFR exposures into consideration is warranted. Symptoms reported today may be classic microwave sickness, first described in 1978. Nonionizing electromagnetic fields are among the fastest growing forms of environmental pollution. Some extrapolations can be made from research other than epidemiology regarding biological effects from exposures at levels far below current exposure guidelines.

Key words: radiofrequency radiation (RFR), antenna arrays, cellular phone base stations, microwave sickness, nonionizing electromagnetic fields, environmental pollution.

Résumé : La localisation des stations de base pour téléphones cellulaires et autres infrastructures cellulaires, comme les installations d'antennes sur les toitures, surtout dans les quartiers résidentiels, constitue un sujet litigieux d'utilisation du territoire. La résistance locale de la part des résidents et propriétaires fonciers limitrophes repose souvent sur les craintes d'effets adverses pour la santé, en dépit des réassurances venant des fournisseurs de services de télécommunication, à l'effet qu'ils appliquent les standards internationaux d'exposition. En plus de rapports anecdotiques, certaines études épidémiologiques font état de maux de tête, d'éruption cutanée, de perturbation du sommeil, de dépression, de diminution de libido, d'augmentations du taux de suicide, de problèmes de concentration, de vertiges, d'altération de la mémoire, d'augmentation du risque de cancers, de trémulations et autres effets neurophysiologiques, dans les populations vivant au voisinage des stations de base. Les auteurs révisent ici les études existantes portant sur les gens, vivant ou travaillant près d'infrastructures cellulaires ou autres études pertinentes qui pourraient s'appliquer aux expositions à long terme à la radiation de radiofréquence de faible intensité « RFR ». Bien que la recherche épidémiologique spécifique dans ce domaine soit rare et contradictoire, et que de telles expositions soient difficiles à quantifier compte tenu des degrés croissants du bruit de fond des RFR provenant de produits de myriades de consommateurs personnels, il existe certaines recherches qui justifient la prudence dans l'installation des infrastructures. Les futures études épidémiologiques sont nécessaires afin de prendre en compte la totalité des expositions à la RFR ambiante. Les symptômes rapportés jusqu'ici pourraient correspondre à la maladie classique des micro-ondes, décrite pour la première fois en 1978. Les champs électromagnétiques non-ionisants constituent les formes de pollution environnementale croissant le plus rapidement. On peut effectuer certaines extrapolations à partir de recherches autres qu'épidémiologiques concernant les effets biologiques d'expositions à des degrés bien au-dessous des directives internationales.

Mots-clés : radiofréquence de faible intensité « RFR », les installations d'antennes, des stations de base pour téléphones cellulaires, la maladie classique des micro-ondes, les champs électromagnétiques non-ionisants, pollution environnementale.

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1. Introduction

Wireless technologies are ubiquitous today. According to the European Information Technology Observatory, an industry-funded organization in Germany, the threshold of 5.1 billion cell phone users worldwide will be reached by the end of 2010 — up from 3.3 billion in 2007. That number is expected to increase by another 10% to 5.6 billion in 2011, out of a total worldwide population of 6.5 billion.[2] In 2010, cell phone subscribers in the U.S. numbered 287 million, Russia 220 million, Germany 111 million, Italy 87 million, Great Britain 81 million, France 62 million, and Spain 57 million. Growth is strong throughout Asia and in South America but especially so in developing countries where landline systems were never fully established.

The investment firm Bank of America Merril-Lynch estimated that the worldwide penetration of mobile phone customers is twice that of landline customers today and that America has the highest minutes of use per month per user.[3] Today, 94% of Americans live in counties with four or more wireless service providers, plus 99% of Americans live in counties where next generation, 3G (third generation), 4G (fourth generation), and broadband services are available. All of this capacity requires an extensive infrastructure that the industry continues to build in the U.S., despite a 93% wireless penetration of the total U.S. population.[4]

Next generation services are continuing to drive the buildout of both new infrastructure as well as adaptation of preexisting sites. According to the industry, there are an estimated 251 618 cell sites in the U.S. today, up from 19 844 in 1995.[4] There is no comprehensive data for antennas hidden inside of buildings but one industry-maintained Web site (www.antennasearch.com), allows people to type in an address and all antennas within a 3 mile (1 mile = 1.6 km) area will come up. There are hundreds of thousands in the U.S. alone.

People are increasingly abandoning landline systems in favor of wireless communications. One estimate in 2006 found that 42% of all wireless subscribers used their wireless phone as their primary phone. According to the National Center for Health Statistics of the U.S. Centers for Disease Control (CDC), by the second half of 2008, one in every five American households had no landlines but did have at least one wireless phone (Department of Health and Human Services 2008). The figures reflected a 2.7% increase over the first half of 2008 — the largest jump since the CDC began tracking such data in 2003, and represented a total of 20.2% of the U.S. population — a figure that coincides with industry estimates of 24.50% of completely wireless households in 2010.[5] The CDC also found that approximately 18.7% of all children, nearly 14 million, lived in households with only wireless phones. The CDC further found that one in every seven American homes, 14.5% of the population, received all or almost all of their calls via wireless phones, even when there was a landline in the home. They called these "wireless-mostly households."

The trend away from landline phones is obviously increasing as wireless providers market their services specifically toward a mobile customer, particularly younger adults who readily embrace new technologies. One study (Silke et al. 2010) in Germany found that children from lower socioeconomic backgrounds not only owned more cell phones than children from higher economic groups, but also used their cell phones more often — as determined by the test groups' wearing of personal dosimetry devices. This was the first study to track such data and it found an interesting contradiction to the assumption that higher socioeconomic groups were the largest users of cell services. At one time, cell phones were the status symbol of the wealthy. Today, it is also a status symbol of lower socioeconomic groups. The CDC found in their survey discussed above that 65.3% of adults living in poverty or living near poverty were more likely than higher income adults to be living in households with wireless only telephones. There may be multiple reasons for these findings, including a shift away from cell phone dialogues to texting in younger adults in higher socioeconomic categories.

In some developing countries where landline systems have never been fully developed outside of urban centers, cell phones are the only means of communication. Cellular technology, especially the new 3G, 4G, and broadband services that allow wireless communications for real-time voice communication, text messaging, photos, Internet connections, music and video downloads, and TV viewing, is the fastest growing segment of many economies that are in otherwise sharp decline due to the global economic downturn.

There is some indication that although the cellular phone markets for many European countries are more mature than in the U.S., people there may be maintaining their landline use while augmenting with mobile phone capability. This may be a consequence of the more robust media coverage regarding health and safety issues of wireless technology in the European press, particularly in the UK, as well as recommendations by European governments like France and Germany[6] that citizens not abandon their landline phones or wired computer systems because of safety concerns. According to OfCom's 2008 *Communications Market Interim Report* (OfCom 2008), which provided information up to December 2007, approximately 86% of UK adults use cell phones. While four out of five households have both cell phones and landlines, only 11% use cell phones exclusively, a total down from 28% noted by this group in 2005. In addition, 44% of UK adults use text messaging on a daily basis. Fixed landline services fell by 9% in 2007 but OfCom notes that landline services continue to be strong despite the fact that mobile services also continued to grow by 16%. This indicates that people are continuing to use both landlines and wireless technology rather than choosing one over the other in the UK. There were 51 300 UK base station sites in

[2] http://www.eito.com/pressinformation_20100811.htm. (Accessed October 2010.)
[3] http://www.ctia.org/advocacy/research/index.cfm/AID/10377. (Accessed October 2010.)
[4] http://www.ctia.org/advocacy/research/index.cfm/AID/10323. (Accessed October 2010.)
[5] http://www.ctia.org/advocacy/research/index.cfm/AID/10323. (Accessed October 2010.)
[6] http://www.icems.eu/docs/deutscher_bundestag.pdf and http://www.icems.eu/docs/resolutions/EP_EMF_resolution_2APR09.pdf. (Accessed October 2010.)

the beginning of 2009 (two-thirds installed on existing buildings or structures) with an estimated 52 900 needed to accommodate new 3G and 4G services by the end of 2009.

Clearly, this is an enormous global industry. Yet, no money has ever been appropriated by the industry in the U.S., or by any U.S. government agency, to study the potential health effects on people living near the infrastructure. The most recent research has all come from outside of the U.S. According to the CTIA – The Wireless Association, "If the wireless telecom industry were a country, its economy would be bigger than that of Egypt, and, if measured by GNP (gross national product), [it] would rank as the 46th largest country in the world." They further say, "It took more than 21 years for color televisions to reach 100 million consumers, more than 90 years for landline service to reach 100 million consumers, and less than 17 years for wireless to reach 100 million consumers."[7]

In lieu of building new cell towers, some municipalities are licensing public utility poles throughout urban areas for Wi-Fi antennas that allow wireless Internet access. These systems can require hundreds of antennas in close proximity to the population with some exposures at a lateral height where second- and third-storey windows face antennas. Most of these systems are categorically excluded from regulation by the U.S. Federal Communications Commission (FCC) or oversight by government agencies because they operate below a certain power density threshold. However, power density is not the only factor determining biological effects from radiofrequency radiation (RFR).

In addition, when the U.S. and other countries permanently changed from analog signals used for television transmission to newer digital formats, the old analog frequencies were reallocated for use by municipal services such as police, fire, and emergency medical dispatch, as well as to private telecommunications companies wanting to expand their networks and services. This creates another significant increase in ambient background exposures.

Wi-Max is another wireless service in the wings that will broaden wireless capabilities further and place additional towers and (or) transmitters in close proximity to the population in addition to what is already in existence. Wi-Max aims to make wireless Internet access universal without tying the user to a specific location or "hotspot." The rollout of Wi-Max in the U.S., which began in 2009, uses lower frequencies at high power densities than currently used by cellular phone transmission. Many in science and the activist communities are worried, especially those concerrned about electromagnetic-hypersensitivity syndrome (EHS).

It remains to be seen what additional exposures "smart grid" or "smart meter" technology proposals to upgrade the electrical powerline transmission systems will entail regarding total ambient RFR increases, but it will add another ubiquitous low-level layer. Some of the largest corporations on earth, notably Siemens and General Electric, are involved. Smart grids are being built out in some areas of the U.S. and in Canada and throughout Europe. That technology plans to alter certain aspects of powerline utility metering from a wired system to a partially wireless one. The systems require a combination of wireless transmitters attached to homes and businesses that will send radio signals of approximately 1 W output in the 2.4000–2.4835 GHz range to local "access point" transceivers, which will then relay the signal to a further distant information center (Tell 2008). Access point antennas will require additional power density and will be capable of interfacing with frequencies between 900 MHz and 1.9 GHz. Most signals will be intermittent, operating between 2 to 33 seconds per hour. Access points will be mounted on utility poles as well as on free-standing towers. The systems will form wide area networks (WANs), capable of covering whole towns and counties through a combination of "mesh-like" networks from house to house. Some meters installed on private homes will also act as transmission relays, boosting signals from more distant buildings in a neighborhood. Eventually, WANs will be completely linked.

Smart grid technology also proposes to allow homeowners to attach additional RFR devices to existing indoor appliances, to track power use, with the intention of reducing usage during peak hours. Manufacturers like General Electric are already making appliances with transmitters embedded in them. Many new appliances will be incapable of having transmitters deactivated without disabling the appliance and the warranty. People will be able to access their home appliances remotely by cell phone. The WANs smart grids described earlier in the text differ significantly from the current upgrades that many utility companies have initiated within recent years that already use low-power RFR meters attached to homes and businesses. Those first generation RFR meters transmit to a mobile van that travels through an area and "collects" the information on a regular billing cycle. Smart grids do away with the van and the meter reader and work off of a centralized RFR antenna system capable of blanketing whole regions with RFR.

Another new technology in the wings is broadband over powerlines (BPL). It was approved by the U.S. FCC in 2007 and some systems have already been built out. Critics of the latter technology warned during the approval process that radiofrequency interference could occur in homes and businesses and those warnings have proven accurate. BPL technology couples radiofrequency bands with extremely low frequency (ELF) bands that travel over powerline infrastructure, thereby creating a multi-frequency field designed to extend some distance from the lines themselves. Such couplings follow the path of conductive material, including secondary distribution lines, into people's homes.

There is no doubt that wireless technologies are popular with consumers and businesses alike, but all of this requires an extensive infrastructure to function. Infrastructure typically consists of freestanding towers (either preexisting towers to which cell antennas can be mounted, or new towers specifically built for cellular service), and myriad methods of placing transceiving antennas near the service being called for by users. This includes attaching antenna panels to the sides of buildings as well as roof-mountings; antennas hidden inside church steeples, barn silos, elevator shafts, and any number of other "stealth sites." It also includes camouflaging towers to look like trees indigenous to areas where they are placed, e.g., pine trees in northern climates, cacti

[7] CTIA website: http://www.ctia.org/advocay/research/index.cfm/AID/10385. (Accessed 9 December 2008.)

in deserts, and palm trees in temperate zones, or as chimneys, flagpoles, silos, or other tall structures (Rinebold 2001). Often the rationale for stealth antenna placement or camouflaging of towers is based on the aesthetic concerns of host communities.

An aesthetic emphasis is often the only perceived control of a municipality, particularly in countries like America where there is an overriding federal preemption that precludes taking the "environmental effects" of RFR into consideration in cell tower siting as stipulated in Section 704 of *The Telecommunications Act of 1996* (USFCC 1996). Citizen resistance, however, is most often based on health concerns regarding the safety of RFR exposures to those who live near the infrastructure. Many citizens, especially those who claim to be hypersensitive to electromagnetic fields, state they would rather know where the antennas are and that hiding them greatly complicates society's ability to monitor for safety.[8]

Industry representatives try to reassure communities that facilities are many orders of magnitude below what is allowed for exposure by standards-setting boards and studies bear that out (Cooper et al. 2006; Henderson and Bangay 2006; Bornkessel et al. 2007). These include standards by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) used throughout Europe, Canada, and elsewhere (ICNIRP 1998). The standards currently adopted by the U.S. FCC, which uses a two-tiered system of recommendations put out by the National Council on Radiation Protection (NCRP) for civilian exposures (referred to as uncontrolled environments), and the International Electricians and Electronics Engineers (IEEE) for professional exposures (referred to as controlled environments) (U.S. FCC 1997). The U.S. may eventually adopt standards closer to ICNIRP. The current U.S. standards are more protective than ICNIRP's in some frequency ranges so any harmonization toward the ICNIRP standards will make the U.S. limits more lenient.

All of the standards currently in place are based on RFRs ability to heat tissue, called thermal effects. A longstanding criticism, going back to the 1950s (Levitt 1995), is that such acute heating effects do not take potentially more subtle non-thermal effects into consideration. And based on the number of citizens who have tried to stop cell towers from being installed in their neighborhoods, laypeople in many countries do not find adherence to exisitng standards valid in addressing health concerns. Therefore, infrastructure siting does not have the confidence of the public (Levitt 1998).

2. A changing industry

Cellular phone technology has changed significantly over the last two decades. The first wireless systems began in the mid-1980s and used analog signals in the 850–900 MHz range. Because those wavelengths were longer, infrastructure was needed on average every 8 to 10 miles apart. Then came the digital personal communications systems (PCS) in the late 1990s, which used higher frequencies, around 1900 GHz, and digitized signals. The PCS systems, using shorter wavelengths and with more stringent exposure guidelines, require infrastructure approximately every 1 to 3 miles apart. Digital signals work on a binary method, mimicking a wave that allows any frequency to be split in several ways, thereby carrying more information far beyond just voice messages.

Today's 3G network can send photos and download music and video directly onto a cell phone screen or iPod. The new 4G systems digitize and recycle some of the older frequencies in the 700 to 875 MHz bands to create another service for wireless Internet access. The 4G network does not require a customer who wants to log on wirelessly to locate a "hot spot" as is the case with private Wi-Fi systems. Today's Wi-Fi uses a network of small antennas, creating coverage of a small area of 100 ft ($\sim$30 m) or so at homes or businesses. Wi-fi can also create a small wireless computer system in a school where they are often called wireless local area networks (WLANs). Whole cities can make Wi-Fi available by mounting antennas to utility poles.

Large-scale Wi-Fi systems have come under increasing opposition from citizens concerned about health issues who have legally blocked such installations (Antenna Free Union[9]). Small-scale Wi-Fi has also come under more scrutiny as governments in France and throughout Europe have banned such installations in libraries and schools, based on precautionary principles (REFLEX Program 2004).

3. Cell towers in perspective: some definitions

Cell towers are considered low-power installations when compared to many other commercial uses of radiofrequency energy. Wireless transmission for radio, television (TV), satellite communications, police and military radar, federal homeland security systems, emergency response networks, and many other applications all emit RFR, sometimes at millions of watts of effective radiated power (ERP). Cellular facilities, by contrast, use a few hundred watts of ERP per channel, depending on the use being called for at any given time and the number of service providers co-located at any given tower.

No matter what the use, once emitted, RFR travels through space at the speed of light and oscillates during propagation. The number of times the wave oscillates in one second determines its frequency.

Radiofrequency radiation covers a large segment of the electromagnetic spectrum and falls within the nonionizing bands. Its frequency ranges between 10 kHz to 300 GHz; 1 Hz = 1 oscillation per second; 1 kHz = 1000 Hz; 1 MHz = 1 000 000 Hz; and 1 GHz = 1 000 000 000 Hz.

Different frequencies of RFR are used in different applications. Some examples include the frequency range of 540 to 1600 kHz used in AM radio transmission; and 76 to 108 MHz used for FM radio. Cell-phone technology uses frequencies between 800 MHz and 3 GHz. The RFR of 2450 MHz is used in some Wi-Fi applications and microwave cooking.

Any signal can be digitized. All of the new telecommunications technologies are digitized and in the U.S., all TV is

[8] See, for example, www.radiationresearch.org. (Accessed October 2010.)
[9] http://www.antennafreeunion.org/. (Accessed October 2010.)

broadcast in 100% digital formats — digital television (DTV) and high definition television (HDTV). The old analog TV signals, primarily in the 700 MHz ranges, will now be recycled and relicensed for other applications to additional users, creating additional layers of ambient exposures.

The intensity of RFR is generally measured and noted in scientific literature in watts per square meter (W/m^2); milliwatts per square centimetre (mW/cm^2), or microwatts per square centimetre ($\mu W/cm^2$). All are energy relationships that exist in space. However, biological effects depend on how much of the energy is absorbed in the body of a living organism, not just what exists in space.

4. Specific absorption rate (SAR)

Absorption of RFR depends on many factors including the transmission frequency and the power density, one's distance from the radiating source, and one's orientation toward the radiation of the system. Other factors include the size, shape, mineral and water content of an organism. Children absorb energy differently than adults because of differences in their anatomies and tissue composition. Children are not just "little adults". For this reason, and because their bodies are still developing, children may be more susceptible to damage from cell phone radiation. For instance, radiation from a cell phone penetrates deeper into the head of children (Gandhi et al. 1996; Wiart et al. 2008) and certain tissues of a child's head, e.g., the bone marrow and the eye, absorb significantly more energy than those in an adult head (Christ et al. 2010). The same can be presumed for proximity to towers, even though exposure will be lower from towers under most circumstances than from cell phones. This is because of the distance from the source. The transmitter is placed directly against the head during cell phone use whereas proximity to a cell tower will be an ambient exposure at a distance.

There is little difference between cell phones and the domestic cordless phones used today. Both use similar frequencies and involve a transmitter placed against the head. But the newer digitally enhanced cordless technology (DECT) cordless domestic phones transmit a constant signal even when the phone is not in use, unlike the older domestic cordless phones. But some DECT brands are available that stop transmission if the mobile units are placed in their docking station.

The term used to describe the absorption of RFR in the body is specific absorption rate (SAR), which is the rate of energy that is actually absorbed by a unit of tissue. Specific absorption rates (SARs) are generally expressed in watts per kilogram (W/kg) of tissue. The SAR measurements are averaged either over the whole body, or over a small volume of tissue, typically between 1 and 10 g of tissue. The SAR is used to quantify energy absorption to fields typically between 100 kHz and 10 GHz and encompasses RFR from devices such as cellular phones up through diagnostic MRI (magnetic resonance imaging).

Specific absorption rates are a more reliable determinant and index of RFR's biological effects than are power density, or the intensity of the field in space, because SARs reflect what is actually being absorbed rather than the energy in space. However, while SARs may be a more precise model, at least in theory, there were only a handful of animal studies that were used to determine the threshold values of SAR for the setting of human exposure guidelines (de Lorge and Ezell 1980; de Lorge 1984). (For further information see Section 8). Those values are still reflected in today's standards.

It is presumed that by controlling the field strength from the transmitting source that SARs will automatically be controlled too, but this may not be true in all cases, especially with far-field exposures such as near cell or broadcast towers. Actual measurement of SARs is very difficult in real life so measurements of electric and magnetic fields are used as surrogates because they are easier to assess. In fact, it is impossible to conduct SAR measurements in living organisms so all values are inferred from dead animal measurements (thermography, calorimetry, etc.), phantom models, or computer simulation (FDTD).

However, according to the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) *Health Effects of Exposure to EMF*, released in January of 2009:

> ... recent studies of whole body plane wave exposure of both adult and children phantoms demonstrated that when children and small persons are exposed to levels which are in compliance with reference levels, exceeding the basic restrictions cannot be excluded [Dimbylow and Bloch 2007; Wang et al. 2006; Kuhn et al., 2007; Hadjem et al., 2007]. While the whole frequency range has been investigated, such effects were found in the frequency bands around 100 MHz and also around 2 GHz. For a model of a 5-year-old child it has been shown that when the phantom is exposed to electromagnetic fields at reference levels, the basic restrictions were exceeded by 40% [Conil et al., 2008].... Moreover, a few studies demonstrated that multipath exposure can lead to higher exposure levels compared to plane wave exposure [Neubauer et al. 2006; Vermeeren et al. 2007]. It is important to realize that this issue refers to far field exposure only, for which the actual exposure levels are orders of magnitude below existing guidelines. (p. 34–35, SCENIHR 2009)

In addition to average SARs, there are indications that biological effects may also depend on how energy is actually deposited in the body. Different propagation characteristics such as modulation, or different wave-forms and shapes, may have different effects on living systems. For example, the same amount of energy can be delivered to tissue continuously or in short pulses. Different biological effects may result depending on the type and duration of the exposure.

5. Transmission facilities

The intensity of RFR decreases rapidly with the distance from the emitting source; therefore, exposure to RFR from transmission towers is often of low intensity depending on one's proximity. But intensity is not the only factor. Living near a facility will involve long-duration exposures, sometimes for years, at many hours per day. People working at home or the infirm can experience low-level 24 h exposures. Nighttimes alone will create 8 h continuous exposures. The current standards for both ICNIRP, IEEE and the NCRP (adopted by the U.S. FCC) are for whole-body exposures

averaged over a short duration (minutes) and are based on results from short-term exposure studies, not for long-term, low-level exposures such as those experienced by people living or working near transmitting facilities. For such populations, these can be involuntary exposures, unlike cell phones where user choice is involved.

There have been some recent attempts to quantify human SARs in proximity to cell towers but these are primarily for occupational exposures in close proximity to the sources and questions raised were dosimetry-based regarding the accuracy of antenna modeling (van Wyk et al. 2005). In one study by Martínez-Búrdalo et al. (2005) however, the researchers used high-resolution human body models placed at different distances to assess SARs in worst-case exposures to three different frequencies — 900, 1800, and 2170 MHz. Their focus was to compute whole-body averaged SARs at a maximum 10 g averaged SAR inside the exposed model. They concluded that for

> ... antenna–body distances in the near zone of the antenna, the fact that averaged field values are below reference levels, could, at certain frequencies, not guarantee guidelines compliance based on basic restrictions.
>
> (p. 4125, Martínez-Búrdalo et al. 2005)

This raises questions about the basic validity of predicting SARs in real-life exposure situations or compliance to guidelines according to standard modeling methods, at least when one is very close to an antenna.

Thus, the relevant questions for the general population living or working near transmitting facilities are: Do biological and (or) health effects occur after exposure to low-intensity RFR? Do effects accumulate over time, since the exposure is of a long duration and may be intermittent? What precisely is the definition of low-intensity RFR? What might its biological effects be and what does the science tell us about such exposures?

6. Government radiofrequency radiation (RFR) guidelines: how spatial energy translates to the body's absorption

The U.S. FCC has issued guidelines for both power density and SARs. For power density, the U.S. guidelines are between 0.2–1.0 mW/cm^2. For cell phones, SAR levels require hand-held devices to be at or below 1.6 W/kg measured over 1.0 g of tissue. For whole body exposures, the limit is 0.08 W/kg.

In most European countries, the SAR limit for hand-held devices is 2.0 W/kg averaged over 10 g of tissue. Whole body exposure limits are 0.08 W/kg.

At 100–200 ft (~30–60 m) from a cell phone base station, a person can be exposed to a power density of 0.001 mW/cm^2 (i.e., 1.0 μW/cm^2). The SAR at such a distance can be 0.001 W/kg (i.e., 1.0 mW/kg). The U.S. guidelines for SARs are between 0.08–0.40 W/kg.

For the purposes of this paper, we will define low-intensity exposure to RFR of power density of 0.001 mW/cm^2 or a SAR of 0.001 W/kg.

7. Biological effects at low intensities

Many biological effects have been documented at very low intensities comparable to what the population experiences within 200 to 500 ft (~60–150 m) of a cell tower, including effects that occurred in studies of cell cultures and animals after exposures to low-intensity RFR. Effects reported include: genetic, growth, and reproductive; increases in permeability of the blood–brain barrier; behavioral; molecular, cellular, and metabolic; and increases in cancer risk. Some examples are as follows:

- Dutta et al. (1989) reported an increase in calcium efflux in human neuroblastoma cells after exposure to RFR at 0.005 W/kg. Calcium is an important component in normal cellular functions.
- Fesenko et al. (1999) reported a change in immunological functions in mice after exposure to RFR at a power density of 0.001 mW/cm^2.
- Magras and Xenos (1997) reported a decrease in reproductive function in mice exposed to RFR at power densities of 0.000168–0.001053 mW/cm^2.
- Forgacs et al. (2006) reported an increase in serum testosterone levels in rats exposed to GSM (global system for mobile communication)-like RFR at SAR of 0.018–0.025 W/kg.
- Persson et al. (1997) reported an increase in the permeability of the blood–brain barrier in mice exposed to RFR at 0.0004–0.008 W/kg. The blood–brain barrier is a physiological mechanism that protects the brain from toxic substances, bacteria, and viruses.
- Phillips et al. (1998) reported DNA damage in cells exposed to RFR at SAR of 0.0024–0.024 W/kg.
- Kesari and Behari (2009) also reported an increase in DNA strand breaks in brain cells of rats after exposure to RFR at SAR of 0.0008 W/kg.
- Belyaev et al. (2009) reported changes in DNA repair mechanisms after RFR exposure at a SAR of 0.0037 W/kg. A list of publications reporting biological and (or) health effects of low-intensity RFR exposure is in Table 1.

Out of the 56 papers in the list, 37 provided the SAR of exposure. The average SAR of these studies at which biological effects occurred is 0.022 W/kg — a finding below the current standards.

Ten years ago, there were only about a dozen studies reporting such low-intensity effects; currently, there are more than 60. This body of work cannot be ignored. These are important findings with implications for anyone living or working near a transmitting facility. However, again, most of the studies in the list are on short-term (minutes to hours) exposure to low-intensity RFR. Long-term exposure studies are sparse. In addition, we do not know if all of these reported effects occur in humans exposed to low-intensity RFR, or whether the reported effects are health hazards. Biological effects do not automatically mean adverse health effects, plus many biological effects are reversible. However, it is clear that low-intensity RFR is not biologically inert. Clearly, more needs to be learned before a presumption of safety can continue to be made regarding placement of antenna arrays near the population, as is the case today.

Table 1. List of studies reporting biological effects at low intensities of radiofrequency radiation (RFR).

Reference	Frequency	Form of RFR	Exposure duration	SAR (W/kg)	Power density ($\mu W/cm^2$)	Effects reported
Balmori (2010) (in vivo) (eggs and tadpoles of frog)	88.5–1873.6 MHz	Cell phone base station emission	2 months		3.25	Retarded development
Belyaev et al. (2005) (in vitro)	915 MHz	GSM	24, 48 h	0.037		Genetic changes in human white blood cells
Belyaev et al. (2009) (in vitro)	915 MHz, 1947 MHz	GSM, UMTS	24, 72 h	0.037		DNA repair mechanism in human white blood cells
Blackman et al. (1980) (in vitro)	50 MHz	AM at 16 Hz		0.0014		Calcium in forebrain of chickens
Boscol et al. (2001) (in vivo) (human whole body)	500 KHz–3 GHz	TV broadcast			0.5	Immunological system in women
Campisi et al. (2010) (in vitro)	900 MHz	CW (CW– no effect observed) AM at 50 Hz	14 days, 5, 10, 20 min per day		26	DNA damage in human glial cells
Capri et al. (2004) (in vitro)	900 MHz	GSM	1 h/day, 3 days	0.07		A slight decrease in cell proliferation when human immune cells were stimulated with mitogen and a slight increase in the number of cells with altered distribution of phosphatidylserine across the membrane
Chiang et al. (1989) (in vivo) (human whole body)	Lived and worked close to AM radio and radar installations for more than 1 year				10	People lived and worked near AM radio antennas and radar installations showed deficits in psychological and short-term memory tests
de Pomerai et al. (2003) (in vitro)	1 GHz		24, 48 h	0.015		Protein damages
D'Inzeo et al. (1988) (in vitro)	10.75 GHz	CW	30–120 s	0.008		Operation of acetylcholine-related ion-channels in cells. These channels play important roles in physiological and behavioral functions
Dutta et al. (1984) (in vitro)	915 MHz	Sinusoidal AM at 16 Hz	30 min	0.05		Increase in calcium efflux in brain cancer cells
Dutta et al. (1989) (in vitro)	147 MHz	Sinusoidal AM at 16 Hz	30 min	0.005		Increase in calcium efflux in brain cancer cells
Fesenko et al. (1999) (in vivo) (mouse- wavelength in mm range)	From 8.15–18 GHz		5 h to 7 days direction of response depended on exposure duration		1	Change in immunological functions
Forgacs et al. (2006) (in vivo) (mouse whole body)	1800 MHz	GSM, 217 Hz pulses, 576 μs pulse width	2 h/day, 10 days	0.018		Increase in serum testosterone
Guler et al. (2010) (In vivo) (rabbit whole body)	1800 MHz	AM at 217 Hz	15 min/day, 7 days		52	Oxidative lipid and DNA damages in the brain of pregnant rabbits

Table 1 (*continued*).

Reference	Frequency	Form of RFR	Exposure duration	SAR (W/kg)	Power density ($\mu W/cm^2$)	Effects reported
Hjollund et al. (1997) (in vivo) (human partial or whole body)	Military radars				10	Sperm counts of Danish military personnel, who operated mobile ground-to-air missile units that use several RFR emitting radar systems, were significantly lower compared to references
Ivaschuk et al. (1997) (in vitro)	836.55 MHz	TDMA	20 min	0.026		A gene related to cancer
Jech et al. (2001) (in vivo) (human partial body exposure-narcoleptic patients)	900 MHz	GSM— 217 Hz pulses, 577 μs pulse width	45 min	0.06		Improved cognitive functions
Kesari and Behari (2009) (in vivo) (rat whole body)	50 GHz		2 h/day, 45 days	0.0008		Double strand DNA breaks observed in brain cells
Kesari and Behari (2010) (in vivo) (rat whole body)	50 GHz		2 h/day, 45 days	0.0008		Reproductive system of male rats
Kesari et al. (2010) (in vivo) (rat whole body)	2450 MHz	50 Hz modulation	2 h/day, 35 days	0.11		DNA double strand breaks in brain cells
Kwee et al. (2001) (in vitro)	960 MHz	GSM	20 min	0.0021		Increased stress protein in human epithelial amnion cells
Lebedeva et al. (2000) (in vivo) (human partial body)	902.4 MHz	GSM	20 min		60	Brain wave activation
Lerchl et al. (2008) (in vivo) (hamster whole body)	383 MHz 900 and 1800 MHz	TETRA GSM	24 h/day, 60 days	0.08		Metabolic changes
Magras and Xenos (1997) (in vivo) (mouse whole body)	"Antenna park"	TV and FM-radio	Exposure over several generations		0.168	Decrease in reproductive function
Mann et al. (1998) (in vivo) (human whole body)	900 MHz	GSM pulse-modulated at 217 Hz, 577 μs width	8 h		20	A transient increase in blood cortisol
Marinelli et al. (2004) (in vitro)	900 MHz	CW	2–48 h	0.0035		Cell's self-defense responses triggered by DNA damage
Markovà et al. (2005) (in vitro)	915 and 905 MHz	GSM	1 h	0.037		Chromatin conformation in human white blood cells
Navakatikian and Tomashevskaya (1994) (in vivo) (rat whole body)	2450 MHz 3000 MHz	CW (no effect observed) Pulse-modulated 2 μs pulses at 400 Hz	Single (0.5–12hr) or repeated (15–60 days, 7–12 h/day) exposure, CW–no effect	0.0027		Behavioral and endocrine changes, and decreases in blood concentrations of testosterone and insulin
Nittby et al. (2008) (in vivo) (rat whole body)	900 MHz,	GSM	2 h/week, 55 weeks	0.0006		Reduced memory functions
Novoselova et al. (1999) (in vivo) (mouse whole body – wavelength in mm range)	From 8.15–18 GHz		1 s sweep time – 16 ms reverse, 5 h		1	Functions of the immune system
Novoselova et al. (2004) (in vivo) (mouse whole body – wavelength in mm range)	From 8.15–18 GHz		1 s sweep time16 ms reverse, 1.5 h/day, 30 days		1	Decreased tumor growth rate and enhanced survival

Table 1 (*continued*).

Reference	Frequency	Form of RFR	Exposure duration	SAR (W/kg)	Power density ($\mu W/cm^2$)	Effects reported
Panagopoulos et al. (2010) (in vivo) (fly whole body)	900 and 1800 MHz	GSM	6 min/day, 5 days		1–10	Reproductive capacity and induced cell death
Panagopoulos and Margaritis (2010*a*) (in vivo) (fly whole body)	900 and 1800 MHz	GSM	6 min/day, 5 days		10	'Window' effect of GSM radiation on reproductive capacity and cell death
Panagopoulos and Margaritis (2010*b*) (in vivo) (fly whole body)	900 and 1800 MHz	GSM	1–21 min/day, 5 days		10	Reproductive capacity of the fly decreased linearly with increased duration of exposure
Pavicic and Trosic (2008) (in vitro)	864 and 935 MHz	CW	1–3 h	0.08		Growth affected in Chinese hamster V79 cells
Pérez-Castejón et al. (2009) (in vitro)	9.6 GHz	90% AM	24 h	0.0004		Increased proliferation rate in human astrocytoma cancer cells
Persson et al. (1997) (in vivo) (mouse whole body)	915 MHz	CW and pulse-modulated (217 Hz, 0.57 ms; 50 Hz, 6.6 ms)	2–960 min; CW more potent	0.0004		Increase in permeability of the blood–brain barrier
Phillips et al. (1998) (in vitro)	813.5625 MHz 836.55 MHz	iDEN TDMA	2, 21 h 2, 21 h	0.0024		DNA damage in human leukemia cells
Pologea-Moraru et al. (2002) (in vitro)	2.45 GHz		1 h		15	Change in membrane of cells in the retina
Pyrpasopoulou et al. (2004) (in vivo) (rat whole body)	9.4 GHz	GSM (50 Hz pulses, 20 μs pulse length)	1–7 days postcoitum	0.0005		Exposure during early gestation affected kidney development
Roux et al. (2008*a*) (in vivo) (tomato whole body)	900 MHz				7	Gene expression and energy metabolism
Roux et al. (2008*b*) (in vivo) (plant whole body)	900 MHz				7	Energy metabolism
Salford et al. (2003) (in vivo) (rat whole body)	915 MHz	GSM	2 h	0.02		Nerve cell damage in brain
Sarimov et al. (2004) (in vitro)	895–915 MHz	GSM	30 min	0.0054		Human lymphocyte chromatin affected similar to stress response
Schwartz et al. (1990) (in vitro)	240 MHz	CW and sinusoidal modulation at 0.5 and 16 Hz, effect only observed at 16 Hz modulation	30 min	0.00015		Calcium movement in the heart
Schwarz et al. (2008) (in vitro)	1950 MHz	UMTS	24 h	0.05		Genes in human fibroblasts
Somosy et al. (1991) (in vitro)	2.45 GHz	CW and 16 Hz square-modulation, modulated field more potent than CW		0.024		Molecular and structural changes in cells of mouse embryos

Table 1 (*concluded*).

Reference	Frequency	Form of RFR	Exposure duration	SAR (W/kg)	Power density ($\mu W/cm^2$)	Effects reported
Stagg et al. (1997) (in vitro)	836.55 MHz	TDMA duty cycle 33%	24 h	0.0059		Glioma cells showed significant increases in thymidine incorporation, which may be an indication of an increase in cell division
Stankiewicz et al. (2006) (in vitro)	900 MHz	GSM 217 Hz pulses, 577 ms width		0.024		Immune activities of human white blood cells
Tattersall et al. (2001) (in vitro)	700 MHz	CW	5–15 min	0.0016		Function of the hippocampus
Velizarov et al. (1999) (in vitro)	960 MHz	GSM 217 Hz square-pulse, duty cycle 12%	30 min	0.000021		Decrease in proliferation of human epithelial amnion cells
Veyret et al. (1991) (in vivo) (mouse whole body)	9.4 GHz	1 μs pulses at 1000 pps, also with or without sinusoidal AM between 14 and 41 MHz, response only with AM, direction of response depended on AM frequency		0.015		Functions of the immune system
Vian et al. (2006) (in vivo) plant	900 MHz				7	Stress gene expression
Wolke et al. (1996) (in vitro)	900, 1300, 1800 MHz 900 MHz	Square-wave modulated at 217 Hz CW, 16 Hz, 50 Hz, and 30 KHz modulations		0.001		Calcium concentration in heart muscle cells of guinea pig
Yurekli et al. (2006) (in vivo) (rat whole body)	945 MHz	GSM, 217 Hz pulse-modulation	7 h/day, 8 days	0.0113		Free radical chemistry

Note: These papers gave either specific absorption rate, SAR, (W/kg) or power density ($\mu W/cm^2$) of exposure. (Studies that did not contain these values were excluded). AM, amplitude-modulated or amplitude-modulation; CW, continuous wave; GSM, global system for mobile communication; iDEN, integrated digital enhanced network; TDMA, time division multiple access, TETRA, terrestrial trunked radio; UMTS, universal mobile telecommunications system.

8. Long-term exposures and cumulative effects

There are many important gaps in the RFR research. The majority of the studies on RFR have been conducted with short-term exposures, i.e., a few minutes to several hours. Little is known about the effects of long-term exposure such as would be experienced by people living near telecommunications installations, especially with exposures spanning months or years. The important questions then are: What are the effects of long-term exposure? Does long-term exposure produce different effects from short-term exposure? Do effects accumulate over time?

There is some evidence of cumulative effects. Phillips et al. (1998) reported DNA damage in cells after 24 h exposure to low-intensity RFR. DNA damage can lead to gene mutation that accumulates over time. Magras and Xenos (1997) reported that mice exposed to low-intensity RFR became less reproductive. After five generations of exposure the mice were not able to produce offspring. This shows that the effects of RFR can pass from one generation to another. Persson et al. (1997) reported an increase in permeability of the blood–brain barrier in mice when the energy deposited in the body exceeded 1.5 J/kg (joule per kilogram) — a measurement of the total amount of energy deposited. This suggests that a short-term, high-intensity exposure can produce the same effect as a long-term, low-intensity exposure, and is another indication that RFR effects can accumulate over time.

In addition, there is some indication that test animals become more sensitive to radiation after long-term exposure as seen in two of the critical experiments that contributed to the present SAR standards, called the "behavior–disruption experiments" carried out in the 1980s.

In the first experiment, de Lorge and Ezell (1980) trained rats on an auditory observing-response task. In the task, an animal was presented with two bars. Pressing the right bar would produce either a low-pitch or a high-pitch tone for half a second. The low-pitch tone signaled an unrewarded situation and the animal was expected to do nothing. However, when the high-pitch tone was on, pressing the left bar would produce a food reward. Thus, the task required continuous vigilance in which an animal had to coordinate its motor responses according to the stimulus presented to get a reward by choosing between a high-pitch or low-pitch tone. After learning the task, rats were then irradiated with 1280 MHz or 5620 MHz RFR during performance. Disruption of behavior (i.e., the rats could not perform very well) was observed within 30–60 min of exposure at a SAR of 3.75 W/kg for 1280 MHz, and 4.9 W/kg for 5620 MHz.

In another experiment, de Lorge (1984) trained monkeys on a similar auditory observing response task. Monkeys were exposed to RFR at 225, 1300, and 5800 MHz. Disruption of performance was observed at 8.1 mW/cm^2 (SAR 3.2 W/kg) for 225 MHz; at 57 mW/cm^2 (SAR 7.4 W/kg) for 1300 MHz; and at 140 mW/cm^2 (SAR 4.3 W/kg) for 5800 MHz. The disruption occurred when body temperature was increased by 1°C.

The conclusion from these experiments was that "... disruption of behavior occurred when an animal was exposed at an SAR of approximately 4 W/kg, and disruption occurred after 30–60 minutes of exposure and when body temperature increased by 1°C" (de Lorge 1984). Based on just these two experiments, 4 W/kg has been used in the setting of the present RFR exposure guidelines for humans. With theoretical safety margins added, the limit for occupational exposure was then set at 0.4 W/kg (i.e., 1/10 of the SAR where effects were observed) and for public exposure 0.08 W/kg for whole body exposures (i.e., 1/5 of that of occupational exposure).

But the relevant question for establishing a human SAR remains: Is this standard adequate, based on so little data, primarily extrapolated from a handful of animal studies from the same investigators? The de Lorge (1984) animal studies noted previously describe effects of short-term exposures, defined as less than one hour. But are they comparable to long-term exposures like what whole populations experience when living or working near transmitting facilities?

Two series of experiments were conducted in 1986 on the effects of long-term exposure. D'Andrea et al. (1986*a*) exposed rats to 2450 MHz RFR for 7 h a day, 7 days per week for 14 weeks. They reported a disruption of behavior at an SAR of 0.7 W/kg. And D'Andrea et al. (1986*b*) also exposed rats to 2450 MHz RFR for 7 h a day, 7 days per week, for 90 days at an SAR of 0.14 W/kg and found a small but significant disruption in behavior. The experimenters concluded, "... the threshold for behavioral and physiological effects of chronic (long-term) RFR exposure in the rat occurs between 0.5 mW/cm^2 (0.14 W/kg) and 2.5 mW/cm^2 (0.7 W/kg)" (p. 55, D'Andrea et al. 1986*b*).

The previously mentioned studies show that RFR can produce effects at much lower intensities after test animals are repeatedly exposed. This may have implications for people exposed to RFR from transmission towers for long periods of time.

Other biological outcomes have also been reported after long-term exposure to RFR. Effects were observed by Baranski (1972) and Takashima et al. (1979) after prolonged, repeated exposure but not after short-term exposure. Conversely, in other work by Johnson et al. (1983), and Lai et al. (1987, 1992) effects that were observed after short-term exposure disappeared after prolonged, repeated exposure, i.e., habituation occurred. Different effects were observed by Dumansky and Shandala (1974) and Lai et al. (1989) after different exposure durations. The conclusion from this body of work is that effects of long-term exposure can be quite different from those of short-term exposure.

Since most studies with RFR are short-term exposure studies, it is not valid to use their results to set guidelines for long-term exposures, such as in populations living or working near cell phone base stations.

9. Effects below 4 W/kg: thermal versus nonthermal

As described previously, current international RFR exposure standards are based mainly on the acute exposure experiments that showed disruption of behavior at 4 W/kg. However, such a basis is not scientifically valid. There are many studies that show biological effects at SARs less than 4 W/kg after short-term exposures to RFR. For example, since the 4 W/kg originated from psychological and (or) be-

havioral experiments, when one surveys the EMF literature on behavioral effects, one can find many reports on behavioral effects observed at SARs less than 4 W/kg, e.g., D'Andrea et al. (1986*a*) at 0.14 to 0.7 W/kg; DeWitt et al. (1987) at 0.14 W/kg; Gage (1979) at 3 W/kg ; King et al. (1971) at 2.4 W/kg; Kumlin et al. (2007) at 3 W/kg; Lai et al. (1989) at 0.6 W/kg; Mitchell et al. (1977) at 2.3 W/kg (1977); Navakatikian and Tomashevskaya (1994) at 0.027 W/kg; Nittby et al. (2008) at 0.06 W/kg; Schrot et al. (1980) at 0.7 W/kg; Thomas et al. (1975) at 1.5 to 2.7 W/kg; and Wang and Lai (2000) at 1.2 W/kg.

The obvious mechanism of effects of RFR is thermal (i.e., tissue heating). However, for decades, there have been questions about whether nonthermal (i.e., not dependent on a change in temperature) effects exist. This is a well-discussed area in the scientific literature and not the focus of this paper but we would like to mention it briefly because it has implications for public safety near transmission facilities.

Practically, we do not actually need to know whether RFR effects are thermal or nonthermal to set exposure guidelines. Most of the biological-effects studies of RFR that have been conducted since the 1980s were under nonthermal conditions. In studies using isolated cells, the ambient temperature during exposure was generally well controlled. In most animal studies, the RFR intensity used usually did not cause a significant increase in body temperature in the test animals. Most scientists consider nonthermal effects as established, even though the implications are not fully understood.

Scientifically, there are three rationales for the existence of nonthermal effects:

1. Effects can occur at low intensities when a significant increase in temperature is not likely.
2. Heating does not produce the same effects as RFR exposure.
3. RFR with different modulations and characteristics produce different effects even though they may produce the same pattern of SAR distribution and tissue heating.

Low-intensityeffects have been discussed previously (see Section 7.). There are reports that RFR triggers effects that are different from an increase in temperature, e.g., Wachtel et al. (1975); Seaman and Wachtel (1978); D'Inzeo et al. (1988). And studies showing that RFR of the same frequency and intensity, but with different modulations and waveforms, can produce different effects as seen in the work of Baranski (1972); Arber and Lin (1985); Campisi et al. (2010); d'Ambrosio et al. (2002); Frey et al. (1975); Oscar and Hawkins (1977); Sanders et al. (1985); Huber et al. (2002); Markkanen et al. (2004); Hung et al. (2007); and Luukkonen et al. (2009).

A counter-argument for point 1 is that RFR can cause micro-heating at a small location even though there is no measurement change in temperature over the whole sample. This implies that an effect observed at low intensities could be due to localized micro-heating, and, therefore, is still considered thermal. However, the micro-heating theory could not apply to test subjects that are not stationary, such as in the case of Magras and Xenos (1997) who reported that mice exposed to low-intensity RFR became less reproductive over several generations. "Hot spots" of heating move within the body when the subject moves in the field and, thus, cannot maintain sustained heating of certain tissue.

The counter argument for point 2 is that heating by other means does not produce the same pattern of energy distribution as RFR. Thus, different effects would result. Again, this counter argument does not work on moving objects. Thus, results supporting the third point are the most compelling.

10. Studies on exposure to cell tower transmissions

From the early genesis of cell phone technology in the early 1980s, cell towers were presumed safe when located near populated areas because they are low-power installations in comparison with broadcast towers. This thinking already depended on the assumption that broadcast towers were safe if kept below certain limits. Therefore, the reasoning went, cell towers would be safer still. The thinking also assumed that exposures between cell and broadcast towers were comparable. In certain cities, cell and broadcast tower transmissions both contributed significantly to the ambient levels of RFR (Sirav and Seyhan 2009; Joseph et al. 2010).

There are several fallacies in this thinking, including the fact that broadcast exposures have been found unsafe even at regulated thresholds. Adverse effects have been noted for significant increases for all cancers in both men and women living near broadcast towers (Henderson and Anderson 1986); childhood leukemia clusters (Maskarinec et al. 1994; Ha et al. 2003; Park et al. 2004); adult leukemia and lymphoma clusters, and elevated rates of mental illness (Hocking et al. 1996; Michelozzi et al. 2002; Ha et al. 2007); elevated brain tumor incidence (Dolk et al. 1997*a*, 1997*b*); sleep disorders, decreased concentration, anxiety, elevated blood pressure, headaches, memory impairment, increased white cell counts, and decreased lung function in children (Altpeter et al. 2000); motor, memory, and learning impairment in children (Kolodynski and Kolodynski 1996), nonlinear increases in brain tumor incidence (Colorado Department of Public Health 2004); increases in malignant melanoma (Hallberg and Johansson 2002); and nonlinear immune system changes in women (Boscol et al. 2001). (The term "nonlinear" is used in scientific literature to mean that an effect was not directly proportional to the intensity of exposure. In the case of the two studies mentioned previously, adverse effects were found at significant distances from the towers, not in closer proximity where the power density exposures were higher and therefore presumed to have a greater chance of causing effects. This is something that often comes up in low-level energy studies and adds credence to the argument that low-level exposures could cause qualitatively different effects than higher level exposures.)

There is also anecdotal evidence in Europe that some communities have experienced adverse physical reactions after the switch from analog TV broadcast signals to the new digital formats, which can be more biologically complex

Three doctors in Germany, Cornelia Waldmann-Selsam, MD, Christine Aschermann, MD, and Markus Kern, MD,

wrote (in a letter to the U.S. President, entitled *Warning — Adverse Health Effects From Digital Broadcast Television*)[10], that on 20 May 2006, two digital broadcast television stations went on the air in the Hessian Rhoen area. Prior to that time that area had low radiation levels, which included that from cell phone towers of which there were few. However, coinciding with the introduction of the digital signals, within a radius of more than 20 km, there was an abrupt onset of symptoms for constant headaches, pressure in the head, drowsiness, sleep problems, inability to think clearly, forgetfulness, nervousness, irritability, tightness in the chest, rapid heartbeat, shortness of breath, depression, apathy, loss of empathy, burning skin, sense of inner burning, leg weakness, pain in the limbs, stabbing pain in various organs, and weight gain. They also noted that birds fled the area. The same symptoms gradually appeared in other locations after digital signals were introduced. Some physicians accompanied affected people to areas where there was no TV reception from terrestrial sources, such as in valleys or behind mountain ranges, and observed that many people became symptom free after only a short time. The digital systems also require more transmitters than the older analog systems and, therefore, somewhat higher exposure levels to the general population are expected, according to the 2009 SCENIHR Report (SCENIHR 2009).

Whether digital or analog, the frequencies differ between broadcast and cell antennas and do not couple with the human anatomy in whole-body or organ-specific models in the same ways (NCRP 1986; ICNIRP 1998). This difference in how the body absorbs energy is the reason that all standards-setting organizations have the strictest limitations between 30–300 MHz — ranges that encompass FM broadcast where whole body resonance occurs (Cleveland 2001). Exposure allowances are more lenient for cell technology in frequency ranges between 300 MHz and 3 GHz, which encompass cellular phone technology. This is based on the assumption that the cell frequencies do not penetrate the body as deeply and no whole-body resonance can occur.

There are some studies on the health effects on people living near cell phone towers. Though cell technology has been in existence since the late 1980s, the first study of populations near cell tower base stations was only conducted by Santini et al. (2002). It was prompted in part by complaints of adverse effects experienced by residents living near cell base stations throughout the world and increased activism by citizens. As well, increasing concerns by physicians to understand those complaints was reflected in professional organizations like the ICEMS (International Committee on Electromagnetic Safety) Catania Resolution[11], the Irish Doctors Environmental Association (IDEA)[12], and the Freiburger Appeal[13].

Santini conducted a survey study of 530 people (270 men, 260 women) on 18 nonspecific health symptoms (NSHS) in relation to self-reported distance from towers of <10 m, 10 to 50 m, 50 to 100 m, 100 to 200 m, 200 to 300 m, and >300 m. The control group compared people living more than 300 m (approximately 1000 ft) or not exposed to base stations. They controlled for age, presence of electrical transformers (<10 m), high tension lines (<100 m), and radio/TV broadcast transmitters (<4 km), the frequency of cell phone use (>20 min per day), and computer use (>2 h per day). Questions also included residents' location in relation to antennas, taking into account orientations that were facing, beside, behind, or beneath antennas in cases of roof-mounted antenna arrays. Exposure conditions were defined by the length of time living in the neighborhood (<1 year through >5 years); the number of days per week and hours per day (<1 h to >16 h) that were spent in the residence.

Results indicated increased symptoms and complaints the closer a person lived to a tower. At <10 m, symptoms included nausea, loss of appetite, visual disruptions, and difficulty in moving. Significant differences were observed up through 100 m for irritability, depressive tendencies, concentration difficulties, memory loss, dizziness, and lower libido. Between 100 and 200 m, symptoms included headaches, sleep disruption, feelings of discomfort, and skin problems. Beyond 200 m, fatigue was significantly reported more often than in controls. Women significantly reported symptoms more often than men, except for libido loss. There was no increase in premature menopause in women in relation to distance from towers. The authors concluded that there were different sex-dependent sensitivities to electromagnetic fields. They also called for infrastructure not to be sited <300 m (~1000 ft) from populations for precautionary purposes, and noted that the information their survey captured might not apply to all circumstances since actual exposures depend on the volume of calls being generated from any particular tower, as well as on how radiowaves are reflected by environmental factors.

Similar results were found in Egypt by Abdel-Rassoul et al. (2007) looking to identify neurobehavioral deficits in people living near cell phone base stations. Researchers conducted a cross-sectional study of 85 subjects: 37 living inside a building where antennas were mounted on the rooftop and 48 agricultural directorate employees who worked in a building (~ 10 m) opposite the station. A control group of 80 who did not live near base stations were matched for age, sex, occupation, smoking, cell phone use, and educational level. All participants completed a questionnaire containing personal, educational, and medical histories; general and neurological examinations; a neurobehavioral test battery (NBTB) involving tests for visuomotor speed, problem solving, attention, and memory, in addition to a Eysenck personality questionnaire (EPQ).

Their results found a prevalence of neuropsychiatric complaints: headaches, memory changes, dizziness, tremors, depressive symptoms, and sleep disturbance were significantly higher among exposed inhabitants than controls. The NBTB indicated that the exposed inhabitants exhibited a significantly lower performance than controls in one of the tests of attention and short-term auditory memory (paced auditory

[10] http://www.notanotherconspiracy.com/2009/02/warning-adverse-health-effects-from.html. (Accessed October 2010.)
[11] http://www.icems.eu/resolution.htm
[12] http://www.ideeaireland.org/emr.htm
[13] http://www.laleva.cc/environment/freiburger_appeal.html

serial addition test (PASAT)). Also, the inhabitants opposite the station exhibited a lower performance in the problem-solving test (block design) than those who lived under the station. All inhabitants exhibited a better performance in the two tests of visuomotor speed (digit symbol and Trailmaking B) and one test of attention (Trailmaking A) than controls.

Environmental power-density data were taken from measurements of that building done by the National Telecommunications Institute in 2000. Measurements were collected from the rooftop where the antennas were positioned, the shelter that enclosed the electrical equipment and cables for the antennas, other sites on the roof, and within an apartment below one of the antennas. Power-density measurements ranged from 0.1–6.7 $\mu W/cm^2$. No measurements were taken in the building across the street. The researchers noted that the last available measurements of RFR in 2002 in that area were less than the allowable standards but also noted that exposures depended on the number of calls being made at any given time, and that the number of cell phone users had increased approximately four times within the 2 years just before the beginning of their study in 2003. They concluded that inhabitants living near mobile phone base stations are at risk for developing neuropsychiatric problems, as well as some changes in the performance of neurobehavioral functions, either by facilitation (over-stimulation) or inhibition (suppression). They recommended the standards be revised for public exposure to RFR, and called for using the NBTB for regular assessment and early detection of biological effects among inhabitants near base stations (Abdel-Rassoul et al. 2007).

Hutter et al. (2006) sought to determine cognitive changes, sleep quality, and overall well-being in 365 rural and urban inhabitants who had lived for more than a year near 10 selected cell phone base stations. Distance from antennas was 24 to 600 m in rural areas, and 20 to 250 m in the urban areas. Field strength measurements were taken in bedrooms and cognitive tests were performed. Exposure to high-frequency EMFs was lower than guidelines and ranged from 0.000002 to 0.14 $\mu W/cm^2$ for all frequencies between 80 MHz and 2 GHz with the greater exposure coming from mobile telecommunications facilities, which was between 0.000001 and 0.14 $\mu W/cm^2$. Maximum levels were between 0.000002 and 0.41 $\mu W/cm^2$ with an overall 5% of the estimated maximum above 0.1 $\mu W/cm^2$. Average levels were slightly higher in rural areas (0.005 $\mu W/cm^2$) than in urban areas (0.002 $\mu W/cm^2$). The researchers tried to ascertain if the subjective rating of negative health consequences from base stations acted as a covariable but found that most subjects expressed no strong concerns about adverse effects from the stations, with 65% and 61% in urban and rural areas, respectively, stating no concerns at all. But symptoms were generally higher for subjects who expressed health concerns regarding the towers. The researchers speculated that this was due to the subjects with health complaints seeking answers and consequently blaming the base station; or that subjects with concerns were more anxious in general and tended to give more negative appraisals of their body functions; and the fact that some people simply give very negative answers.

Hutter's results were similar to those of Santini et al. (2002) and Abdel-Rassoul et al. (2007). Hutter found a significant relationship between symptoms and power densities. Adverse effects were highest for headaches, cold hands and feet, cardiovascular symptoms, and concentration difficulties. Perceptual speed increased while accuracy decreased insignificantly with increasing exposure levels. Unlike the others, however, Hutter found no significant effects on sleep quality and attributed such problems more to fear of adverse effects than actual exposure. They concluded that effects on well-being and performance cannot be ruled out even as mechanisms of action remain unknown. They further recommended that antenna siting should be done to minimize exposure to the population.

Navarro et al. (2003) measured the broadband electric field (E-field) in the bedrooms of 97 participants in La Nora, Murcia, Spain and found a significantly higher symptom score in 9 out of 16 symptoms in the groups with an exposure of 0.65 V/m (0.1121 $\mu W/cm^2$) compared with the control group with an exposure below 0.2 V/m (0.01061 $\mu W/cm^2$), both as an average. The highest contributor to the exposure was GSM 900/1800 MHz signals from mobile telecommunications. The same researchers also reported significant correlation coefficients between the measured E-field and 14 out of 16 health-related symptoms with the five highest associations found for depressive tendencies, fatigue, sleeping disorders, concentration difficulties, and cardiovascular problems. In a follow up work, Oberfeld et al. (2004) conducted a health survey in Spain in the vicinity of two GSM 900/1800 MHz cell phone base stations, measuring the E-field in six bedrooms, and found similar results. They concluded that the symptoms are in line with "microwave syndrome" reported in the literature (Johnson-Liakouris 1998). They recommended that the sum total for ambient exposures should not be higher than 0.02 V/m — the equivalent of a power density of 0.00011 $\mu W/cm^2$, which is the indoor exposure value for GSM base stations proposed by the Public Health Office of the Government of Salzburg, Austria in 2002[14].

Eger et al. (2004) took up a challenge to medical professionals by Germany's radiation protection board to determine if there was an increased cancer incidence in populations living near cell towers. Their study evaluated data for approximately 1000 patients between the years of 1994 and 2004 who lived close to cell antennas. The results showed that the incidence of cancer was significantly higher among those patients who had lived for 5 to 10 years at a distance of up to 400 m from a cell installation that had been in operation since 1993, compared with those patients living further away, and that the patients fell ill on an average of 8 years earlier than would be expected. In the years between 1999 and 2004, after 5 years operation of the transmitting installation, the relative risk of getting cancer had tripled for residents in proximity of the installation compared with inhabitants outside of the area.

Wolf and Wolf (2004) investigated increased cancer incidence in populations living in a small area in Israel exposed

[14] http://www.salzburg.gv.at/umweltmedizin. (Accessed October 2010.)

to RFR from a cell tower. The antennas were mounted 10 m high, transmitting at 850 MHz and 1500 W at full-power output. People lived within a 350 m half circle of the antennas. An epidemiologic assessment was done to determine whether the incidence of cancer cases among individuals exposed to the base station in the south section of the city of Netanya called Irus (designated area A) differed from expected cancer rates throughout Israel, and in the town of Netanya in general, as compared with people who lived in a nearby area without a cell tower (designated area B). There were 622 participants in area A who had lived near the cell tower for 3 to 7 years and were patients at one health clinic. The exposure began 1 year before the start of the study when the station first came into service. A second cohort of individuals in area B, with 1222 participants who received medical services at a different clinic located nearby, was used as a control. Area B was closely matched for environment, workplace, and occupational characteristics. In exposure area A, eight cases of different types of cancer were diagnosed in a period of 1 year, including cancers of the ovary (1), breast (3), Hodgkins lymphoma (1), lung (1), osteoid osteoma (1), and hypernephroma (1). The RFR field measurements were also taken per house and matched to the cancer incidents. The rate of cancers in area A was compared with the annual rate of the general population (31 cases per 10 000) and to incidence for the entire town of Netanya. There were two cancers in area B, compared to eight in area A. They also examined the history of the exposed cohort (area A) for malignancies in the 5 years before exposure began and found only two cases in comparison to eight cases 1 year after the tower went into service. The researchers concluded that relative cancer rates for females were 10.5 for area A, 0.6 for area B, and 1.0 for the whole town of Netanya. Cancer incidence in women in area A was thus significantly higher (p <0.0001) compared with that of area B and the whole city. A comparison of the relative risk revealed that there were 4.15 times more cases in area A than in the entire population. The study indicated an association between increased incidence of cancer and living in proximity to a cell phone base station. The measured level of RFR, between 0.3 to 0.5 $\mu W/cm^2$, was far below the thermal guidelines.

11. Risk perception, electrohypersensitivity, and psychological factors

Others have followed up on what role risk perception might play in populations near cell base stations to see if it is associated with health complaints.

Blettner et al. (2008) conducted a cross-sectional, multiphase study in Germany. In the initial phase, 30 047 people out of a total of 51 444, who took part in a nationwide survey, were also asked about their health and attitudes towards mobile phone base stations. A list of 38 potential health complaints were used. With a response rate of 58.6%, 18.0% were concerned about adverse health effects from base stations, 10.3% directly attributed personal adverse effects to them. It was found that people living within 500 m, or those concerned about personal exposures, reported more health complaints than others. The authors concluded that even though a substantial proportion of the German population is concerned about such exposures, the observed higher health complaints cannot be attributed to those concerns alone.

Kristiansen et al. (2009) also explored the prevalence and nature of concerns about mobile phone radiation, especially since the introduction of new 3G–UMTS (universal mobile telecommunications system) networks that require many more towers and antennas have sparked debate throughout Europe. Some local governments have prohibited mobile antennas on public buildings due to concerns about cancer, especially brain cancer in children and impaired psychomotor functions. One aim of the researchers was risk assessment — to compare people's perceptions of risk from cell phones and masts to other fears, such as being struck by lightening. In Denmark, they used data from a 2006 telephone survey of 1004 people aged 15+ years. They found that 28% of the respondents were concerned about exposure to mobile phone radiation and 15% about radiation from masts. In contrast, 82% of respondents were concerned about other forms of environmental pollution. Nearly half of the respondents considered the mortality risk of 3G phones and masts to be of the same order of magnitude as being struck by lightning (0.1 fatalities per million people per year), while 7% thought it was equivalent to tobacco-induced lung cancer (approximately 500 fatalities per million per year). Among women, concerns about mobile phone radiation, perceived mobile phone mortality risk, and concerns about unknown consequences of new technologies, increased with educational levels. More than two thirds of the respondents felt that they had not received adequate public information about the 3G system. The results of the study indicated that the majority of the survey population had little concern about mobile phone radiation, while a minority is very concerned.

Augner et al. (2009) examined the effects of short-term GSM base station exposure on psychological symptoms including good mood, alertness, and calmness as measured by a standardized well-being questionnaire. Fifty-seven participants were randomly assigned to one of three different exposure scenarios. Each of those scenarios subjected participants to five 50 min exposure sessions, with only the first four relevant for the study of psychological symptoms. Three exposure levels were created by shielding devices, which could be installed or removed between sessions to create double-blinded conditions. The overall median power densities were 0.00052 $\mu W/cm^2$ during low exposures, 0.0154 $\mu W/cm^2$ during medium exposures, and 0.2127 $\mu W/cm^2$ during high-exposure sessions. Participants in high- and medium-exposure scenarios were significantly calmer during those sessions than participants in low-exposure scenarios throughout. However, no significant differences between exposure scenarios in the "good mood" or "alertness" factors were found. The researchers concluded that short-term exposure to GSM base station signals may have an impact on well-being by reducing psychological arousal.

Eltiti et al. (2007) looked into exposures to the GSM and UMTS exposures from base stations and the effects to 56 participants who were self-reported as sensitive to electromagnetic fields. Some call it electro-hypersensitivity (EHS) or just electrosensitivity. People with EHS report that they suffer negative health effects when exposed to electro-

magnetic fields from everyday objects such as cell phones, mobile phone base stations, and many other common things in modern societies. EHS is a recognized functional impairment in Sweden. This study used both open provocation and double-blind tests to determine if electrosensitive and control individuals experienced more negative health effects when exposed to base-station-like signals compared with sham exposures. Fifty-six electrosensitive and 120 control participants were tested first in an open provocation test. Of these, 12 electrosensitive and six controls withdrew after the first session. Some of the electrosensitive subjects later issued a statement saying that the initial exposures made them too uncomfortable to continue participating in the study. This means that the study may have lost its most vulnerable test subjects right at the beginning, possibly skewing later outcomes. The remainder completed a series of double-blind tests. Subjective measures of well-being and symptoms, as well as physiological measures of blood-volume pulse, heart rate, and skin conductance were obtained. They found that during the open provocation, electrosensitive individuals reported lower levels of well-being to both GSM and UMTS signals compared with sham exposure, whereas controls reported more symptoms during the UMTS exposure. During double-blind tests the GSM signal did not have any effect on either group. Electrosensitive participants did report elevated levels of arousal during the UMTS condition, but the number or severity of symptoms experienced did not increase. Physiological measures did not differ across the three exposure conditions for either group. The researchers concluded that short-term exposure to a typical GSM base-station-like signal did not affect well-being or physiological functions in electrosensitive or control individuals even though the electrosensitive individuals reported elevated levels of arousal when exposed to a UMTS signal. The researchers stated that this difference was likely due to the effect of the order of the exposures throughout the series rather than to the exposure itself. The researchers do not speculate about possible data bias when one quarter of the most sensitive test subjects dropped out at the beginning.

In follow-up work, Eltiti et al. (2009) attempted to clarify some of the inconsistencies in the research with people who report sensitivity to electromagnetic fields. Such individuals, they noted, often report cognitive impairments that they believe are due to exposure to mobile phone technology. They further said that previous research in this area has revealed mixed results, with the majority of research only testing control individuals. Their aim was to clarify whether short-term (50 min) exposure at 1 $\mu W/cm^2$ to typical GSM and UMTS base station signals affects attention, memory, and physiological endpoints in electrosensitive and control participants. Data from 44 electrosensitive and 44 matched-control participants who performed the digit symbol substitution task (DSST), digit span task (DS), and a mental arithmetic task (MA), while being exposed to GSM, UMTS, and sham signals under double-blind conditions were analyzed. Overall, the researchers concluded that cognitive functioning was not affected by short-term exposure to either GSM or UMTS signals. Nor did exposure affect the physiological measurements of blood-volume pulse, heart rate, and skin conductance that were taken while participants performed the cognitive tasks. The GSM signal was a combined signal of 900 and 1800 MHz frequencies, each with a power flux density of 0.5 $\mu W/cm^2$, which resulted in combined power flux density of 1 $\mu W/cm^2$ over the area where test subjects were seated. Previous measurements in 2002 by the National Radiological Protection Board in the UK, measuring power density from base stations at 17 sites and 118 locations (Mann et al. 2002), found that in general, the power flux density was between 0.001 $\mu W/cm^2$ to 0.1 $\mu W/cm^2$, with the highest power density being 0.83 $\mu W/cm^2$. The higher exposure used by the researchers in this study was deemed comparable by them to the maximum exposure a person would encounter in the real world. But many electrosensitive individuals report that they react to much lower exposures too. Overall, the electrosensitive participants had a significantly higher level of mean skin conductance than control subjects while performing cognitive tasks. The researchers noted that this was consistent with other studies that hypothesize sensitive individuals may have a general imbalance in autonomic nervous system regulation. Generally, cognitive functioning was not affected in either electrosensitives or controls. When Bonferroni corrections were applied to the data, the effects on mean skin conductance disappeared. A criticism is that this averaging of test results hides more subtle effects.

Wallace et al. (2010) also tried to determine if short-term exposure to RFR had an impact on well-being and what role, if any, psychological factors play. Their study focused on "Airwave", a new communication system being rolled out across the UK for police and emergency services. Some police officers have complained about skin rashes, nausea, headaches, and depression as a consequence of using Airwave two-way radio handsets. The researchers used a small group of self-reported electrosensitive people to determine if they reacted to the exposures, and to determine if exposures to specific signals affect a selection of the adult population who do not report sensitivity to electromagnetic fields. A randomized double-blind provocation study was conducted to establish whether short-term exposure to a terrestrial trunked radio (TETRA) base station signal has an impact on health and well-being in individuals with electrosensitivity and controls. Fifty-one individuals with electrosensitivity and 132 age- and gender-matched controls participated first in an open provocation test, while 48 electrosensitive and 132 control participants went on to complete double-blind tests in a fully screened semi-anechoic chamber. Heart rate, skin conductance, and blood pressure readings provided objective indices of short-term physiological response. Visual analogue scales and symptom scales provided subjective indices of well-being. Their results found no differences on any measure between TETRA and sham (no signal) under double-blind conditions for either control or electrosensitive participants and neither group could detect the presence of a TETRA signal above chance (50%). The researchers noted, however, that when conditions were not double-blinded, the electrosensitive individuals did report feeling worse and experienced more severe symptoms during TETRA compared with sham exposure. They concluded that the adverse symptoms experienced by electrosensitive individuals are caused by the belief of harm from TETRA base stations rather than because of the low-level EMF exposure itself.

It is interesting to note that the three previously men-

tioned studies were all conducted at the same Electromagnetics and Health Laboratory at the University of Essex, Essex, UK, by the same relative group of investigators. Those claiming to be electrosensitive are a small subgroup in the population, often in touch through Internet support groups. In the first test, many electrosensitives dropped out because they found the exposures used in the study too uncomfortable. The drop-out rate decreased with the subsequent studies, which raises the question of whether the electrosensitive participants in the latter studies were truly electrosensitive. There is a possibility that a true subgroup of electrosensitives cannot tolerate such study conditions, or that potential test subjects are networking in a way that preclude their participation in the first place. In fact, researchers were not able to recruit their target numbers for electrosensitive participants in any of the studies. The researchers also do not state if there were any of the same electrosensitive participants used in the three studies. Nor do they offer comment regarding the order of the test methods possibly skewing results.

Because of uncertainty regarding whether EMF exposures are actually causing the symptoms that electrosensitives report, and since many electrosensitives also report sensitivities to myriad chemicals and other environmental factors, it has been recommended (Hansson Mild et al. 2006) that a new term be used to describe such individuals — idiopathic environmental intolerance with attribution to electromagnetic fields (IEI-EMF).

Furubayashi et al. (2009) also tried to determine if people who reported symptoms to mobile phones are more susceptible than control subjects to the effect of EMF emitted from base stations. They conducted a double-blind, cross-over provocation study, sent questionnaires to 5000 women and obtained 2472 valid responses from possible candidates. From those, they were only able to recruit 11 subjects with mobile phone related symptoms (MPRS) and 43 controls. The assumption was that individuals with MPRS matched the description of electrosensitivity by the World Health Organization (WHO). There were four EMF exposure conditions, each of which lasted 30 min: (*i*) continuous, (*ii*) intermittent, (*iii*) sham exposure with noise, and (*iv*) sham exposure without noise. Subjects were exposed to EMF of 2.14 GHz, 10 V/m (26.53 $\mu W/cm^2$) wideband code division multiple access (W-CDMA), in a shielded room to simulate whole-body exposure to EMF from base stations, although the exposure strength they used was higher than that commonly received from base stations. The researchers measured several psychological and cognitive parameters immediately before and after exposure, and monitored autonomic functions. Subjects were asked to report on their perception of EMF and level of discomfort during the experiment. The MPRS group did not differ from the controls in their ability to detect exposure to EMF. They did, however, consistently experience more discomfort in general, regardless of whether or not they were actually exposed to EMF, and despite the lack of significant changes in their autonomic functions. The researchers noted that others had found electrosensitive subjects to be more susceptible to stress imposed by task performance, although they did not differ from normal controls in their personality traits. The researchers concluded that the two groups did not differ in their responses to real or sham EMF exposure according to any psychological, cognitive or autonomic assessment. They said they found no evidence of any causal link between hypersensitivity symptoms and exposure to EMF from base stations. However, this study, had few MPRS participants.

Regel et al. (2006) also investigated the effects of the influence of UMTS base-station-like signals on well-being and cognitive performance in subjects with and without self-reported sensitivity to RFR. The researchers performed a controlled exposure experiment in a randomized, double-blind crossover study, with 45 min at an electric field strength of 0 V/m, 1.0 V/m (0.2653 $\mu W/cm^2$), or 10.0 V/m (26.53 $\mu W/cm^2$), incident with a polarization of 45° from the left-rear side of the subject, at weekly intervals. A total of 117 healthy subjects that included 33 self-reported sensitive subjects and 84 nonsensitive subjects, participated in the study. The team assessed well-being, perceived field strength, and cognitive performance with questionnaires and cognitive tasks and conducted statistical analyses using linear mixed models. Organ-specific and brain-tissue-specific dosimetry, including uncertainty and variation analysis, was performed. Their results found that in both groups, well-being and perceived field strength were not associated with actual exposure levels. They observed no consistent condition-induced changes in cognitive performance except for two marginal effects. At 10 V/m (26.53 $\mu W/cm^2$) they observed a slight effect on speed in one of six tasks in the sensitive subjects and an effect on accuracy in another task in nonsensitive subjects. Both effects disappeared after multiple endpoint adjustments. They concluded that they could not confirm a short-term effect of UMTS base-station-like exposure on well-being. The reported effects on brain functioning were marginal, which they attributed to chance. Peak spatial absorption in brain tissue was considerably smaller than during use of a mobile phone. They concluded that no conclusions could be drawn regarding short-term effects of cell phone exposure or the effects of long-term base-station-like exposures on human health.

Siegrist et al. (2005) investigated risk perceptions associated with mobile phones, base stations, and other sources of EMFs through a telephone survey conducted in Switzerland. Participants assessed both risks and benefits associated with nine different sources of EMF. Trust in the authorities regulating these hazards was also assessed. Participants answered a set of questions related to attitudes toward EMF and toward mobile phone base stations. Their results were: high-voltage transmission lines are perceived as the most risky source of EMF; and mobile phones and base stations received lower risk ratings. Trust in authorities was positively associated with perceived benefits and negatively associated with perceived risks. Also, people who use their mobile phones frequently perceived lower risks and higher benefits than people who use their mobile phones infrequently. People who believed they lived close to a base station did not significantly differ in their perceived level of risks associated with mobile phone base stations from people who did not believe they lived close to a base station. A majority of participants favored limits to exposures based on worst-case scenarios. The researchers also correlated perceived risks with other beliefs and found that belief in paranormal phenomena is related to level of perceived risks associated with

EMF. In addition, people who believed that most chemical substances cause cancer also worried more about EMF than people who did not believe that chemical substances are harmful. This study found the obvious — that some people worry more about environmental factors than others across a range of concerns.

Wilen et al. (2006) investigated the effects of exposure to mobile phone RFR on people who experience subjective symptoms when using mobile phones. Twenty subjects with MPRS were matched with 20 controls without MPRS. Each subject participated in two experimental sessions, one with true exposure and one with sham exposure, in random order. In the true exposure condition, the test subjects were exposed for 30 min to an RFR field generating a maximum SAR (1 g) in the head of 1 W/kg through an indoor base station antenna attached to signals from a 900 MHz GSM mobile phone. Physiological and cognitive parameters were measured during the experiment for heart rate and heart rate variability (HRV), respiration, local blood flow, electrodermal activity, critical flicker fusion threshold (CFFT), short-term memory, and reaction time. No significant differences related to RFR exposure conditions and no differences in baseline data were found between subject groups with the exception for reaction time, which was significantly longer among the test subjects than among the controls the first time the test was performed. This difference disappeared when the test was repeated. However, the test subjects differed significantly from the controls with respect to HRV as measured in the frequency domain. The test subjects displayed a shift in the low/high frequency ratio towards a sympathetic dominance in the autonomous nervous system during the CFFT and memory tests, regardless of exposure condition. They interpreted this as a sign of differences in the autonomous nervous system regulation among persons with MPRS and persons with no such symptoms.

12. Assessing exposures

Quantifying, qualifying, and measuring radiofrequency (RF) energy both indoors and outdoors has frustrated scientists, researchers, regulators, and citizens alike. The questions involve how best to capture actual exposure data — through epidemiology, computer estimates, self-reporting, or actual dosimetry measurements. Determining how best to do this is more important than ever, given the increasing background levels of RFR. Distance from a generating source has traditionally been used as a surrogate for probable power density but that is imperfect at best, given how RF energy behaves once it is transmitted. Complicated factors and numerous variables come into play. The wearing of personal dosimetry devices appears to be a promising area for capturing cumulative exposure data.

Neubauer et al. (2007) asked the question if epidemiology studies are even possible now, given the increasing deployment of wireless technologies. They examined the methodological challenges and used experts in engineering, dosimetry, and epidemiology to critically evaluate dosimetric concepts and specific aspects of exposure assessment regarding epidemiological study outcomes. They concluded that, at least in theory, epidemiology studies near base stations are feasible but that all relevant RF sources have to be taken into account. They called for pilot studies to validate exposure assessments and recommended that short-to-medium term effects on health and well-being are best investigated by cohort studies. They also said that for long-term effects, groups with high exposures need to be identified first, and that for immediate effects, human laboratory studies are the preferred approach. In other words, multiple approaches are required. They did not make specific recommendations on how to quantify long-term, low-level effects on health and well-being.

Radon et al. (2006) compared personal RF dosimetry measurements against recall to ascertain the reliability of self-reporting near base stations. Their aim was to test the feasibility and reliability of personal dosimetry devices. They used a 24 h assessment on 42 children, 57 adolescents, and 64 adults who wore a Maschek dosimeter prototype, then compared the self-reported exposures with the measurements. They also compared the readings of Maschek prototype with those of the Antennessa DSP-090 in 40 test subjects. They found that self-reported exposures did not correlate with actual readings. The two dosimeters were in moderate agreement. Their conclusion was that personal dosimetry, or the wearing of measuring devices, was a feasible method in epidemiology studies.

A study by Frei et al. (2009) also used personal dosimetry devices to examine the total exposure levels of RFR in the Swiss urban population. What they found was startling — nearly a third of the test subjects' cumulative exposures were from cell base stations. Prior to this study, exposure from base stations was thought to be insignificant due to their low-power densities and to affect only those living or working in close proximity to the infrastructure. This study showed that the general population moves in and out of these particular fields with more regularity than previously expected. In a sample of 166 volunteers from Basel, Switzerland, who agreed to wear personal exposure meters (called exposimeters), the researchers found that nearly one third of total exposures came from base stations. Participants carried an exposimeter for 1 week (2 separate weeks in 32 participants) and also completed an activity diary. Mean values were calculated using the robust regression on order statistics (ROS) method. Results found a mean weekly exposure to all RFR and (or) EMF sources was 0.013 $\mu W/cm^2$ (range of individual means 0.0014–0.0881 $\mu W/cm^2$). Exposure was mainly from mobile phone base stations (32.0%), mobile phone handsets (29.1%), and digital enhanced cordless telecommunications (DECT) phones (22.7%). People owning a DECT phone (total mean 0.015 $\mu W/cm^2$) or mobile phone (0.014 $\mu W/cm^2$) were exposed more than those not owning a DECT or mobile phone (0.010 $\mu W/cm^2$). Mean values were highest in trains (0.116 $\mu W/cm^2$), airports (0.074 $\mu W/cm^2$), and tramways or buses (0.036 $\mu W/cm^2$) and were higher during daytime (0.016 $\mu W/cm^2$) than nighttime (0.008 $\mu W/cm^2$). The Spearman correlation coefficient between mean exposure in the first and second week was 0.61. Another surprising finding of this study contradicted Neubauer et al. (2008) who found that a rough dosimetric estimate of a 24 h exposure from a base station (1–2 V/m) (i.e., 0.2653–1.061 $\mu W/cm^2$) corresponded to approximately 30 min of mobile phone use. But Frei et al. (2009) found, using the exposimeter, that cell phone use was 200 times higher than the average base sta-

tion exposure contribution in self-selected volunteers (0.487 versus 0.002 $\mu W/cm^2$). This implied that at the belt, backpack, or in close vicinity to the body, the mean base station contribution corresponds to about 7 min of mobile phone use (24 h divided by 200), not 30 min. They concluded that exposure to RFR varied considerably between persons and locations but was fairly consistent for individuals. They noted that cell phones, base stations, and cordless phones were important sources of exposure in urban Switzerland but that people could reduce their exposures by replacing their cordless domestic phones with conventional landlines at home. They determined that it was feasible to combine diary data with personal exposure measurements and that such data was useful in evaluating RFR exposure during daily living, as well as helpful in reducing exposure misclassification in future epidemiology studies.

Viel et al. (2009) also used personal exposure meters (EME SPY 120 made by Satimo and ESM 140 made by Maschek) to characterize actual residential exposure from antennas. Their primary aim was to assess personal exposures, not ambient field strengths. Two hundred randomly selected people were enrolled to wear measurement meters for 24 h and asked to keep a time–location–activity diary. Two exposure metrics for each radiofrequency were then calculated: the proportion of measurements above the detection limit of 0.05 V/m (0.0006631 $\mu W/cm^2$) and the maximum electric field strength. Residential addresses were geocoded and distances from each antenna were calculated. They found that much of the time-recorded field strength was below the detection level of 0.05 V/m, with the exception of the FM radio bands, which had a detection threshold of 12.3%. The maximum electric field was always lower than 1.5 V/m (0.5968 $\mu W/cm^2$). Exposure to GSM and digital cellular system (DCS) frequencies peaked around 280 m in urban areas and 1000 m from antennas in more suburban/rural areas. A downward trend in exposures was found within a 10 km distance for FM exposures. Conversely, UMTS, TV3, and TV 4 and 5 signals did not vary with distance. The difference in peak exposures for cell frequencies were attributed to microcell antennas being more numerous in urban areas, often mounted a few meters above ground level, whereas macrocell base stations in less urban areas are placed higher (between 15 and 50 m above ground level) to cover distances of several kilometres. They concluded that despite the limiting factors and high variability of RF exposure assessments, in using sound statistical technique they were able to determine that exposures from GSM and DCS cellular base stations actually increase with distance in the near source zone, with a maximum exposure where the main beam intersects the ground. They noted that such information should be available to local authorities and the public regarding the siting of base stations. Their findings coincide with Abdel-Rassoul et al. (2007) who found field strengths to be less in the building directly underneath antennas, with reported health complaints higher in inhabitants of the building across the street.

Amoako et al. (2009) conducted a survey of RFR at public access points close to schools, hospitals, and highly populated areas in Ghana near 50 cell phone base stations. Their primary objective was to measure and analyze field strength levels. Measurements were made using an Anritsu model MS 2601A spectrum analyzer to determine the electric field level in the 900 and 1800 MHz frequency bands. Using a GPS (global positioning system), various base stations were mapped. Measurements were taken at 1.5 m above ground to maintain line of sight with the RF source. Signals were measured during the day over a 3 h period, at a distance of approximately 300 m. The results indicated that power densities for 900 MHz at public access points varied from as low as 0.000001 $\mu W/cm^2$ to as high as 0.001 $\mu W/cm^2$. At 1800 MHz, the variation of power densities was from 0.000001 to 0.01 $\mu W/cm^2$. There are no specific RFR standards in Ghana. These researchers determined that while their results in most cites were compliant with the ICNIRP standards, levels were still 20 times higher than values typically found in the UK, Australia, and the U.S., especially for Ghana base stations in rural areas with higher power output. They determined that there is a need to reduce RFR levels since an increase in mobile phone usage is foreseen.

Clearly, predicting actual exposures based on simple distance from antennas using standardized computer formulas is inadequate. Although power density undoubtedly decreases with distance from a generating source, actual exposure metrics can be far more complex, especially in urban areas. Contributing to the complexity is the fact that the narrow vertical spread of the beam creates a low RF field strength at the ground directly below the antenna. As a person moves away or within a particular field, exposures can become complicated, creating peaks and valleys in field strength. Scattering and attenuation alter field strength in relation to building placement and architecture, and local perturbation factors can come into play. Power density levels can be 1 to 100 times lower inside a building, depending on construction materials, and exposures can differ greatly within a building, depending on numerous factors such as orientation toward the generating source and the presence of conductive materials. Exposures can be twice as high in upper floors than in lower floors, as found by Anglesio et al. (2001).

However, although distance from a transmitting source has been shown to be an unreliable determinant for accurate exposure predictions, it is nevertheless useful in some general ways. For instance, it has been shown that radiation levels from a tower with 15 nonbroadcast radio systems will fall off to hypothetical natural background levels at approximately 1500 ft ($\sim$500 m) (Rinebold 2001). This would be in general agreement with the lessening of symptoms in people living near cell towers at a distance over 1000 ft ($\sim$300 m) found by Santini et al. (2002) .

The previously mentioned studies indicate that accuracy in both test design and personal dosimetry measurements are possible in spite of the complexities and that a general safer distance from a cell tower for residences, schools, daycare centers, hospitals, and nursing homes might be ascertained.

13. Discussion

Numerous biological effects do occur after short-term exposures to low-intensity RFR but potential hazardous health effects from such exposures on humans are still not well es-

tablished, despite increasing evidence as demonstrated throughout this paper. Unfortunately, not enough is known about biological effects from long-term exposures, especially as the effects of long-term exposure can be quite different from those of short-term exposure. It is the long-term, low-intensity exposures that are most common today and increasing significantly from myriad wireless products and services.

People are reporting symptoms near cell towers and in proximity to other RFR-generating sources including consumer products such as wireless computer routers and Wi-Fi systems that appear to be classic "microwave sickness syndrome," also known as "radiofrequency radiation sickness." First identified in the 1950s by Soviet medical researchers, symptoms included headache, fatigue, ocular dysfunction, dizziness, and sleep disorders. In Soviet medicine, clinical manifestations include dermographism, tumors, blood changes, reproductive and cardiovascular abnormalities, depression, irritability, and memory impairment, among others. The Soviet researchers noted that the syndrome is reversible in early stages but is considered lethal over time (Tolgskaya et al. 1973).

Johnson-Liakouris (1998) noted there are both occupational studies conducted between 1953 and 1991 and clinical cases of acute exposure between 1975 and 1993 that offer substantive verification for the syndrome. Yet, U.S. regulatory agencies and standards-setting groups continue to quibble about the existence of microwave sickness because it does not fit neatly into engineering models for power density, even as studies are finding that cell towers are creating the same health complaints in the population. It should be noted that before cellular telecommunications technology, no such infrastructure exposures between 800 MHz and 2 GHz existed this close to so many people. Microwave ovens are the primary consumer product utilizing a high RF intensity, but their use is for very brief periods of time and ovens are shielded to prevent leakage above 1000 $\mu W/cm^2$ — the current FDA standard. In some cases, following the U.S. Telecommunications Act of 1996 preemption of local health considerations in infrastructure siting, antennas have been mounted within mere feet of dwellings. And, on buildings with roof-mounted arrays, exposures can be lateral with top floors of adjacent buildings at close range.

It makes little sense to keep denying health symptoms that are being reported in good faith. Though the prevalence of such exposures is relatively new to a widespread population, we, nevertheless, have a 50 year observation period to draw from. The primary questions now involve specific exposure parameters, not the reality of the complaints or attempts to attribute such complaints to psychosomatic causes, malingering, or beliefs in paranormal phenomenon. That line of argument is insulting to regulators, citizens, and their physicians. Serious mitigation efforts are overdue.

There is early Russian and U.S. documentation of long-term, very low-level exposures causing microwave sickness as contained in *The Johns Hopkins Foreign Service Health Status Study* done in 1978 (Lilienfield et al. 1978; United States Senate 1979). This study contains both clinical information, and clear exposure parameters. Called the Lilienfield study, it was conducted between 1953 and 1976 to determine what, if any, effects there had been to personnel in the U.S. Embassy in Moscow after it was discovered that the Soviet government had been systematically irradiating the U.S. government compound there.

The symptoms reported were not due to any known tissue heating properties. The power densities were not only very low but the propagation characteristics were remarkably similar to what we have today with cell phone base stations. Lilienfield recorded exposures for continuous-wave, broadband, modulated RFR in the frequency ranges between 0.6 and 9.5 GHz. The exposures were long-term and low-level at 6 to 8 h per day, 5 days per week, with the average length of exposure time per individual between 2 to 4 years. Modulation information contained phase, amplitude, and pulse variations with modulated signals being transmitted for 48 h or less at a time. Radiofrequency power density was between 2 and 28 $\mu W/cm^2$ — levels comparable to recent studies cited in this paper.

The symptoms that Lilienfield found included four that fit the Soviet description for dermographism — eczema, psoriasis, allergic, and inflammatory reactions. Also found were neurological problems with diseases of peripheral nerves and ganglia in males; reproductive problems in females during pregnancy, childbearing, and the period immediately after delivery (puerperium); tumor increases (malignant in females, benign in males); hematological alterations; and effects on mood and well-being including irritability, depression, loss of appetite, concentration, and eye problems. This description of symptoms in the early literature is nearly identical to the Santini, Abdel-Rassoul, and Narvarro studies cited earlier, as well as the current (though still anecdotal) reports in communities where broadcast facilities have switched from analog to digital signals at power intensities that are remarkably similar. In addition, the symptoms in the older literature are also quite similar to complaints in people with EHS.

Such reports of adverse effects on well-being are occurring worldwide near cell infrastructure and this does not appear to be related to emotional perceptions of risk. Similar symptoms have also been recorded at varying distances from broadcast towers. It is clear that something else is going on in populations exposed to low-level RFR that computer-generated RFR propagation models and obsolete exposure standards, which only protect against acute exposures, do not encompass or understand. With the increase in so many RFR-emitting devices today, as well as the many in the wings that will dramatically increase total exposures to the population from infrastructure alone, it may be time to approach this from a completely different perspective.

It might be more realistic to consider ambient outdoor and indoor RFR exposures in the same way we consider other environmental hazards such as chemicals from building materials that cause sick building syndrome. In considering public health, we should concentrate on aggregate exposures from multiple sources, rather than continuing to focus on individual source points like cell and broadcast base stations. In addition, whole categorically excluded technologies must be included for systems like Wi-Fi, Wi-Max, smart grids, and smart metering as these can greatly increase ambient radiation levels. Only in that way will low-level electromagnetic energy exposures be understood as the broad environmental factor it is. Radiofrequency radiation is a

form of energetic air pollution and it should be controlled as such. Our current predilection to take this one product or service at a time does not encompass what we already know beyond reasonable doubt. Only when aggregate exposures are better understood by consumers will disproportionate resistance to base station siting bring more intelligent debate into the public arena and help create safer infrastructure. That can also benefit the industries trying to satisfy customers who want such services.

Safety to populations living or working near communications infrastructure has not been given the kind of attention it deserves. Aggregate ambient outdoor and indoor exposures should be emphasized by summing up levels from different generating source points in the vicinity. Radiofrequency radiation should be treated and regulated like radon and toxic chemicals, as aggregate exposures, with appropriate recommendations made to the public including for consumer products that may produce significant RFR levels indoors. When indoor consumer products such as wireless routers, cordless/DECT phones, leaking microwave ovens, wireless speakers, and (or) security systems, etc. are factored in with nearby outdoor transmission infrastructure, indoor levels may rise to exposures that are unsafe. The contradictions in the studies should not be used to paralyze movement toward safer regulation of consumer products, new infrastructure creation, or better tower siting. Enough good science exists regarding long-term low-level exposures — the most prevalent today — to warrant caution.

The present U.S. guidelines for RFR exposure are not up to date. The most recent IEEE and NCRP guidelines used by the U.S. FCC have not taken many pertinent recent studies into consideration because, they argue, the results of many of those studies have not been replicated and thus are not valid for standards setting. That is a specious argument. It implies that someone tried to replicate certain works but failed to do so, indicating the studies in question are unreliable. However, in most cases, no one has tried to exactly replicate the works at all. It must be pointed out that the 4 W/kg SAR threshold based on the de Lorge studies have also not been replicated independently. In addition, effects of long-term exposure, modulation, and other propagation characteristics are not considered. Therefore, the current guidelines are questionable in protecting the public from possible harmful effects of RFR exposure and the U.S. FCC should take steps to update their regulations by taking all recent research into consideration without waiting for replication that may never come because of the scarcity of research funding. The ICNIRP standards are more lenient in key exposures to the population than current U.S. FCC regulations. The U.S. standards should not be "harmonized" toward more lenient allowances. The ICNIRP should become more protective instead. All standards should be biologically based, not dosimetry based as is the case today.

Exposure of the general population to RFR from wireless communication devices and transmission towers should be kept to a minimum and should follow the "As Low As Reasonably Achievable" (ALARA) principle. Some scientists, organizations, and local governments recommend very low exposure levels — so low, in fact, that many wireless industries claim they cannot function without many more antennas in a given area. However, a denser infrastructure may be impossible to attain because of citizen unwillingness to live in proximity to so many antennas. In general, the lowest regulatory standards currently in place aim to accomplish a maximum exposure of 0.02 V/m, equal to a power density of 0.0001 $\mu W/cm^2$, which is in line with Salzburg, Austria's indoor exposure value for GSM cell base stations. Other precautionary target levels aim for an outdoor cumulative exposure of 0.1 $\mu W/cm^2$ for pulsed RF exposures where they affect the general population and an indoor exposure as low as 0.01 $\mu W/cm^2$ (Sage and Carpenter 2009). In 2007, *The BioInitiative Report, A rationale for a biologically based public exposure standard for electromagnetic fields (ELF and RF)*, also made this recommendation, based on the precautionary principle (Bioinitiative Report 2007).

Citizens and municipalities often ask for firm setbacks from towers to guarantee safety. There are many variables involved with safer tower siting — such as how many providers are co-located, at what frequencies they operate, the tower's height, surrounding topographical characteristics, the presence of metal objects, and others. Hard and fast setbacks are difficult to recommend in all circumstances. Deployment of base stations should be kept as efficient as possible to avoid exposure of the public to unnecessary high levels of RFR. As a general guideline, cell base stations should not be located less than 1500 ft ($\sim$500 m) from the population, and at a height of about 150 ft ($\sim$50 m). Several of the papers previously cited indicate that symptoms lessen at that distance, despite the many variables involved. However, with new technologies now being added to cell towers such as Wi-Max networks, which add significantly more power density to the environment, setback recommendations can be a very unpredictable reassurance at best. New technology should be developed to reduce the energy required for effective wireless communication.

In addition, regular RFR monitoring of base stations should be considered. Some communities require that ambient background levels be measured at specific distances from proposed tower sites before, and after, towers go online to establish baseline data in case adverse effects in the population are later reported. The establishment of such baselines would help epidemiologists determine what changed in the environment at a specific point in time and help better assess if RFR played a role in health effects. Unfortunately, with so much background RFR today, it is almost impossible to find a clean RFR environment. Pretesting may have become impossible in many places. This will certainly be the case when smart grid technologies create a whole new blanket of low-level RFR, with millions of new transceivers attached to people's homes and appliances, working off of centralized RFR hubs in every neighborhood. That one technology alone has the ability to permanently negate certain baseline data points.

The increasing popularity of wireless technologies makes understanding actual environmental exposures more critical with each passing day. This also includes any potential effects on wildlife. There is a new environmental concept taking form — that of "air as habitat" (Manville 2007) for species such as birds, bats, and insects, in the same way that water is considered habitat for marine life. Until now, air has been considered something "used" but not necessarily "lived in" or critical to the survival of species. How-

ever, when air is considered habitat, RFR is among the potential pollutants with an ability to adversely affect other species. It is a new area of inquiry deserving of immediate funding and research.

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A BRIEFING MEMORANDUM: What We Know, Can Infer, and Don't Yet Know about Impacts from Thermal and Non-thermal Non-ionizing Radiation to Birds and Other Wildlife — for Public Release

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Introduction

There continues to be an active yet unsettled controversy about current radiation safety standards and their effects on humans and wildlife (www.livingplanet.be), most especially (1) with the exponential growth of ultra-high frequency (UHF) microwave radiation of electromagnetic fields (EMF) ranging from 900 MHz to 2500 GHz. The 900 and 1800 MHz fields are commonly used in communication devices such as cellular (cell) telephones, their antennas, related "smart" phones, digital "smart meters," computer wi-fi communication systems, and other sources of point-to-point and Internet communication. Much less attention is being paid to (2) frequency modulated (FM) impacts on migratory birds, including bandwidths ranging from 70 to 110 MHz also briefly discussed in this memo.

However, as concluded in this memo, the impacts from radiation especially at the non-thermal level (thermal effects are generally pretty clear) have already been well documented. Most scientists consider non-thermal effects as well established even though the implications are not fully understood. For example, in the June 2016 *Scientific American Blog* (Portier and Leonard 2016), in response to the question, *"do cell phones cause cancer?"* The authors response was clear: *"probably, but it's complicated. The degree of risk almost certainly depends on the length and strength of exposure — but we still don't know how significant the actual danger is."* These same issues pertain to impacts to wildlife from both thermal and non-thermal effects emitted from cellular (cell) communication towers and FM antennas (discussed in detail beyond). The radiation effects on wildlife need to be addressed by the Federal Communications Commission (FCC), the Environmental Protection Agency (EPA), the Department of Commerce, the U.S. Fish and Wildlife Service (FWS) and other governmental entities.

Focusing in the remainder of this memo primarily on wildlife impacts, radiation effects can be characterized as *"near-field"* (near the source of radiation), *"far-field"* (some distance from the source) or *"intermediate."* Negative reports of near-field (i.e., very close to power sources such as on or very near cellular antennas and antenna arrays) thermal radiation effects (capable of heating tissue) on laboratory animals and wildlife have been published in the scientific literature since at least 1950. An example includes Clark 1950, cited in Tanner 1966. Much of the controversy about effects involves *"far field,"* non-thermal, low-level radiation impacts on humans, laboratory animals and wildlife. These are effects that can occur further away from the peak source of radiation (i.e., the tower antennas) due to signal attenuation, signal interference from objects and water droplets in the air, and other physical obstructions and disturbances. As concluded by Beason and Semm (2002), non-thermal effects had been the most difficult

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to explain because the mechanism by which they affect biological tissue was usually unknown or unclear. With much more current research and recent discoveries, the explanations are becoming much clearer as new research results become available and causality becomes more evident.

For human exposures, however, the FCC has operating rules. These rules require that power to cell and other broadcast towers must be turned off when workers are on and/or climbing the towers — due to health impacts and safety concerns from the thermal radiation.

Complicating the issue is the fact that there currently are no standards for wildlife exposure, including by the licensing and regulatory rules and procedures of the FCC. Other than a letter from the Interior Department's (DOI) Director of the Office of Environmental Policy and Compliance to the Commerce Department's National Telecommunications and Information Administration (NTIA; USDOI 2014) — Attachment A involving effects of tower collisions and non-thermal radiation on migratory birds which I authored — neither DOI nor the FWS have any policy or quasi policy that currently addresses radiation effects to migratory birds. Arguably, "effects" need to be determined by the EPA, which has no funding for this, and regulated as part of a National Environmental Policy Act (NEPA) site review for a proposed cell tower, including both thermal and non-thermal effects.

Undebatable, however, is the exponential growth of cell phone technologies with an estimated 7 billion cell phones now available worldwide to a human population of 7.4+ billion (NPR March 2016 news report based on 2015 data). With this growing cell phone use and the communication systems that transmit and receive the signals from them, as well as the paucity of government regulatory oversight, this memorandum very briefly summarizes some of the major studies and take-aways conducted primarily on laboratory animals and wildlife, especially migratory birds. The issue represents a growing and troubling concern since migratory birds are in decline (at least 36% of which are in trouble species-wide in North America [USFWS 2008]), and which face additional uncertain impacts from non-ionizing, thermal and non-thermal radiation (Manville 2015, 2016).

Tests on laboratory animals such as chicken embryos, mice and rats are used as surrogates to predict harm to humans, protected migratory birds and other wildlife which, for practical, ethical and legal reasons in the United States would not otherwise be subjected to laboratory studies on impacts from radiation. Furthermore, scientists generally do not want to perform harmful experiments on either humans or protected wildlife such as migratory birds. Studies on the negative effects of non-thermal radiation to wild birds in Europe are clearly relevant as predictors of what will/is likely/is happening to wild birds in North America — the Bald Eagle as such as example due to its population growth and growing proximity to existing and proposed cell towers. That is why the published research results from European avian studies are so troubling.

Biological Systems and EMF

Living systems operating in animals support a variety of oscillatory electrical and/or biochemical activities which have been well documented to be affected by EMF. However, the direct relationship between electromagnetic radiation and wildlife health continues to be complicated and in cases involving non-thermal effects, still unclear. We know, for example, that brain waves are electrical, the heartbeat is electrical, the cell membrane has an electric field potential, cell division is electrically influenced, communication between neurons is electrical, and all of the hormonal and enzymatic activities are electrically regulated. Even the chemical-mechanistic model of the human and animal anatomy is essentially an electromagnetic model, because all chemical reactions involve the sharing, trading, or exchange of electrons at the elemental level (www.livingplanet.be) as explained by scientist J. Everaert in his website.

As J. Everaert further explains, there are studies showing frequency-specific biological effects, and studies demonstrating that a high frequency signal modulated at certain low frequencies, or a signal that is pulsed, has more harmful effects than an unmodulated, steady carrier wave (www.livingplanet.be).

Early Studies on EMF in the Microwave Bandwidth

Dating back to at least 1950, Tanner (1966, citing Clark 1950) concluded that much had been published on effects of microwave radiation on body tissues and animals, but most of the early experiments were concerned with the production of heat and its physiological effects. Tanner et al. (1967) looked briefly at the effects of microwave radiation on domestic chickens, and concluded that thermal effects were manifested by a rise in temperature of the irradiated birds, which were accompanied by physiological responses based on intensity and duration of the radiation field — escape or avoidance — but that non-thermal effects that impacted other physiological systems were more difficult to discern. Tanner (1966) and Tanner et al. (1967) discovered that birds' feathers are known to have piezoelectric properties, capable of conducting EMF/RF deep within bird body cavities. This finding can help, in part, explain increased bird sensitivity to EMF/RF radiation. In this early research, however, it remains unclear if thermal and non-thermal effects were adequately differentiated.

Wasserman et al. (1984) conducted field studies on 12 flocks of migratory birds subjected to various combinations of microwave power density and duration under winter conditions at Monomet, MA, with birds from 2 additional flocks serving as controls. Increased levels of aggression were noted in some of the irradiated birds suggesting effects, but calling for further study.

More Recent EMF Studies on Birds, Other Wildlife and Laboratory Animals in the Microwave Bandwidth

There is an increasing body of published laboratory research that finds DNA damage at low intensity exposures — well below levels of thermal heating — which may be comparable to far field exposures from cell antennas. This body of work would apply to all species, including migratory birds, since DNA is DNA, whether single-strand or double helix. The first study to find such effects was conducted by H. Lai and N.P. Singh in 1995 (Lai and Singh 1995). Their work has since been replicated (e.g., Lai and Singh 1996, as well as in hundreds of other more recent published studies), performed in at least 14 laboratories worldwide. The take-home message: low level transmission of EMF from cell towers and other sources probably causes DNA damage. The laboratory research findings strongly infer this relationship. Since DNA is the primary building block and genetic "map" for the very growth, production, replication and survival of all living organisms, deleterious effects can be critical.

The entire thermal model and all FCC categorical exclusions for all of the devices we see today, rests on the incorrect assumption that low-level, non-ionizing non-thermal radiation cannot cause DNA breaks because it is *"so low-power"* (B. Levitt and H. Lai, Comments Filed Jointly to FCC, ET Docket No. 13-84, 2013). These issues need to be adequately addressed by the appropriate authorities including the FCC, EPA and FWS. Currently they are not.

In laboratory studies by T. Litovitz (2000 pers. comm.) and DiCarlo et al. (2002) from the standard 915 MHz cell phone frequency on domestic chicken embryos showed that radiation from extremely low levels (0.0001 the level emitted by the average digital cellular telephone) caused heart attacks and deaths in some embryos. Controls, however, were unaffected (DiCarlo et al. 2002). In replicated experiments, similar results were obtained by Grigor'ev (2003) and Xenos and Magras (2003). These findings are important since similar evidence exists for lethal and injurious impacts to wild birds in Europe from cell

tower radiation, and based on anecdotal reports from the U.S., are very likely also occurring in North America (Manville 2016).

In field studies on wild birds in Spain, Balmori (2005) found strong negative correlations between levels of tower-emitted microwave radiation and bird breeding, nesting, roosting and survival in the vicinity of electromagnetic fields. He documented nest and site abandonment, plumage deterioration, locomotion problems, and death in Wood Storks, House Sparrows, Rock Doves, Magpies, Collared Doves, and other species. While these species had historically been documented to roost and nest in these areas, Balmori (2005) did not observe these symptoms prior to construction and operation of the cell phone towers. Results were most strongly negatively correlated to proximity to antennas and Stork recruitment and survival. Twelve nests (40% of his study sample) were located within 200 m of the antennas and never successfully raised any chicks, while only 1 (3.3%), located further than 300 m, never had chicks. Strange behaviors were observed at Stork nesting sites within 100 m of one or several cell tower antennas. Those birds that the main beam impacted directly (i.e., electric field intensity/EFI > 2 V/m) included young that died from unknown causes. Within 100 m, paired adults frequently fought over nest construction sticks and failed to advance the construction of the nests with sticks falling to the ground while nests were being constructed. Balmori (2005) reported that some nests were never completed and the Storks remained passively in front of cellsite antennas. The electric field intensity was higher on nests within 200 m (2.36 ± 0.82 V/m) than on nests further than 300 m (0.53 ± 0.82 V/m). However, the EMF levels, including for nests < 100 m from the antennas, were not intense enough to be classified as thermally active. Power densities need to be at least 10 mW/cm2 to produce tissue heating of even 0.5 C (Bernhardt 1992).

Balmori and Hallberg (2007) and Everaert and Bauwens (2007) found similar strong negative correlations among male House Sparrows and electromagnetic radiation in their studies. In another review, Balmori (2009) reported health effects to birds which were continuously irradiated. They suffered long-term effects including reduced territorial defense posturing, deterioration of bird health, problems with reproduction, and reduction of useful territories due to habitat deterioration.

Beason and Semm (2002) demonstrated that microwave radiation used in cell phones produces non-thermal responses in several types of neurons of the nervous system of Zebra Finches. The brain neurons of anesthetized birds were tested with a 900 MHz carrier, modulated at 217 Hz. Stimulation resulted in changes in the amount of neural activity by more than half of the brain cells with most (76%) of the responding cells increasing their rates of firing by an average 3.5-fold as opposed to controls — a clearly definitive study showing non-thermal effects. The other responding cells exhibited a decrease in their rates of spontaneous activity suggesting potential effects to humans using hand-held cell phones affecting sleep (Borbely et al. 1999). The Beason and Semm (2002) theoretical model could also help explain why birds may be attracted to cell towers, an important theoretical premise that they previously hypothesized in regard to Bobolinks (Semm and Beason 1990).

In a meta-review of studies through 2008, and based on laboratory research they conducted, Panagopoulos and Margaritas (2008) determined maximum radiation distances for both cell phones and for communication towers, based on the Global System for Mobile Telecommunications (GSM) and the Digital Cellular System (DCS). This maximum radiation distance corresponds to an intensity around 10 mW/cm2 for both types of radiation in regards to the RF components — i.e., Bernhardt's (1992) threshold for thermal heating effects. Panagopoulos and Margaritas (2008) recorded an *"intensity window"* — a thermal effect — around 10 mW/cm2 RF exposure where bio-effects became even more severe than at intensities higher than 200 mW/cm2. This *"intensity window"* appeared at a distance of 20-30 cm from the cell phone antenna, corresponding to a distance of about 20-30 meters from a base station antenna. This could be considered a classic nonlinear effect and would apply to far field exposures. Since cell phone base station antennas are frequently located within residential areas where houses and workplaces are often situated at distances 20-30 m from such antennas, not to mention birds nesting and roosting close to

these antennas (e.g., Balmori 2005), humans, migratory birds and other wildlife may be exposed up to 24 hours per day.

Based on their research and meta-analyses, Panagopoulos and Margaritas (2008) concluded that large decreases in reproductive capacity were being caused by GSM and DCS radiation fields. This included extensive DNA fragmentation on reproductive cells of experimental animals induced by these fields, exerting an intense biological action able to kill cells, damage DNA, and dramatically decrease the reproductive capacity of living organisms, including populations of wild birds and insects. They cautioned, however, that the physical parameters of these radiations, including intensity, carrier frequency, pulse repetition frequency, distance from the antenna, and similar factors provided inconsistency and lack of standardization making it difficult to correlate specific thermal and non-thermal effects to specific types of radiation. Their take-away message, however, was clear: bio-effects to migratory birds, other wildlife, insects, laboratory animals and humans continue to be documented from thermal and non-thermal exposures, as well as effects from intermediate exposures between the near-field and far-field levels. All migratory birds are potentially at risk, whether they be Bald Eagles, Golden Eagles, Birds of Conservation Concern (USFWS 2008), Federally and/or State-listed bird species, other birds in peril regionally or population-wide, or birds whose populations are stable.

Cucurachi et al. (2013) reported on 113 studies from original peer-reviewed publications and relevant existing reviews. A limited number of ecological studies was identified, the majority of which were conducted in a laboratory setting on bird embryos or eggs, small rodents and plants. In 65% of the studies, ecological effects of RF-EMF (50% of the animal studies and about 75% of the plant studies) were found both at high as well as at low dosages. Lack of standardization and limited sampling made generalizing results from the organism to the ecosystem level very difficult. Cucurachi et al. (2013) concluded, however, that due to the number of variables, no clear dose–effect relationship could be found especially for non-thermal effects. However, effects from some of the studies reviewed were well documented, and certainly can serve as predictors for effects to wild, protected migratory birds and other wildlife in North America.

Engels et al. (2014) investigated *"electromagnetic noise"* emitted everywhere humans use electronic devices including from cell phones and their towers. While prior to their study on European Robins, no *"noise effect"* had been widely accepted as scientifically proven, the authors in this double-blind experiment were able to show that migratory birds are unable to use their magnetic compass in the presence of urban electromagnetic noise. The magnetic compass is integral to bird movement and migration. The findings clearly demonstrated a non-thermal effect on European Robins and clearly serves as a predictor for effects to other migratory birds including those in North America.

Levitt and Lai (2010) reported numerous biological effects from cell tower radiation documented at very low intensities comparable to what the population experiences within 60–150 m distance from a cell tower, including effects that occurred in studies of cell cultures and animals after exposures to low-intensity RFR. These reported effects were genetic, growth, and reproductive in nature; they documented increases in permeability of the blood–brain barrier; showed behavioral responses; illustrated molecular, cellular, and metabolic changes; and provided evidence of increases in cancer risk — all applicable to migratory birds, other wildlife and to far field exposures in general. They cited published, peer-reviewed examples of effects that included:

Dutta et al. (1989) who reported an increase in calcium efflux in human neuroblastoma cells after exposure to RFR at 0.005 W/kg. Calcium is an important component in normal cellular functions.

Fesenko et al. (1999) who reported a change in immunological functions in mice after exposure to RFR at a power density of 0.001 mW/cm2. These results can serve as predictors for impacts to wild animals.

Magras and Xenos (1997) who reported a decrease in reproductive function in mice exposed to RFR at power densities of 0.000168— 0.001053 mW/cm2. The results also serve as predictors for reproductive impacts to wildlife.

Forgacs et al. (2006) who reported an increase in serum testosterone levels in rats exposed to GSM-like RFR at specific absorption rates (SAR) of 0.018— 0.025 W/kg. The results also serve as predictors for reproductive impacts to wildlife.

Persson et al. (1997) who reported an increase in the permeability of the blood–brain barrier in mice exposed to RFR at 0.0004– 0.008 W/kg. The blood–brain barrier is a physiological mechanism that protects the brain from toxic substances, bacteria, and viruses. These findings have clear applicability to wildlife including migratory birds.

Phillips et al. (1998) who reported DNA damage in cells exposed to RFR at the SAR of 0.0024– 0.024 W/kg. DNA is integral to the very function and survival of all living organisms, including migratory birds.

Kesari and Behari (2009) also reported an increase in DNA strand breaks in brain cells of rats after exposure to RFR at the SAR of 0.0008 W/kg. The results also serve as predictors for impacts to DNA in wildlife. And,

Belyayev et al. (2009) who reported changes in DNA repair mechanisms after RFR exposure at a SAR of 0.0037 W/kg. DNA is integral to the maintenance and repair of cells and cellular function in all animals. All sources from above were cited in Levitt and Lai (2010).

In a 2-year study conducted by the National Toxicology Program (NTP) of the National Institutes of Health (May 2016), NTP (Wyde 2016) reported partial findings from their $25 million study on cancer risk to laboratory rodents from cellphone radiation. The report summarizes a long-term exposure study to cell phone radiation, with statistically significant evidence of DNA damage from non-thermal exposure to cellphone radiation to laboratory mice and rats. Controlled studies on laboratory rats showed that cellphone radiation caused 2 types of tumors, glioma and schwannoma, the results which *"could have broad implications for public health."* The report has been characterized as a *"game-changer"* as it proves that non-ionizing, radiofrequency radiation can cause cancer without heating tissue. The researchers controlled the temperature of the test animals to prevent heating effects so the cancers were caused by a non-thermal mechanism. The report on the mice component of the study will be released at a later date. Not surprisingly, much of the media coverage contained considerable bias or "media spin" intended to create doubt about the study's important findings regarding cancer risk from exposure to cellphone radiation (Moskowitz 2016). The implications are troubling for migratory birds and other wildlife.

Likely Impacts to Migratory Birds from Frequency Modulated (FM) Signals

FM signals travel in line-of-sight paths, so antennas are located on the highest ground available to blanket an area wherever the target signal recipients are located, also providing convenient perches for migratory birds. FM digital (on/off) signals which simulate pulsed waves pose additional health concerns to migratory birds, especially from thermal heating which will be coupled with the UHF's from cell phone providers often colocated on the same antennas (e.g., see cellphonetaskforce.com; work of Dr. O. Johansson). This creates a very dangerous frequency potential for protected migratory birds such as Bald Eagles since

the length of the FM signal is about 6 feet, creating a full-body resonant effect for both humans and Bald Eagles — an Eagle wingspan extends to about 6 feet. Power levels for FM transmission (e.g., 6,000 Watts for a commercial radio station) are far higher than that for a colocated UHF antenna(s), exacerbating thermal heating effects.

Modulated FM signals infuse the atmosphere with lower frequencies which become more bioactive, even at lower power intensities. These, in turn, coupled with a UHF cell phone frequency(s) will create greater thermal and non-thermal effects. Generally the approved level of power for an FM transmission antenna is considerable. The FCC does not measure the modulated signal, only the carrier signal (Levitt 1995). Let's evaluate a hypothetical FM antenna array, with a carrier signal of 104.9 MHz at 47 meters above ground level (AGL), and an effective radiated power of 6,000 Watts. Here, nesting, roosting, feeding and potentially breeding birds such as Bald Eagles using this hypothetical tower would almost certainly be affected by thermal heating, in addition to non-thermal impacts. These issues need to be assessed including through the NEPA review process (either an Environmental Assessment or an Environmental Impact Statement) by FCC and FWS.

The specific absorption rate (SAR) is the energy absorbed per unit of biological tissue, usually expressed in watts per kilogram or milliwatts per gram of tissue, and the SAR is used to focus on *"harmful effects"* to humans. SARs peak in the bands of 70 — 100 MHz (Cleveland 2001). However, as previously mentioned in this memo, there currently are no standards for wildlife exposure to RFR — both from FM and UHF radiation — including for Bald Eagles and all other protected migratory birds. These issues need to be addressed both by FCC and FWS.

Summary Recommendations

Levitt and Lai (2010) concluded that the obvious mechanism of effects from RFR are thermal (i.e., tissue heating) — which is what FCC bases its current radiation standards on, even if they are more than 30 years out of date and rejected both by the Department of Interior and Department of Commerce (USDOI 2014, Manville 2016) as incomplete. However, for decades, there have been questions about non-thermal (i.e., not dependent on a change in temperature) effects, whether they exist, and what specifically causes the effects to surface. The sources cited above should help dispel that doubt or at the very least show that non-thermal effects do indeed occur, have been well documented, and can have significant deleterious effects on migratory birds and other wildlife.

Practically, as Levitt and Lai (2010) concluded, we do not actually need to know whether RFR effects are thermal or non-thermal to set exposure guidelines. Most of the biological-effects studies of RFR that have been conducted since the 1980s were under non-thermal conditions, including the most recent NTP (2016) studies. In studies using isolated cells, the ambient temperature during exposure was generally well controlled. In most animal studies, the RFR intensity used usually did not cause a significant increase in body temperature in the test animals. Most scientists consider non-thermal effects as well established, even though the implications are not fully understood.

Scientifically, Levitt and Lai (2010) concluded that there are three rationales for the existence of non-thermal effects:

1. Effects can occur at low intensities when a significant increase in temperature is not likely.

2. Heating does not produce the same effects as RFR exposure.

3. RFR with different modulations and characteristics produce different effects even though they may produce the same pattern of SAR distribution and tissue heating.

There is virtually no non-thermal research to indicate what is safe for either humans or wildlife, including migratory birds which are highly sensitive to perturbations in ways humans are not (see previous citations). Unfortunately, there also is very little far-field, distance-to-safety research for wildlife — most especially for migratory birds — as this has not been studied with that focus in mind. What little EMF/RF field research on wildlife that has been conducted, its focus has been on behavior, mortality and reproductive outcomes (e.g., B. Levitt and H. Lai, Comments Filed Jointly to FCC, ET Docket No. 13-84, 2013; Balmori 2005, 2009; Balmori and Hallberg 2007; Everaert and Bauwens 2007; Engels et al. 2014; Wasserman et al. 1984; and Semm and Beason 1990).

In summary, we need to better understand, tease out, and refine how to address these growing and poorly understood radiation impacts to migratory birds, bees, bats, and myriad other wildlife. At present, given industry and agency intransigence (with the exception of the Interior Department and Department of Commerce both which are now beginning to address non-thermal radiation issues), massive amounts of money being spent to prevent addressing impacts from non-thermal radiation — not unlike the battles over tobacco and smoking — and a lack of significant, dedicated and reliable funding to advance independent field studies and better understand the etiology and consequences of impacts, we are left with few options. Currently, other than to proceed using the precautionary approach and keep emissions as low as reasonably achievable, we are at loggerheads in advancing meaningful guidelines, policies and regulations that address non-thermal effects. The good news: there appears to be an awakening at least within a significant segment the scientific community to the realization that these issues must be addressed — for the health of humans, wildlife and our environment — and DOI and the Department of Commerce are also beginning to address non-thermal effects to migratory birds.

Next Steps

The following suggestions would help significantly advance the need to address effects/impacts from non-thermal radiation on migratory birds and other wildlife:

- We desperately need to conduct field research on thermal and non-thermal radiation impacts to wild migratory birds and other wildlife here in North America, similar to studies conducted in Europe. Specifically, the research focus should center on causality for *"near-field," "far-field"* and *"intermediate"* effects, ideally based on some standard, agree-upon radiation metrics. The metrics need to be consistent with standards for intensity, carrier frequency, pulse repetition frequency, distance from the antenna, and similar factors. The research must be based on peer-reviewed monitoring and testing protocols (e.g., upgrades to the Manville 2002 peer-reviewed research protocol submitted to the U.S. Forest Service for studies on cell towers in Arizona, and key methodologies used in studies previously referenced in this memo, among others). The research needs to be conducted by credible, independent third party research entities with no vested interest in the outcomes, and the results need to be published in refereed scientific journals, made available to the public.

- Studies need to be designed to better tease out and understand causality of thermal and non-thermal impacts from radiation on migratory birds. Results need to be carefully compared with findings from Europe and elsewhere on wild birds, and efforts need to be made to begin developing exposure guidelines for migratory birds and other wildlife based on dose-effect and other nonlinear relationships. We do not actually need to know whether RFR effects are thermal or non-thermal to develop and set exposure guidelines (Levitt and Lai 2013).

- To minimize deleterious radiation exposures, these guidelines should include use of avoidance measures such as those developed by the electric utility industry for bird collision and electrocution avoidance (APLIC 2006, 2012) — both publications which I co-authored. In the case of Bald Eagles, the communication tower guidelines refined and updated by FWS (Manville 2013) — and submitted to the FCC and industry — recommend one-mile disturbance free buffers during active nesting of Ferruginous Hawks and Bald Eagles, and 0.5-mile buffers around other active raptor nests, based on nest studies conducted by the Wyoming Ecological Services Field Office in that State; Guideline #5). Impacts must address collision mortality, crippling loss, and injury; mortality, injury, population viability and survivorship based on impacts from radiation; as well as disturbance and habitat fragmentation. The updated 2013 Service Guidelines were intended to be inclusive.

- Studies need to be conducted on the use of "faux" branches (i.e., metal arms that mimic pine or fir branches) on cell and/or FM towers intended to disguise the towers as trees, but provide nesting and roosting opportunities for migratory bird including Bald Eagles, which will almost certainly be impacted both by thermal and non-thermal radiation effects. Additionally, birds such as Bald Eagles and others are subject to possible impalement from the sharp metal arms, with enhanced chances of injury and death due to disturbance from tower maintenance. Even if these "faux" branches are not constructed, Eagles for example tend to use the tallest objects available for roosting, so impacts from roosting, feeding and breeding on the antenna supports all must be considered by FCC and FWS.

- Agencies tasked with the protection, management, and research on migratory birds and other wildlife (e.g., FWS, U.S. Geological Survey, National Park Service, U.S. Forest Service, Bureau of Land Management, and USDA Wildlife Services, among others) need to develop radiation policies that avoid or minimize impacts to migratory birds and other trust wildlife species. This means supporting — and where applicable — conducting research, and developing policies that help minimize radiation impacts.

- As Levitt and Lai (2010) concluded, we do not actually need to know whether RFR effects are thermal or non-thermal to set exposure guidelines. Most scientists consider non-thermal effects as well established, even though the implications are not fully understood.

- Given the rapidly growing database of peer-reviewed, published scientific studies (e.g., http://www.saferemr.com, School of Public Health, University of California, Berkeley), it is time that FCC considers thermal and non-thermal effects from EMR in their tower permitting, and incorporates changes into their rulemaking regarding "effects of communication towers on migratory birds."

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Impacts of radio-frequency electromagnetic field (RF-EMF) from cell phone towers and wireless devices on biosystem and ecosystem – a review

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Impacts of radio-frequency electromagnetic field (RF-EMF) from cell phone towers and wireless devices on biosystem and ecosystem – a review

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Abstract
This paper summarizes the effect of radio-frequency electromagnetic field (RF-EMF) from cell towers and wireless devices on the biosphere. Based on current available literature, it is justified to conclude that RF-EMF radiation exposure can change neurotransmitter functions, blood-brain barrier, morphology, electrophysiology, cellular metabolism, calcium efflux, and gene and protein expression in certain types of cells even at lower intensities. The biological consequences of such changes remain unclear. Short-term studies on the impacts of RF-EMF on frogs, honey bees, house sparrows, bats, and even humans are scarce and long-term studies are non-existent in India. Identification of the frequency, intensity, and duration of non-ionizing electromagnetic fields causing damage to the biosystem and ecosystem would evolve strategies for mitigation and would enable the proper use of wireless technologies to enjoy its immense benefits, while ensuring one's health and that of the environment.

Keywords: Radio-frequency electromagnetic field; cell phone tower; power density; SAR; non-ionizing radiation; non-thermal.

Introduction

There has been an unprecedented growth in the global communication industry in recent years which has resulted in a dramatic increase in the number of wireless devices. Mobile services were launched in India in 1995 and it is one of the fastest growing mobile telephony industries in the world. According to the Telecom Regulatory Authority of India (TRAI, 2012), the composition of telephone subscribers using wireless form of communication in urban area is 63.27% and rural area is 33.20%. By 2013, it is estimated that more than one billion people will be having cell phone connection in India. This has led to the mushrooming of supporting infrastructure in the form of cell towers which provide the link to and from the mobile phone. With no regulation on the placement of cell towers, they are being placed haphazardly closer to schools, creches, public playgrounds, on commercial buildings, hospitals, college campuses, and terraces of densely populated urban residential areas. Hence, the public is being exposed to continuous, low intensity radiations from these towers. Since the electromagnetic radiations, also known as electrosmog cannot be seen, smelt or felt, one would not realize their potential harm over long periods of exposure until they manifest in the form of biological disorders. Various studies have shown the ill-effects of radio-frequency electromagnetic field (RF-EMF) on bees, fruit flies, frogs, birds, bats, and humans, but the long-term studies of such exposures are inconclusive and scarce, and almost non-existent in India (MOEF, 2010; DoT, 2010). In 2011, International Agency for Research on Cancer (IARC), part of WHO, designated RF-EMF from cell phones as a "possible human carcinogen" Class 2B (WHO, 2011). Cancer, diabetes, asthma, infectious diseases, infertility, neurodegenerative disorders, and even suicides are on the rise in India. This invisible health hazard pollution (IHHP) is a relatively new environmental threat.

Electromagnetic radiation, in the form of waves of electric and magnetic energy, have been circulating together through space. The electromagnetic spectrum includes radio waves, microwaves, infrared rays, light rays, ultraviolet rays, X-rays, and gamma rays (ARPANSA, 2011;

FCC, 1999). The electromagnetic radiations are of two types, one being ionizing radiations such as X-rays and gamma rays, and the other being non-ionizing radiations such as electric and magnetic fields, radio waves, radio-frequency band which includes microwaves, infrared, ultraviolet, and visible radiation (Figure 1). The biological effects of RF-EMF at molecular level induce thermal and non-thermal damage, which may be due to dielectric heating leading to protein denaturation, polar molecular agitation, cellular response through molecular cascades and heat shock proteins, and changes in enzyme kinetics in cells (Instituto Edumed, 2010). The three major physical parameters of RF-EMF radiations is frequency, intensity, and exposure duration. Although the non-ionizing radiations are considered less dangerous than ionizing radiation, over-exposure can cause health hazards (FCC, 1999).

Electromagnetic Spectrum and RF-EMF Radiation

The RF-EMF radiations fall in the range of 10 MHz–300 GHz. Cell phone technology uses frequencies mainly between 800 MHz and 3 GHz and cell tower antenna uses a frequency of 900 or 1800 MHz, pulsed at low frequencies, generally known as microwaves (300 MHz–300 GHz).

Power Density and Specific Absorption Rate (SAR)

Variables used in the measurement of these radiations are power density, measured in watts per meter squared (W/m^2) and specific absorption rate (SAR). The term used to describe the absorption of RF-EMF radiation in the body is SAR, which is the rate of energy that is actually absorbed by a unit of tissue, expressed in watts per kilogram (W/kg) of tissue. The SAR measurements are averaged either over the whole body or over a small volume of tissue, typically between 1 and 10 g of tissue. SAR was set with the help of a phantom, known as specific anthropomorphic mannequin (SAM) derived from the size and dimensions of the 90th percentile large adult male reported in a 1988 US Army study who is 6 feet 2 inches and weighed 200 pounds (Davis, 2010). SAR is set at 1.6 W/kg averaged over 1 g of body tissue in the US and Canada and 2 W/kg averaged over 10 g of body tissue in countries adopting the ICNIRP guidelines. The SAR is used to quantify energy absorption to fields typically between 100 kHz and 10 GHz and encompasses radio-frequency radiation from devices such as cellular phones up through diagnostic magnetic resonance imaging (MRI). The biological effects depend on how much of the energy

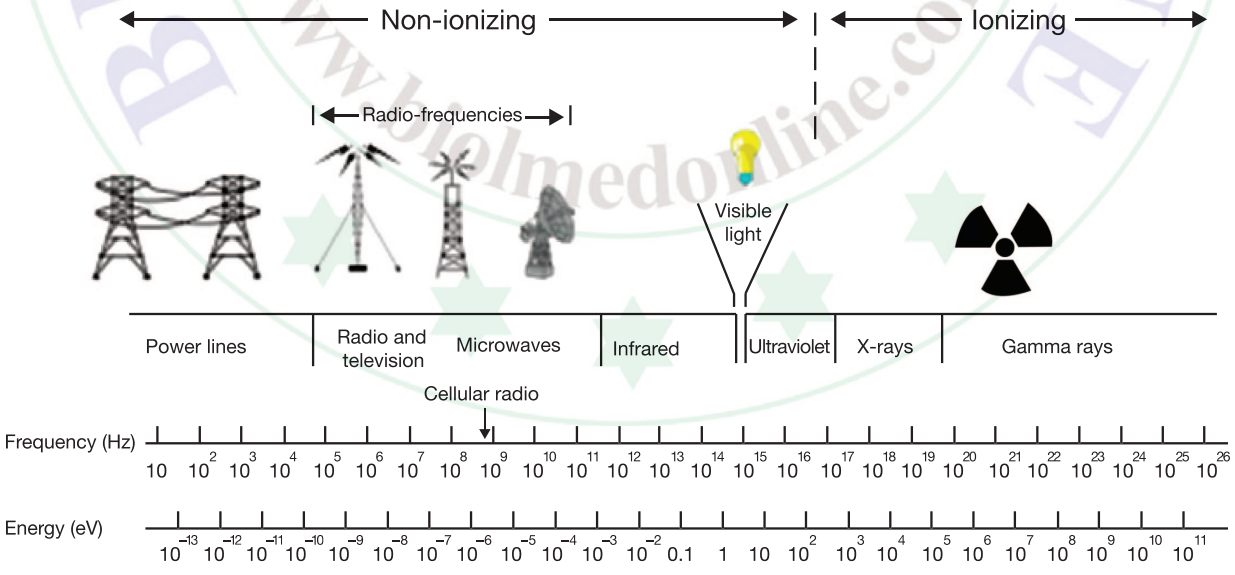

Figure 1: Electromagnetic spectrum from the Federal Communications Commission (FCC), OET Bulletin 56, 1999.

is absorbed in the body of a living organism, not just what exists in space. Absorption of RF-EMF radiations depend on frequency of transmission, power density, distance from the radiating source and the organism's size, shape, mineral, and water content. Exposure will be lower from towers under most circumstances than from cell phones because the transmitter is placed directly against the head during cell phone use whereas proximity to a cell tower will be an ambient exposure at a distance (Levitt and Lai, 2010). Exposure guidelines for RF protection had adopted the value of 4 W/kg averaged over the whole body (SARWB) as the threshold for the induction of adverse thermal effects associated with an increase of the body core temperature of about 1°C in animal experiments. This standard is set by International Commission on Non-ionizing Radiation Protection (ICNIRP), national Radiological Protection Board (NRPB), and Institute of Electrical and Electronics Engineers (IEEE) (Barnes and Greenebaum, 2007).

Cell Phones and Cell Tower Standards in India

India has adopted ICNIRP guidelines as the standard for safety limits of exposure to radio-frequency energy produced by mobile handsets for general public as follows: whole-body average SAR of 0.08 W/kg, localized SAR for head and trunk of 2 W/kg, and localized SAR for limbs 4 W/kg. The basic restrictions/proper limits for power density specified in ICNIRP guidelines for safe frequencies between 400 and 2000 MHz, adopted in India, for occupational exposure is 22.5 W/m^2, and general public is 4.5 W/m^2 for 900 MHz (ICNIRP, 1998).

Antennas of cell tower transmit in the frequency range of 869–890 MHz for CDMA, 935–960 MHz for GSM-900, 1805–1880 MHz for GSM-1800, and 2110–2170 MHz for 3G. Wi-Fi frequency range is 2.4 GHz, WiMAX is 2.5–3.3 GHz, and 4G LTE is 2.99 GHz. The antennas for cellular transmissions are typically located on towers mounted on terraces of houses, apartments or other elevated structures including rooftops and the sides of buildings, and also as a freestanding tower. Typical heights for cell towers are 50–200 feet. Sector antennas for 2G and 3G transmission, broader sector antennas for 4G transmission, and parabolic microwave antennas for point-to-point communications are used in urban and suburban areas (Table 1). There are different types of base stations used by operators in India and they include the macro cell, micro cell, or pico cell. Categorization is based on the purpose of the site rather than in terms of technical constraints such as radiated power or antenna height. In India, macro cellular base station provide the main infrastructure for a mobile phone network and their antennas are mounted at sufficient height to give them a clear view over the surrounding geographical area. The maximum power for individual macro cellular base station transmitter is 20 W. According to FCC (1999), depending on the cell tower height, the majority of cellular base stations in urban and suburban areas operate at an effective radiated power (ERP) of 100 W per channel or less. ERP is a quantity that takes into consideration transmitter power and antenna directivity. An ERP of 100 W corresponds to an actual radiated power of about 5–10 W, depending on the type of antenna used. In urban areas, an ERP of 10 W per channel (corresponding to a radiated power of 0.5–1 W) or less is commonly used. In India, cell tower sites transmit hundreds of watts of power with antenna gain of 50, so ERP sometimes equals 5000 W (Kumar, 2010).

For installation of mobile towers, the standing advisory committee on radio frequency

Table 1: Radio-frequency sources in India.

RF source	Operating frequency	Transmission powers	Numbers
AM towers	540–1600 kHz	100 KW	197 towers
FM towers	88–108 MHz	10 KW	503 towers
TV towers	180–220 MHz	40 KW	1201 towers
Cell towers	800, 900, 1800 MHz	20 W	5.4 lakh towers
Mobile phones	GSM-1800/CDMA GSM-900	1 W 2 W	800+ million
Wi-Fi	2.4–2.5 GHz	10–100 mW	Wi-Fi hot spots

allocations (SACFA) clearances are issued by the wireless monitoring organization, Department of Telecommunications (DoT), after getting no objection from defence and airport authority considering aviation hazards, obstruction to line of sight of existing/planned networks and interferences. In many metros in India, there is no restriction on the location of the towers leading to a situation of overlapping of towers, where even more than 30 cell towers can be seen within 1 km^2.

As mobile technology progresses, the data demands on mobile network increases, coupled with lower costs, their use has increased dramatically and the overall levels of exposure of the population as a whole has increased drastically. Table 2 gives the reference levels for general public exposure adopted by various countries and organizations.

Impacts on Biosystem and Ecosystem

Every living being is tuned into the earth's electromagnetism and uses it for various purposes. A natural mineral magnetite, which is found in living tissues, seems to play an important role. These magnetite crystals are found in bacteria, protozoa, teeth of sea mollusks, fish and sea mammals, eye and beak of birds, and in humans. They are also found in the ethmoid bone above the eye and sinuses and blood-brain barrier (Warnke, 2007). Migratory birds rarely get lost, but sometimes there are disruptions due to storms and magnetic disturbances caused by man (Kirschvink *et al.*, 2001). The traditional and most effective approach to study cause–effect relationships in biological sciences is by experimentation with cells and organisms. The areas of enquiry and experimentation of in vitro studies include genotoxicity, cancer-related gene and protein expression, cell proliferation and differentiation, and apoptosis and in vivo studies include thermal effects, animal behavior, brain biochemistry, neuropathology, teratogenicity, reproduction and development, immune function, blood-brain barrier, visual auditory systems and effects on genetic material, cell function, and biochemistry (Repacholi and Cardis, 2002). In human health studies, concerns have been expressed about the possible interactions of RF-EMF with several human organ systems such as nervous, circulatory, reproductive, and endocrine systems. In order to reveal the global effects of RF-EMF on gene and protein expression, transcriptomics,

Table 2: Reference levels for the general public.

Country/organization \ Standards	Power density (W/m^2)	
	900 MHz	1800 MHz
ICNIRP, 1998, adopted by India	4.5	9
FCC, 1999	6	10
IEEE, USA, 1999	6	12
Australia	2	2
Belgium	1.1	2.4
Italy	1	1
Israel	x	1
New Zealand	x	0.5
China	x	0.4
Russia	x	0.2
Hungary	0.1	0.1
Toronto Board of Health, Canada, 1999	0.06	0.1
Switzerland	0.04	0.1
France	x	0.1
Germany, ECOLOG, 1998	x	0.09
Austria's precautionary limit	0.001	0.001

and proteomics as high-throughput screening techniques (HTSTs), were eventually employed in EMF research with an intention to screen potential EMF responsive genes and/or proteins without any bias (Nylund and Leszczynski, 2004). The safety standards set by ICNIRP, adopted by India, has only taken into account the short-term effects and not against the biological effects from long-term, non-thermal, low-level microwave exposure from mobile phones, cell phone towers, and many other wireless devices.

Current Research

Various studies have shown that even at low levels of this radiation, there is evidence of damage to cell tissue and DNA, and it has been linked to brain tumors, cancer, suppressed immune function, neuroendocrine disruption, chronic fatigue syndrome, and depression (Rogers, 2002; Milham, 2010). Oncogenesis studies at molecular and cellular levels due to RF-EMF radiations are considered particularly important (Marino and Carrubba, 2009). Orientation, navigation, and homing are critical traits expressed by organisms ranging from bacteria through higher vertebrates. Across many species and groups of organisms, compelling evidence exists that the physical basis of this response is tiny crystals of single-domain magnetite (Fe_3O_4) (Kirschvink *et al.*, 2001). All magnetic field sensitivity in living organisms, including elasmobranch fishes, is the result of a highly evolved, finely-tuned sensory system based on single-domain, ferromagnetic crystals. Animals that depend on the natural electrical, magnetic, and electromagnetic fields for their orientation and navigation through earth's atmosphere are confused by the much stronger and constantly changing artificial fields created by technology and fail to navigate back to their home environments (Warnke, 2007).

Studies on Plants

Tops of trees tend to dry up when they directly face the cell tower antennas and they seem to be most vulnerable if they have their roots close to the water (Belyavskaya, 2004). They also have a gloomy and unhealthy appearance, possible growth delays, and a higher tendency to contract plagues and illnesses. According to Levitt (2010), trees, algae, and other vegetation may also be affected by RF-EMF. Some studies have found both growth stimulation and dieback. The browning of tree tops is often observed near cell towers, especially when water is near their root base. The tree tops are known as RF waveguides. In fact, military applications utilize this capability in trees for low-flying weapon systems. In an observational study, it was found that the output of most fruit-bearing trees reduced drastically from 100% to $<$5% after 2.5 years of cell tower installation in a farm facing four cell towers in Gurgaon–Delhi Toll Naka (Kumar and Kumar, 2009).

Studies on Insects

Monarch butterflies and locusts migrate great distances using their antennae to sense air currents and earths electromagnetic fields. Moths are drawn to light frequencies. Ants, with the help of their antennas are adept at electrical transmission and found to respond to frequencies as low as 9 MHz. Flying ants are very sensitive to electromagnetic fields (Warnke, 2007).

Bees have clusters of magnetite in the abdominal areas. Colony collapse disorder (CCD) was observed in beehives exposed to 900 MHz for 10 minutes, with sudden disappearance of a hive's inhabitants, leaving only queen, eggs, and a few immature workers behind. With navigational skills affected, worker bees stopped coming to the hives after 10 days and egg production in queen bees dropped drastically to 100 eggs/day compared to 350 eggs (Sharma and Kumar, 2010). Radiation affects the pollinators, honeybees, whose numbers have recently been declining due to CCD by 60% at US West Coast apiaries and 70% along the East Coast (Cane and Tepedino, 2001). CCD is being documented in Greece, Italy, Germany, Portugal, Spain, and Switzerland. Studies performed in Europe documented navigational disorientation, lower honey production, and decreased bee survivorship (Kimmel *et al.*, 2007). EMFs from telecommunication infrastructure interfere with bees' biological clocks that enable them to compensate properly for the sun's movements, as a result of which, may fly in the wrong direction when attempting to return to the hive (Rubin *et al.*, 2006). Bee colonies irradiated with digital enhanced cordless communications (DECT) phones and mobile handsets had a dramatic impact on the behavior of the bees, namely by inducing the worker

piping signal. In natural conditions, worker piping either announces the swarming process of the bee colony or is a signal of a disturbed bee colony (Favre, 2011).

A study by the University of Athens on fruit flies exposed to 6 minutes of 900 MHz pulsed radiation for 5 days showed reduction in reproductive capacity (Panagopoulos *et al.*, 2004). Likewise in 2007, in both 900 and 1800 MHz, similar changes in reproductive capacity with no significant difference between the two frequencies were observed (Panagopoulos *et al.*, 2007). In a third study, it was found it was due degeneration of large numbers of egg chambers after DNA fragmentation (Panagopoulos *et al.*, 2010). When *Drosophila melanogaster* adult insects were exposed to the radiation of a GSM 900/1800 mobile phone antenna at different distances ranging from 0 to 100 cm, these radiations decreased the reproductive capacity by cell death induction at all distances tested (Levengood, 1969).

Studies on Amphibians and Reptiles

Salamanders and turtles have navigational abilities based on magnetic sensing as well as smell. Many species of frogs have disappeared all over the world in the last 3–5 years. Amphibians can be especially sensitive because their skin is always moist, and they live close to, or in water, which conducts electricity easily (Hotary and Robinson, 1994). Toads when exposed to 1425 MHz at a power density of 0.6 mW/cm^2 developed arrhythmia (Levitina, 1966). Increased mortality and induced deformities were noted in frog tadpoles (*Rana temporaria*) (Levengood, 1969). It was observed that experimental tadpoles developed more slowly, less synchronously than control tadpoles, remain at the early stages for a longer time, developed allergies and that EMF causes changes in the blood counts (Grefner *et al.*, 1998). In a two-month study in Spain in common frog tadpoles on the effects of mobile phone mast located at a distance of 140 m noted low coordination of movements, an asynchronous growth, resulting in both big and small tadpoles, and a high mortality (90%) in exposed group. For the unexposed group in Faraday cage, the coordination of movements was normal, the development was synchronous, and a mortality of 4.2% was obtained (Balmori, 2009). In the eggs and embryos of *Rana sylvatica* and *Ambystoma maculatum* abnormalities at several developmental stages were noted such as microcephalia, scoliosis, edema, and retarded growth. Tadpoles developed severe leg malformations and extra legs, as well as a pronounced alteration of histogenesis which took the form of subepidermal blistering and edema. Effects were noted in reproduction, circulatory, and central nervous system, general health and well being (Balmori, 2010; Balmori, 2005).

Studies on Birds

A study by the Centre for Environment and Vocational Studies of Punjab University noted that embryos of 50 eggs of house sparrows were damaged after being exposed to mobile tower radiation for 5–30 minutes (MOEF, 2010). Observed changes included reproductive and coordination problems and aggressiveness. Tower-emitted microwave radiation affected bird breeding, nesting, and roosting in Valladolid, Spain (US Fish & Wildlife Service, 2009). House sparrows, white storks, rock doves, magpies, collared doves exhibited nest and site abandonment, plumage deterioration (lack of shine, beardless rachis, etc.), locomotion problems, and even death among some birds. No symptoms were observed prior to construction of the cell phone towers. According to Balmori, plumage deterioration and damaged feather are the first signs of weakening, illnesses, or stress in birds. The disappearance of insects, leading to lack of food, could have an influence on bird's weakening, especially at the first stages in young bird's life. In chick embryos exposed to ELF pulsed EMR, a potent teratogenic effect was observed, leading to microphthalmia, abnormal trunkal torsion, and malformations on the neural tube (Lahijani and Ghafoori, 2000).

White storks were heavily impacted by the tower radiation during the 2002–2004 nesting season in Spain. Evidence of a connection between sparrow decline in UK and the introduction of phone mast GSM was established (Balmori, 2009). In a study in Spain, the effects of mobile phone mast has been noted in house sparrow (*Passer domesticus*), white stork (*Ciconia ciconia*), reporting problems with reproduction, circulatory, and central nervous system, general health and well-being (microwave syndrome) (Balmori, 2009). Deformities and deaths were noted in the domestic chicken embryos subjected to low-level, non-thermal radiation from the standard 915 MHz cell phone

frequency under laboratory conditions (US Fish & Wildlife Service, 2009). Neural responses of Zebra Finches to 900 MHz radiation under laboratory conditions showed that 76% of the neurons responded by 3.5 times more firings (Beason and Semm, 2002). Eye, beak, and brain tissues of birds are loaded with magnetite, sensitive to magnetic fields, interferes with navigation (Mouritsen and Ritz, 2005).

Studies on Mammals

In a survey of two berry farms in similar habitats in Western Massachusetts (Doyon, 2008), one with no cell phone towers, there were abundant signs of wildlife, migrating and resident birds, bats, small and large mammals, and insects including bees and the other farm with a cell-phone tower located adjacent to the berry patch, virtually no signs of wildlife, tracks, scat, or feathers were noted. The berries on bushes were uneaten by birds and insects and the berries that fell to the ground were uneaten by animals. Whole body irradiation of 20 rats and 15 rabbits at 9.3 GHz for 20 minutes revealed statistically significant changes in cardiac activity (Repacholi *et al.*, 1998). Bradycardia developed in 30% of the cases. Separate ventricular extra systoles also developed. In a study on cows and calves on the effects of exposure from mobile phone base stations, it was noted that 32% of calves developed nuclear cataracts, 3.6% severely. Oxidative stress was increased in the eyes with cataracts, and there was an association between oxidative stress and the distance to the nearest mast (Hässig *et al.*, 2009). It was found that at a GSM signal of 915 MHz, all standard modulations included, output power level in pulses 2 W, specific absorption rate (SAR) 0.4 mW/g exposure for 2 hours, 11 genes were up-regulated and one down-regulated, hence affected expression of genes in rat brain cells (Belyaev *et al.*, 2006). The induced genes encode proteins with diverse functions including neurotransmitter regulation, blood-brain barrier (BBB), and melatonin production.

When rats were exposed for 2 hours a day for 45 days at 0.21 mW/cm^2 power density SAR (0.038 W/kg), a significant decrease in melatonin and increase in both creatine kinase and caspase 3 was found (Kesari *et al.*, 2011). This shows that chronic exposure to these radiations may be an indication of possible tumor promotion. A study on pregnant rats and brains of fetal rats was carried out after irradiating them with different intensities of microwave radiation from cellular phones for 20 days three times a day. Superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), malondialdehyde (MDA), noradrenaline (NE), dopamine (DA), and 5-hydroxyindoleacetic acid (5-HIAA) in the brain were assayed. The significant content differences of noradrenaline and dopamine were found in fetal rat brains (Jing *et al.*, 2012). A study in rabbits exposed to continuous wave and pulsed power at 5.5 GHz found acute effects in the eyes, where lens opacities developed within 4 days (Birenbaum *et al.*, 1969).

Behavioral tasks, including the morris water maze (MWM), radial arm maze, and object recognition task have been extensively used to test cognitive impairment following exposure of rodents to mobile phone radiation (GSM 900 MHz) on various frequencies and SAR values (Fragopoulou *et al.*, 2010). Exposed animals in most of the cases revealed defects in their working memory possibly due to cholinergic pathway distraction. Mobile phone RF-EMF exposure significantly altered the passive avoidance behavior and hippocampal morphology in rats (Narayanan *et al.*, 2010).

With regards to DNA damage or cell death induction due to microwave exposure, in a series of early experiments, rats were exposed to pulsed and continuous-wave 2450 MHz radiation for 2 hours at an average power density of 2 mW/cm^2 and their brain cells were subsequently examined for DNA breaks by comet assay. The authors found a dose-dependent (0.6 and 1.2 W/kg whole body SAR) increase in DNA single-strand and double-strand breaks, 4 hours after the exposure to either the pulsed or the continuous-wave radiation. The same authors found that melatonin and PBN (N-tert-butyl-alpha-phenylnitrone) both known free radical scavengers, block the above effect of DNA damage by the microwave radiation (Lai and Singh, 1995, 1996, 1997). Death in domestic animals like hamsters and guinea pigs were noted (Balmori, 2003). Bats use electromagnetic sensors in different frequencies. Since 1998, a study on a free-tailed bat colony, having *Tadarida teniotis* and *Pipistrellus pipistrellus* has been carried out in Spain and a decrease in number of bats were noted with several phone masts 80 m from the colony. A dead specimen of *Myotis myotis* was found near a small antenna in the city centre (Balmori, 2009).

The most affected of the species are bees, birds, and bats and without these pollinators visiting flowers, 33% of fruits and vegetables would not exist, and as the number of pollinators decline, the agricultural crops will fall short and the price of groceries will go up (Kevan and Phillips, 2001).

Studies on Humans

The exposure to continuous RF-EMF radiation poses a greater risk to children, particularly due to their thinner skulls and rapid rate of growth. Also at risk are the elderly, the frail, and pregnant women (Cherry, 2001). DNA damage via free radical formation inside cells has also been recorded (Lai and Singh, 1996). Free radicals kill cells by damaging macromolecules such as DNA, protein, and membrane are carcinogenic. In fact, EMR enhances free radical activity. Single- and double-strand DNA breaks are seen in rat brain cells after acute exposure to radio-frequency electromagnetic radiation. Kane (2001) denotes that RF-EMF radiations lead to tissue damage, DNA damage, or chromosome mutations. In 2008, the Austrian Department of Health found a higher risk of cancer among people living within 200 m of a mobile phone base station and that cancer risk rose with increasing exposure, reaching 8.5 times the norm for people most exposed. From a study on in vitro cell response to mobile phone radiation (900 MHz GSM signal) using two variants of human endothelial cell line, it was suggested that the cell response to mobile phone radiation might be genome- and proteome-dependent. Therefore, it is likely that different types of cells and from different species might respond differently to mobile phone radiation or might have different sensitivity to this weak stimulus (Nylund and Leszczynski, 2006).

The results of the Interphone, an international case–control study to assess the brain tumor risk in relation to mobile telephone use, reveals no overall increase in risk of glioma or meningioma but there were suggestions of an increased risk of glioma at the highest exposure levels (30 minutes per day of cell phone use for 8–10 years) and ipsilateral exposures (ICNIRP, 2011). Children and young adults were excluded from the study and a separate study called Mobi-Kids is underway. According to Santini *et al.* (2002), comparisons of complaints in relation with distance from base station show significant increase as compared to people living greater than 300 m or not exposed to base station, till 300 m for tiredness, 200 m for headache, sleep disturbance, and discomfort, and 100 m for irritability, depression, loss of memory, dizziness, and libido decrease. Women significantly more often than men complained of headache, nausea, loss of appetite, sleep disturbance, depression, discomfort, and visual perturbations (Santini *et al.*, 2002). According to Oberfeld *et al.* (2004) in Spain, a follow-up study found that the most exposed people had a higher incidence of fatigue, irritability, headaches, nausea, loss of appetite, sleeping disorders, depression, discomfort, difficulties concentrating, memory loss, visual disorders, dizziness, and cardiovascular problems. Women are more at risk as they tend to spend more time at home and are exposed to radiation continuously. The authors recommended a maximum exposure of 0.0001 $\mu W/cm^2$ or 0.000001 W/m^2. There was prevalence of neuropsychiatric complaints among people living near base stations (Abdel-Rassoul *et al.*, 2007). Urban electromagnetic contamination (electrosmog) 900 and 1800 MHz pulsated waves interfere in the nervous system of living beings (Hyland, 2000). Growing amounts of published research show adverse effects on both humans and wildlife far below a thermal threshold, usually referred to as "non-thermal effects", especially under conditions of long-term, low-level exposure (Levitt and Lai, 2010).

Australian research conducted by De Iuliis *et al.* (2009) by subjecting in vitro samples of human spermatozoa to radio-frequency radiation at 1.8 GHz and SAR of 0.4–27.5 W/kg showed a correlation between increasing SAR and decreased motility and vitality in sperm, increased oxidative stress and 8-Oxo-2′-deoxyguanosine markers, stimulating DNA base adduct formation and increased DNA fragmentation. GSM mobile phone exposure can activate cellular stress response in both humans and animal cells and cause the cells to produce heat shock proteins (HSP27 and HSP70) (Leszczynski, 2002). HSPs inhibit natural programmed cell death (apoptosis), whereby cells that should have committed suicide continue to live. Recent studies have shown that these HSPs inhibit apoptosis in cancer cells. In several cases, melatonin hormone which controls the daily biological cycle and has an oncostatic action, produced by the epiphysis (pineal gland) in mammals, mainly during the night, is found to reduce the action of EMR exposure, but the synthesis of melatonin itself seems to be reduced

by EMR (Panagopoulos *et al.*, 2008). In a study to observe the effects of melatonin in hormone balance in a diabetic, it was found that melatonin caused reduction in serum insulin, serum cortisol, serum ACTH, and serum TSH levels while increase in serum gastrin level. Of the biochemical parameters, melatonin caused reductions in TLC, LDLC, and FBS while increase in HDLC. It also caused reduction in neutrophil and increase in lymphocyte count in a diabetic with increase in faecal fat excretion (Mitra and Bhattacharya, 2008).

RF-EMR produces DNA damage via free radical formation inside cells. Free radicals kill cells by damaging macromolecules such as DNA, protein, and membrane, also shown to be carcinogenic. EMR enhances free radical activity. EMR interferes with navigational equipments, lifeline electronic gadgets in hospitals, and affects patients with pacemakers. A short-term exposure (15 and 30 minutes) to RFR (900 MHz) from a mobile phone caused a significant increase in DNA single strand breaks in human hair root cells located around the ear which is used for the phone calls (Çam and Seyhan, 2012). Various in vitro studies have shown that 1800 MHz RF-EMF radiation could cause oxidative damage to mtDNA in primary cultured neurons. Oxidative damage to mtDNA may account for the neurotoxicity of RF radiation in the brain (Xu *et al.*, 2010).

Studies carried out on the RF levels in North India, particularly at the mobile tower sites at Delhi have shown that people in Indian cities are exposed to dangerously high levels of EMF pollution (Tanwar, 2006). An independent study was commissioned by the Cellular Operators Association of India (COAI) and Association of Unified Telecom Service Providers of India (AUSPI) as a proactive measure stemming from the concern for the public health and safety issues on electromagnetic radiation measurement at New Delhi showed compliance with ICNIRP standards. 180 areas were studied across the capital to understand the extent of RF-EMF radiations emitting from the mobile towers, revealed that the readings were 100 times below international safety guidelines. The study measured cumulative emissions within the 800–2000 MHz band of frequency (which includes both GSM and CDMA technologies) across in the nation's capital using carefully calibrated equipment, as per the DoT prescribed procedure in line with the ICNIRP specifications. In a similar, but independent case study in Mumbai, it was found that people living within 50–300 m radius are in the high radiation zone and are more prone to ill-effects of electromagnetic radiation. Four cases of cancer were found in three consecutive floors (6th, 7th, 8th) directly facing and at similar height as four mobile phone towers placed at the roof of the opposite building (Kumar, 2010). According to the Seletun Scientific Statement (2011), low-intensity (non-thermal) bioeffects and adverse health effects are demonstrated at levels significantly below existing exposure standards. ICNIRP/WHO and IEEE/FCC public safety limits are inadequate and obsolete with respect to prolonged, low-intensity exposures (New International EMF Alliance, 2011). New, biologically-based public exposure standards are urgently needed to protect public health world-wide. EMR exposures should be reduced now rather than waiting for proof of harm before acting (Fragopoulou *et al.*, 2010).

Electrohypersensitivity (EHS) and Electromagnetic Field Intolerance (EFI) Syndrome

Electrosensitivity of people is now recognized as a physical impairment by government health authorities in the United Kingdom and Sweden. The UK Health Protection Agency (HPA) recognized that people can suffer nausea, headaches, and muscle pains when exposed to electromagnetic fields from mobile phones, electricity pylons, and computer screens. A case study in Sweden, one of the first countries where mobile technology was introduced approximately 15 years ago, shows that 250,000 Swedes are allergic to mobile phone radiation. Sweden has now recognized EHS as a physical degradation and EHS sufferers are entitled to have metal shielding installed in their homes free of charge from the local government (Kumar, 2010; Johansson, 2010).

Belpomme (2011) in his presentation at the 8th National Congress on Electrosmog in Berne in 2011 elaborates on the dangers of wireless technology and the diagnostics and treatment of the electromagnetic field intolerance (EFI) Syndrome. In his study from 2008 to 2011, the patients with EHS were investigated with a pulse equilibrium brain scan, dosage of histamine in the blood, dosage of the heat shock proteins HSP70 and HSP27, and appearance and disappearance of symptoms on exposure to an electromagnetic field source. Diagnosis of fatigue and depression were noted. The physiological changes such as vitamin D deficiency, decrease in heat

shock proteins, increase in histamines, increase in biomarker of the opening of blood-brain barrier, protein S100P, decrease in urinary melatonin, and increase in blood anti-myelin proteins were noted in the electrosensitives. Around 50% of the patients in the study had used a mobile phone for more than one hour per day during several years and his findings were similar to the figures published by Hardell's study (2007) dealing with the cancer occurrences and electromagnetic fields.

Future Challenges and Solutions

Research into the advantages of radio-frequency energies seen in tissue heating in benign prostatic hyperplasia (BPH), electrical therapy for cardiac arrhythmia, radio-frequency ablation, use of 41.5–44.5°C temperature to kill tumors, shortwave and microwave diathermy for musculoskeletal injuries, and microwave oven used in food preparation are all carried out under controlled conditions. But effects, if any, from RF-EMF radiations released into the environment over a long period of time in densely populated areas where people are continuously exposed to them will show in years to come. According to Osepchuk (1983), frequencies used in industrial, scientific, and medical heating processes are 27.12, 40.68, 433, 915, 2450, and 5800 MHz. Out of which, for diathermy, frequencies used are 27.12, 915, and 2450 MHz in US and 433 MHz is authorized in Europe. According to Kasevich (2000), "the physics of electromagnetic waves and their interactions with material and biological systems is based on the concept that the electromagnetic wave is a force field which exerts a mechanical torque, pressure or force on electrically charged molecules. All living things contain these dielectric properties. The thermal effects produced by absorption of electromagnetic energy are the direct result of water molecules acted upon by the oscillating electric field, rubbing against each other to produce electric heat (thermal effects)". Research work on electromagnetic bioeffects in humans and animals in the non-thermal range is continuing where effects are noted even at intensities lower than 1 mW/m^2 (0.001 W/m^2 or 1000 ∝W/m^2, 0.0001 mW/cm^2 or 0.1 ∝W/cm^2).

According to Levitt (2007), adverse outcomes of pregnancy can be mutagenic, teratogenic, oncogenic or carcinogenic, and ionizing radiations can cause all three. In animal studies, non-ionizing radiation was also found to be teratogenic and oncogenic, and likely mutagenic, but it is unclear if these observations were due to heating affect, non-thermal affects or both. Trees, plants, soil, grass, and shrubs have the ability to absorb electromagnetic wave energy over a very broad range of wavelengths. According to the resonance concept, human beings can act as receiving antennas for some frequencies, where the absorbed energy is maximized in some areas of the body, like the brain (Levitt, 2007).

In the Bioinitiative Report, a document prepared by 14 international experts in a nine-month project, in which over 2000 scientific studies were reviewed, Sage (2007) came to a conclusion that there may be no lower limit that may be safe, and there was a need for biologically-based limits (1 mW/m^2 or 0.001 W/m^2) and children are at most risk. Safety limits suggested are 0.001 W/m^2 for outdoor cumulative radio-frequency exposure and 0.0001 W/m^2 for indoor, cumulative radio-frequency exposure. According to Blank (2012), there is a need for a realistic biological standard to replace the thermal (SAR) standard. The precautionary approaches includes prudence avoidance for public and ALARA, which stands for "as low as reasonably attainable" for regulatory agencies.

According to Havas (2006), several disorders, including asthma, ADD/ADHD, diabetes, multiple sclerosis, chronic fatigue, fibromyalgia, are increasing at an alarming rate, as is electromagnetic pollution in the form of dirty electricity, ground current, and radio-frequency radiation from wireless devices and the connection between electromagnetic pollution and these disorders needs to be investigated and the percentage of people sensitive to this form of energy needs to be determined. According to Milham (2010), 20th century epidemic of the so-called diseases of civilization, including cardiovascular disease, cancer, diabetes, and also suicides, was caused by electrification and the unique biological responses we have to it and that our evolutionary balance, developed over the millennia has been severely disturbed and disrupted by man-made EMFs.

Conclusion

The Department of Telecommunication (DoT) in India has set new norms for cell phone towers with effect from September 1, 2012 (The Hindu, 2012). Exposure standards for RF-EMF radiation has been reduced to one-tenth of the existing level and SAR from 2 to 1.6 W/kg. This came after the Ministry of Environment and Forests

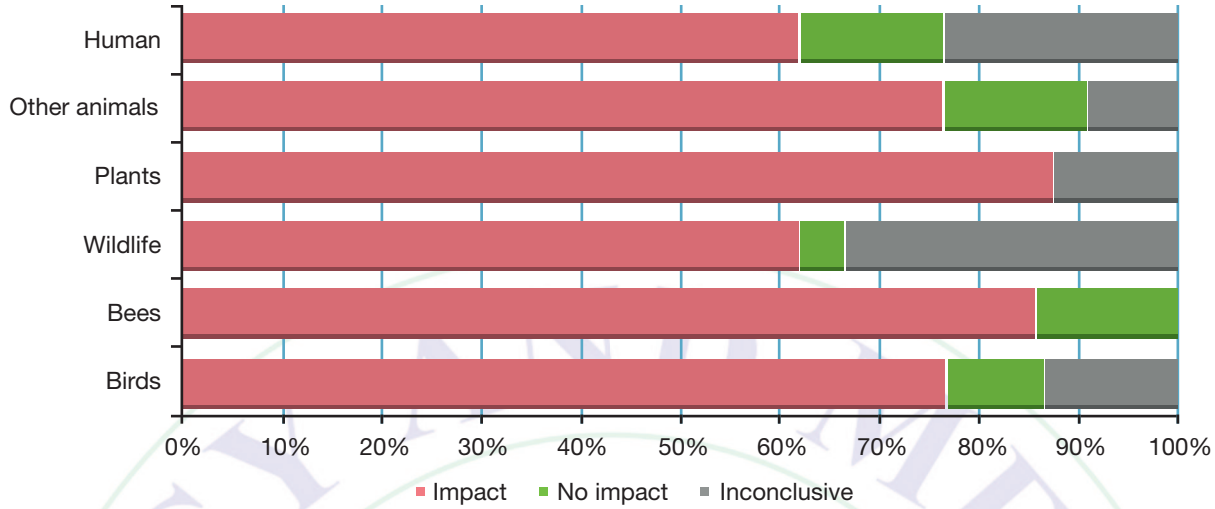

Figure 2: Percentage of studies that reported harmful effect of EMR in various groups of organisms (n = 919), MOEF Report (2010).

(MOEF) set up an Inter-Ministerial Committee (IMC) to study the effects of RF-EMF radiations on wildlife (Figure 2) and concluded that out of the 919 research papers collected on birds, bees, plants, other animals, and humans, 593 showed impacts, 180 showed no impacts, and 196 were inconclusive studies. They conclude that there are no long-term data available on the environmental impacts of RF-EMF radiations in India. The population of India is increasing as well as the cell phone subscribers and the cell towers as supporting infrastructure. Hence, there is an urgent need to fill the gaps and do further research in this field with emphasis on the effects of early life and prenatal RF-EMF radiation exposure in animals, dosimetry studies, cellular studies using more sensitive methods, and human epidemiological studies, especially on children and young adults on behavioral and neurological disorders and cancer. Meanwhile, one can take the precautionary principle approach and reduce RF-EMF radiation effects of cell phone towers by relocating towers away from densely populated areas, increasing height of towers or changing the direction of the antenna.

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Report for the United Nations Educational Scientific and Cultural Organization

(UNESCO)

And

International Union for the Conservation of Nature

(IUCN)

Report detailing the exodus of species from the Mt. Nardi area of the Nightcap National Park World Heritage Area during a 15-year period (2000-2015.)

Subject:

The correspondence of species disappearance from the Mt. Nardi-Mt. Matheson area of the World Heritage Site with the application of an increasing amount of electromagnetic technology designated as electromagnetic radiation (EMR) and electromagnetic frequencies (EMF.)

ID 368-006 Nightcap National Park 1986

New South Wales, Australia Co-ordinates: S28 32 24.60 E153 16 56.90
4,945 ha.
http://whc.unesco.org/en/list/368

Report prepared by: **Mark Broomhall (naturalist / ethno-botanist)**
Signed:

Mark Broomhall

Contents

Introduction

The following report is designed as a simple register of the effects on wildlife in the Nightcap National Park World Heritage area of Mt. Nardi – Mt. Matheson as a result of a significant increase in both output and variety of electromagnetic radiation (EMR) and electromagnetic frequencies (EMF) from the Mt. Nardi industrial tower complex.

I acknowledge there is a greater body of knowledge within the community surrounding Australia's first rainforest National Park than just my own. Informed community understanding has corroborated my own observations at every turn. I have lived on Mt. Nardi for forty years and my evidence in the Land & Environment Court of New South Wales in 1982 was decisive in stopping the logging operations, opening the path for the subsequent declaration of the National Park and World Heritage. This evidence was given as a result of public action. I have been a forest coordinator of Tuntable Falls community for 10 years; coordinator, director and fund-raiser for the Rainforest Information Centre for more than a decade, as well as being co-founder, director of the Pacific-Eco-forestry projects in Papua New Guinea and the Solomon Islands, funded by the Australia Government and the Australian Council of Churches. I was also the Australian representative for the international 'Save the Siberian Tiger Project,' charged with locating and establishing their presence.

The Mt Nardi-Mt Matheson plateau is of unique importance. I believe it to be of major international concern that the genetic heart of our ancient 'Gondwanaland' forest is exposed to such a compound of electromagnetic frequencies without any forethought in their reckless application. This is in spite of clear international regulations that prohibit it and a growing body of internationally recognised peer-reviewed studies and literature that accuse the industry of being carcinogenic, neurotoxic, mutagenic and geno toxic.

This cool mountainous terrain, with its extensive cliff-lines, narrow ridges, steep gorges and deep valleys, provides the fire-proof niches able to support the ancient rainforest remnants and the majority of endangered plants and animals that depend on this habitat. They are all to be found in this area of the Nightcap range, centrally located on the southern rim of the great volcanic caldera of Mt Warning. My studies lead me to believe that the Mt Nardi-Mt Matheson complex is the most pristine, the most botanically complex and bio-diverse area of the Nightcap National Park. The entire caldera has been identified as Neo-Pleistocene *Refugia.* (Kooyman, et al 2011.)

The Mt Nardi-Mt Matheson sector could be considered the 'jewel in the crown' and holds an exalted status within the global context of prehistoric Gondwanaland forest.

In 2014, when the IUCN and UNECSO held the decennial reunion in Sydney, the central theme of the reunion was the necessity of the public to participate in the protection of World Heritage Sites.

In this spirit of co-operation I compiled this report.

Background:

From the 1960's until just after the millennium, the Mt. Nardi telecommunications tower complex used analogue technology. Since late in the 1970's Mt. Nardi residents have witnessed a steady increase in species diversity. It wasn't until the Analogue Era was drawing to a close, along with the advent of digital wireless technology in the years 2002 to 2004, that I began to notice a decline in insect diversity and population. This period was at the back-end of a prolonged nationwide drought and there was much talk of global warming.

Initially, I attributed the insect decline to these events. I later learnt of *"mobile phone pulsed microwave technology"* and understood from press reports that this was being installed on Mt. Nardi. This technology is named universally by the industry, the press, and the public at large, as "3G." With this knowledge, I began to suspect that perhaps something else was happening on Mt. Nardi. At the same time, further additions included Wideband Code Division Multiple Access (WCDMA) technology.

In the year 2009, enhanced 3G technology was installed and a further 150 pay television channels were added to the tower. Following these additions, I witnessed the exodus of 27 bird species from Mt. Nardi while simultaneously, insect volumes and species variety dropped dramatically.

In late 2012 and early 2013, with the construction of a new tower in the complex and the introduction of a 600,000-watt generator, the system was upgraded to what became universally known as "4G." Immediately after, I witnessed the rapid exodus of a further 49 bird species. From this time, all locally known bat species became scarce, 4 common species of cicada almost disappeared, as well as the once enormous, varied population of moths & butterfly species. Frogs and tadpole populations were drastically reduced; the massive volumes and diverse species of ant populations became uncommon to rare.

Without further refined studies, it is difficult to estimate the percentage of wildlife once common on Mt. Nardi that has become rare or disappeared from the World Heritage Area. I estimate, in both volume and species that from 70 to 90 % of the wildlife has become rare or has disappeared from the Nightcap National Park within a 2-3 km radius of the Mt. Nardi tower complex.

This statement can be summarised with concrete data:

3 bat species once common have become rare or gone
11 threatened and endangered bird species are gone
11 migratory bird species are gone
86 bird species are demonstrating unnatural behaviours
66 once common bird species are now rare or gone

A frequency refinement enabled a cutback of power output in 2015. Since then, a handful of bird species returned to the area on an irregular basis. Preceding this limited return, there was

another unexpected peak in the species count when repairs caused the power on the installation to be cut for three days. This biological explosion was also occasioned by the last seen demonstration of termites (*Isoptera*) leaving their nests, which resulted in a veritable 'festival of birds.' The precision of the biological response to the 3-day power cut was both extraordinary and telling; I have not seen the termites *en masse* since that time.

Due to the undulating topography of the region and the tower complex placed on top of the mountain where the World Heritage Site is located, many of the missing species now appear below the 450 m level, out of immediate range of the tower. They have chosen a less diverse habitat and in effect, have been driven from previously safe World Heritage Park.

As indicated, it took me time to understand what was happening. **I penned this background in August 2016.** Since then, I have been able to locate the industrial connection to these events and can demonstrate this with precision. I refer you to the Timeline as part of this report. With the inclusion of the Register of Radio-communication Licenses, I have a license-by-licence, date-by-date application of the technology, along with the frequency emissions, designator and ID of the transaction.

It is evident that pulsed microwaves are particularly toxic.

It should be considered a National Emergency that this Matter of National Significance is protected immediately. The Mt Nardi transmission towers are non-compliant with the EPBS Act.

Methodology

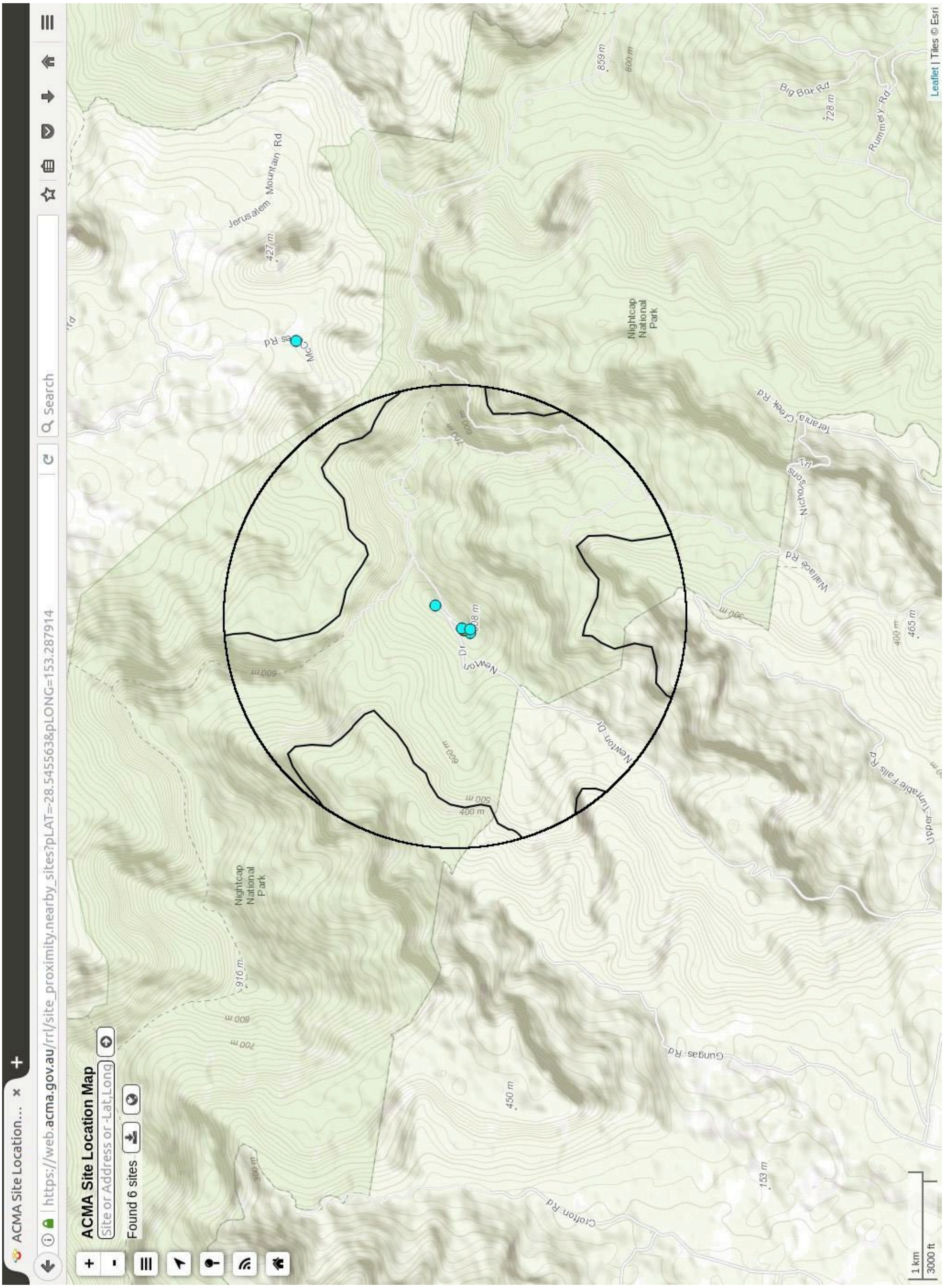
The format is simple: comparative species lists of the documented population and missing species.

As background to these populations, I supply a list of the *Threatened Plant and Animal Species* in the area, as listed by the Commonwealth Scientific and Industrial Research Organization (CSIRO) in 1995, in concurrence with the declaration of the Environmental Protection Act of NSW in the same year. The accredited lists from which the Plant and Animal species have been compiled have been assembled from a larger body of environmental data. Without further botanical studies on Mt Nardi, some of the species are therefore listed as 'likely to occur.' Otherwise, I indicate those I have sighted.

The second list of 30 *Threatened Fauna* is compiled again from CSIRO listed species that are believed to inhabit Mt. Nardi. I again indicate those I have sighted.

Having set the scene, subsequent lists show the corresponding disappearance of wildlife as the technology and the power to drive it are added to the Mt. Nardi industrial complex.

There are also some additional notes that provide a more detailed picture of what is happening to individual species in real terms. I also include a short list of scientific studies and research papers that effectively corroborate what I am witness to on the ground, cross referencing bird studies, insect studies and so forth. (List of Study References P.37)



Estimation of high intensity microwave footprint bisecting species flow around Mt Nardi

towers

List A

LIST OF RARE OR THREATENED AUSTRALIAN PLANTS

that are "very likely to occur" in the many complex old growth rainforest and sclerophyll plant communities of the area, exemplifying evolutionary links to Gondwanaland on Mt. Nardi and Mt Matheson.

Habitat and known potential distributions from TSC Act-NSW Threatened Species Conservation Act 1995, listed species; rare or threatened Australian Plants (ROTAP); ROTAP codes are provided in Briggs and Leigh (1995 revised addition.) Schedule 1 'endangered,' Schedule 2 'vulnerable.'

Species very likely to occur = # Species sited by Mark Broomhall = *

Species	Family	TSC Act	ROTAP
#*Corokia whiteana	Argophyllaceae	Sch 2	
*Eidothea hardeniana	Proteaceae	Sch 1	
*Eleocarpus sedentarius (syn. 'minyon')	Elaecarpaceae	Sch 1	
*Endiandra hayesii	Lauraceae	Sch 2	
*Ediandra muelleri ssp. Bracteata	Lauraceae	Sch 1	
Fontainea australis	Euphorbiaceae	Sch 2	
*Hibbertia hexandra	Dilleniaceae	Sch 1	
*Hicksbeachia pinnatifolia	Proteaceae	Sch 2	
#Marsdenia longiloba	Apocynaceae	Sch 1	
*Niemeyera whitei	Sapotaceae	Sch 2	
*Ochrosia moorei	Apocynaceae	Sch 1	
Plectranthus nitidus	Lamiaceae	Sch 1	
Sarcochilus fitzgeraldii	Orchidaceae	Sch 2	
Sarcochilus hartmanii	Orchidaceae	Sch 2	
*Symplocos baeuerlenii	Symplocaceae	Sch 2	
*Syzygium hodgkinsomiae	Myrtaceae	Sch 2	
#*Uromyrtus australis	Myrtaceae	Sch 1	
*Acronychia baeuerlenii	Rutaceae		3 RC
#*Archidendron muellerianum	Fabaceae		3 RCa

**Austrobuxus swainii*	*Picrodendraceae*	3 RCa
Callerya australis	*Fabaceae*	3 RC -+
*#*Cupaniopsis australis*	*Sapindaceae*	2 RC-
**Helmholtzia glaberrima*	*Phylidraceae*	2 RCa
**Marsdenia liisae*	*Apocynaceae*	3 RC-
**Olearia heterocarpa*	*Asteraceae*	2 RCa
**Ozothamnus whitei*	*Asteraceae*	3 RC
**Quasia (Unnamed)*	*Simaroubaceae*	
**Tricosanthes subvelutina*	*Cucurbitaceae*	

NB I sighted two other species of flora that are now included in the list. *Quasia* unnamed, which I have dubbed *Quasia Mount Nardii* and *Tricosanthes Subvelutina.*

List B

LIST OF 30 VULNERABLE & ENDANGERED SPECIES

as listed in the TSC Act-NSW Threatened Species Conservation Act 1995. Commonwealth Environment and Biodiversity Conservation Act 1995.

Species sighted by Mark Broomhall = *

Common Name	Scientific Name	TSC Act	EPBC Act
*Pouched Frog	*Assa darlingtoni*	V	
*Fleay's Frog	*Mixophyes fleayi*	E	E
*Giant Barred Frog	*Mixophyes iteratus*	E	E
Loveridge's Frog	*Philoria loveridgei*	E	
Three-toed Skink	*Coeranoscincus reticulatus*	V	V
*Stephen's Banded Snake	*Hoplocephalus stephensii*	V	
*White-eared Monarch	*Carterornis leucotis*	V	
*Wompoo Fruit Dove	*Ptilinopus magnificus*	V	
*Rose-crowned Fruit-Dove	*Ptilinopus regina*	V	
Superb Fruit-Dove	*Ptilinopus superbus*	V	
Double-eyed Fig Parrot	*Cyclopsitta diophthalma*	CE	E
*Albert's Lyre-bird	*Menura alberti*	V	
*Olive Whistler	*Pachycephala olivacea*	V	
*Powerful Owl	*Ninox strenua*	V	
*Sooty Owl	*Tyto tenebricosa*	V	
*Marbled Frogmouth	*Podargus ocellatus*	V	
*Little Bent-winged Bat	*Miniopterus australis*	V	
*Eastern Bent-winged Bat	*Miniopterus schreibersii oceanensis*	V	
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V	
Eastern Long-eared Bat	*Nyctophilus bifax*	V	
Golden-tipped Bat	*Kerivoula papuensis*	V	
Eastern Blossom-Bat	*Syconycteris australis*	V	
Eastern Tube-nosed Bat	*Nyctimene robinsoni*	V	
*Grey-headed Fying Fox	*Pteropus poliocephalus*	V	V

*Spotted Quoll	*Dasyurus maculatus*	V	
*Common Planigale	*Planigale maculata*	V	
*Koala	*Phascolarctos cinereus*	V	V
Long-nosed Potoroo	*Potorous tridactylus*	V	V
Parma Wallaby	*Macropus parma*	V	
*Red-legged Pademelon	*Thylogale stigmatica*	V	

V = vulnerable E = endangered CE = critically endangered

List C

LIST OF 27 BIRD SPECIES THAT HAVE BECOME RARE

List C corresponds to the application of enhanced 3G microwave technology during the years 2009-2012.List of 27 bird species once common to very common on Mt. Nardi that now have become uncommon to rare and or disappeared above 450 m in approximately 2-3 km diameter around the Mt. Nardi tower complex.

T=Threatened M=Migratory U=Uncommon R=Rare G=Gone F=Found below 450 m and or outside 3 km diameter

Species	Latin Name	M	T	G	F
Silver Eye	*Zosterops lateralis*	M		G	
Jacky Winter	*Microeca leucophaea*			G	
Superb Blue Wren	*Malurus cyaneus*			G	F
Variegated Wren	*Malurus lamberti*			G	F
Red Backed Wrens	*Malurus melanocephalus*			G	F
Crested Hawk	*Aviceda subcrisata*			G	
Rose Crowned Fruit Pigeon	*Ptilinopus regina*		T	G	
Bush Hen	*Gallinula olivacea*			G	
Crested Pigeon	*Ocyphaps lophotes*			G	
Rainbow Lorikeet	*Trichoglossus haematodus*			G	F
Scaly Breasted Lorikeet	*Trichoglossus chlorolepidotus*			R	F
Rose Robin	*Petroica rosea*			G	
Restless Flycatcher	*Myiagra inquiela*			G	F
Willy Wagtail	*Rhipidura leucophrys*			G	F
Rainbow Bee Eater	*Merops ornatus*			G	F
Dollar Bird	*Eurystomus orientalis*	M		G	F
Fig Bird	*Sphecotheres viridis*			G	F
Eastern Spine Bill	*Acanthorhynchus tenuirostris*			R	F
Black Faced Cuckoo Shrike	*Coracina novaehollandiae*			R	F
Cicada Bird	*Coracina tenuirostris*			R	F
White Winged Triller	*Lalage tricolor*			U	F
Rufous Whistler	*Pachycephala rufiventris*			G	F
Leaden Flycatcher	*Myiagra rubecula*			G	F

Diamond Firetail Finch	*Steganopleura guttatum*		R	F
Olive Backed Oriole	*Oriolus sagittatus*	M	G	
Double Barred Finch	*Poepholia Vichenovii*		G	
Red-Browed Firetail Finch	*Emblema Temporalis*		G	F

List D

LIST OF 49 BIRDS & 3 BAT SPECIES THAT HAVE BECOME RARE

List D corresponds with the application of 4G in 2012-2013 up until 1-10-2015.

List of 49 birds and 3 bat species once common to very common on Mt. Nardi that now have become uncommon to rare and or have completely disappeared above 450 m in approximately a 2-3 km diameter around Mt. Nardi tower complex.

T=Threatened M=Migratory U=Uncommon R=Rare G=Gone F=Found below 450 m and or outside 3km diameter

Species	**Latin Name**	**T**	**G**	**U**	**R**	**F**
Wedge Tailed Eagle's	*Aquila audax*	T	G			F
Regent Bower Bird	*Sericulus chrysocephalus*	T	G			F
Satin Bower Bird	*Ptilinorhynchus violaceus*		G			F
King Parrot	*Alisterus scapalaris*	T			R	F
Grey Headed Flying Fox	*Pteropus poliocephalus*	T			R	F
Little Bent Winged Bat	*Miniopterus australis*	T			R	F
Eastern Tubed Nosed Bat	*Nyetimene robinsoni*	T			R	F
Grey Goshawk	*Accipeter novaehollandiae*	T	G			
Red Goshawk	*Erythrotriorchis radiatus*	T	G			
Spine Tailed Chowchilla	*Orthonyx temminckii*	T			R	F
Noisy Pitta	*Pitta versicolor*		G			F
Paradise Rifle Bird	*Ptiloris paradiseus*	T			R	F
Rufous Fantail	*Rhipidura rufifrons*			U		F
Grey Shrike Thrush	*Colluricincla harmonica*				R	F
Topknot Pidgeon	*Lopholaimus antarcticus*		G			F
Eastern Whip Bird	*Psophodes olivaceus*			U		F
Crimson Rosella	*Platycercus elegans (nigrescens)*		G	U		F
Eastern Rosella	*Platycercus eximius*					F
Rose Robin	*Petroica rosea*		G		R	
Scaly Thrush	*Zoothera lunulata*		G			
Rufous Shrike Thrush	*Colluricincla megarhyncha*					
Little Yellow Robin	*Tregallasia capito*		G		R	F
Brush Cuckoo	*Cuculus variolosus*		G	M		

Pallid Cuckoo	*Cuculus pallidus*		G	M		
Fantailed Cuckoo	*Cuculus flabelliformus*		G	M		
Little Bronze Cuckoo	*Chrysococcyx minutillus*		G			
Indian Koel	*Eudynamis scolopacea*		G	M		F
Channel Billed Cuckoo	*Scythrops novaehollandiae*		G	M		F
Pheasant Coucal	*Centropus phasianinus*			U		F
Azure King Fisher	*Ceyx azurea*		G			
Spangled Drongo	*Dicrurus bracteatus*		G	M		F
Green Cat Bird	*Ailuroedus crassirostris*	T	G			F
Red Browed Tree Creeper	*Climacteris erythrops*		G			F
Brown Throated Tree Creeper	*Climaacteris picumnus*		G			F
White Throated Tree Creeper	*Cormobates leucophaea*		G			F
Yellow Throated Scrub Wren	*Sericorms citreogularis*		G			
Brown Thorn Bill	*Acanthiza pusilla*				R	F
Yellow Tailed Black Cockatoo	*Calyptorhynchus funereus*			U		F
Sulphur Crested White Cockatoo	*Cacatua galerita*			U		F
Grey Fantail	*Rhypidura fuliginosa*		G			F
Pied Currawong	*Strepera graculina*			U		F
Golden Whistler	*Pachycephala pectoralis*		G			F
White Browed Scrub Wren	*Sericornis frontalis*				R	F
Black Faced Monarch	*Monarcha melanopsis*		G			F
Spectacled Monarch	*Monarcha trivirgatus*		G			F
Mistletoe Bird	*Dicaeum hirundinaceum*		G			F
Varied Triller	*Lalage leucomela*				R	
Olive Whistler	*Pachycephala olivacea*		G			
Red Necked Rail	*Rallina tricolor*		G			

List E

LIST OF BIRD SPECIES STILL EXTANT IN THE REGION

A list of a few bird species during the years 2009-2015 were the only species that still continued to be seen or heard on a daily and nightly basis. Fluctuations in populations have a direct correlation with the number of people in the nearby town of Nimbin. When there is more people and mobile phone Wi-Fi traffic, we see less wildlife. For example, on Sundays and Monday mornings, bird populations on this list can sometimes double.

P=Increase Population D=Decrease T=Threatened

F=Found below 450 m and or outside a 2-3 km radius of the transmission towers.

Species	**Latin Names**	**P**	**D**	**T**	**F**
Wompoo Pigeon	*Ptilinopus magnificus*	P		T	F
Lewin's Honey Eater	*Meliphaga lewinii*				F
Bar Shouldered Dove	*Geopelia humeralis*				F
Pale Yellow Robin	*Eopsaltria Australis*				F
White Headed Pigeon	*Colomba leucomela*				F
Brown Pigeon	*Macropygia amboinensis*	P			F
Emerald Dove	*Chalcophapis indica*		D		F
Common Bronze Wing	*Phaps Chalcoptera*				F
Kookaburra	*Dacelo novaeguineae*	P			F
Albert's Lyerbird	*Menura alberti*		D	T	F
Tawny Frogmouth	*Podargus strigoides*				F
Marbled Frogmouth	*Podargus ocellatus*	P		T	
Boobook Owl	*Ninox novaeseolandiae*				F
Brush Turkey	*Alectura lathami*		D		F
Wonga Pigeon	*Leucosarcia melanoleuca*	P			

List F

LIST OF RETURNING BIRD SPECIES OCTOBER 2015

A list of bird species not seen since 2012-2013 that arrived back to Mt. Nardi on the 1st October 2015. This corresponds with the lessening of intensity of the "4G" microwave technology. On the first weekend in October 2015 Mt. Nardi experienced a dramatic explosion of insects and birds not seen since 2012-2013. This corresponded to the new technical applications that were cut for three days that allowed for the last explosion of termites (*Isoptera*) we have seen on Mt. Nardi.

T=Threatened M=Migratory C=Common O=Occasional U=Uncommon R=Rare

Species	**Latin Name**	**T**	**O**	**C**	**U**	**R**
Noisy Pitta	*Pitta versicolor*	T	O			
Golden Whistler	*Pachycephala pectoralis*			C		
Green Cat Bird	*Ailuroedus crassirostris*	T			U	
Grey Shrike Thrush	*Colluricincla harmonica*				U	
Eastern Whip Bird	*Psophodes nigrogularis*		O			
Grey Headed Flying Fox	*Pteropus poliocephalus*	T				R
Scaly Thrush	*Zoothera lunulata*					R
Scarlet Honey Eater	*Myzomela sanguinolenta*		O			
White Throated Tree Creeper	*Cormobates leucophaea*		O			
Black Faced Monarch	*Monarcha melanopsis*		O			
Yellow Throated Scrub Wren	*Sericornis citreogularis*		O			
White Browed Scrub Wren	*Sericornis frontalis*			C		
Spectacled Monarch	*Monarcha trivirgatus*		O			
Pied Currawong	*Strepera graculina*		O			
King Parrot	*Alisterus scapularis*		O			
Grey Fantail	*Rhipidura fuliginosa*		O			
Spined Tailed Chowchilla	*Orthonyx temminkii*		O			
Red Necked Rail	*Rallina tricolor*		O			
Pheasant Coucal	*Centropus phasianinus*				U	

Additional Notes

The following notes give an individual breakdown of bird species observations. I see the birds as a key identifier to the larger event, the veritable ‘canary in the cage’ if you will. I also wish to demonstrate other extraordinary processes that have occurred within the same timeframe.

BIRDS:

Wedge Tailed Eagle

The only local pair moved away from Mt. Nardi-Neville, outside the National Park, when 4G was switched on.

Regent Bower Bird

Secretive and rare and a bird sighted only occasionally; it has now gone.

Satin Bower Bird

Once very common, these large populations have gone from the mountains, retreating to the valleys below.

King Parrot

Once common, their chattering was a remarked-upon feature of the forest but is now rarely heard; the only audible sound is their call of alarm.

Grey Headed Flying Fox

Once common both day and night, they are now heard rarely, only very late at night and very early in the morning when power use drops to a minimum.

Grey Goshawks

These birds, seen patrolling the roadway to the National Park (Newton Drive) for thirty years, have now vanished completely.

Spangled Drongo

Once a conspicuous visitor and breeder, has now gone from the mountain but still common in the valleys below.

Grey Shrike Thrush

Once one of the prominent early birds of the Dawn Chorus, they are now uncommon to rare.

Alberts Lyre Bird

This bird is endemic to the Mount Warning caldera, a relic species exclusive to Gondwanaland habitat.

For example, since 2014 the *Alberts Lyrebird* has been heard calling in an area 5 to 10 km from the towers, below 300 m. In May of 2017, an *Alberts Lyrebird* nest with 2 chicks was discovered beneath wild Lantana brush, about 20 m from the base of the mountain. This site is a small strip of 35 year-old natural regrowth, 6 km from the towers, below 100 m altitude, that is sheltered from the mountain and towers.

Rare photo Alberts Lyre Bird Nest with Chicks

Greatly reduced singing and mimicking frequency. Once common, Lyre Bird numbers have dwindled, retreating in all directions away from the towers. Their singing is now heard down in the Tuntable Falls and Gungas Valleys beyond the National Park. Notably, they are being heard in these ex-farming valleys for the first time in 30 years as they are forced from the National Park.

Marbled Frogmouth

Once very rare, they have now become common at the periphery of the affected area. This bird's beautiful call is most commonly heard when the Tawny Frogmouths and Boobook Owls are calling.

Sooty Owl

Still here, still rare.

Channel Billed Cuckoo
Pallad Cuckoo
Brush Cuckoo
Little Bronze Cuckoo

All of these Cuckoos were common in season and are now rare or have vanished.

Indian Koel

Once a common breeding visitor, it no longer visits.

Mistletoe bird (*Dicaeum hirundinaceum*)

A bird that lives across the entire continent of mainland Australia but has now disappeared from Mt. Nardi. It has not been seen or heard for years. It is the only specie that proliferates the mistletoe and is a prime example of how genetic diversity unravels when the key dispersers are affected.

Superb Blue Wren
Red-backed Wren (*Malurus melanocephalus*)
Variegated Wren

All once very common, have disappeared since 2009. They are still to be found down the mountain, below 450 m.

INSECTS/Cicadas/Moths/Butterflies/Ants/Bees/Flies
Cicadas (*Cicadoidea)*

There exist four commonly known species: the Black Prince, Big Green Cicada, Little Green Cicada and Large Brown Cicadas. Once abundant every other year, singing all day throughout the summer months, they all disappeared by 2012. I have seen a momentary reappearance since the power output change in spring of 2015. I believe that only two of the original four species have reappeared and now, in summer, can be heard about an hour before dusk for only about fifteen minutes and sporadic attempts at trilling around dawn for ten to fifteen minutes.

Moths/Butterflies/Ants/Bees/Flies

Most have become uncommon to occasional. From the year 2000 flying insects have been noticeably diminishing. From 2012-2017 populations have crashed, estimating as high as 80-90% less insects than before 2000.

Ants

Once abundant populations of all species represented in the World Heritage are now hard to find, mostly emerging just before the rain. Biting Ants have become more aggressive than before 2000, now always biting on contact.

Richmond Bird-Wing Butterfly (*Orinthoptera richmandia*)

Once an iconic species abundant around the tower complex, is now a rare sight.

The Giant Yellow Wasp/Giant Sticky Wasp

Once abundant, have now disappeared.

White Ants/Termites (*Isoptera)*

Previously there was an annual explosion of White Ants as storms approached. Now Flying White Ant eruptions are nearly non-existent, rarely emerging to release a few ants. These ‘insect emergences’ are no longer calibrated with the weather patterns.

NATIVE BEES

Once abundant, this little bee's large populations have crashed; its historical contribution as a dominant pollinator has been greatly impaired.

FROGS

Populations and diversity have decreased significantly. They are singing less and their chants have become shorter in time span. Before 2012 frogs would sing almost all day. Now it is uncommon. Mt Nardi area is known as the recognised home of the Giant Barred Frog.

ORNITHOLOGICAL STUDY

I bring to your attention to a study titled, *'A Baseline Assessment Of Mt Nardi Bird Community Indicators & Spatial Variation Among Sites-July 1997.'* The study is produced by Sandy Gilmore, renowned bird species expert of the region, in fact the world expert on the ornithology of the local region and beyond. (See Annex #3)

The data was collected in 1997 from a study of the ground birds of the region that had, as its point of departure the tower complex on M Nardi. It reveals increasing numbers of birds and bird species the further one moves away from the complex. Mr Gilmore reached the conclusion that the tower is the most likely cause of the decrease in number and speciation. As already mentioned, the data was previously collected in 1997. I extended my research and discovered that the first Wi-Fi apparatus was attached to the tower in 1995.

SIGNIFICANCE OF THE DAWN CHORUS

Once there were hundreds of birds joining the dawn chorus, now only a handful can be heard. The dawn chorus may be considered the most extravagant indicator of species and populations.

In conclusion to the additional notes, I would like to remark that this study is based on a complex genetic seed bank. None of my research has so far revealed a study of this scope or nature. I stress that with the backdrop of such a diverse environment, the effects of this technology are more dramatically revealed.

Mt. Nardi Tower Activation Timeline

MARCH-APRIL 2003 – 3G STARTS UP -850 MHz

MARCH-NOVEMBER 2004 – WI-FI BROADBAND LAUNCHES

PERIOD 2002-2004 INSECTS DECLINE DRAMATICALLY

2005 OTHER 3G SERVICES LAUNCHED

2006-2009 TELSTRA “NEXTG”MORE POWERFUL 3G LAUNCHES – 2100 MHz

AUGUST 2009 VODAPHONE NATIONAL 3G LAUNCH

PERIOD 2009

27 BIRD SPECIES VANISH (SEE LIST C)

INSECTS DECLINE

2010-2011 TELSTRA 4G LAUNCHED – 1800 MHz

PLUS 3G UPGRADE

JULY 2012 OPTUS LAUNCHES 4G – 2300 MHz & 2600 MHz

PERIOD 2012-2013

49 BIRD SPECIES VANISH (SEE LIST D)

BATS, CICADAS, BUTTERFLYS, FROGS AND ANTS DECLINE

AUGUST 2012 3G TURNED OFF

2014 4G EXPANDS, ADDS NEW SPECTRUM & SPEED

OCTOBER 2015 OPTUS &TELSTRA SWITCH TO “4GX”

ASSUMES BROADER SPECTRUM (OLD ANALOGUE SPECTRUM)

DROP TO 700 MHz frequency range

(via Australian Mobile Timeline 1981 to 2013 http://3gwiz.com.au/ozmobilenet/?page_id=4)

The Register of Radio-communication Licenses-Site Details

Register of Radiocommunications Licences and Broadcast Service Licences

Site Details

Site ID	8533
Name	Broadcast Australia Tower 30 km N of Lismore
Location	MT NARDI NSW 2480
Precision	Within 10 meters
Elevation	783 m
Lat,Long (GDA94)	-28.545563°,153.287606° [KML]
Licence Fee Density	Low Density Area

[Show Nearby Sites in Map] [Site Location Map for this Site Only]
[Sites 1km, 10km, 20km, 100km] [Site Location Map] [Nearby Assignments]
[New Site Search]

Assignments at this Site

Results **1 - 88** of **88** assignments.

ID	Frequency	Emission Designator	T/R	Client	BSL/Licence No	
893887	932.75 MHz	75K0D7W	R	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1923881/1	6-4-10
893888	856.75 MHz	75K0D7W	T	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1923881/1	6-4-10
910513	8.251745 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936288/1	6-4-10
910249	6.1231 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936069/1	21-10-11
910309	6.74 GHz	40M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936077/1	21-10-11
996704	7.04 GHz	38M5D7WET	R	Telstra Corporation Limited (39310)	1983830/1	7-7-15
996705	6.7 GHz	38M5D7WET	T	Telstra Corporation Limited (39310)	1983830/1	7-7-15
1005407	7.6625 GHz	13M7D7W	R	Vertical Telecoms Pty Limited (1209404)	1987512/1	17-4-15
1005408	7.5015 GHz	13M7D7W	T	Vertical Telecoms Pty Limited (1209404)	1987512/1	17-4-15
929430	6.22689 GHz	28M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948632/1	23-3-12
929431	5.97485 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948632/1	23-3-12
1011296	7.5925 GHz	13M7D7W	R	Vertical Telecoms Pty Limited (1209404)	1990332/1	14-5-14
1011297	7.4315 GHz	13M7D7W	T	Vertical Telecoms Pty Limited (1209404)	1990332/1	14-5-14
759871	7.666 GHz	7M00D7W	R	Australian Broadcasting Corporation (336877)	1189929/1	19-4-07
759872	7.505 GHz	7M00D7W	T	Australian Broadcasting Corporation (336877)	1189929/1	19-4-07
773981	13.031 GHz	28M0F7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1222611/1	13-3-02
773982	12.765 GHz	28M0F7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1222611/1	13-3-02
910516	7.940425 GHz	28M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936288/1	4-5-11
910300	6.92 GHz	40M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936075/1	21-10-11

910301	6.58 GHz	40M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936075/1	21-10-11
981170	460.16875 MHz	10K1F3E	T	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1976010/1	16-9-16
981175	450.66875 MHz	10K1F3E	R	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1976010/1	16-9-16
1005846	8.162795 GHz	29M6D7W	T	Vertical Telecoms Pty Limited (1209404)	1987727/1	23-04-15
1005849	7.851475 GHz	29M6D7W	R	Vertical Telecoms Pty Limited (1209404)	1987727/1	23-04-15
929447	6.03415 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948634/1	23-3-12
1005834	8.222095 GHz	27M5D7W	T	Vertical Telecoms Pty Limited (1209404)	1987726/1	23-4-15
1005837	7.910775 GHz	27M5D7W	R	Vertical Telecoms Pty Limited (1209404)	1987726/1	23-4-15
929439	6.0045 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948633/1	23-03-12
929446	6.28619 GHz	28M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948634/1	23-3-12
1056733	163.1 MHz	10K1F3E	T	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1917372/1	10-5-10
1056736	158.5 MHz	10K1F3E	R	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1917372/1	10-5-10
1597917	564.5 MHz	6M70V7W	T	SPECIAL BROADCASTING SERVICE CORPORATION (1133847)	1159683/1	21-3-14
9613481	723 MHz	20M0W7D	R	Telstra Corporation Limited (1103275)	9469862	13-5-15
9613482	778 MHz	20M0W7D	T	Telstra Corporation Limited (1103275)	9469862	13-5-15
9613483	723 MHz	20M0W7D	R	Telstra Corporation Limited (1103275)	9469862	13-5-15
9613484	778 MHz	20M0W7D	T	Telstra Corporation Limited (1103275)	9469862	13-5-15
9613485	723 MHz	20M0W7D	R	Telstra Corporation Limited (1103275)	9469862	13-5-15
9613486	778 MHz	20M0W7D	T	Telstra Corporation Limited (1103275)	9469862	13-5-15
896028	413.875 MHz	16K0F3E	T	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1924878/1	10-5-10
896031	404.425 MHz	16K0F3E	R	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1924878/1	10-5-10
1003547	7.673 GHz	7M00D7W	R	Vertical Telecoms Pty Limited (1209404)	1986540/1	7-5-15
1003548	7.512 GHz	7M00D7W	T	Vertical Telecoms Pty Limited (1209404)	1986540/1	7-5-15
1003554	11.585 GHz	40M0D7W	T	Vertical Telecoms Pty Limited (1209404)	1986541/1	7-5-15
1003557	11.095 GHz	40M0D7W	R	Vertical Telecoms Pty Limited (1209404)	1986541/1	7-5-15
929438	6.25654 GHz	28M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948633/1	23-3-12
1011278	7.603 GHz	7M00D7W	R	Vertical Telecoms Pty Limited (1209404)	1990329/1	7-7-15
1011281	7.442 GHz	7M00D7W	T	Vertical Telecoms Pty Limited (1209404)	1990329/1	7-7-15
1011292	15.1485 GHz	7M00D7W	R	Vertical Telecoms Pty Limited (1209404)	1990331/1	7-7-15
1599678	98.5 MHz	200KF8EHF	T	Australian Broadcasting Corporation (1103909)	1189262/1	12-3-07
1598024	543.5 MHz	6M70V7W	T	Prime Television (Northern) Pty Limited (1155718)	1159792/1	21-03-14
10102814	840 MHz	9M90G7W	R	Telstra Corporation Limited (1103275)	9263433	16-9-16
10102815	885 MHz	9M90G7W	T	Telstra Corporation Limited (1103275)	9263433	16-9-16

10102816	840 MHz	9M90G7W	R	Telstra Corporation Limited (1103275)	9263433	16-9-16
910225	5.97485 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936066/1	21-10-11
910232	6.25654 GHz	28M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936067/1	21-10-11
910304	7 GHz	40M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936076/1	21-10-11
910305	6.66 GHz	40M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936076/1	21-10-11
910296	6.84 GHz	40M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936074/1	21-10-11
910297	6.5 GHz	40M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936074/1	21-10-11
929422	6.19724 GHz	28M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948631/1	23-3-12
929423	5.9452 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948631/1	23-3-12
1011293	14.5045 GHz	7M00D7W	T	Vertical Telecoms Pty Limited (1209404)	1990331/1	13-5-15
1450370	6.03415 GHz	29M6D7W	T	Vertical Telecoms Pty Limited (1209404)	9939776/1	8-3-16
1598045	550.5 MHz	6M70V7W	T	NBN Pty Ltd (28768)	1159813/1	21-3-14
1596760	94.5 MHz	200KF8EHF	T	Australian Broadcasting Corporation (1103909)	1150259/1	31-1-93
1596761	95.3 MHz	200KF8EHF	T	Australian Broadcasting Corporation (1103909)	1150260/1	3-12-91
1596764	96.1 MHz	200KF8EHF	T	Australian Broadcasting Corporation (1103909)	1150263/1	1-10-94
10102817	885 MHz	9M90G7W	T	Telstra Corporation Limited (1103275)	9263433	16-9-16
10102818	840 MHz	9M90G7W	R	Telstra Corporation Limited (1103275)	9263433	16-9-16
10102819	885 MHz	9M90G7W	T	Telstra Corporation Limited (1103275)	9263433	16-9-16
10102820	840 MHz	9M90G7W	R	Telstra Corporation Limited (1103275)	9263433	16-9-16
10102821	885 MHz	9M90G7W	T	Telstra Corporation Limited (1103275)	9263433	16-9-16
892601	460.8 MHz	16K0F3E	T	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1922974/1	11-3-10
892604	451.3 MHz	16K0F3E	R	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1922974/1	11-3-10
910216	6.19724 GHz	28M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936065/1	21-10-11
910217	5.9452 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936065/1	21-10-11
910224	6.22689 GHz	28M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936066/1	21-10-11
910233	6.0045 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936067/1	21-10-11
910240	6.31584 GHz	28M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936068/1	21-10-11
910241	6.0638 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936068/1	21-10-11
910248	6.37514 GHz	28M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936069/1	21-10-11
910308	7.08 GHz	40M0D7W	R	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936077/1	30-3-15
1002995	7.694 GHz	7M00D7W	R	Vertical Telecoms Pty Limited (1209404)	1986364/1	22-4-15

1002996	7.533 GHz	7M00D7W	T	Vertical Telecoms Pty Limited (1209404)	1986364/1	22-4-15
1450369	6.28619 GHz	29M6D7W	R	Vertical Telecoms Pty Limited (1209404)	9939776/1	8-3-16
1597655	536.5 MHz	6M70V7W	T	Australian Broadcasting Corporation (1137920)	1158507/1	22-8-03
1596767	96.9 MHz	200KF8EHF	T	Australian Broadcasting Corporation (1103909)	1150266/1	13-01-93
1597771	557.5 MHz	6M70V7W	T	Northern Rivers Television Pty Ltd (29420)	1159167/1	2-8-05

Mt Nardi Towers.

Sites where within 1km of Latitude: -28.542669, Longitude: 153.290154

Results 1 - 5 of 5 possible matches. Sorted by Distance.

Site ID	Name	City	https://web.acma.gov.au/rrl/site_search.results_page?pQRY=-28.542669,153.290154&pSUB_TYPE=%3c1km from&pEXACT_IND=matches&pSORT_BY=district	State & Postcode	Asgn	KM
8535	NRN8 TV Tower 30 km N of Lismore MT NARDI	MT NARDI		NSW 2480	152	[K
8542	Telstra Tower 2 30 km N of Lismore MT NARDI	MT NARDI		NSW 2480	4	[K
8541	Telstra Tower 1 30 km N of Lismore MT NARDI	MT NARDI		NSW 2480		[K
9011268	Nimbin Optus Site Newton Drive TUNTABLE FALLS NSW 2480	MT NARDI		NSW 2480	18	[K
8533	Broadcast Australia Tower 30 km N of Lismore MT NARDI	MT NARDI		NSW 2480	80	[K

Site ID	8535
Name	NRN8 TV Tower 30 km N of Lismore
Location	MT NARDI NSW 2480
Precision	Within 10 meters
HCIS Level 2	NU3J
Elevation	776 m
Lat,Long (GDA94)	-28.542669°,153.290154° [KML]
Licence Fee Density	Low Density Area

Assignments at this Site

Results 1 - 100 of 152 assignments.

ID	Frequency	Emission Designator	T / R	Client	BSL/Licence No
708524	460.55 MHE	16K0F3	T	Essential Energy (1214220)	101421/1

708418	460.125 MHz	16K0F2D	T	Essential Energy (1214220)	101378/1
708480	461.08125 MHz	10K1F2D	T	Essential Energy (1214220)	101397/1
767707	460.35 MHz	16K0F3E	T	NSW Rural Fire Service (5832)	1209102/1
783901	414.05 MHz	16K0F3E	T	Forestry Corporation of New South Wales (13634)	1280435/1
817769	413.3125 MHz	10K1F3E	T	NSW Rural Fire Service (5832)	1209571/1
870450	853.20625 MHz	10K1F2D	T	NSW Rural Fire Service (5832)	1907892/1
870474	853.20625 MHz	10K1F2D	T	NSW Rural Fire Service (5832)	1907895/1
870482	853.20625 MHz	10K1F2D	T	NSW Rural Fire Service (5832)	1907896/1
939038	414.14375 MHz	10K1F3E	T	State Emergency Service (Nsw) (516364)	1953883/1
981950	414.175 MHz	20K4D7W	T	NSW Rural Fire Service (5832)	1976408/1
1186438	7.5435 GHz	14M0D7W	T	Soul Pattinson Telecommunications Pty Limited (1131556)	1224975/1
1098042	420.1625 MHz	10K1F9W	T	NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS AUTHORITY (20005985)	1952079/1
1141307	468.9125 MHz	10K1F1E	T	NSW Police Force (31823)	1984777/1
2692400	8.1924 GHz	29M6G7W	T	NETWORK INVESTMENTS PTY LTD (20032976)	42993/2

2692418	8.133145 GHz	29M6G7W	T	NETWORK INVESTMENTS PTY LTD (20032976)	1429172/2
656040	145.05 MHz	16K0F2D	T	Summerland Amateur Radio Club Inc (94279)	164676/1
656056	1.2733 GHz	16K0F3E	T	Summerland Amateur Radio Club Inc (94279)	164676/1
656042	438.875 MHz	16K0F2D	T	Summerland Amateur Radio Club Inc (94279)	164676/1
656044	440.05 MHz	16K0F2D	T	Summerland Amateur Radio Club Inc (94279)	164676/1
656046	440.4 MHz	16K0F2D	T	Summerland Amateur Radio Club Inc (94279)	164676/1
656048	440.85 MHz	16K0F2D	T	Summerland Amateur Radio Club Inc (94279)	164676/1
656050	438.675 MHz	16K0F2D	T	Summerland Amateur Radio Club Inc (94279)	164676/1
656052	147.325 MHz	16K0F3E	T	Summerland Amateur Radio Club Inc (94279)	164676/1
656054	145.175 MHz	16K0F2D	T	Summerland Amateur Radio Club Inc (94279)	164676/1
708430	460.125 MHz	16K0F2D	T	Essential Energy (1214220)	101386/1
784235	450.825 MHz	16K0F3E	T	Essential Energy (1214220)	1281290/1
784245	460.45 MHz	16K0F3E	T	Essential Energy (1214220)	1281302/1
909083	8.1924 GHz	29M6D7W	T	NBN Pty Ltd (28768)	1935084/1
950143	404.07	16K0F9	T	ST. JOHN AMBULANCE AUSTRALIA INCORPORATED	1960565/1

	5 MHz	W	T	(1144303)		
981942	414.175 MHz	20K4D7W	T	NSW Rural Fire Service (5832)	1976407/1	
981960	7.4595 GHz	14M0G7W	T	NSW Rural Fire Service (5832)	1976409/1	
780213	847.2 MHz	380KF1EHX	T	Richmond River Broadcasters Pty Ltd (33520)	1233496/1	
683862	461.19375 MHz	10K1F2D	T	NBN Pty Ltd (28768)	42070/1	
757637	414.1 MHz	16K0F3E	T	Ambulance Service of NSW (17661)	1187688/1	
870402	853.20625 MHz	10K1F2D	T	NSW Rural Fire Service (5832)	1907886/1	
870410	853.20625 MHz	10K1F2D	T	NSW Rural Fire Service (5832)	1907887/1	
870418	853.20625 MHz	10K1F2D	T	NSW Rural Fire Service (5832)	1907888/1	
870426	853.20625 MHz	10K1F2D	T	NSW Rural Fire Service (5832)	1907889/1	
870434	853.20625 MHz	10K1F2D	T	NSW Rural Fire Service (5832)	1907890/1	
945129	413.71875 MHz	12K5F3E	T	Ambulance Service of NSW (17661)	1957911/1	
956210	7.5015 GHz	14M0G7W	T	NSW Rural Fire Service (5832)	1963897/1	
1004077	468.325 MHz	10K1F3E	T	NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS AUTHORITY (20017375)	1802660/1	
1004125	468.5875	10K1F3E	T	NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS	1802666/1	

		MHz			AUTHORITY (20017375)	
1004157		468.8375 MHz	10K1F3E	T	NEW SOUTH WALES GOVERNMENT TELECOMMUNICATIONS AUTHORITY (20017375)	1802671/1
1033379		462.85 MHz	10K1F9W	T	ST. JOHN AMBULANCE AUSTRALIA INCORPORATED (1144303)	1908836/1
1042064		151.125 MHz	10K1F3E	T	ST. JOHN AMBULANCE AUSTRALIA INCORPORATED (1144303)	1912379/1
2692402		8.133145 GHz	24M0F3FNN	T	NETWORK INVESTMENTS PTY LTD (20032976)	531139/2
2692396		8.073845 GHz	18M0F9F	T	NETWORK INVESTMENTS PTY LTD (20032976)	42984/2
661007		79.2625 MHz	10K1F3E	T	Forestry Corporation of New South Wales (13634)	24427/1

https://web.acma.gov.au/rrl/assignment_search.lookup?pEFL_ID=661006 https://web.acma.gov.au/rrl/client_search.client_lookup?pCLIENT_NO=13634 https://web.acma.gov.au/rrl/licence_search.licence_lookup?pLICENCE_NO=24427/1

Site Details

Site ID	8542
Name	Telstra Tower 2 30 km N of Lismore
Location	MT NARDI NSW 2480
Precision	Within 10 meters
HCIS Level 2	NU3J
Elevation	778 m
Lat,Long (GDA94)	-28.544867°,153.288034° [KML]
Licence Fee Density	Low Density Area

Assignments at this Site

Results 1 - 4 of 4 assignments.

ID	Frequency	Emission Designator	T/R	Client	BSL/Licence No
983736	7.449 GHz	7M00D7WET	T	Airservices Australia (401054)	1977346/1
1029956	120.3 MHz	6K00A3E	T	Airservices Australia (391222)	420357/1

https://web.acma.gov.au/rrl/client_search.client_lookup?pCLIENT_NO=391222

https://web.acma.gov.au/rrl/licence_search.licence_lookup?pLICENCE_NO=420357/1

Site Details

Site ID	8541
Name	Telstra Tower 1 30 km N of Lismore
Location	MT NARDI NSW 2480
Precision	Within 10 meters
HCIS Level 2	NU3J
Lat,Long (GDA94)	-28.545039°,153.287901° [KML]
Licence Fee Density	Low Density Area

No assignments are listed for this site.

Site Details

Site ID 9011268

Name Nimbin Optus

Site Newton Drive

Location TUNTABLE FALLS NSW 2480 NSW 2480

Precision Within 10 meters

HCIS Level 2 NU3J

Elevation 783 m Lat,Long (GDA94) - 28.545563°,153.287914° [KML] Licence Fee Density Low Density Area

https://web.acma.gov.au/rrl/hcis2kml_proxy.kml?pHCIS=NU3J

Assignments at this Site

Results 1 - 18 of 18 assignments.

ID	Frequency	Emission Designator	T/R	Client	BSL/Licence No
10170018	1.8575 GHz	15M0W7D	T	Optus Mobile Pty Limited (1103276)	9263448
9608116	763 MHz	10M0W7D	T	Optus Mobile Pty Limited (1149289)	9469858
9608118	763 MHz	10M0W7D	T	Optus Mobile Pty Limited (1149289)	9469858
10170014	1.8575 GHz	15M0W7D	T	Optus Mobile Pty Limited (1103276)	9263448
10170021	1.8575 GHz	15M0W7D	T	Optus Mobile Pty Limited (1103276)	9263448
10033723/1	947.6 MHz	3M84G7W	T	Optus Mobile Pty Limited (512112)	1136358/1
9608120	763 MHz	10M0W7D	T	Optus Mobile Pty Limited	9469858

				(1149289)	
1291612	8.073845 GHz	28M0D7W	T	Optus Mobile Pty Limited (510769)	1922085/1
10041198/1	947.6 MHz	3M84G7W	T	Optus Mobile Pty Limited (512112)	1136358/1

Site Details

Site ID	8533
Name	Broadcast Australia Tower 30 km N of
Location	MT NARDI NSW 2480
Precision	Within 10 meters
HCIS Level 2	NU3J
Elevation	783 m
Lat,Long (GDA94)	-28.545563°,153.287606° [KML]
Licence Fee Density	Low Density Area

]

Assignments at this Site

Results 1 - 80 of 80 assignments.

ID	Frequency	Emission Designator	T / R	Client	BSL/Licence No
				https://web.acma.gov.au/rrl/client_search.client_lookup?pCLIENT_NO=1103275	https://web.acma.gov.au/rrl/licence_search.licence_lookup?pLICENCE_NO=9469862
759872	7.505 GHz	7M00D7W	T	Australian Broadcasting Corporation (336877)	1189929/1
773982	12.765 GHz	28M0F7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1222611/1
929431	5.97485 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948632/1
929439	6.0045 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948633/1
10029 96	7.533 GHz	7M00D7W	T	Vertical Telecoms Pty Limited (1209404)	1986364/1
15996 78	98.5 MHz	200KF8EHF	T	Australian Broadcasting Corporation (1103909)	1189262/1
25465 96	7.554 GHz	7M00D7W	T	Vertical Telecoms Pty Limited (1209404)	10222199/1
26089 70	8.23692 GHz	55M0D7W	T	Vertical Telecoms Pty Limited (1209404)	1987727/2
15980 45	550.5 MHz	6M70V7W	T	NBN Pty Ltd (28768)	1159813/1
10102 815	885 MHz	9M90G7W	T	Telstra Corporation Limited (1103275)	9263433
89602 8	413.875 MHz	16K0F3E	T	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1924878/1
98117 0	460.16875 MHz	10K1F3E	T	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1976010/1
10058 34	8.222095 GHz	27M5D7W	T	Vertical Telecoms Pty Limited (1209404)	1987726/1
10112 81	7.442 GHz	7M00D7W	T	Vertical Telecoms Pty Limited (1209404)	1990329/1
10112 93	14.5045 GHz	7M00D7W	T	Vertical Telecoms Pty Limited (1209404)	1990331/1
10102 817	885 MHz	9M90G7W	T	Telstra Corporation Limited (1103275)	9263433
10567 33	163.1 MHz	10K1F3E	T	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1917372/1
				https://web.acma.gov.au/rrl/client_search.client_lookup?pCLIENT_NO=115634	https://web.acma.gov.au/rrl/licence_search.licence_lookup?pLICENCE_NO=1917372/1

159676060	94.5 MHz	200KF8EHF	T	Australian Broadcasting Corporation (1103909)	1150259/1
159676161	95.3 MHz	200KF8EHF	T	Australian Broadcasting Corporation (1103909)	1150260/1
159676464	96.1 MHz	200KF8EHF	T	Australian Broadcasting Corporation (1103909)	1150263/1
159676767	96.9 MHz	200KF8EHF	T	Australian Broadcasting Corporation (1103909)	1150266/1
8938888	856.75 MHz	75K0D7W	T	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1923881/1
9102157	5.9452 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936065/1
9102225	5.97485 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936066/1
892601	460.8 MHz	16K0F3E	T	OFFICE OF ENVIRONMENT AND HERITAGE (115634)	1922974/1
996705	6.7 GHz	38M5D7WET	T	Telstra Corporation Limited (39310)	1983830/1
1011297	7.4315 GHz	13M7D7W	T	Vertical Telecoms Pty Limited (1209404)	1990332/1
9613482	778 MHz	20M0W7D	T	Telstra Corporation Limited (1103275)	9469862
9613484	778 MHz	20M0W7D	T	Telstra Corporation Limited (1103275)	9469862
1597655	536.5 MHz	6M70V7W	T	Australian Broadcasting Corporation (1137920)	1158507/1
1597917	564.5 MHz	6M70V7W	T	SPECIAL BROADCASTING SERVICE CORPORATION (1133847)	1159683/1
2692255	557.5 MHz	6M70V7W	T	NETWORK INVESTMENTS PTY LTD (20032976)	1159167/2
10102819	885 MHz	9M90G7W	T	Telstra Corporation Limited (1103275)	9263433
9102303	6.0045 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936067/1
9102401	6.0638 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936068/1
9102419	6.1231 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1936069/1
1003548	7.512 GHz	7M00D7W	T	Vertical Telecoms Pty Limited (1209404)	1986540/1
				https://web.acma.gov.au/rrl/client_search.client_lookup?pCLIENT_NO=1209404	https://web.acma.gov.au/rrl/licence_search.licence_lookup?pLICENCE_NO=1986540/1
1003554	11.585 GHz	40M0D7W	T	Vertical Telecoms Pty Limited (1209404)	1986541/1
1005408	7.5015 GHz	13M7D7W	T	Vertical Telecoms Pty Limited (1209404)	1987512/1
10102821	885 MHz	9M90G7W	T	Telstra Corporation Limited (1103275)	9263433
2626812	6.09345 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	10238733/1
929423	5.9452 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948631/1
929447	6.03415 GHz	28M0D7W	T	DIGITAL DISTRIBUTION AUSTRALIA PTY LIMITED (1104256)	1948634/1
1598024	543.5 MHz	6M70V7W	T	Prime Television (Northern) Pty Limited (1155718)	1159792/1

CONDENSED DATA FROM LIST:

50 transmitters listed for NRN8 TV tower site ID 8535. 8 of these transmit in the 7 to 8 GHz bands.

2 transmitters listed for Telstra Tower 2 site ID 8542. 1 transmits in the 7.449 GHz band.

9 transmitters for Optus site ID 8541. 4 of these transmit in the 1.8 to 8.1 GHz bands.

44 transmitters for site ID 8533. 23 of these transmit in the 5.9 to 14.5 GHz bands.

Overall there appear to be 105 transmitters operating on Mt Nardi.

Summary

The effects on this area of the World Heritage by the microwave radiation coming from the tower divides the larger Nightcap Park into two pieces by blocking the species flow through the East - West corridor of the Park. (see Mt Nardi map page: 6)

The use of a huge diesel powered generator to boost the power and the general effects of 3G and 4G and the many other frequencies that have been added, impose a frequency message of such magnitude and complexity that the interplay between the naturally occurring electromagnetic oscillatory bands, a vibrational zone of great subtlety wherein dwells most of known biology, is simply overridden. The message is too powerful and creatures both great and small simply flee or perish.

There have been unmeasured diesel spills from the generator.

Walking trails are neglected and power-line corridors transect the delicate ecology triggering a massive incursion of introduced non-native species such as cane toads and wild dogs.

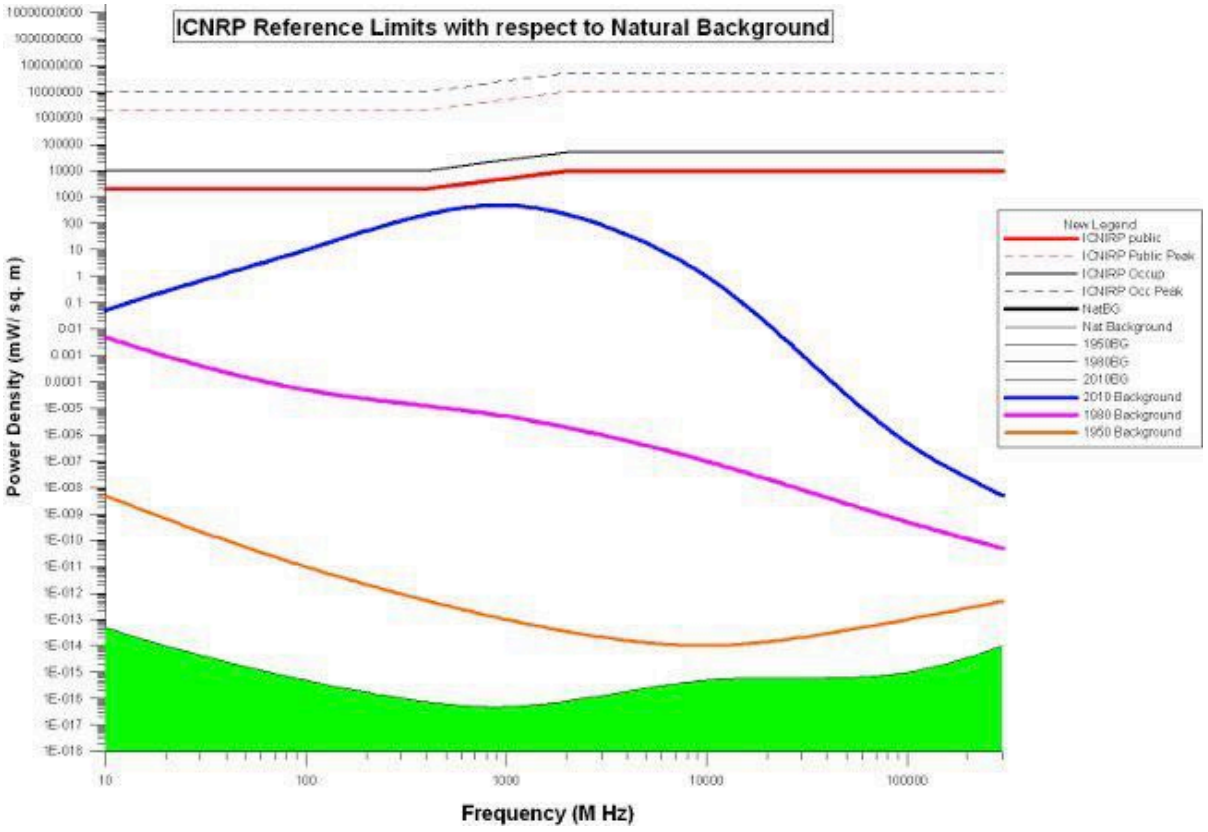
- There is no information or *liaison* with visitors who come from around the country and the world, to be confronted by these "Towers of Doom." Many people, like other sensible species, don't even leave their car; they simply leave.

My own observations correspond so well with the explanation revealed by the Register of Radio-communications Licenses and Broadcast Services, as well as the Timeline of application of the technology, that our community has little choice but to believe the overwhelming evidence of our own eyes and ears. The Mt. Nardi - Mt. Matheson area has been consistently neglected, consistently abused and with the intensifying storm of invisible frequencies emanating from the towers it is accurate to say that Mt. Nardi is under siege.

Since 2000 many more towers and new technologies that utilise a broader spectrum of frequencies have been added to the transmission facilities on top of Mt Nardi. Currently there are about 105 transmitters operating on the mountain.

I understand from my research that EMR levels near towers are millions of times greater than the natural background levels that wildlife has evolved to utilize for navigation, homing, etc. Every new network is more complex in signal structure than the previous. Given the number of transmitters on-site, it is also relevant that virtually no research has been conducted upon the biological effects of simultaneous exposure to multiple signals, much less dropping them into a World Heritage gene bank without foresight.

My 'urgency to act' is not only for the reasons already demonstrated but also because upcoming technologies likely represent an even more serious threat to biology. I would like you to note that it would be simple to verify my findings, rather than undertaking years of protracted studies. Turn off the 4G for a predetermined period and have the biologists note species reappearance. I have indicated previously what happened when the towers were turned off for two days and the resultant explosion of biology on the mountain.



Conclusion

With these short explanations of events we can appreciate that the effects of this technology and its application on Mt. Nardi over the last fifteen years, affect not only the top of the life chain species but they are devastating the fabric of the continuity of the World Heritage, causing genetic deterioration in an insidious, massive and ever escalating scale. To truly understand what these studies reveal is to stare into the abyss.

List of Appendices:

1. Site Assessment. Kooyman R. (see Pdf.1)

2. ‘Gondwanaland Rainforest of Australia.’ UNESCO World Heritage.
3. ‘A Baseline Assessment Of Mt Nardi Bird Community Indicators And Spatial Variation Among Sites – July 1997.’ Sandy Gilmore, Ecologist. (See Pdf.2)

List of Study References:

Australian Mobile Timeline 1981 to 2013
http://3gwiz.com.au/ozmobilenet/?page_id=4
Australian Mobile Network Frequencies
http://whirlpool.net.au/wiki/mobile_phone_frequencies

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Svenga, Engels, Nils-Allss Shneider, Nele, Lefefedt, Christine Maira Hien, Manuela Zapka, Andreas Michalik, Dana Elbers, Achim Kittel, P, J Hore and Henrik Mouritson.

Belyavskaya,N.A. Biological effects due to weak magnetic field on plants (2004). Published by Elsevier on behalf of COSPAR https://www.nebi-nlm.nip.gov/pubmed15880893

© Alfonso Balmori Martinez Valladolid-spain-december2003 The effects of microwaves on trees.

Radiofrequency Radiation Injures Trees around mobile phone based station. Walldmann-Selsam C[1], Balmori- de la Puente [3], Breunig H[3], Balmori A[4].

Pm ID: 2755133
DOI: 10:1016/j.scitotenv2016.08.045

Doctor Mae-Wan Ho

Mobile Phones and Vanishing Bees

Doctor Wolfgang Volkrodt, Engineer. Bad Neuslodt (F.R Germany)

Transaltion from German: Mikrowellensmog und Waldschaden-Tut sichdoctnochwasinbon?"
Microwave Smog and Forest Damage-Movement in Bon After All

Singer-Katie

Electronic Silent Spring. Facing the Dangers and Creating Safe Limits
http://www.electronicsilentspring.com/primers/wildlife/wireless-devices-wildlife/

Possible Effects of Electromagnetic Fields from Phone Masts on a Population of White Stalk (Ciconia ciconia) Electromagnetic Biology and Medicine, 24;109-119:215 Taylor & Francis, Inc. Doi:10.1080/15368370500205472

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© Alfonso Balmori Martinez Valladolid Spain February, 2003

Response of Maize Seedlinfs to Microwaves at 945 mHz

A.A. Khalafallah, Samira M. Sallam ROMANIAN J. BIOPHYS, Vol. 19, No. 1, P.49-62, BUCHAREST, 2009

Ultrastructure and calcium balance in meristem cells of pea roots exposed to extremely low magnetic fields. Belyavskaya NA[1]

PMID: 1180 3967 for MEDLINE

PLANTS &WILDLIFE Studies:

https://app.box.com/s/tivdzn6msilsfcmyeflsm3o0go9zk9dn

Press Report Telstra, Optus, TPG, spend 1.9 bn on Spectrum,

Luke Hopewell-May 7, 2013.
http://www.gizmodo.com.au/2013/05/telstra-optus-and-tpg-buy-spectrum-in.government-auctions/

Telstra, Optus, TPG, spend 1.9bn on Spectrum,

Renai Lemay 07/05/2013
https://delimiter.com.au/2013/05/07telstra-optus-tpg-spend-1-9bn-on-spectrum/

153 Peer-reviewed Studies or Articles Reporting Significant Effects from EMF Exposures on Wildlife (see pdf.3)

The Oceania Radiofrequency Scientific Advisory Association maintains a large database of published science on EMR.

Trees in Bamberg and Hallstadt in the radiation field of 65 mobile phone base stations

Examples from a documentation about 700 trees (2006-2016)

A Tree Damages beginning on one side

The trees of the Bamberg-Documentation are numbered from 1 to 700.
Those trees which are part of the study „Radiofrequency radiation injures trees around mobile phone base stations“ (Science of the Total Environment 572 (2016) 554-569) have a second, red number.

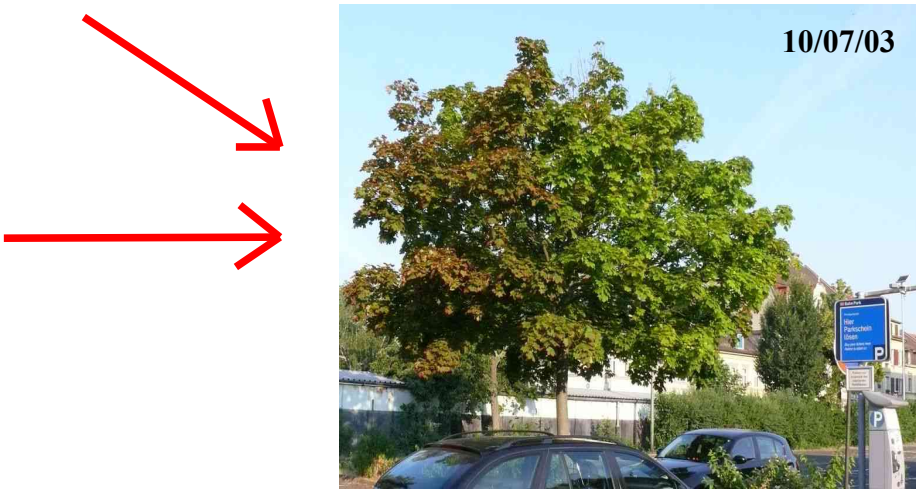
Tree names	Tree species	No	No.	Addresses	Years of document.	felled	page
Maple	Acer platanoides	1	71	Railway station	2009-2013		3
Maple	Acer platanoides	2	56	Hauptsmoorstr. 26a	2008-2012		4
Maple	Acer platanoides	3	234	Berliner Ring	2013-2015		5
Maple	Acer platanoides	4	150	Katzenberg	2010-2011		6
Maple	Acer platanoides	5	304	P&R Heinrichsdamm	2008-2016		7
Maple	Acer platanoides	12	658	Hallstadt, LichtenfelserStr.	2008-2015		9
Maple	Acer platanoides	14	642	Hallstadt, Cemetery	2008-2016		11
Hornbeam	Carpinus betulus	17	181	Hauptsmoorstr. 85	2011-2012		12
Lime tree	Tilia sp.	28	673	Hotel Residenzschloss	2010-2015		13
Lime tree	Tilia sp.	38	668	Hallstadt, Marktplatz	2009-2015		14
Chestnut	Aesculus hippocast.	35	240	Franz-Ludwig-Straße	2008-2012		15
Locust tree	Robinia pseudoacacia	36	290	Gutenbergstraße	2008-2015		16
Mountain ash	Sorbus occuparia	38	158	Hezilostraße	2010-2016	X	17
Box elder maple	Acer negundo	39	193	Kindergarten St. Heinrich	2012-2014		18
Walnut tree	Juglans regia	41	675	Garden of St. Michael	2012-2015		19
Tree of life	Thuja occidentalis	47	118	Cemetery Gaustadt	2009-2012		20
Tree of life	Thuja occidentalis	48	309	Ottostraße	2011-2013	X	21
Douglas fir	Pseudotsuga menziesii	56	24	B22/Strullendorfer Straße	2007-2014		22
Lime tree	Tilia sp.		13	Am Kranen	2006-2011		23
Lime tree	Tilia sp.		534	Klosterhof St. Michael	2007-2012		24
Chestnuts	Aesculus hippocast.		533	Altenburg Castle	2007-2009		26
Lime tree	Tilia sp.		203	Am Hahnenweg	2007-2013		27
Birch	Betula pendula		204	Am Hahnenweg 16	2007-2016		28
Chestnut	Aesculus hippocast.		51	Schützenstraße	2008	X	29

Montain ashes	Sorbus occuparia		14	Breitäckerstraße	2008-2014	X	30
Spruce trees	Picea		538	Zollnerstraße	2008-2016	X	32
Maple	Acer platanoides		59	Robert-Bosch-Straße	2008-2013	X	34
Maple	Acer platanoides		60	Hauptsmoorstr. 67	2008-2011	X	35
Conifer	Conifer		165	Dr.-Rattel-Straße	2008-2016		37
Lime tree	Tilia sp.		226	Residenzstraße/Ottoplatz	2008-2013		38
Poplar	Populus nigra		95	Am Regnitzufer	2008-2016	X	40
Oak	Quercus		94	Bridge in Bug	2008-2014		41
Birch	Betula pendula		252	Grounds of horticult. show	2009-2015	X	42
Birches	Betula pendula		203	Am Hahnenweg	2009-2016	X	43
Walnut	Juglans regia		186	Schoolyard Gangolfschool	2009-2014	X	44
Lime tree	Tilia sp.		355	Garden Heidelsteigschool	2009-2013		45
Birches	Betula pendula		231	Bank of the river Regnitz	2009-2013	X	46
Hornbeam	Carpinus betulus		535	Hainstraße/Sodenstraße	2009-2014		47
Alders	Alnus		143	Campsite in Bamberg-Bug	2009-2013	X	48
Maple	Acer platanoides		145	Playground at the hospital	2010-2014		49
Silver maples	Acer saccharinum		146	Meadow at the hospital	2010-2014		50
Locust tree	Robinia pseudoacacia		164	Don-Bosco-Straße	2010-2013	X	51
Lime tree	Tilia sp.		275	Campsite in Bamberg-Bug	2010-2014	X	52
Pine	Pinus		170	Babenbergerring	2011-2012	X	53
Chestnut	Aesculus hippocast.		410	Beer garden Mahr's-Bräu	2011-2014	X	54
Beech	Fagus sylvatica		254	Grounds of horticult. show	2012-2016		55
Lime tree	Tilia sp.		217	Schönleinspl./Promenade	2013-2014		56
Maple	Acer platanoides		427	Babenbergerring	2014-2016		58

Maple, parking-lot at the railway station (2009-2013)

View from the east

On 27 July 2009 the difference between the two sides was striking. The leaves on the left side had brown margins, the leaves on the right side were green.



In 2010 the side difference was visible already on 3 July. Southwards (left) visual contact to phone masts Ludwigstr. 2 (275 m) und Ludwigstr. 25 (190 m). Phone mast Heiliggrabstr. 15 (280 m) westwards was hidden behind trees at that time.

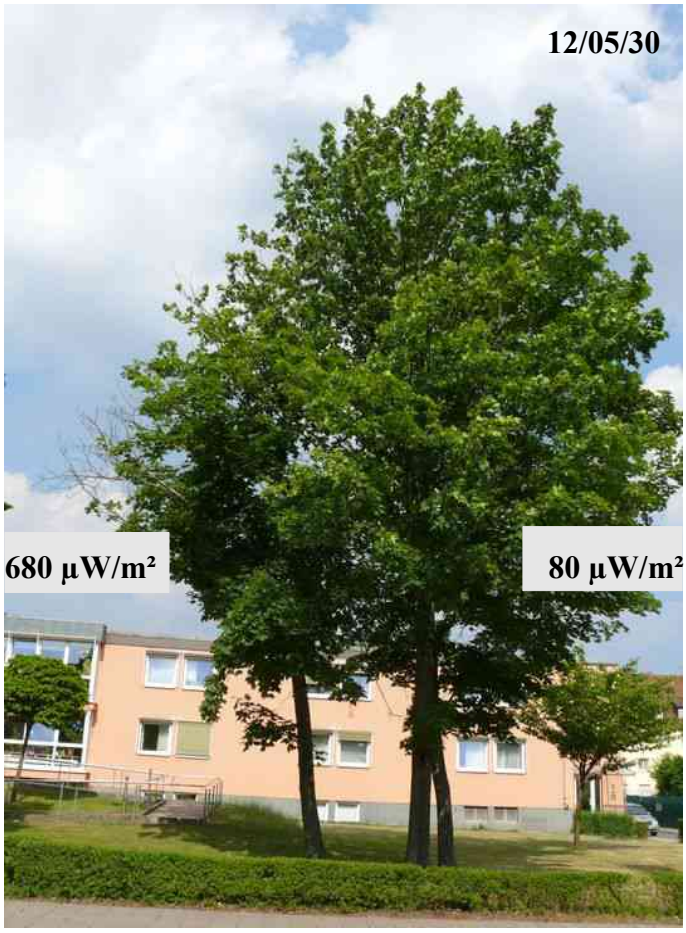
970 µW/m²
Measurement on the left side in a height of 3 m

130 µW/m²
Measurement on the right side in a height of 3 m

Measurements on 30 May 2012 standing at the top of a ladder: south side 970 µW/m² (0.60 V/m), north side130 µW/m² (0.22 V/m). On 5 Aug. 2013 the maple had already lost leaves on the left side.

Maple, Hauptsmoorstr. 26a (2008-2012)

On 8 June 2008 it was noticed, that the northern side of a group of maples (on the right) was damaged. It was the side facing the mobile phone antennas situated on the building. Side beams of the sector antennas reach the maples.



View from the west
In May 2012 the damage had increased on the left side. The right side showed no damage.

680 µW/m²

80 µW/m²

On 30 May 2012 measurements were carried out with the EMF-broadband analyzer HF 59B (27 MHz – 3300 MHz), UBB27_G3, from Gigahertz Solutions (measurement of the sum, peak values of power flux density in µW/m²). Value left side: 680 µW/m², value right side: 80µW/m². This difference can be explained by attenuation within the tree. A part of the RF-EMF is absorbed from the leaves, a part is reflected, scattered and diffracted.

Maple, Berliner Ring (2013-2015)

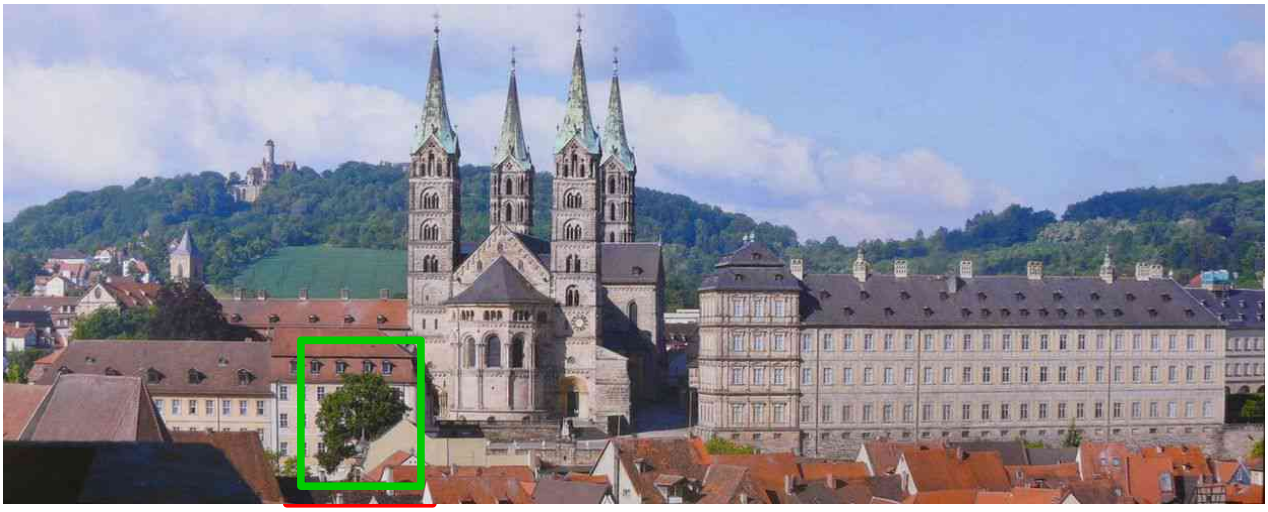
View from the east

On 13 May 2013 crown transparency was observed in the upper left section.
Phone mast Pödeldorfer Straße 144 (height 23 m, 18 sector antennas) in a distance of 77 m.

On 7 June 14 dead branches were seen in the upper left section. Leaves on the left side were brown.

On 4 June 15 the damage had increased. Measurements were carried out on 14 June 2015.

Maple at the Cathedral square (2010-2011)



Postcard: View from St. Martin to the Cathedral, the New Residence, Altenburg and the maple

Since 2008 early browning on the eastside.

Since 2011 severe crown damage.

Visual contact to phonemast Grüner Markt 23 (440 m).

Broken branches besides passing tourists.

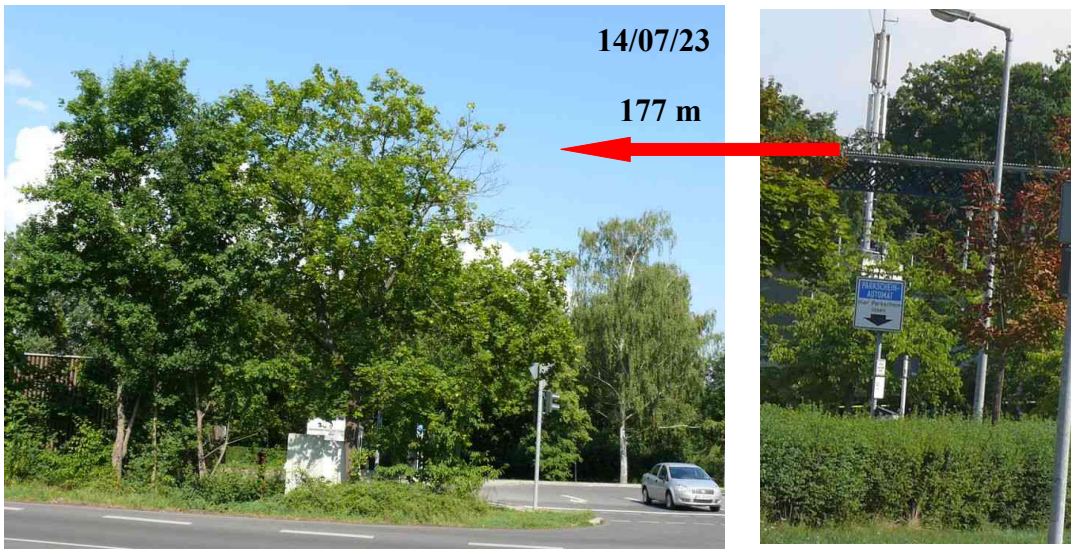
Maple, P&R-Heinrichsdamm (2008-2016)

View from the west

On 29 August 2008 crown transparency in the upper right section was remarked. Visual contact to phone mast Heinrichsdamm 33 a (height 17 m, 6 sector antennas) in a distance of 177 m was given.

On 25 September 2009 the maple had lost its leaves in the upper right section too early in the year.

On 25 August 2010 some little branches were dead.



On 23 July 2014 more branches died off. Birch with crown tranparency in the background.

On 30 July 2015 dead branches on the south side had been cut. The birch had already lost leaves. The phone mast had been enlarged (12 antennas). Measurements with the help of a telescopic rod.

On 1 July 2016 the dead birch had been felled. The injury to the maple will go on.

Maple, Hallstadt, Lichtenfelser Straße (2008-2015)

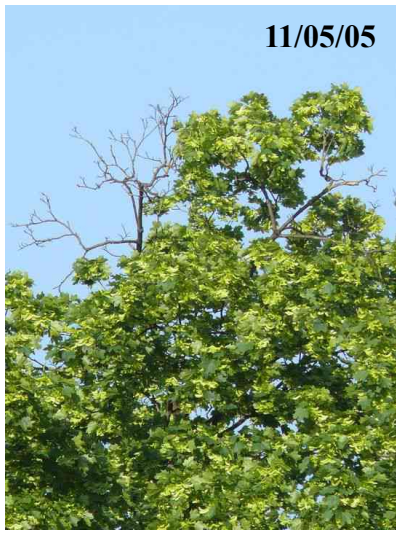
View from the west

View from the east

The lime tree on the left is shielded, the maple on the right is exposed. Damage on the exposed side.

View from the west

In May 2011 the situation was similar.



View from the northwest

Dead twigs and branches on the top.

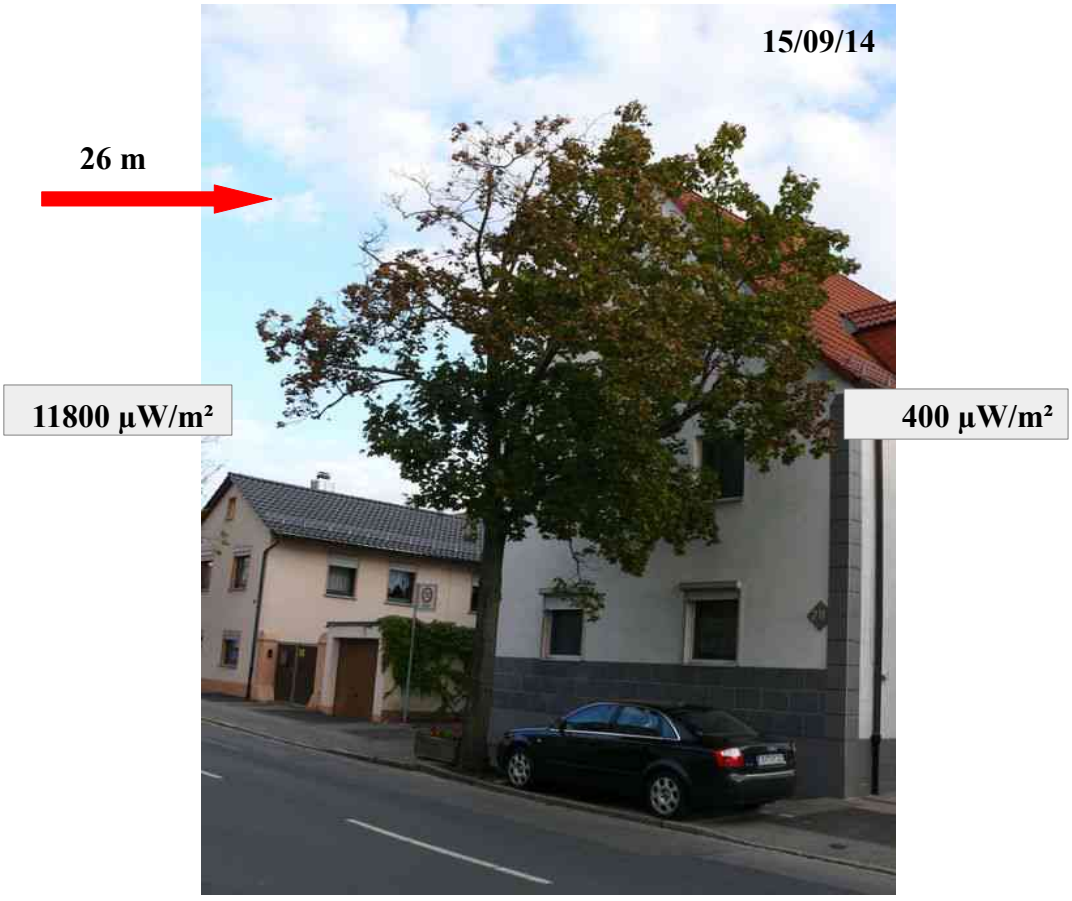
View from the west

In September 2015 the lime tree has dense, green foliage but the maple is brown and has lost leaves.

View from the northwest

View from the north

In May 2011 dead twigs and branches on treetop and on the northeast side, facing the antenna.



View from the northwest

On 14 September 2015 the difference between the northeast side and the southwest side is considerable. The measurements were done with the help of a telescopic rod.

Maple, Hallstadt, cemetery (2008-2016)

View from the southeast

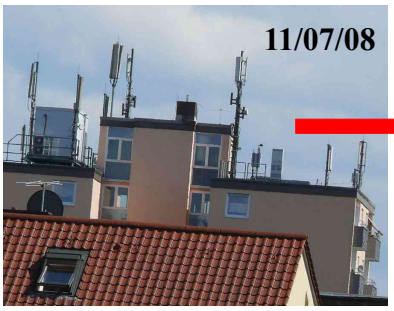
On 27 June 2008 dead branches were observed on the left side of the maple. Visual contact was given to phone mast Landsknechtstr. 23 (height 14-17 m, 6 sector antennas) in a distance of 142 m.

View from the west

On 5 october 2015 parts of the left side had been cut off. In the middle the tree was transparent and brown. The right side had dense, green foliage. Measurements with the help of a telescopic rod.

Numerous trees in and around the cemetery have been felled in the last years - again in winter 2015.

Hornbeam, Hauptsmoorstr. 85 (2011-2012)



Mobile phone site
Hauptsmoorstr. 26 a
with 18 sector antennas

450 m

View from the northeast

Detail from the upper crown

On 8 July 2011 leaves on the left (southeast) side of the hornbeam had brown margins.
Visual contact was given to phonemast Hauptsmoorstr. 26a in a distance of 450 m.

View from the northwest
Scale mW/m²
Measurement on the southeast side,
visual contact to the phonemast.

Scale mW/m²
Measurement on the northwest side,
no visual contact to the phonemast.

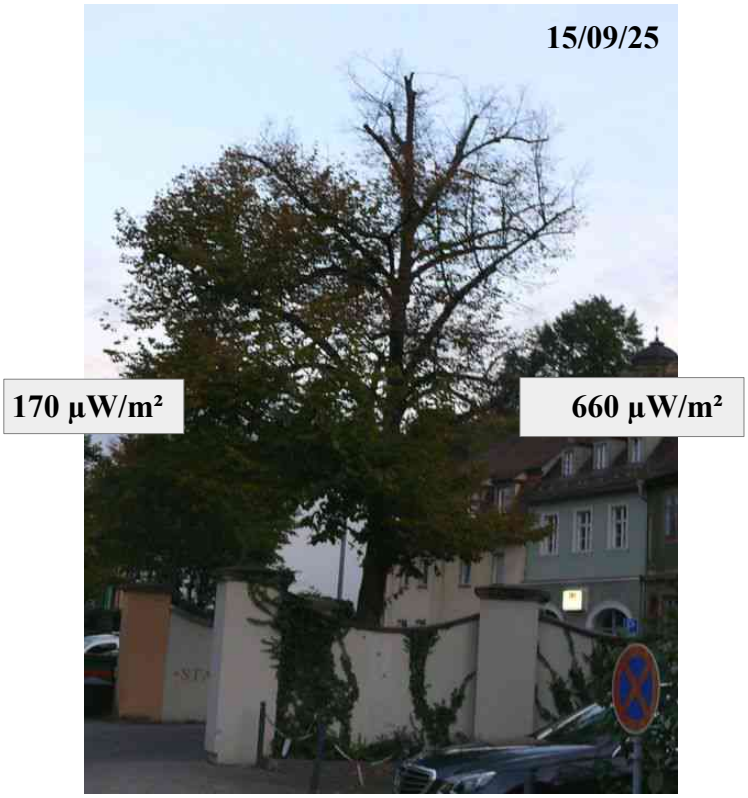
On 23 May 2012 measurements were carried out
Measured value southeast side: 1100 µW/m², northwest side: 0 µW/m².

Lime tree, Hotel Residenzschloss (2010-2015)

View from northeast over lime to the former Monastery St. Michael with phonemast

Looking from northwest the difference between the left and the right side was sharp.

On 20 August 2014 the left side was green. The right side and the top were brown or leafless

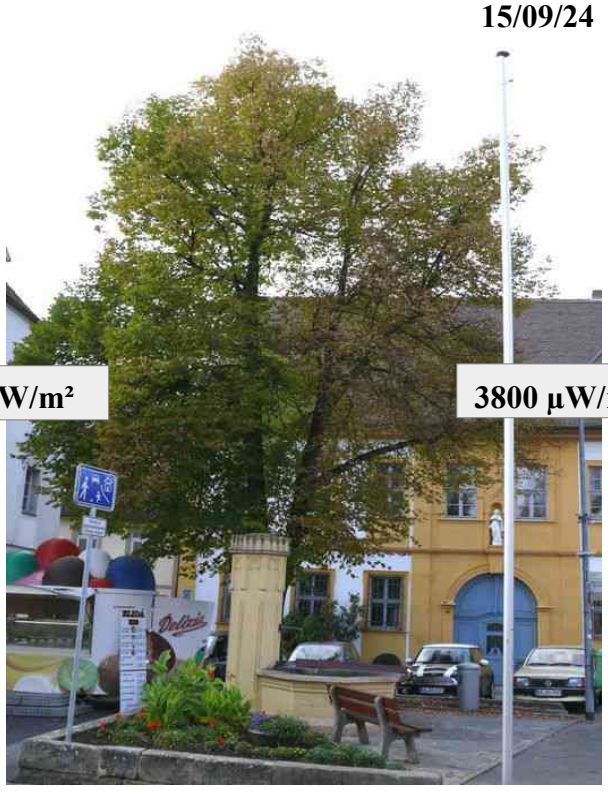


In 2015 the situation was similar. Measurements were done on 25.09.15.

Lime tree, Hallstadt, Marktplatz (2009-2015)

View from the south
On 26 September 2009 the lime tree was brown on its right (east) side.

View from the southwest
From the east side visual contact to phone mast Lichtenfelser Str. (height 16 m, 6 antennas) in a distance of 354 m

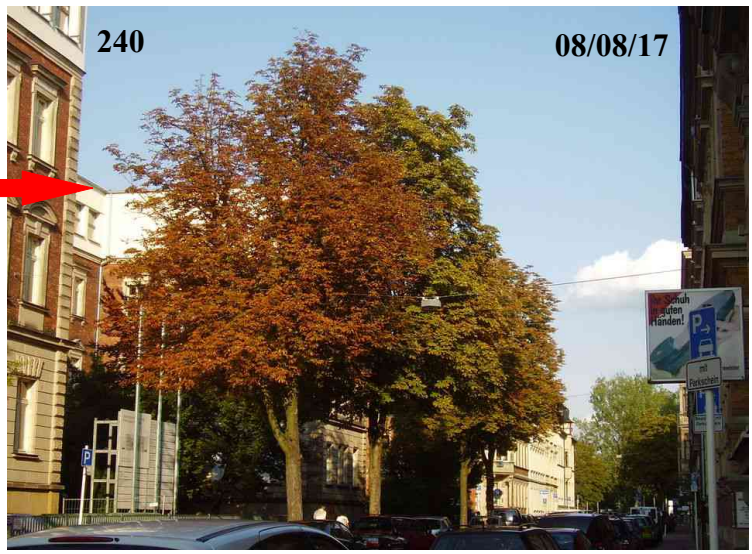


On 24 September 2015 the right side was brown and had already lost leaves. .

On 9 October 2015 the right side was leafless. The phone mast had now 18 sector antennas.

Chestnuts, Franz- Ludwig- High school (2008-2012)

470 m



View from the west

In August 2008 the first chestnut was brown and on treetop leafless; the second chestnut was green.

In 2010 the first chestnut had lost already many leaves. The browning began at the leaf margins.

Measurements on 30 July 2015 in front (west) of chestnut 1: 400 µW/m², behind (east): 20 µW/m².
Visual contact from the first chestnut to phone mast Grüner Markt 23 (height 35 m, 23 antennas).

Locust tree, Gutenbergstraße (2008-2015)

View from northeast

On 29 August 2008 the beginning difference between the left (southeast) and the right side (north-west) was observed. Visual contact to phone mast Gutenbergstraße (height 39-46 m, 22 antennas).

On 1 August 2012 branches in the upper part of the right side were dead

On 14 July 2015 measurements in a height of 3 m had been carried out with the help of a ladder.

Mountain ash, Hezilostraße (2010-2016)

555 m

View from the east

In August 2010 the remarkable side difference was noticed. Altenburg Castle with Visual contact to the Altenburg Castle in the north was given (distance 555 m). 17 sector antennas

Measurement on the left side: 8.2 µW/m² (scale µW/m²)

Measurement on the right side: 83.9 µW/m² (scale µW/m²)

In 2012 the side difference was seen already in May. The left (southern) half had dense foliage. The right (northern) half showed defoliation. Measurements were carried out on 29 May 2012.

In 2014 the whole mountain ash was tranparent and partly leafless already in July. Damages at other trees in this southwestern part of Bamberg had increased also.

In May 2016 the tree had been cut down.

Box elder maple, Kindergarten St. Heinrich, Pödeldorfer Straße (2012-2014)

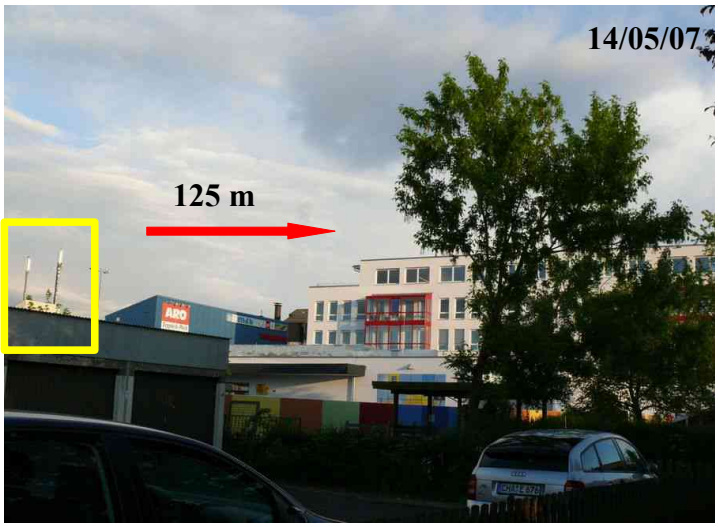
193 **12/05/31**

Measurement on the side of the tree, which is facing the phone mast.

View from the northwest
This Box elder maple in the garden of Kindergarten St. Heinrich had severe damage on the left side.

Measurement on the opposite side.

In summer and in autumn 2013 the gardener had cut off several branches.



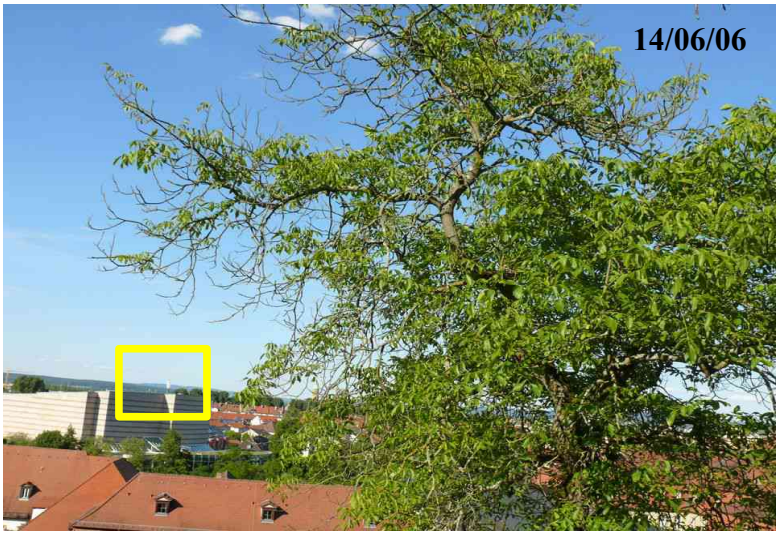
Visual contact was given to phonemast Pödeldorfer Str. 144 in a distance of 125 m.

Walnut tree, Garden of the former Benedictine monastery of Michelsberg (2012-2015)

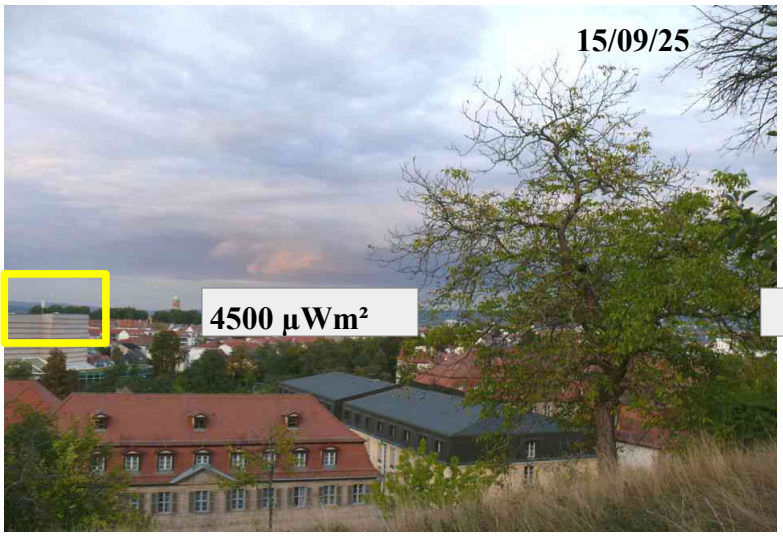
Concert and Congress Hall of the „Bamberg Symphony Orchestra“ with phone mast

190 m

View from the southwest
On 12 July 2012 the walnut tree showed severe crown tranparency.



On 6 June 2014 many branches on the north and on the east side were dead.



On 25 September 2015 the walnut tree had leaves only on its southwest side.
On the Concert and Congress Hall the number of sector antennas had increased from 6 up to 21.

Tree of life, Cemetery Gaustadt (2009-2012)

118 **09/08/25**

108 m

10/08/13

View from the southwest
On 25 August 2009 the unilateral damage of the tree of life was observed. From the right side visual contact is given to phone mast Breitäckerstr. 9 (height 27 m, 12 antennas).

On 13 August 2010 the damage was similar. On the cemetery and in the surrounding gardens numerous trees and shrubs with severe crown damage were found.

12/04/25

30 µW/m²

12/04/25

12/04/25

910 µW/m²

On 25 April 2012 the power flux density on the left side was in the range between 30 and 130 µW/m², on the right side between 360 und 1600 µW/m². The tree attenuates the radiation.

Pine tree, tree of life and maple, Ottostraße (2011-2013)

Leaves of the maple

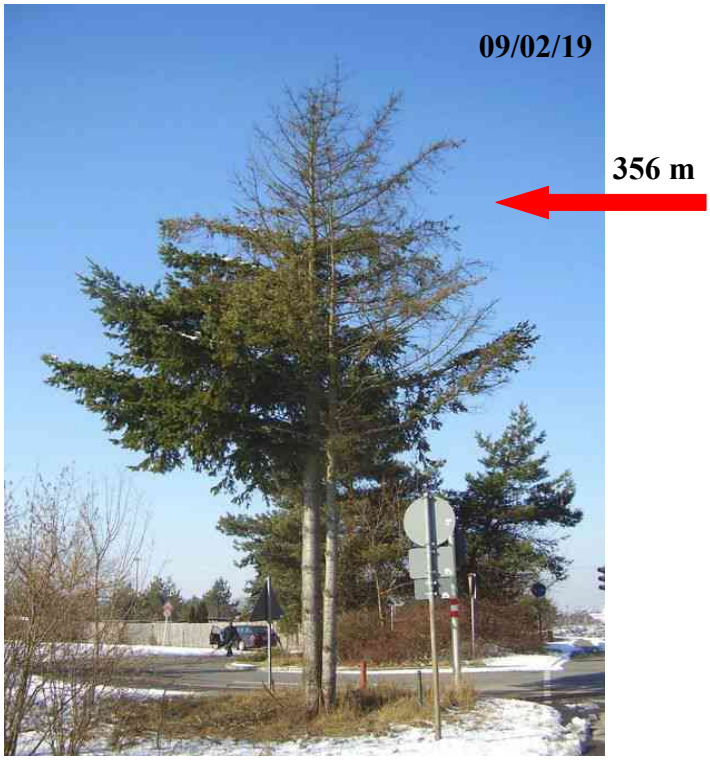
View from the southwest to pine tree, tree of life and maple. On 16 June 2011 the leaves on the south side of the maple had brown margins, the south side of the tree of life was leafless and the south side of the pine tree had lost many needles.
Visual contact was given to phone mast Hainstr. 39 (height 18 m, 6 antennas) in a distance of 395m.

View from the trees to the phone mast in the south

On 11 September 2013 the damages of the tree of life and of the maple had increased. The phone mast had been enlarged up to 21 sector antennas. Measurements were carried out at the tree of life in 2015. South side: 120 µW/m², north side 10 µW/m².

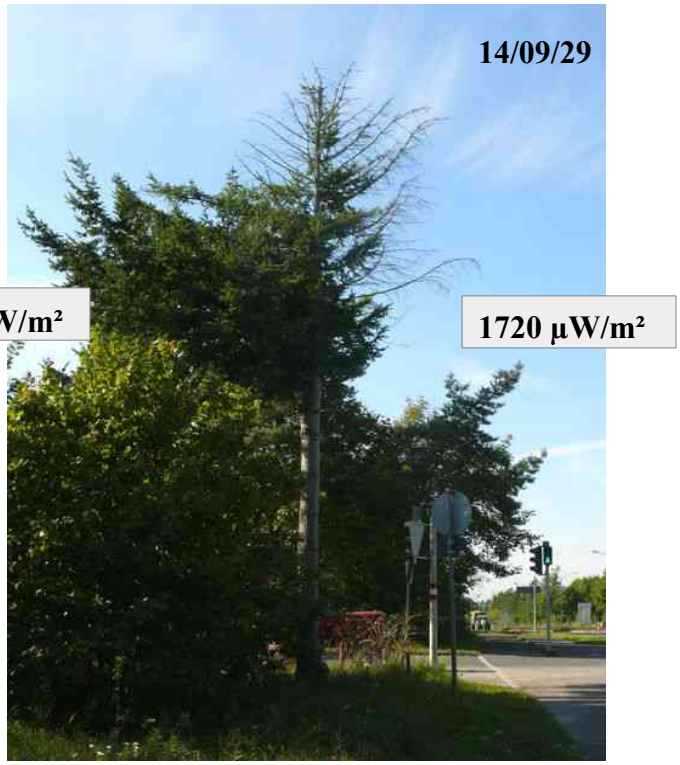
Douglas fir, B22/Strullendorfer Straße (2007-2014)

View from the south to the Douglas fir and phone mast Gutenbergstr. 20. On 24 July 2007 an unusual distribution of damage was seen.



View from the southeast to the Douglas fir. The tree had lost its needles in the upper part and on the right side.

Increase of needle loss.

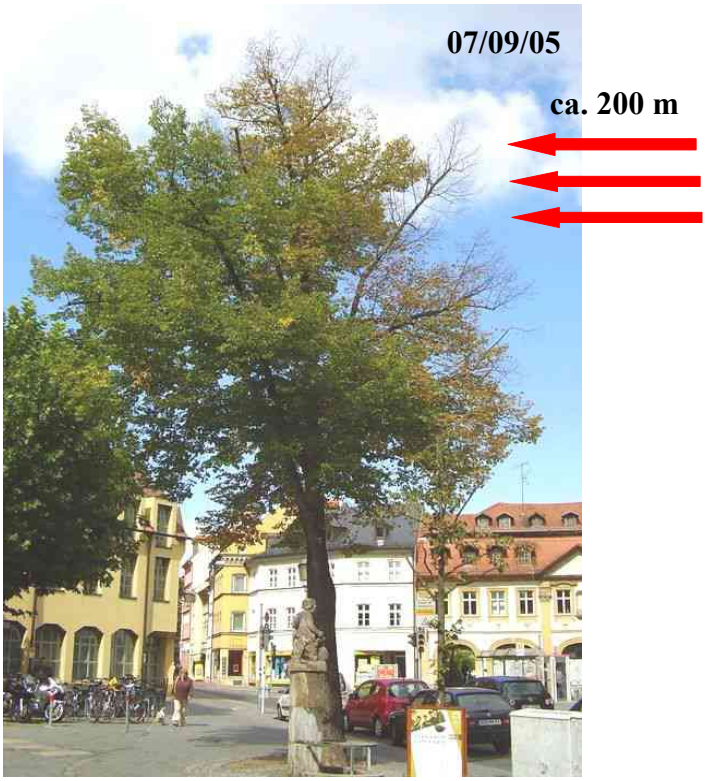


Needles only in the lower quarter on the left.

Heat, frost, drought, compaction and sealing of the soil, road salts, air and soil pollutants, diseases or pests cannot explain this “three-quarter-illness”. RF-EMF from phone mast Gutenberstr. 20 (height 39- 46 m, 22 sector antennas) reach the Douglas fir. Measurements on 27 September 2015.

Lime tree, Am Kranen (2006-2011)

View from the south
In Sept. 2006 a difference between left and right side was noticed. The right side was brown and partly leafless; the left side green with dense foliage



On 5 September 2007 the difference between left and right had increased.

On 26 Sept. 2009 branches on the right were dead.

On 17 Sept. 2011 dead parts had been cut off.

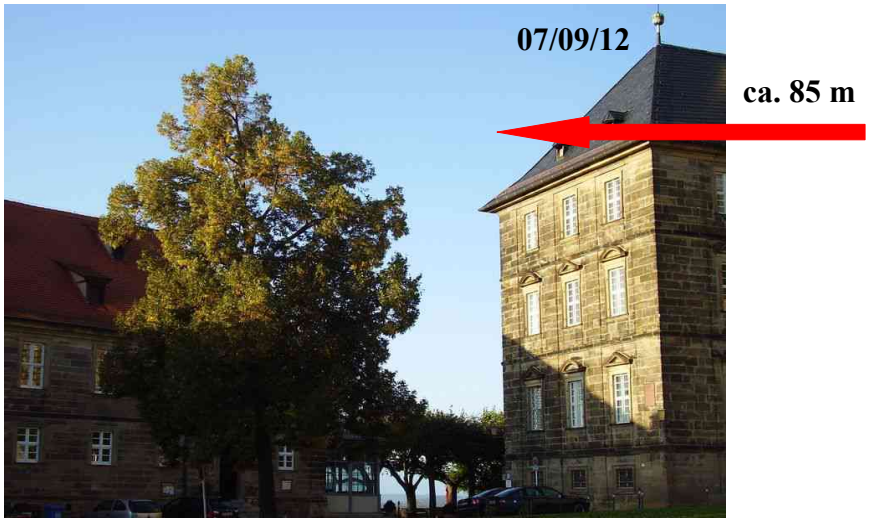
RF-EMF from phone mast Grüner Markt 23 (height 28- 35 m, 23 sector antennas) reach the tree.

Lime tree, Michelsberg Monastery (2007-2012)

View from the west

On 12 Sept. 2007 beginning crown tranparency was seen. Some leaves turned yellow too early. A phone mast is situated in the roof of the former monastery. The RF-EMF hit the lime tree. The chestnut in the background, which is located in a radio shadow, is still green

On19 August 2012 holes were noticed in the upper crown. The chestnut was healthy.



View from the south

On 12 September 2007 the view from the south showed a difference between the left and the right side in the upper part The leaves on the right side on top were already brown.

On 2 October 2009 the differences between left and right and top and down were more pronounced.

On 19 October 2011 it was visible that branches had been cut. There were no construction works which could have injured the roots. In the year 2005 three sector antennas were added to the existing Nondirectional antenna. The Lime tree stands in the radiation field of the 230°- sector antenna.

Chestnuts, Altenburg (2007-2009)

Altenburg tower with 17 sector antennas and directional antennas

On 12 Sept. 2007 the difference between the two chestnuts was noticed.

On 30 August 2008 chestnut left was green, chestnut right yellowish brown (leaf margins brown).

On 20 Oct. 2009 chestnut left still had leafs. Chestnut right was leafless. The chestnut on the right is probably hit by side beams. She attenuated radiation and protected the chestnut left from RF-EMF.

Lime tree, Am Hahnenweg/Würzburger Straße (2007-2013)

View from the north
The early loss of leaves on the west side was noticed. From the west (Altenburg) RF-EMF reach the tree. Additionally directional radio link crosses here.

View from the south
In the year 2010 the brown colouring and the loss of leaves on the west side were observed already on August 22.
On the west side branches hat been cut

On 14 August 2011 it was noticed, that dead twigs and branches had again been cut off.

On 30 Sept.2013 left side leafless, right side leafy. Nearby a further phonemast was installed in 2014.

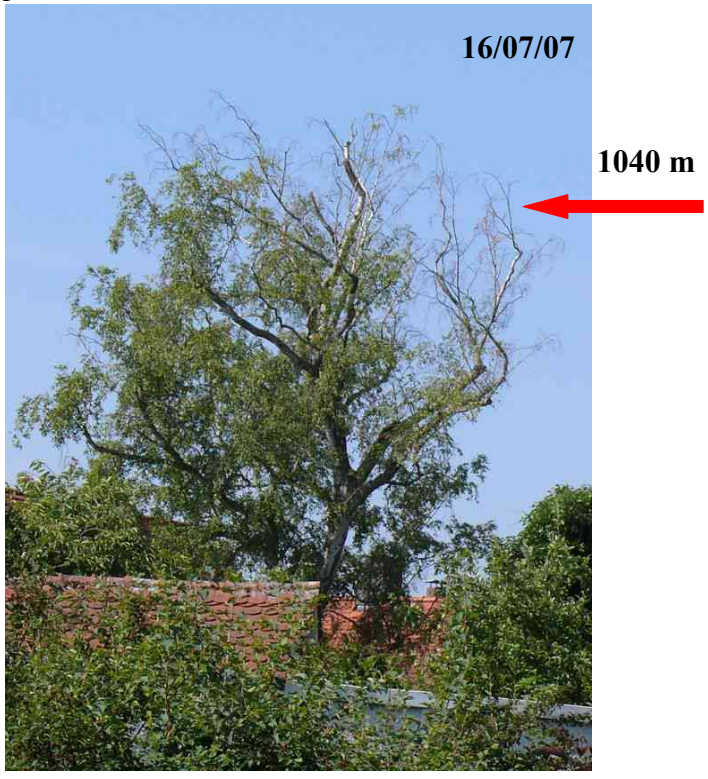
14/11/05

Birch and Conifer, Am Hahnenweg (2007-2016)

View from the south
On 18 September 2007 the birch had already lost many leaves.

View from the south
In the following years damage in the upper part of the birch was observed.

View from the southeast
In February 2011 dead parts on the top had been removed. The tree on the northwest side had been cut down. The tower of the Altenburg is visible.
The conifer had lost needles on the exposed side.



View from the northeast
This perspective shows that the damage has begun on the side which is oriented towards the Altenburg (distance 1040 m) with 17 sector antennas.

Chestnut, Schützenstraße/Busstop Sodenstraße (May- October 2008)

51 **08/05/15**

08/07/08

In May 2008 the chestnut had grown no leaves on its left side.

In July some leaves were already brown. One dead branch had been cut off.

Visual contact was given to phone mast Hainstr. 39, which started operating in 2007.

08/08/19

08/10/22

In August 2008 the whole chestnut was brown.

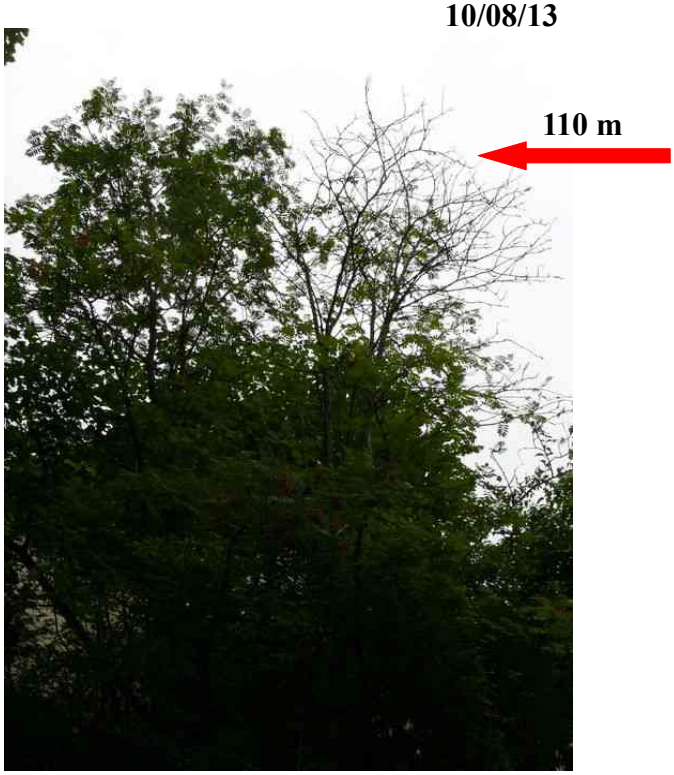
In October 2008 the chestnut had been felled.

Mountain ashes, Breitäckerstraße (2008-2014)

14 **08/06/07**

View from the northwest
On 7 June 2008 the difference between the two mountain ashes in a garden was noticed.

10/08/13



On13 August 2010 the difference had increased. Many branches of the ash on the right were dead. The ash was felled.

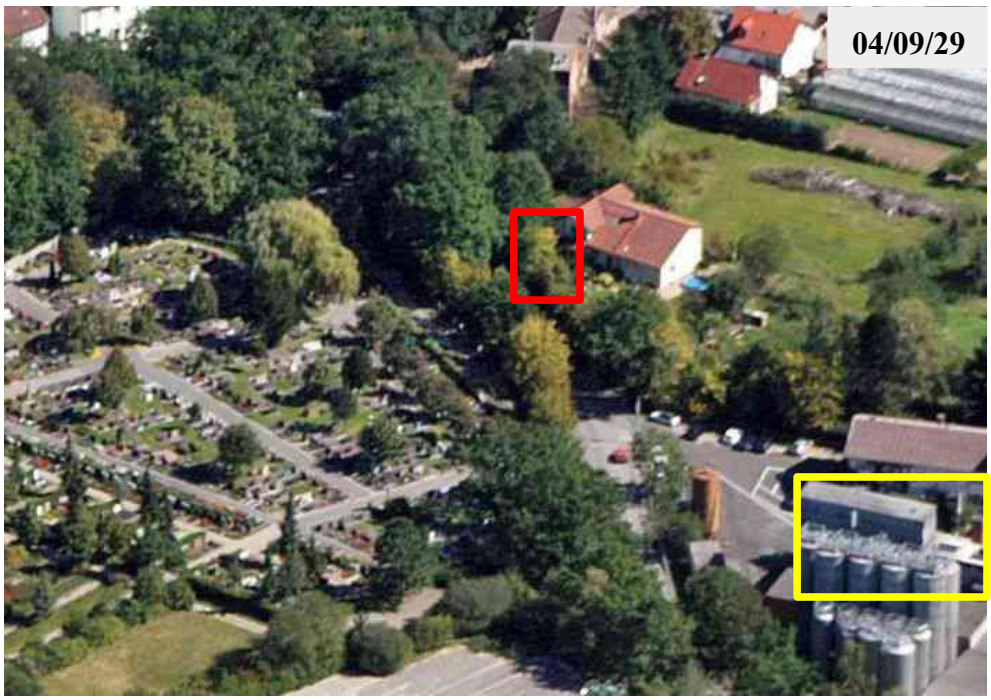
As a result the ash on the left was not shielded anymore. On 31 August 2013 the left ash had died back also.

In the summer 2014 the second mountain ash had been felled too..

This difference between the two mountain ashes in 2008 can be explained by the attenuation of radiation through leaves. In the year 2008 a great amount of the RF-EMF was absorbed from the ash on the right and reflected, scattered or diffracted. Therefore the exposure of the ash on the left was initially much lower than the exposure of the ash on the right. However, after the ash on the right hat been felled, the radiation increased considerably.
In the garden numerous other decidous trees and conifers showing damage were found. In the southern property line which is close to phonemast Breitäckerstr. 9, a gap in the tree population had occured already in 2007. Measurement in the garden on 22 November 2004: 1400 µW/m².
The phonemast is situated in a distance of 110 m from house and garden of a family with four children. The whole family suffered since 2000 from unexpainable symptoms.

29.09.04

Phone mast Breitäckerstraße 9 (07.07.10): height 25,7 m – 26,8 m, 12 sector antennas (2 x 30°, 60°, 95°, 2 x 150°, 180°, 215°, 2 x 270°, 300°, 335°) und directional radio.



Aerial picture, H. Dietz, NürnbergLuftbild

View from southwest to the cemetery of Gaustadt and the phone mast Breitäckerstr. 9 (yellow). The effects on trees could already be recognized through the early yellowing in the year 2004. The mountain ashes, which have been cut down meanwhile, are marked red.

Spruce trees and birch, Zollnerstraße (2008-2016)

View from the southwest

In June 2008, the spruce, which was closer to the phone mast (distance of 55 m), lost many needles in the upper part. The birch did not grow upwards.

In July 2011 the loss of needles had increased. The birch did not prosper.

In August 2013 most needles had gone. The phone mast was enlarged. Measurement: 3280 µW/m².

In April 2014 the situation was similar.

In April 2015 the spruce on the right had been felled.

In May 2016 the birch had died off. The spruce on the left began to loose needles.

Maple, Robert-Bosch-Straße (2008-2013)

View from the south
In June 2009 the damage on the right (east) side and on the top was noticed.

Phone mast
Robert-Bosch-Str. 40
Height 30 m,
9 antennas

In 2009 the damage had increased.
The distance to the phone mast was 320 m.

In 2011 further decline. In July 2012 the dead branch broke during a storm.
Measurement on 21.07.12: 1680µW/m².

13/05/01

Later in 2012 the maple was felled.
Large parts of the Virginia Creeper on the east side of the house died off.

Maple, Hauptsmoorstraße (2008-2011)

60 **08/07/08** **10/08/07**

280 m

View from the northeast
In July 2008 the unilateral damage of the maple tree was seen. Visual contact was given to the mobile phone site Hauptsmoorstr. 26a.

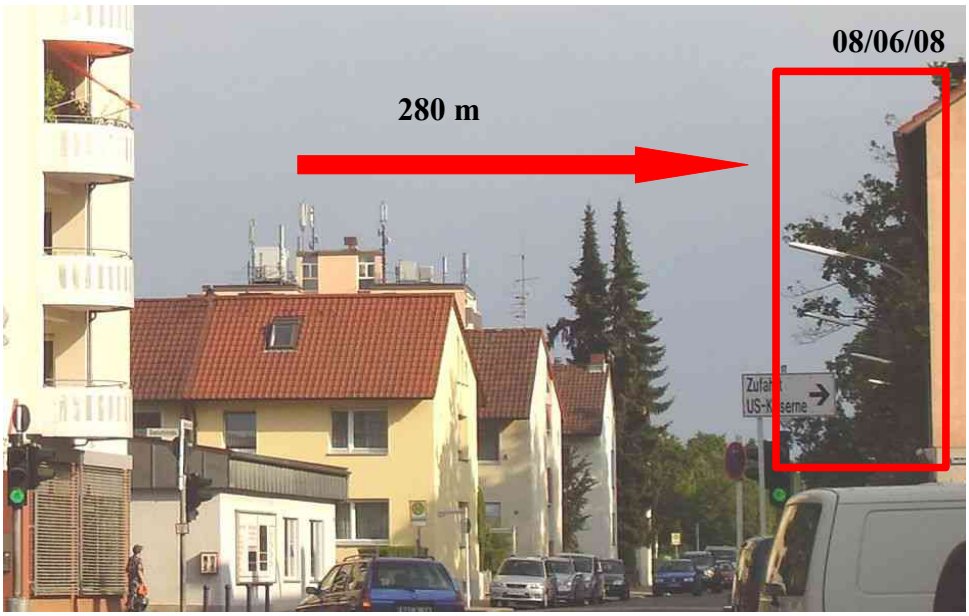
The dead branches had been cut off.
On 7 August 2010 the leaves on the left side were brown.

11/02/05

The maple tree showed even without leaves that damage had taken place.

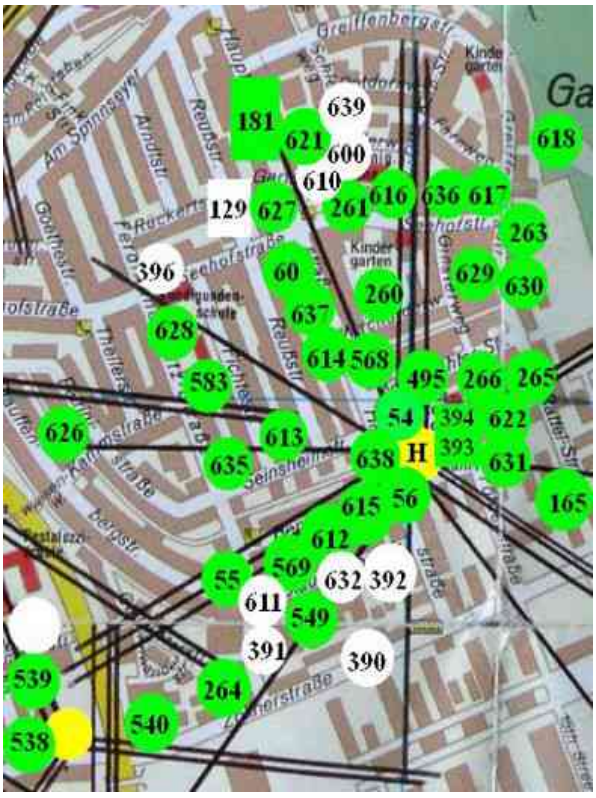
11/06/03

Road safety was not ensured anymore because of the asymmetrical shape.
In spring 2011 the maple tree was felled.



View from the crossing Hauptsmoorstraße/ Seehofstraße on the damaged maple tree to the right, mobile phone site Hauptsmoorstr. 26 a and two conifers with growth disturbance on the top. Mounting height: 26,6 m – 31,1 m, eighteen sector antennas (3 x 0°, 2 x 60°, 95°, 3 x 120°, 140°, 180°, 215°, 3 x 240°, 270°, 300°, 335°).
Around this mobile phone site numerous tree damages in gardens often beginning on the side, which was facing the antennas, were documented since 2008. All existing trees were affected: pear, cherry, walnut, birch, lime tree, beech, oak, hornbeam, field maple, tree of life, yew, sugarloaf spruce and various conifers. Only in the radio shadow of buildings one could see healthy trees.
More trees around this site: pages 80, 81, 195, 222, 252, 371-380, 498, 499, 569, 608, 623, 636.

View from the west
Unilateral damaged cherry tree in Benkertstraße with visual contact to the phone mast.



Phone mast Hauptsmoorstr.(H), sites of exposed trees (green), of trees in radio shadow (white).

Conifer, Dr.-Rattel-Straße/US-Army (2008-2016)

192 m

View from the northeast

On 8 July 2008 this unilateral damage pattern of a conifer was perplexing.

Over eight years only a slight increase of the damage appeared.

View from the east

From the conifer on the left visual contact to the phone mast Haupstsmoorstr. 26a is given.

Lime tree, Residenzstraße/Ottoplatz (2008-2013)

View from the southeast

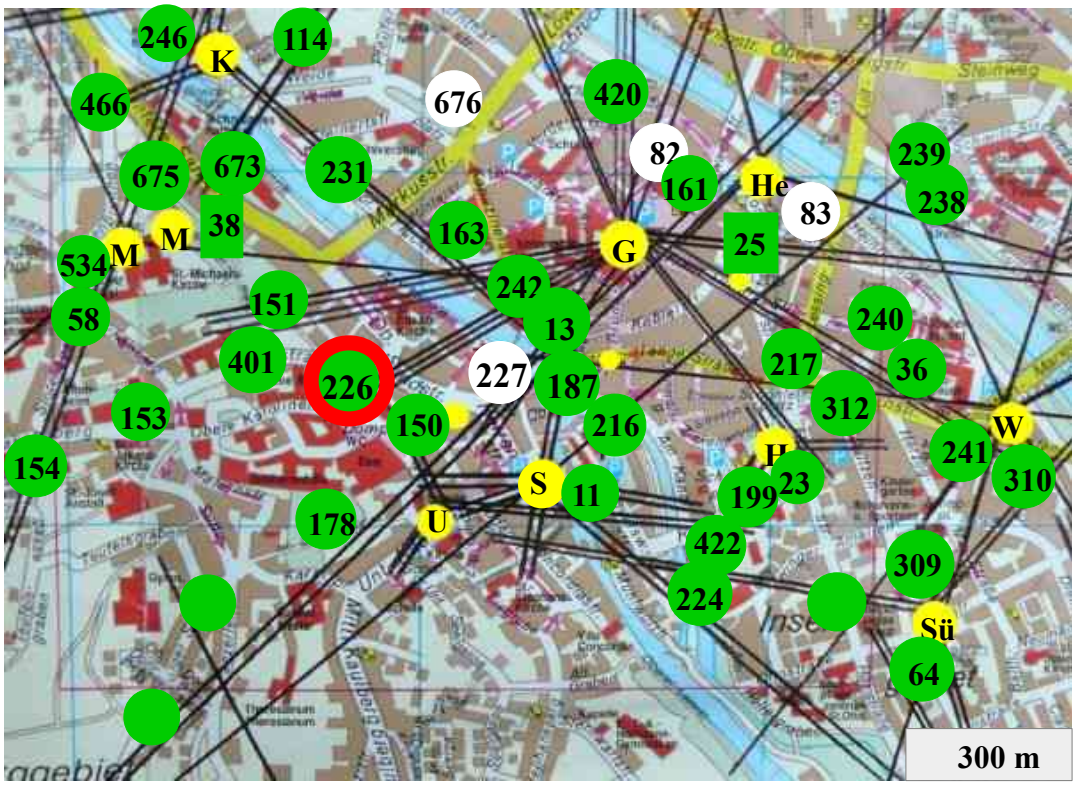
On 18 August 2008 loss of leaves and brown colouring was noticed. Only on the left green leaves were seen.

In the following time the asymmetrical damage pattern in the crown increased.

In 2011 dead branches on the eastside had been cut off. On 7 July the tree had already lost many leaves.

In 2013 the situation was similar.

From the east RF-EMF of several phone masts reach the tree (see map).



Detail from City map Bamberg with Cathedral square, Michelsberg, Concert Hall, Center, Schranne, Wilhelmsplatz and a part of the Haingebiet. The sites of the phone masts (yellow), the main beam directions of the sector antennas (black), sites of exposed trees (green) and sites of trees in the radio shadow of buildings were added (base of the map: City map Bamberg, 23. edition, Städte-Verlag E. v. Wagner & J. Mitterhuber).

10/07/12

View from the southwest
View from the Rosengarten over the lime tree to phone mast Grüner Markt 23.
On its westside the lime tree was still green.
Measurement on 12 July 2010: 3830 µW/m²

227 **08/09/21**

On 21 Sept. 2008 the lime tree in the court of the former Dominican Monastery (now Schlenkerla) had still dense foliage. The tree is shielded by the sourrounding buildings.

Poplar, Am Regnitzufer (2008-2016)

ca. 2 km

View from the north to poplar and elder. On18 August 08 the poplar was yellow on the left side. Visual contact is given to phonemast Gutenbergstr. 20 in a distance of around 2 km,

View from the northwest. On 24 Sept. 09 the poplar had lost many leaves on the left side.

On the left side branches had been cut. In the following years the crown grew asymmetrically. On 22.09.13 the elder had already lost most leaves.

Because of the asymmetrical shape road safety was not ensured anymore. In winter 2015 the poplar was felled.

Oak, Brigde in Bamberg-Bug (2008-2014)

ca. 2 km

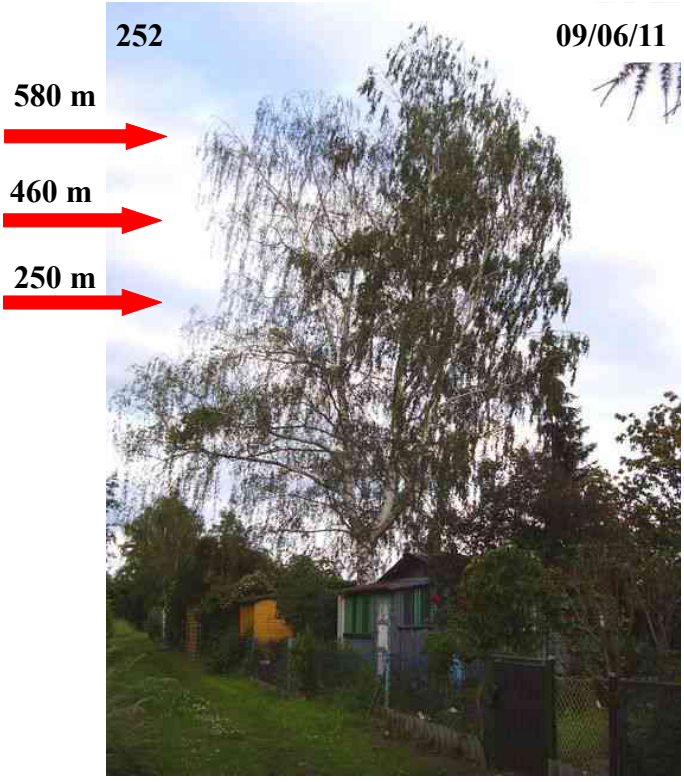
View from the northwest

In Oct. 2008 differences concerning defoliation between left and right side and between upper and lower part of the oak were noticed. From left (northeast) radiation of phone mast Gutenbergstr. 20.

In May 2010 crown transparency on the left side and on the top

In July 2014 some branches on the left side and on the top had died off.

Birch, Allotment garden Black bridge/grounds of horticultural show 2012 (2009-2015)



View from the northwest
Allotment garden Black bridge.
In June 2009 the unilaterally damaged birch was seen. More birches had already been felled.

Horticultural show 2012, Port adventure path.
RF-EMF from three phone masts in the port. reach the birch. Measurements along the path.

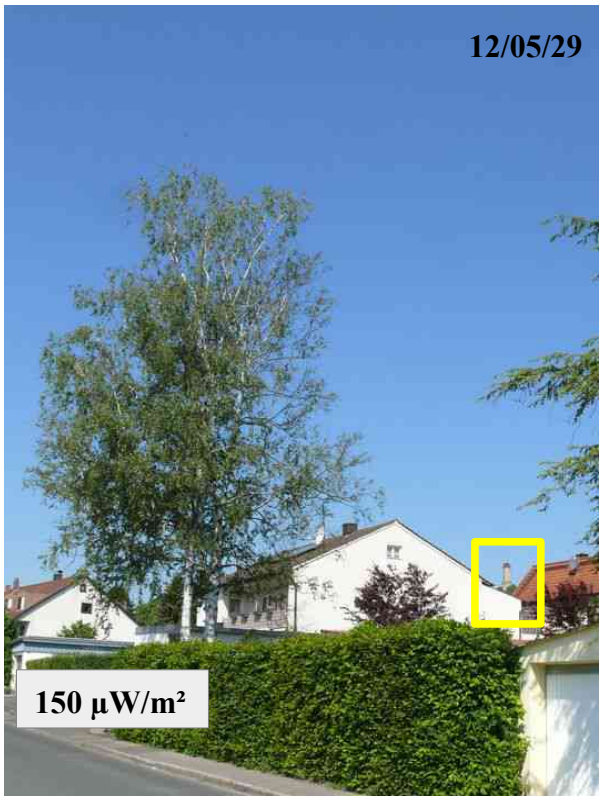
On 06 August 2014 the leaves had turned brown - probably as a result of putting into operation 4 G (LTE Long-Term Evolution).

In winter 2014/2015 the birch had been felled.

Birches, Am Hahnenweg (2009-2016)

View from the east
On 14 June 2009 a slight difference between the south and the north side of the birches was visible. The growth of the conifer was disturbed.

On 22 June 2010 the difference between the two sides was clearer. Visual contact was given to the phone mast Altenburg (810 m).



View from the southeast
On 29 May 2012 the unilateral damage and the damage of the treetop had increased.

From year to year it became worse.
In 2016 the birches had been felled.

Walnut, Schoolyard of the Gangolfschool (2009-2014)

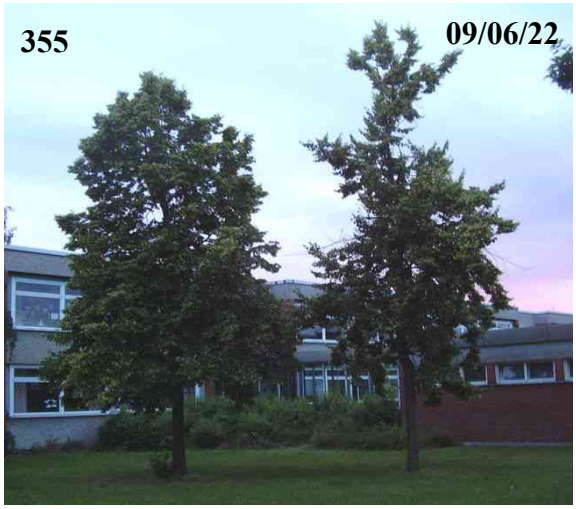
View from the southeast
In June 2009 crown damage and a difference between the left and the right side was seen.

In July 2011 branches on the right had died off.
RF-EMF from northeast (Ludwigstr. 25).

In August 2013 dead parts on the right and on top had been cut off. But the right side was leafless.

In July 2014 the walnut was felled. Phone mast Ludwigstr. 25: height 37 m, 3 (now 12) antennas.

Lime trees, Heidelsteigschool (2009-2013)



View from the southeast

In June 2009 the difference between the two lime trees on a meadow was perplexing because they stood under largely identical site conditions.

However, there is one difference: from the right RF-EMF from the phone masts Kantstr. 33 (height 43 m, 9 sector antennas) and An der Breitenau 2 (height 28 m, 21 sector antennas) reach the trees. A great amount of the electromagnetic waves is absorbed from the lime tree on the right and reflected, scattered or diffracted. Therefore the exposure of the lime tree on the left is much lower.

On 17 Sept. 13 the lime tree on the right had already lost many leaves. Measurements on 1 Nov. 15.

Birch trees on the bank of the river Regnitz (2009-2013)

Concert and Congress Hall of the „Bamberg Symphony Orchestra“ with phone mast

View from the southwest to the eastbank of Regnitz. Crown transparency at both birches. The upper half of the left birch had severe damage. From the left side (northwest) RF-EMF (main beams of two 130°- sector antennas) hit the left birch. Phone mast Concert and Congress Hall: height 25 m, 6 sector antennas.

In August 2013 the left birch was felled. Crown tranparency at the right birch.
In 2014 the phone mast on the Concert hall had been enlarged to 21 sector antennas.
In April 2016 it was shocking to see that more trees along the river had been cut down.

Hornbeam, Hainstraße/Sodenstraße (2009-2014)

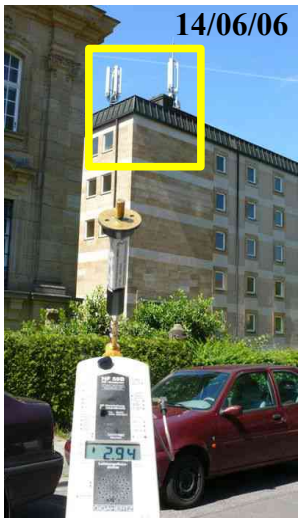
95 m

View from the northwest

In 2007 the phone mast Hainstr. 39 started transmission.

In October 2009 a side difference at the hornbeam was seen: left side almost leafless, right side with dense foliage.

In May 2013 the tree had grown only few leaves on the left.



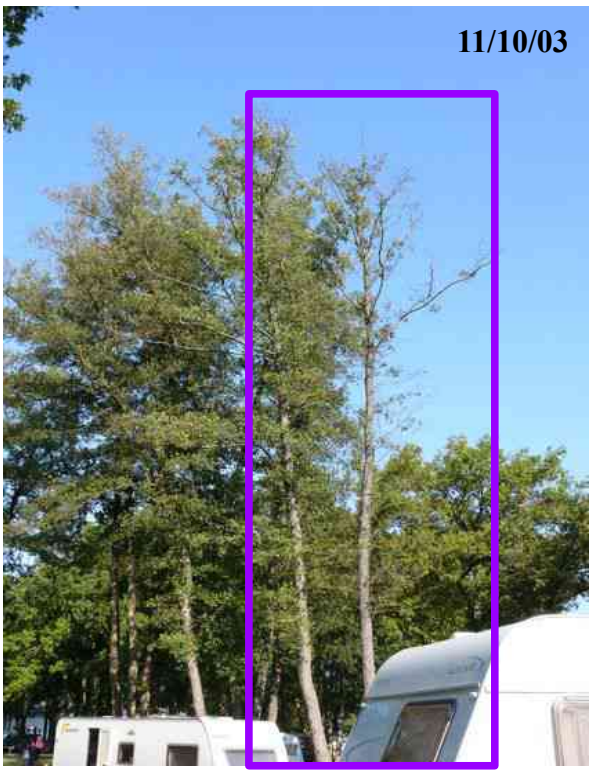
In 2014 the mobile phone site had been enlarged from 6 to 21 sector antennas.

In June 2014 branches had been cut off. Measured value: 2940 µW/m²

Alders, Campsite in Bamberg-Bug (2009-2013)

View from the south

In October 2009 two alders on the eastern side of a larger group of alders had died.
The dead alders (marked black) were felled in winter 2009/2010. From east RF-EMF are coming from the phone masts Gutenbergstr. (2,3 km) and A 73 at Strullendorf (4 km), from the television station (also DVB-T) Kälberberg (10 km) and from the radio station (DAB) Geisberg (11 km).



In the following period the next alders died (purple). In winter 2012/13 these were felled also.
Since 2004 severe tree damages occurred on the campsite. The damages increased rapidly. All tree species were affected. Numerous trees were felled (p. 170, 367, 570, 585, 605, 629).

Maple trees, Playground at the Hospital (2010-2014)

View from the northeast

Phone mast Altenburg with 17 sector antennas and directional radio (10/10/21)

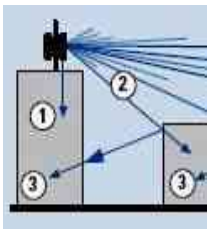
Maple trees at the playground of the hospital. On 1 July 2010 the difference between the maple trees on the right and on the left was noticed.
Visual contact is given to the phone mast Altenburg Castle in a distance of 2 km.

View from the Hospital over the playground to the Altenburg. Value at a window: **88 µW/m²**

On 2 August 2013 the maple tree on the right side was brown und had already lost leaves.

On 29 Aug.2014 the situation was similar. Additionally, new planted trees nearby did not grow well.

Silver maple trees, Hospital (2010-2014)



Main beam and side beams, reflection on a building. Detail from „Mobilfunk“ STMUGV (2007)

View from the northeast

Tree on the right in another perspective

Silver maples on the left of the playground above. On 1 July 10 crown tranparency at the two trees on the right, whereas the tree in the middle had dense foliage. The silver maple on the left had in turn sparse leafs. The reflections of the RF-EMF on the facade could be the cause (see figure).

On 23 August 2012 the impression was similar. Only the tree in the middle was in full leaf.

On 29 August 2014 furthermore, the trees don't develop well except the tree in the middle.

Locust trees, Don-Bosco-Straße (2010-2013)

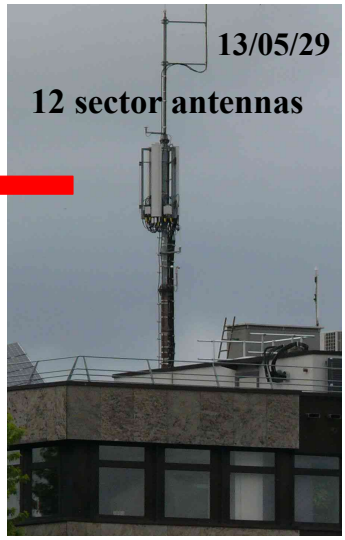
280 m

In Oct. 2010 considerable difference between the two trees.
Locust tree on the right leafless; visual contact to phone mast.

Phone mast Margaretendamm 28
(height 26 m, 6 sector antennas)

View from the southeast
In 2011 the locust tree on the right died off and was felled.

Measurement: 2920 µW/m²

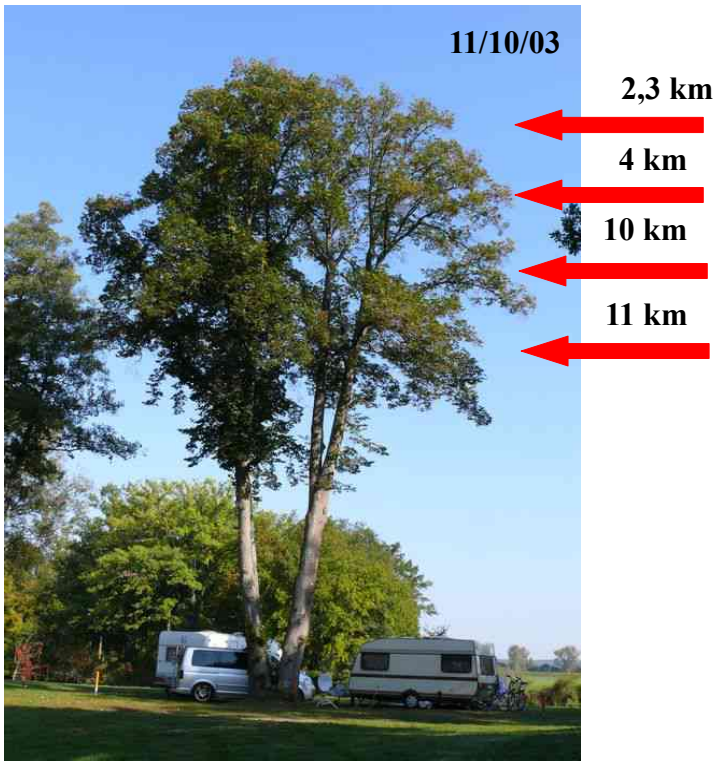


The second locust tree was felled in winter 2012/2013.
Numerous trees in the radiation field of this phone mast are damaged or already felled

The phone mast was enlarged.

Lime trees, Campsite in Bamberg-Bug (2010-2014)

View from the southwest
On 12 Oct. 2010 the great contrast between the right and the left lime tree was noticed.



On 3 Oct. 2011 the lime on the right was not brown, as in the year before, but transparent.
From the east RF-EMF are coming from the phone masts Gutenbergstr. (2,3 km) and A 73 at Strullendorf (4 km), from the television station (also DVB-T) Kälberberg (10 km) and from the radio station (DAB) Geisberg (11 km).

In 2013 branches had died and broke off.

It is dangerous under the trees

Pine, Babenbergerring/Schlüsselbergerstraße (2011-2012)

170 **11/02/11**

632 m

View from the southwest
In February 2011 loss of needles on the left side. On the right side many needles were brown.

11/07/05

View from the southeast
In July 2011 the pine had lost further needles. Visual contact to phone mast Altenburg (632m).

12/05/29

View from the southwest
In May 2012 the loss of needles had increased.

12/08/23

View from the southeast
In August 2012 only a few brown needles were left. Measurement: 250 µW/m²
In 2013 the pine was felled.

Chestnuts, Beer Garden, Mahr's-Bräu (2011-2014)

View from the west

On 3 June 2011 the two chestnuts on the westside of the Beer Garden were brown. RF-EMF from the three phone masts Wilhelmsplatz, Theresienstraße and Erlichstraße interfere at this place.

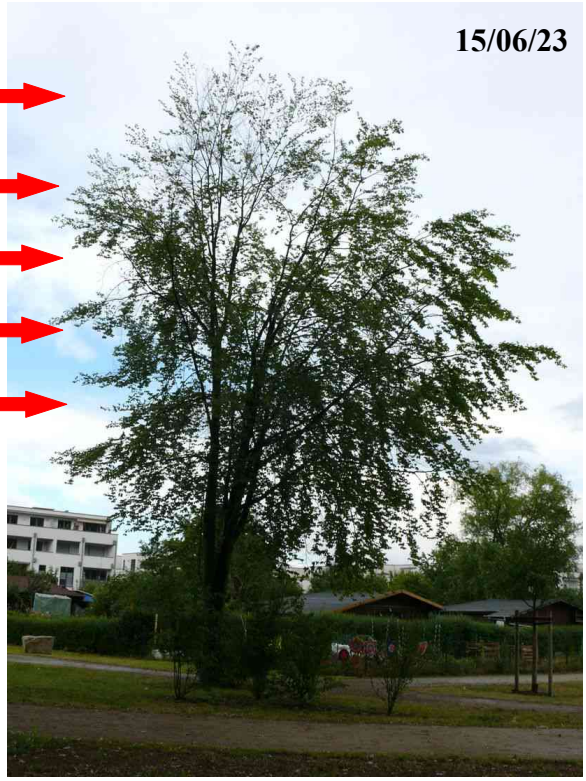
On 20 Sept. 2012 the two chestnuts were leafless; the other chestnuts and a lime tree still had leafs.

On 25 August 2014 the stem of one chestnut was cut; the second chestnut was leafless.
The third chestnut began to turn brown. RF-EMF come not only from the west but also from the southeast through gaps between the buildings (distances 432 m, 622 m, 633 m).

Beech, Southern part of horticultural show 2012 (2012-2016)

View from the southwest
On 27 August 2012, during the horticultural show, crown transparency on the left side was observed. RF-EMF from the northwest and the north (three phone masts in the port) reach the tree.

View from the west
From this perspective the difference between the north and the south side is better recognizable.



View from the west
In June 2015 crown transparency had increased.

View from the west
In July 2016 the beech was almost leafless.

In 2014/15 LTE (4 G) was added to many phone masts. A further phone mast started transmission.

Lime tree, Lange Straße/Südliche Promenade (July 2013 - April 2014)

View from the southwest
On 15 July2013 leaves turned yellow top left.

On 14 August 2013 the section top left was leafless.

On 7 Sept.2013 the whole left side had turned brown. On 30 Sept. 13 the lime had lost many leaves.

View from the south

View from the road intersection at the Schönleinsplatz to the lime tree behind the advertising pillar. In the background on the left a gap between buildings is visible.

View from the southeast

Looking from the southern end of the green area at the Schönleinsplatz to the lime tree, a part of the phone mast Grüner Markt 23 is visible.

View from the southwest

In winter 2013/2014 branches had been cut.

Maple, Babenbergerring (2014-2016)

View from the southeast
In July 2014 the upper right section showed damage. In September 2014 many leaves had fallen.

In August 2015 the damage was similar In July 2016 the damage had increased.
Visual contact is given to the phone mast Altenburg in a distance of 630 m.

BEES, BIRDS AND MANKIND

Destroying Nature by 'Electrosmog'

Ulrich Warnke

Effects of Wireless Communication Technologies

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

Brochure 1

Effects of Wireless Communication Technologies

A Brochure Series by the Competence Initiative for the Protection of Humanity, Environment and Democracy Brochure 1

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

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BEES, BIRDS AND MANKIND

Destroying Nature by 'Electrosmog'

Translation by Marlies von Lüttichau*

Ulrich Warnke

Project supported by E.Oppenheimer & Son and the Diamond Route (<http://www.diamondroute.co.za>):

* Kentum Translators, South Africa, www.kentum.co.za <http://www.kentum.co.za>

For different protection of mankind, environment and democracy

Preamble by the publishers at the launch of the series of papers: *Effects of Wireless Communication Technologies*

The bio-scientist Ulrich Warnke is more familiar with nature's electromagnetic housekeeping than most. In this paper, he shows how wise and sensitive nature was about using electrical and magnetic fields in the creation of life. But he can for this reason also convincingly criticise the present foolish and irresponsible interference in nature's house-keeping. It is clear from his paper that the powers that be in politics, the economy and science are in the process of destroying what nature has built up over millions of years. The traces of this destruction have long been evident in our living environment. The paper shows, however, how short-sightedly we are treating not only our health and the economy, but especially also future generations' right to life.[1] All of the above is documented not as probabilities but based on reproducible effects. This should give pause also to those who regularly justify their actions with the argument that they are unaware of any proof of damage.

Under the term "radio communication", we combine all wireless communication technology, increasingly flooding our residential zones and the environment with electromagnetic fields. A recent, comprehensive research report by the BioInitiative Working Group, a consortium of renowned international scientists, shows how many of the damaging effects of such fields have already been proven (www.bioinitiative.org). The report evaluates the present limiting values as a useless edifice, protecting nobody. Based on this, the European Environment Agency (EEA), the top scientific environment authority of the EU, has warned of the possibility of looming environmental disasters following the increasing density of electromagnetic fields. And the coordinator of the European Reflex project, Prof. Franz Adlkofer, has informed the public on the new research results, proving the high degree of gene-toxicity of UMTS radiation.

The public is little aware of these risks because they are hardly addressed in the "enlightenment" provided by officialdom and industry. The public is given the assurance that they are well-protected by the limits and the compliance-assuring measurements and that UMTS radiation is as harmless as GSM radiation – more antennae in residential areas are recommended in principle.[2] And whilst Ulrich Warnke demonstrates how vulnerable man and environment are, we are told that we are more robustly organised than our machines.[3] The original "radiation protection" has deteriorated to the protection of commercial interests.

The involvement of government in industry and the high percentage of industry-financed research and industry-beholden panels and consultants, have spawned a questionable system of environment and consumer protection. Only that which does not seriously endanger common commercial interests is noted and supported. The rights of the citizen to protection and the suffering of the people are flatly ignored. Those with political responsibility have apparently still not realised that their negligent handling of the obligation to take precautions has long since been proven to be one of the main causes of past environmental disasters and scandals.[4]

As a result of their quarrel with politics of carelessness, an interdisciplinary association of scientists and physicians founded the Competence Initiative for the Protection of Mankind, Environment and Democracy in May 2007 (www.kompetenzinitiative.de). This paper is the first in a new scientific series. The reported results are intended as a correction to trivialising "enlightenment" that does not protect, but endangers. The series intends to maintain a high level of technical information, without being unreadable to the interested layman.

Placing economic interests above culture and morality has contributed significantly to turning Germany into a country of declining education. As the journalist Hans Leyendecker so tellingly describes in his book Die große Gier[5], it started Germany too on a new career on the ladder of corruption. There is nothing that the business lo-

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[1] On injury to the health of children and the youth refer also to the collection published by Heike-Solweig Bleuel "Generation Handy... grenzenlos im Netz verführt", St. Ingbert 2007.

[2] Quoting scientists of the Jacobs University Bremen-Grohn under Prof. Alexander Lerchl: "UMTS doch nicht schädlicher als GSM", www.pcmagazin.de, 2.7.2007, and A. Lerchl at a presentation in Ritterhude acc. to a newspaper report of the Osterholzer Kreisblatt dated 16.6.2007: "More radio masts in the centre of town". Professor Lerchl appeals to all communities not to spend further tax money on mobile radio studies

cation Germany needs more, he concludes, than "new ethics". But this also requires a different perception of progress. Whether we can watch TV via our mobile telephone, is irrelevant to our future. Our future will depend on whether we can return to more human, social and ethical values again in the shaping of our lives and our relationship with nature.

Everyone who thinks beyond today and who inquires about what it means to be human is, in our opinion, called upon to contribute to this future: politicians guided by values rather than economical and tactical election issues; scientists and doctors more often remembering their obligation to the wellbeing of society and mankind; companies understanding, also in Germany, that profit and morality must be in harmony if they wish to remain successful in the long term.

But what we need above all is critical citizens, who can spot the difference between technical progress and consumer foolishness: Citizens who, in both their roles as voters and consumers, remember that democracy once meant rule of the people, not ruling the people.

The dramatic escalation of recorded degradation challenges those with political responsibility to take to heart the protection directives of the constitution and the European Convention on Human Rights. To base your actions affecting millions of your protégés on a half truth, at best, appears to us a political crime affecting health and the future – considering the state of our knowledge.
Religious and ethical cultures still profess to the mandate of conserving creation. But its actual treatment is guided by the pseudo culture of a new class of masters who ruthlessly exploit and manipulate the organisation, finally destroying it.

We thank the E. Oppenheimer & Son (South Africa) and the Diamond Route for having financed this translation.

Prof. Dr. Karl Hecht
Dr. med. Markus Kern
Prof. Dr. Karl Richter
Dr. med. Hans-Christoph Scheiner

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[3] Statement at the end of a brochure: Mobilfunk und Funkwellen: Information, Fakten, Antworten; published by the Saarland Department of Justice, Health and Social matters, Saarbrucken 2005 (copy of a brochure of the LfU Baden-Wurtemberg).

[4] Compare the paper published by the European Environmental Agency and its German translation published by the Federal environmental office: "Späte Lehren aus frühen Warnungen: Das Vorsorgeprinzip 1896-2000", Copenhagen and Berlin 2004.

[5] "Die große Gier. Korruption, Kartelle, Lustreisen: Warum unsere Wirtschaft eine neue Moral braucht"; Berlin 2007.

Electromagnetic fields as prerequisite and hazard to life

Author´s introduction to this paper

The question of causal effects and biological relevance of electrical and magnetic parameters is generally posed without simultaneous reference to their relevance to life's organisation. These questions cannot, however, be considered in isolation of each other. What role have the electrical and magnetic fields played in the evolution of life on earth? What role are they playing in the individual development and physiological capacities of an organism? Whoever investigates these questions must sooner or later conclude: Not only did the electrical and magnetic fields of our planet exist before all life, but they have had a decisive hand in the evolution of the species – in water, on land and in the near-earth atmosphere. Living creatures adapted to it in the development of their kind.

Biological experience teaches us that life will use the energy pool in which it finds itself to its best advantage. Advantageous not only because the absorbed energy is a carrier of information, useful for orientation in the environment (see glossary; hereinafter GL). But advantageous also because the organism developed to make use of gravitational and electromagnetic interactions, creating decisive functionalities of life. The biological system expresses itself just as the environment does and unity and coordination with its environment is its guiding principle.

But if bees and other insects disappear, if birds are no longer present in their traditional territories and humans suffer from inexplicable functional deficiencies, then each on its own may appear puzzling at first. The apparently unrelated and puzzling phenomena actually have a common trigger, however. Man-made technology created magnetic, electrical and electromagnetic transmitters which fundamentally changed the natural electromagnetic energies and forces on earth's surface – radically changing million-year-old pivotal controlling factors in biological evolution.

This destruction of the foundations of life has already wiped out many species for ever. Since this extinction of species mostly affected ecological niches and hardly ever own life, most of us were not interested. But now, the endangerment of animals is also threatening the survival of man in a new and unexpected way.

Animals that depend on the natural electrical, magnetic and electromagnetic fields for their orientation and navigation through earth's atmosphere are confused by the much stronger and constantly changing artificial fields created by technology and fail to navigate back to their home environments. Most people would probably shrug this off, but it affects among other one of the most important insect species: the honeybee.
Because the bee happens to be the indispensable prerequisite for fructification: without bees, the fruit, vegetable and agricultural crops will fall short.

We are, however, not only affected by the economic consequences of our actions. It can also be proven that the mechanisms evidently affecting birds and bees are also affecting the human organism. An all-round unnatural radiation with an unprecedented power density (GL) is also harming human health in a novel way.

But, unless mankind reminds itself of the basics of its existence and unless the politicians in charge put a stop to the present development, the damage to health and economic fundamentals is predictable and will fully manifest itself not now, but in the next generation.

The reasons for this are explained in this paper. It endeavours to quantify natural electrical and magnetic signals provided to men and animals as guiding signals throughout evolution. The paper, however, places particular emphasis on what happens when these natural signal amplitudes are suppressed, changed and distorted on an unprecedented scale by technically generated artificial fields. Mankind can only take successful countermeasures if the damage mechanisms are understood.

The following analyses are intended to remain readable also for interested laymen. This approach has its limits where experimental fundamentals or specific technical descriptions must be included. The following text therefore offers three options for reading. In its totality, it is intended for readers with a scientific background. It has, however, also the interested layman in mind, by allowing him to skip identified parts containing specific technical justification and arguments. And the parts against a coloured background are intended as a first overview.

I thank Prof. Dr. Karl Richter for the editorial supervision of the paper and Dipl.-Met. Walter Sönning, medical meteorologist, for his technical comments on the sferics question and the compilation of a glossary for the interested layman.

If all the functions bees perform for natural life and its preservation are observed holistically, their importance cannot be overstated. Without the bees, we humans will also suffer major deficiencies.

1. The organisation of life underlying its vulnerability

1.1 We should have known long ago

The relationship between life and the physical parameters of earth's surface and atmosphere have been known for many decades. Those responsible therefore had the opportunity long ago to question to what extent the excesses of technically created electrical and magnetic fields might have the potential to destroy nature's housekeeping.

There are only two types of energy capable of transmitting information over great distances: electromagnetic and gravitational energy. Any forces acting beyond the boundaries of an atom can be traced back to these two energies; ultimately they have an infinite reach. Both energies are universally present and can be modulated in many ways (GL). This is true, for instance for light, the earth's magnetic field, cloud charges, atmospheric electric fields and changes in atmospheric pressure. Together with atmospheric moisture and olfactory particles, they are recognised as orientation aids to mobile organisms.

In the natural environment, there are "oscillating" electromagnetic fields of many orders of magnitude and with frequencies ranging over a virtually unlimited spectrum covering many frequency decades. They manifest themselves as a continuous and enormous "hiss" – like an unlimited ocean, the surface of which is agitated by waves of any imaginable amplitude and extent. Nature has created senses that filter out very specific frequencies and intensities from this ocean of waves, analyse them and convert them to forces. These filtered frequencies identify a specific sphere of life for specific life forms.
Only those energies that are important to the life of an animal are transformed. The forces generated from these energies control nerve cell membranes and protein structures such as enzymes – creating patterns, images and impressions that we call experience. Sensory organs are organs functioning as frequency analysers (GL), information amplifiers (GL) with gains up to a million, sometimes including contrast enhancement and noise suppression. Eyes, ears, sense of smell, taste, sensitivity of touch, light, warmth, chemical, electrical, magnetic and pain receptors. The living world perceives stimuli such as light (including ultraviolet and infrared), sound (including ultrasound and infrasound), electrical fields and currents, magnetic fields and also smells and water currents. And the sensory performance of animals is often comparable to our technical measurement apparatus, sometimes even far superior. Physiologists can prove this by some astounding numbers: Snakes, for instance, can sense temperature variations of a thousandth of a degree centigrade; long-horned grasshoppers and cockroaches can register mechanical surface vibrations with amplitudes (GL) down to 1/25th of the diameter of a hydrogen atom.

The high "intelligence of the systems" is particularly obvious, however, with orientation, navigation and early warning systems. In this regard, the earth's magnetic field has an important role to play. The local geographic position and time of day can be established from the density, direction and inclination of the field lines and their temporal variation.
Every location, together with other physical information, has a specific identifiable pattern. The sensitive reception apparatus of animals use the magnetic field information for orientation and navigation, among other (WARNKE, 2006).

1.1.1 Magnetic fields as global parameter for space and time orientation of all life

To the best of our present knowledge, biological organisms depend less on static magnetic fields than on the very important intensity variations of sufficiently high frequency. If we take a closer look at such variations, the earth's magnetic field cannot be considered in isolation. Other magnetic fields must also be included in the analysis: such as the ionospheric field, for instance, and the field of the Van Allen belt – a radiation belt of very high intensity with rotational symmetry around the magnetic axis and mirror symmetry around the magnetic equator around the earth. Both the ionosphere and the Van Allen belt are held together by earth's magnetic field. The protons and electrons captured from the cosmic radiation or the solar wind (= stream of ionised particles emanating from the sun) by earth's magnetic field, create a protective shield for all life on earth – the Van Allen radiation belt.

The external magnetic fields act as moderators (GL) on the earth's magnetic field. They exhibit both a pronounced solar and also a lunar (moon-dependent) diurnal variation. The reason for the solar-induced variation lies in the diurnal warming of the atmosphere through solar radiation. This is

accompanied by horizontal eddy currents with amplitudes up to 90 000 Ampere in the ionosphere, that generate magnetic fields again. These daily variations also have a pronounced annual cycle.

The moon-dependent variations are furthermore only evident during the day. These are also generated by electrical currents at about 100 km altitude, but they have current amplitudes of "only" 10 000 Ampere. These eddy currents cannot be explained by temperature gradients as with the solar effects, but they are influenced by the gravitational remote action of the moon. The earth's atmosphere is rocked to and fro inside the earth's magnetic field in the rhythm of the tides, inducing electrical currents in the ionised layers of the upper atmosphere where the conductivity is high through the presence of the negatively and positively charged particles (ions). It appears that the conductivity of the ionosphere is too low at night to maintain induction processes (GL) – due to reduced ion densities (WARNKE 1993).

Within the realm of the conventional variations of the magnetic field that have been explained so far, electromagnetic oscillations that occur in mainly two frequency bands also deserve to be mentioned: 10 Hz and 10-25 kHz. On the one hand, there is a resonating electromagnetic oscillation between earth and ionosphere in the 10 Hz region (Schumann resonance, 7.83 Hz) and on the other, thunderstorm activities on earth constantly reinforce certain electro-magnetic oscillations. The dominant frequency of approximately 10 kHz generated by vertical lightning flashes corresponds to a transmitter dipole of cloud-to-earth length, whilst horizontal cloud-to-cloud lighting generates about 20 kHz.

These characteristics may be exploited for the design of thunderstorm warning apparatus. Our device measures the thunderstorm activity in a range of at least 800 km and simultaneously also the activity within a range of 200 km. Under favourable conditions, we can therefore register thunderstorms over the Mediterranean from our location in Saarbrücken.

Lightning also simultaneously generates very low frequency electromagnetic oscillations. Under certain conditions, these oscillations are all guided through the ionosphere along the magnetic filed lines, travel far into space and return to earth along the opposite magnetic field lines. They are reflected at the ground and the waves travel the same way again and again until their energy is dissipated. The higher frequencies are propagated somewhat faster than the lower ones. If this process is made audible through an amplifier, a whistling noise is heard, continuously decreasing in frequency down to a hum, as in a switched-off siren, but much faster, typically for approx. 1/3 of a second. This phenomenon was therefore called "Whistler".

The so-called earth-magnetic storms (magnetic induction B~1μT) are triggered by the magnetic shock waves escaping from the solar flare region at 2000 km/sec and still have a speed of 100 km/sec as they reach earth. This induces unusually high currents in the earth's magnetic field, which in turn change the earth's magnetic field and generate secondary currents. Such currents manifest themselves in long conductive paths such as pipelines, transmission lines etc. and routinely cause technical headaches.

The most important parameters, constant over millions of years, are: earth's static magnetic field: 31 μT (geomagnetic equator); resultant diurnal variation of the earth's field: 60 nT; magnetic storms: 500 nT; sferics field strengths: 0.25 – 3.6 pT per √Hz.

The natural high frequency radiation sources have far less energy than the technically generated transmission powers and energies. This is a precondition for transmission of news and communication.

*The integrated power density over all frequencies up to 300 GHz is 600-800 **μW/m²** at the earth's surface. The power density of the microwave solar radiation is about 0.1 μW/m², escalating to several 100 μW/m² during solar flares.*

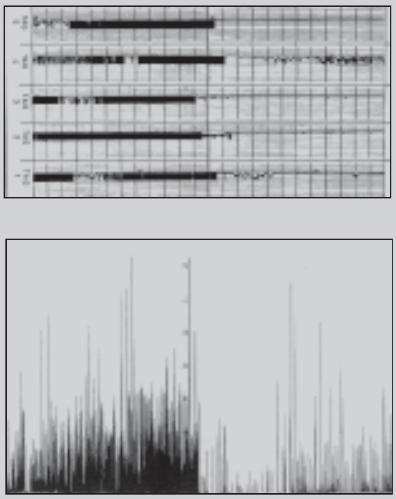

Fig. 1 *Top: The "midnight phenomenon". The activity of the electromagnetic impulses (shown on 5 different days) abruptly ends at midnight.*
Ref. Hans Baumer: (1987) Sferics. Die Entdeckung der Wetterstrahlung. Rowohlt, Hamburg

Bottom: Our original recorded activity cycles of 20 caged bees in a laboratory experiment. The vertical axis (ordinate) shows the total electrical field arising from the electrostatic charging of the wings. It is clear that the bees suddenly all come to rest at midnight.
Acc. to Warnke (1982), published in Baumer's book (1987)

1.1.2 Examples of the utilisation of earth's magnetic field parameters

For a period of millions to a billion years, life on earth had the time in the evolution of the species to adapt to the magnetic and electromagnetic conditions of their environment. They learned to use the natural magnetic field parameters also as conveyors or carriers of a diversity of information:

- The geographic location can be established by the density of the field lines, their direction and variation in time.
- Time of day and annual seasons can be deciphered in the daily, lunar and solar periodic magnetic signals.
- Frontal weather systems and air mass movements transmit characteristic electromagnetic signals, the so-called sferics. These are short oscillations comprising just a few cycles (= impulses) in the range between approx. 3 kHz and 60 kHz (= very low frequency) with a repetition frequency of up to 100/sec or more, depending on the intensity and type of atmospheric processes.

The biosphere at the earth's surface is in contact with the electromagnetic fields of the universe via two narrow frequency windows through the atmosphere. One of these windows is in the narrow medium to long wavelength UV radiation region, including the visible light spectrum and the near (short wave) infrared radiation (average 1milliwatt/m^2); another window is in the high frequency radiation region at wavelengths of 0.1 to 100 m (average 1 nanowatt/m^2 up to 1 milliwatt/m^2 (GL) during solar flares).

Effects of the earth's field and of its compensation or effects of weak artificial fields have been detected in life at all levels of development: with bacteria, single and multi-cellular algae, higher plants, protozoa, flatworms, insects, snails and vertebrates:

- Magneto bacteria (Aquaspirillum magnetotacticum) in the bottom sludge of the oceans utilise the intensity of the earth's magnetic field for orientation. Magnetite crystals (Fe_3O_4) in their bodies form a chain of "compass needles" creating a magnetic moment that the bacteria align against the thermal movement of the water molecules. (The earth's magnetic field applies an energy of 1.4 x 10^{-18} J (GL) to the bacteria – 200 times greater than the energy of the thermal movement at 22°C).
- Fish navigate in the earth's magnetic field. When sharks and stingrays, for instance, move in earth's magnetic field, they experience induced electrical fields of varying strength. The field strength is a function of the direction of movement relative to the direction of the magnetic field. Local physical water currents also generate direction-dependent electrical fields that can be detected. The sensory organ for electrical fields is highly sensitive. (So-called Lorenzian ampoules responding to voltage gradients of less than 0.1 microvolt/m).
- Compass termites (Amitermes) build their metre-high mounds in a north-south direction. With other termites and the woodlouse, the feeding activity is subject to natural magnetic alternating fields (sferics) and the earth's magnetic field.
- Bees make use of the earth's magnetic field and its daily fluctuations for their orientation and communication. They also gain information on weather developments through the natural impulse signals in the atmosphere, i.e. the sferics already mentioned above.
- Whales can sense the magnetic field of the earth.
- Carrier pigeons are affected by variations in the earth's magnetic field down to flux densities in the nano-Tesla region.
- Migratory birds have a mechanism acting like a compass.
- Humans react to atmospheric alternating electromagnetic fields between 10 and 50 kHz through various symptoms of the central nervous system. There are also correlations between activities in earth's magnetic field and sleep-affecting factors, circadian rhythms (HECHT 2005, 2006, 2007), enzyme conversion and hormone production in the central nervous system, the vitamin level in the blood serum, the average skin temperature, vision in half-light and iron content in the blood serum.

All the examples support the existence and the vital control functions of biologically active magnetic and electromagnetic fields with a specific frequency structure and corresponding information content, "arranged" to suit biological systems.

They are characterised by, among other:

- *specific flux densities and gradients ("amplitude windows"), i.e. weak fields may have a greater effect than strong fields,*
- *specific impulse frequencies and impulse sequences ("frequency window"),*
- *specific impulse shapes and a certain complexity of the impulse spectrum,*
- *specific vector characteristics with respect to the body,*
- *minimum effective duration of coherency and specific co-factors, e.g. light.*

Life forms, even of the same species, may be quite differently organised, but coordinated in a collective or social group (fish shoals and flocks of birds). In an isolated form of life, the instantaneous interaction with its environment is therefore exceedingly varied. Reproducible magneto experiments in or between individuals are therefore unlikely in the case of complex organisms, including humans; the specific metabolism parameters are, for instance, also too varied. None of these parameters can be kept as constant as required for reproducibility. "Proof", in the sense of classical scientific criteria, is therefore illusory.

1.1.3 Technical wireless communication is only possible because the transmission is stronger than the natural high-frequency radiation

Technical wireless communication such as mobile radio, radio, TV and satellite

communication is only possible because the power density of the utilised technical high frequency spectrum far exceeds that of natural radiation. Natural radiation at the surface of the earth in the 300 MHz to 300 GHz range is approximately 0.001 microwatt/m^2 (=0.001 $\mu W/m^2$); today's typical technically created radiation level in cities is 10 000 $\mu W/m^2$. And the legal German limits even allow values up to 4.5 million $\mu W/m^2$ for the D-grid, up to 9 million $\mu W/m^2$ for the E-grid and up to 9.8 million $\mu W/m^2$ for UMTS.

As we evolved, we were of course also exposed at times to strong static and low-frequency electrical fields (typical voltages: cloud electricity up to 10 000 V, volcano electricity up to 20 000 V, lightning 500 000 V, sferics 10 V), in addition to constant static and low-frequency magnetic fields (earth's field, lonospheric field, cosmic field, lightning). But there were never fields as constant and with as many superpositions of different frequencies from different sources as we are now generating with our technology.

1.1.4 Radiation by organisms themselves could be established in the evolution, because there was no interference by continuously changing external radiation

The same high frequency radiation that technology utilises for communication is also copiously generated inside our bodies. The body also requires it for communication purposes: for biological communication through functional oscillation of our molecules.
Provided there is no interfering external radiation, the body can utilise its built-in frequencies for its internal organisation.

The body internally radiates frequencies in the 1 to 1 000 gigahertz (GHz) range at power densities of about 0.1 $\mu W/m^2$, i.e. lower than those of average solar radiation. If we add up the total range of high frequencies (HF and VHF) present within our organism, we arrive at natural power densities of about 10 000 $\mu W/m^2$. The power generated by our internal electromagnetic oscillations, that we describe as heat (wavelengths around 3 – 10 µm), corresponds approximately to that of a 100 Watt globe.

To understand the natural oscillation of our functional molecules (enzymes and other proteins, nucleic acids, hormones and many more) it is important to realise that what we generally describe as "chemistry" is actually pure physics. All the bonds and their modulations (changes) between atoms on the one hand and molecules on the other are based on physical phenomena. In this context, the electrostatic Coulomb forces (= force between different electrical charges) and the electromagnetic force (e.g. van der Waal force = force between dipoles with different moments and fast oscillations) are prominent. DNA and all the enzymes, for instance, can only carry out their functions through their natural electromagnetic oscillations.

Resonances are of particular importance here. Chain molecules, for instance, can be excited to so-called wring-resonances by high-frequency electromagnetic fields. Proteins exhibit such natural resonances in the range of 1 – 10 GHz; DNA resonates at 10 MHz to 10 GHz. Both of these therefore fall into the spectrum of common mobile radio frequencies.
Wring frequencies (modes) cause wringing of the molecular chains that directly affect the structure of the individual molecules. The structure of the molecules (conformance and configuration) is essential, however, for their specific functionality. Even minor displacements render the molecule useless. The chains may even break apart under energetic external influences.

Biological systems are obviously very sensitive in their reaction to microwave fields. For instance, Belyaev et al, 1996, reported resonance effects on the DNA structure at extremely low power densities of 0.000001 $\mu W/m^2$ in the 40 – 50 GHz frequency range. This surprising result must still be confirmed by other working groups. Nevertheless, it must be stated that: The ultra-weak, but biologically very effective natural electromagnetic fields are contrasting strangely with the technical radiation fields permitted in Germany. On recommendation by the ICNIRP association (Munich), technical radiation fields up to power densities of 10 000 000 $\mu W/m^2$ were legalised – still considered as harmless by the experts. The population, animals and plants may therefore be legally subjected to radiation in the critical frequency spectrum that is more than 10 orders of magnitude higher than the natural fields.

But organisms are not only sensitive to high frequencies; the following examples show that very high sensitivities evolved also in the low frequency ranges.

2. About the disappearing bees and birds

2.1 The bees as evolutionary force and indispensable economic factor

Honeybees existed on earth from about 40 million years ago; a "primal" honeybee encased in amber was found on the coast of the Baltic Sea. Man soon realised the usefulness of animals. And we know today that the enormous development of earth's vegetation, comprising about 200 000 species of a variety of flowering plants, is based on animals. Because about 85% of these flowers are pollinated mainly by bees and propagate through the formation of fruit and seeds.

Since also fruit trees (such as cherry, apple, pear and plum) and agricultural crops (such as rap, sunflower, red clover, lucerne, horse bean as well as vegetables such as tomato, cucumber, pumpkin) fall under these, it is not difficult to understand that bees are one of mankind's most important production animals.

In central Europe the commercial benefit of bees is estimated at 4 billion euros per annum, in the US it is estimated at over 15 billion dollars. These figures are from the New York Times. It quotes estimates by Cornell University, New York State. This included the pollination of fruit and vegetable plants, almond trees and fodder such as clover. That said, however, even the global honey production of 25 000 tons per annum is an important economic factor already.

But if we aggregate all the functions the bees are performing for nature's life and the preservation thereof, their significance can hardly be overestimated. Their industry cannot be substituted either by other insects or by technical measures. If the bees should disappear, we humans will also suffer major deficiencies.

2.2 No chance of survival: ‚Colony Collapse Disorder' CCD

In some countries there are reports of mysteriously dying bees. It appears as if the losses are at their worst in the northern American states and in neighbouring Canada. 25% to 50% of the American bee-keepers report losses through "Colony Collapse Disorder" (New Scientist, 2007). They reported 50% to 90% of their bees to have disappeared within the previous 6 months, and the remaining bee colonies were said to be so weak they can produce hardly any honey (CNN, 2007).

But unusual losses are also reported in Germany, Switzerland, Austria, South Tyrol, Spain, Poland and New Zealand. In Germany, for instance, the beekeeper associations last winter recorded a loss of about 13% in over 7 000 bee colonies - double the previous year's figure (http://orf.at/070416-11296/-index.html). In accordance with a report in the Stern magazine edition 34/2007, German bee monitoring did not confirm this number, only acknowledging an average loss of just on 8%. A 10% loss over the winter months is not regarded as unusual. What is completely unusual, however, is the statement by the president of the DBIB (German Federation of Occupational and Purchasing Beekeepers), Manfred Hederer, in the Deutschlandradio Kultur, on the Federal territory: "The beehives are empty." He paints a picture of bee colonies reduced by 25% - in some cases even 80% (Spiegel 12/2007).

In 2006, the Swiss federal research institute for production animals and dairy farming, Agroscope, (Federal office for agriculture), reported that also all of Switzerland was affected by bee deaths, to a regionally more or less severe degree (Zürichseezeitung, 5. May 2006). Roughly 30 percent of the bees were lost without a trace after winter – about half a billion animals in this year alone (http://www.heute-online.ch/wissen/play/artikel 60601).

Beekeepers from Styria are also reporting a mysterious disappearance of bees. Beekeepers in Vienna estimate a 30% loss. They agree on the following: "The bees are not developing properly anymore. They do survive the winter, but in spring they disappear as if by magic. The hives are simply empty." (This according to beekeeper Hermann Elsasser of Fladnitz in the Raab valley; http://oesterreich.orf.at/steiermark/stories/184609/). Only the brood remains in the hives, and without the care of the older bees, they will die.

Ferdinand Ruzicka, scientist and beekeeper himself, reports: "I observed a pronounced restlessness in my bee colonies (initially about 40) and a greatly increased urge to swarm. As a frame-hive beekeeper, I use a so-called high floor, the bees did not build their combs in this space in the manner prescribed by the frames, but in random fashion. In the summer, bee colonies collapsed without obvious cause. In the winter, I

observed that the bees went foraging despite snow and temperatures below zero and died of cold next to the hive. Colonies that exhibited this behaviour collapsed, even though they were strong, healthy colonies with active queens before winter. They were provided with adequate additional food and the available pollen was more than adequate in autumn. The problems only materialised from the time that several transmitters were erected in the immediate vicinity of my beehives" (RUZICKA, 2003).

Ruzicka organised a survey through the magazine Der Bienenvater (2003/9):

- Is there a mobile radio antenna within 300 m of your beehives? - This was confirmed in 20 replies (100%).
- Are you observing increased aggressiveness of the bees compared to the time before the transmitters were in operation? – 37.5% confirmed this.
- Is there a greater tendency to swarm? – 25% confirmed.
- Are colonies inexplicably collapsing? - 65% confirmed.

Such colony collapses, heralded by "angry" swarming of the bees, were also reported in New Zealand (FIRSTENBERG, 2007).

Other reasons possibly explaining the disappearance of the bees are also under discussion: Monocultures, pesticides, the Varroa mite, migratory beekeeping, dressed seed, winters too severe, genetically modified plants. There is no doubt that some problems can be attributed to this. But the fairly sudden and country-spanning appearance two to three years ago of the dying bees phenomenon cannot be convincingly explained by any of the aforementioned causes. Should the bees simply be too weak or ill, they should also die in or near the hive. But no ill bees were found in the research into this phenomenon.

About 85% of these flowers are pollinated mainly by bees and propagate through the formation of fruit and seeds. We have the utility of animals to thank for the enormous development of earth's vegetation, comprising about 200 000 species of a variety of flowering plants.

2.3 Some bird species are disappearing

But not only are bees and other insects disappearing – birds as well. The house sparrow, for instance, has become clearly scarcer in England and some western European countries. An investigation carried out between October 2002 and May 2006 in Valladolid in Spain, was launched to examine whether this decline in the sparrow population was related to electromagnetic radiation by mobile base stations. The result showed with a high decree of statistical confidence that the number of sparrows was reduced when the electrical field strengths of the antennae exceeded certain values. (BALMORI, HALLBERG, 2007).

A similar investigation was carried out in Belgium. The numbers of house sparrows were counted in the vicinity of several mobile radio base stations, during their breeding season. This confirmed a significant relationship between the electrical field strength in the 900 and 1 800 MHz bands and the diminishing numbers of birds (EVERAERT, BAUWENS, 2007).

It was noticed even earlier that storks that built their nests within a 200 metre radius of base stations could not rear any chicks, remaining without offspring. The results improved at distances of 200 to 300 metres. From a distance exceeding 300 m, the storks bred with a success rate of 96.7%. The electrical field strength at a distance of 200 metres averaged 2.36 $\pm$ 0.82 V/m, and only 0.53 $\pm$ 0.82 V/m at 300 metres. From their results, the authors concluded that the electrical fields of base stations are damaging to the reproduction of the white stork (BALMORI, 2005).

3. Mechanisms of disorientation and damage

3.1 Magnetic field sensitivity in the animal world

Birds, insects, fish and snails are assumed to have a specific organ for sensing magnetic forces. It is questionable, however, whether it is always necessary to assume such a specific magnetic sense. Electrical fields do not penetrate deep into living organisms and currents follow only certain paths. A magnetic field, however, fully penetrates the organism, without major changes. It is too short-sighted to conclude from this that such fields have no effect because they are not absorbed. To start off with, even weak magnetic fields in the body are more energetic than strong electrical fields. As such, the energy in earth's magnetic field inside us is 10 000 times stronger than the strongest possible electrical field in the atmosphere (3 Megavolt/m; WEISS, 1991). Such penetrating forces as the quasi-static magnetic field and the low-frequency electromagnetic field do not theoretically need an own amplifying reception organ. Inside the organism, they can also directly couple into aggregates of orderly paramagnetic molecules or into the electro-mechanical (photon-phonon) code of the endogenous information transmission and storage.

Magnetite was found in all animals that can navigate using their own compass, sometimes in the form of ferritin-proteins (KIRSCHVINK et al. 1981). But it is also present in our brains (KIRSCHVINK et al. 1992). And it reinforces the external magnetic fields in both cases. In the tissue of birds, bees, fish and whales (WALKER et al. 1992), the magnetite concentration exceeds that in the human brain. Most areas of our brain nevertheless contain about 5 million magnetite crystals per gram and even 100 million in the brain membrane.

Because magnetite reacts about 10 000 000 times stronger to external magnetic fields than normal dia- and para-magnetic tissue, the transmission of information separate from the neurons must be considered. Oscillating magnetite excited by ELF fields could, for instance, play a role in transport channels or cell-interconnection channels, raising the possibility of interference by communication and other negative effects of technically created electro-/magneto-smog.

It is easy to prove mechanically acting forces in insects subjected to relatively strong magnets. Own experiments with bees and flies yielded the following results (WARNKE, not published):

- *A newly captured swarm of bees is exceptionally sensitive to magnetic forces. If a magnet with only a few mT field strengths is brought close to the swarm in a dark wooden hive, the entire swarm becomes excited.*
- *Captive bees assume a horizontal rest position at night, aligned to an artificial magnetic field of several mT in the environment.*
- *Dead bees, flies and a range of other insects can be made to float on an electrostatically neutral water surface and in this condition an electrostatically neutral strong magnet can be used to attract them, drag them across the surface and in some cases repel them.*

In the laboratory, bees can sense not only the compass direction but also the intensity and the gradient of this magnetic field (SCHMITT et al. 1993). It was found in a 1982 publication (KUTERBACH et al. 1982) already that the magnetite found in bees is the source of this sensitivity to magnetic fields, and this theory was recently checked and finally confirmed (HSU et al. 2007). We also found ferrite particles together with pollen lodged in the bristles of the body surface; these might also be responsible for the above-mentioned magnetic moment.

It has been demonstrated that the birds' magnetic compass only functions in a certain range of intensities between 43 µT and 56 µT – precisely in the range of the earth's magnetic field intensity. After a three-day adaptation period the animals could, however, also orientate themselves in fields of 16 µT and 150 µT (SCHNEIDER et al. 1992) – interpreted as an adaptation to the environment.

The platypus of Australia (Ornit-horhynchus anatinus) has the electrical receptors for detecting its prey, in its bill. The receptors can sense direct and alternating voltages in the range of 20 mV and have a connection to the Trigeminus nerve. Fish with similar receptors use the acoustical nerve for transmission of the electrical stimulus. This shows that evolution exploited the electrical and magnetic environment in different ways. The Lorenzian ampoules of fish are capable of distinguishing between stimuli of magnetical or electrical origin (BROWN et al. 1978). It has not been established whether the receptors of platypus also have this capability. This question is of interest because ducks also have bill receptors. Although these are specialised to react to mechanical stimuli, they are so sensitive that the mechanical Coulomb forces accompanying electrical fields might well be detectable as well.

When magnetic fields penetrate an organism, two fundamentally different aspects must be clarified:

1. *Is the organism merely subjected to a large increase in energy - or*
2. *does the organism gain information?*

In various insect species we are aware of a time function based on magnetic field variations. In particular, the feeding habit of termites is correlated with the 27-day solar cycle (BECKER, 1973), and there is also an increased building activity for a few days around new and full moon in laboratory experiments – as it is with bees. It is also known that termites show directional behaviour under the influence of extremely low field strengths (BECKER 1976, 1979). Time triggers via similar channels sensing sun and moon appears a reasonable assumption.

The changes to the circadian activity rhythm of the house sparrow (Passer domesticus) can be correlated with cyclical changes of the earth's magnetic field. The sparrow reacts down to 200 nT in laboratory experiments.

Without doubt, light is the dominant timing mechanism of life. But also the earth's magnetic field is meanwhile recognised as a timing mechanism.

3.2 Bees and other small life forms under investigation

Insects have many aids for their navigation and orientation in space: sunlight, also polarised (WARNKE, 1975), gravity, aromatic molecules, colour as electromagnetic oscillation in a specific frequency range, variations in air pressure, occasionally also the degree of ionisation of the air (ALTMANN et al. 1971, WARNKE, 1976). Many species, however, cannot do without the magnetic field.

In this respect, bees are welcome objects for experimentation. Because different modalities of their orientation are inseparably linked to the magnetic field of the earth and to electromagnetic oscillations (LINDAUER and MARTIN 1968; HÜSING et al. 1959, SCHUA 1952, WARNKE, 1976).

In our working group, we recorded the directional behaviour of captive bees in an artificial field and during the night. A preference to assume rest positions with the body either parallel or orthogonal to the field lines was evident.

They share this alignment reaction with other insects such as various termites (BECKER, 1963), diptera (BEKKER et al. 1964) and Drosophila (WEHNER et al. 1970).
The behaviour of termites (BEKKER, 1963) was studied particularly intensively in Germany, that of the Christmas beetle (SCHNEIDER, 1961, 1963) in Switzerland and that of insects, worms, snails, snakes and other small creatures in the USA. The investigations concentrated on the influence of cosmic physical fields in which the magnetic field time and again played a pivotal role. All experiments confirmed the existing relationships. They also all showed, however, that constant laboratory conditions are impossible in practise, because cosmic influences change the magnetic component in any normal room and cage, thereby affecting the orientation behaviour of the animals.

The experiments with Christmas beetles and termites may be termed spectacular. In accordance with the above literature, Christmas beetles not only determine their rest position by magnetic and electrostatic fields, but also by interference patterns of gravitational waves of terrestrial and cosmic matter. In the final analysis, the evidence points to the influence of a physical field or radiation, varying in space and time in accordance with an unknown programme, that is registered through an unknown organ in the Christmas beetle for an unknown purpose, but the existence of which physicists doubt because it cannot be measured by any instrument. The Christmas beetle therefore becomes the instrument for measuring this unknown agent. The effect is often intimately coupled to that of the magnetic fields (SCHNEIDER, 1974). The orientation at rest is based on the Christmas beetle choosing the position of least or most symmetrical stimuli when awakening from the rigor of cold. Using interference patterns and models resonating with gravitational Earth-Sun waves, complex combinations of dynamic stimuli were constructed, to which the Christmas beetle responded by changing its position (SCHNEIDER, 1972).

Also termites (Isoptera), whose feeding activity and O_2 consumption are important indicators, react to more than just magnetic components. Their communication modes also include natural electromagnetic sferics impulse patterns, gravitational influences and electrical fields. The statistical correlation between the feeding activity of termites in the laboratory and the number of deaths in Berlin is described in detail; the consequences of this are as yet unfathomable. There is an increased frequency of human deaths on the days on which termites feed less. The authors point to the magnetic field of the earth and its variation with solar influences as the common factor linking the apparently unconnected facts. Further down, other and earlier literature is cited in which an increased incidence of human death is described during unusual variations in the magnetic field.

3.3 Birds as prototypes of magnetic field orientation

This research shows that birds' orientation by magnetic fields has been a frequently discussed topic for decades. Thanks to the thorough and meticulous work of a number of researchers (WILTSCHKO, WALCOTT, MERBEL), it is today beyond doubt that several species of birds sense the earth's magnetic field and use it to establish their position during migration. As described for insects and snails, some species of birds are also particularly sensitive to a range of magnetic field strengths corresponding exactly to the earth's magnetic field – the robin, for instance. When the field is attenuated or amplified, the birds become disoriented. Setting on a certain field range could, however, change through adaptation.

The mechanism by which birds sense magnetic fields has meanwhile been largely explained. An area with iron-containing tissue was discovered in the skull of pigeons. Strangely, only one half of the skull contains material that is permanently magnetic. But opposite to this, material was found that is only very weakly permanently magnetic. Measurements indicate magnetite inclusions - the same crystal that was found in bees, bacteria, snails, whales and humans. The magnetite-containing tissue of the pigeons is even supplied with nerve ends that can sense the orientation changes signalled by the crystals (WARNKE, 1993).

It could be demonstrated at the Zoological institute of the University of Frankfurt/Main that the top half of the pigeon's bill has three magnetite-containing bodies, with a neuron ending at each of these. They constitute a three-channel system enabling the brain to construct a spatial picture of the surrounding magnetic field the pi-

geon can use to orientate itself in flight (source: TV programme *Planet Wissen* in BR on 18.09.2007 at 16.15 on carrier pigeons. Reference by W. Sönning).

Birds also have magnetite in the edge of the bill. In addition, light and magnetic fields result in an increase of certain free radicals in the eye, the concentration of which can obviously be accurately registered by the animals (WARNKE, 1995). This relationship will be dealt with again further on.

3.4 Animals with a navigation system are extremely sensitive to electrical and magnetic fields

Birds having a navigation system are extremely sensitive to the weather. A thunderstorm changes the magnetic field, light and many other characteristics – potentially causing the orientation to collapse. Birds and other animals are particularly sensitive to a solar eclipse. They exhibit an abnormally changed behaviour: sometimes lethargic, sometimes restless. Research attributes the reactions to the suddenly occurring electromagnetic long and medium wave radiation, typical for night time, but surprising with the suddenly occurring darkness of a solar eclipse. The lack of ionisation in the ionosphere by light has the effect of many oscillating impulses propagating 100 times better on the surface of the earth.

This unexpected electromagnetic impulse effect may also, in principle, explain the early warning system animals have for earthquakes. The so-called sensitivity to weather or inclement weather, traceable to short electromagnetic impulses with a certain frequency content and rapidly decreasing amplitudes, has also been known for a long time.

These impulses originate at frontal weather systems, where colder air from sub-polar regions undercuts warm subtropical air masses. In the regions where warm or cold fronts mix, thermodynamically driven turbulent air currents with vertical and horizontal components are created. This is in essence where the abovementioned natural electro-magnetic impulse radiation of the atmosphere, also known as sferics, is created. Many life forms such as insects, frogs, birds and various mammals react to this meteorologically based impulse activity in the atmosphere. By receiving and frequency-analysing these "weather code" signals of changes in the weather or approaching thunder-storms, they can then dive for cover or fly around these thunderstorm regions (WARNKE, 2006).

Walter Sönning: "These weather signals or sferics are indicators of unstable processes in the troposphere – the weather-creating layer of the atmosphere -, since their source is in the weather centre. They originate in invisible discharges between positive and negative space charge clouds, created and maintained by different processes of ionisation such as cosmic radiation, UV radiation, natural radioactivity or the Lenard effect (= spray electrification or break-up of droplets or ice crystals with opposite charges). In terms of physics, our air could therefore also be described as a "plasma" gas. When differing space charges of possibly predetermined magnitude are electrically equalised, the ion-front of this basic plasma or gas discharge propagates at velocities of about 200 km/s along a tubular channel of about 40 cm diameter in the direction of the maximum potential difference, covering distances between 40 and 100 metres, until the electrical potentials are equalised. If the ion density in the air is sufficiently high, the following discharge impulse follows immediately. Each of these invisible and "quiet" discharges that occur at varying intensities in all weather conditions, is the source of an electromagnetic, three-dimensional impulse or space wave, a so-called EMP or primal impulse, similar in its waveform to impulses from other sources (nerves, atmospheric nuclear explosions etc.). This 3-dimensional wave propagates at the speed of light. When recorded on an oscilloscope, for instance, it vaguely resembles a sinusoidal half-wave, but has a steeper rise time and an exponential decay of the amplitude. In a Fourier analysis, it is therefore not equivalent to a sine wave of a certain frequency.

Depending on the meteorological and atmospheric electrical propagation conditions, these EMP's are dampened at a distance of 60 to 100 km from the source to lower frequency sinusoidal Fourier components with a continuous spectrum between approx. 3 kHz and 60 kHz. True to their origin in an impulse discharge, these "impulses" have waveshapes of a few oscillations with rapidly decaying amplitudes from a maximum down to zero. Particularly well-defined impulse shapes in the total collection of atmospheric impulses convey, through their resonating sinusoidal oscillations at certain frequencies and also in the subsequent impulse frequencies up to 100 Hz, the meteorological information on their origin and propagation conditions – like a kind of code. These impulses can be displayed after suitable electronic filtering and are known in the technical literature as CD sferics a.t.B. (CD = convective discharge, i.e. created in atmospheric convection or turbulence without luminosity; a.t.B. = according to BAUMER). They gained special significance, however, at the beginning of the eighties in the context of industrial four-colour copper gravure printing. In this context, their highly differentiated effectiveness in the diffusion capability of bio-chemical biological membrane systems, in dependence on characteristic weather processes, was also shown.

The signals of visible lightning, occurring over the period of the main lightning discharge comprising of virtually uninterrupted sequences of such EMP's, together showing impulse periods up to tenths of seconds with a continuous spectrum into the MHz range, are a strictly different phenomenon.

As such, however, they are suitable as a special weather or thunderstorm signal for the animal and possibly the plant world, i.e. for any organism fitted with the corresponding reception sensors.

Sferics or atmospherics of the various kinds could therefore deliver an almost complete picture of the weather of the day, including prognostic clues, for a biological strategy, considering that the sferics propagate from a weather front at the speed of light and are travelling for hundreds of kilometres, always clearly recognisable as encoded weather to those who have the reception sensors. This can be proven by the example of the reactions of the biochemical membrane system of dichromate gelatine. Also: throughout evolutionary time, both the constant impulse frequency spectrum of the CD sferics a.t.B. and the

daily excursions, constant in their climatological average, have provided a wealth of precision information on the meteorological and geophysical environment to those equipped with the receptors for the signals and the experience; which is more than today's weather services can achieve with the most modern high-tech equipment." (End of the contribution by Walter Sönning).

Animals have a typical electrical charge pattern for each weather phase. Since all movement of charge is associated with forces, animals can analyse the approaching weather via the electrical quantities, even long before the arrival of a thunderstorm.

As a function of special electrical weather events, the bodies of the animals are therefore affected through a complicated interaction of different components: charged, reverse charged, discharged, dielectrically polarised. Polarisation is by a natural electrical DC field. It can be shown that animals are slowly electrically charged in good weather, whilst approaching thunderstorms cause a rapid discharge due to a high concentration of small ions in the atmosphere and charging changes rapidly between positive and negative as the thunderstorm approaches.

Insects such as bees receive these oscillations and recognise them as storm warnings. We were able to show that bees return in great numbers when these oscillations are simulated and transmitted, using a highly amplified signal generator signal. If the amplitudes of the artificial oscillations overlap with the natural signals, however, the return rate rapidly decreases. The bees fail to find their way home.

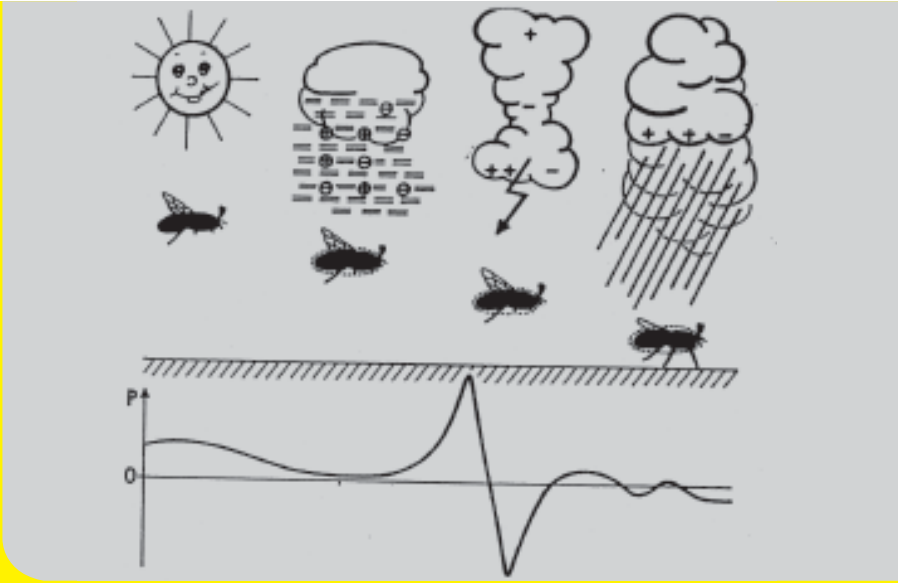

Fig. 2: Top sketch: *The electrical charging of the insects changes typically as the weather parameters change. The bottom curve shows the changes in the electrical field of a freely flying bee as a function of the weather condition.*
Warnke 1989, Copyright Ulrich Warnke

The sensitivity of the honeybee to weather is based mainly on electromagnetic information. When an approaching thunderstorm threatens the bees, flying bees return en masse when the natural 10 – 20 kHz component of the sferics activity increases within a radius of approx. 200 km (WARNKE 1973). The suction performance of the bees also correlates with the approach of the front and the associated sferics (SCHUA, 1952).

And ultimately, bees even use the receptor channel for electromagnetic waves for communication. Russian researchers found in 1975 already that bees generate electromagnetic signals with a modulation frequency between 180 and 250 Hz as they perform their communication dance. Hungry bees react to the frequencies by holding their antennae erect (ESKOV et al. 1976).

Such electromagnetic communication impulses of the antennae when touching another bee can be measured with an oscilloscope (WARNKE, 1989).

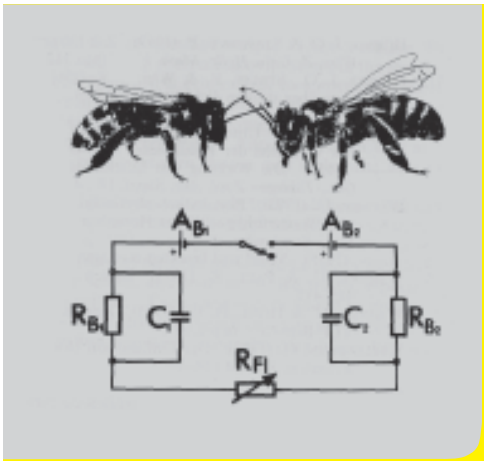

Fig. 3: *Bees communicate via electrical "switching" when their antennae touch.*
Warnke 1989, Copyright Ulrich Warnke

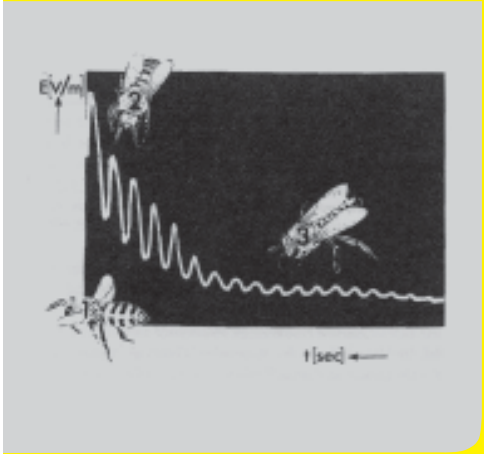

Fig. 4: *Oscillogram of the electrical field of a bee flying past (1). The field strength rises as it approaches a receiver (2) and drops again at a distance from the receiver (3).*
König, H. Unsichtbare Umwelt. Heinz Moos Publishers, Munich 1973. Copyright Ulrich Warnke

Some bird species, such as carrier pigeons, are sensitive to exactly the same electromagnetic oscillation amplitudes as the bees. Birds, particularly species of duck, also communicate by means of electrical fields (WARNKE, 1989). This interesting aspect will be dealt with in more detail below.

3.5 Humans are also sensitive to weather through electromagnetic pulses

The interest in sferics and their effect was greater in the sixties than it is today. In those days, a number of valuable overviews were compiled of their effects on the organism (REITER, 1960; ASSMANN, 1963).

Mammals and man are also influenced by sferics.
Sferics impulses change the tissue pH independent of the amplitude of the field. This is true in the minimal field strengths occurring in nature and also in the laboratory with simulated impulses and increased field strengths. Especially in the frequency band between 2 and 20 kHz, in which the energy of the atmospheric-electrical waves is at a peak, the effect is the strongest. Pain associated with amputations and with brain injury also correlates with the presence of sferics both in the laboratory and in nature (REITER, 1960). The paper by Reiter also contains notes on the triggering of bronchial asthma, heart and circulatory disorders, insomnia, headaches, glaucoma, gall and urinary convulsions, heart attacks and strokes – among other by sferics.

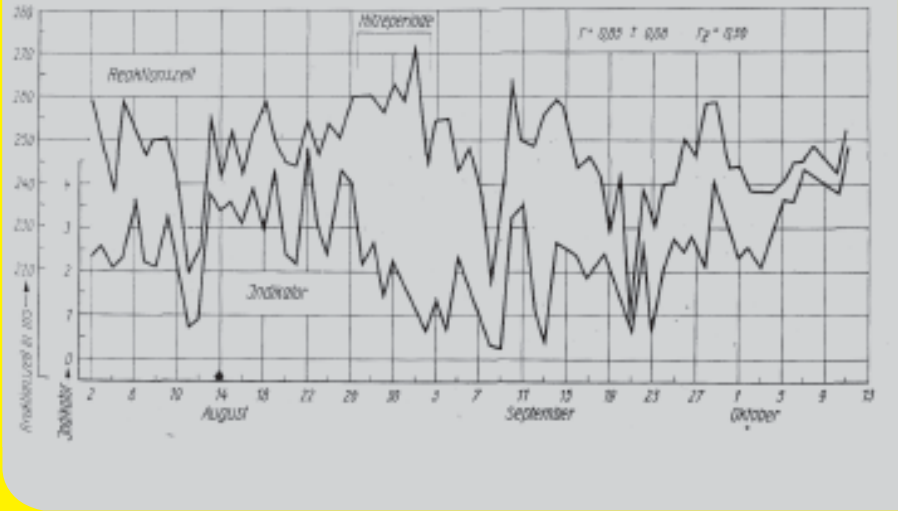

Fig. 5: *Significant linear correlation between electromagnetic very long wave activity and average reaction times of exhibition visitors.*
Reiter, R. 1960 Meteorobiologie und Elektrizität der Atmosphäre. Akademische Verlagsges. Geest & Portig, Leipzig

It has been known for a long time that certain weather conditions give rise to thromboses, heart attacks and embolisms; the correlation is statistically significant (ARNOLD, 1969; BREZOWSKY, 1965). A significant increase in platelet adhesion could be shown with certain electromagnetic oscillations such as those generated by exchange of electrical charge in the frontal regions of the atmosphere. These longwave sferics easily penetrate into buildings. The mean impulse repetition frequency is in the region of 5-15 imp/sec, i.e. in the biologically active window. Thrombocyte adhesion was measured in subjects in a controlled laboratory study using a sferics stimulator (JACOBI et al. 1975). The result was a highly significant ($p < 0.0005$) increase in adhesive property at a carrier frequency of 10 kHz and an impulse repetition frequency of 10 Hz. The thrombocyte adhesiveness was reduced at repetition frequencies of 2.5 and 20 Hz and with no electrical signals. Pharmaka (75 mg Dipyridamol plus 300 mg Acetyl salicylic acid) prevents sferics-related thrombocyte adhesiveness. Mentally unstable subjects were more affected by the change in adhesiveness than stable ones.

The daily work performance is also correlated with diurnal sferics activity (RANTSCHT-FROEMSDORF, 1962).

After further investigation by Jacobi (1977), the physiologic detector location was found to be in the head. If the head is largely screened from sferics, the thrombocyte adhesiveness disappears under otherwise equal experimental conditions – a result that is not in agreement with the effects of screening found by other researchers.

The fundamental sferics frequency is 7.5 Hz, considering the speed of propagation of the electromagnetic oscillations generated by the lightning discharge and the resonant path given by the circumference of the earth between the earth's surface and the ionosphere. The bandwidth of the fields is several kHz.

The correlation between heart attacks and weak magnetic field variations has been described in 1979 in Nature, one of the foremost scientific magazines.

This result is not an isolated case. Other experiments even found a correlation between the average number of deaths and earth's magnetic activity.

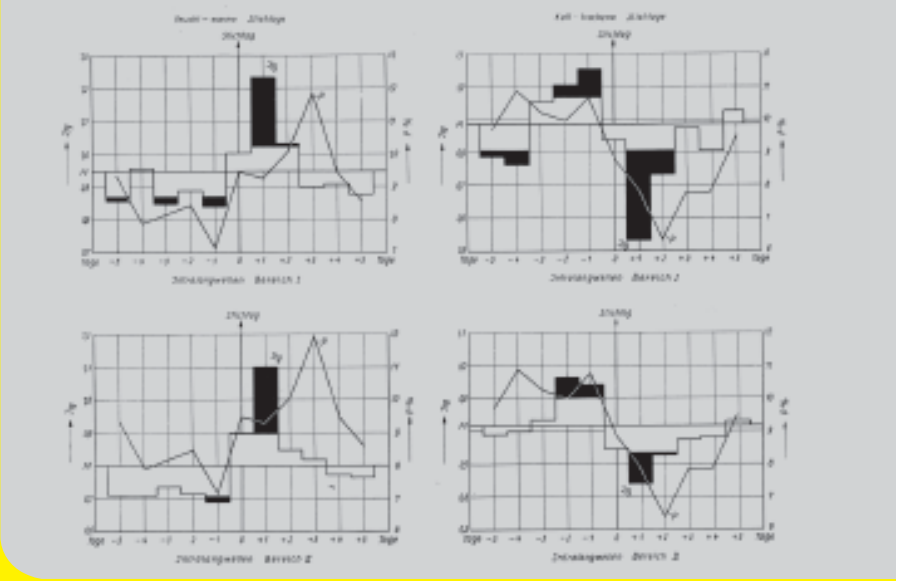

Fig. 6: *Significant synchronicity of very long waves and contracting poliomyelitis. The black bars show days of low (bars downward) or high (bars upward) sferics activity and the superimposed curves show the correlated levels of poliomyelitis contraction in the fifties.*

Reiter, R. 1960 Meteorobiologie und Elektrizität der Atmosphäre. Akademische Verlagsges. Geest & Portig, Leipzig

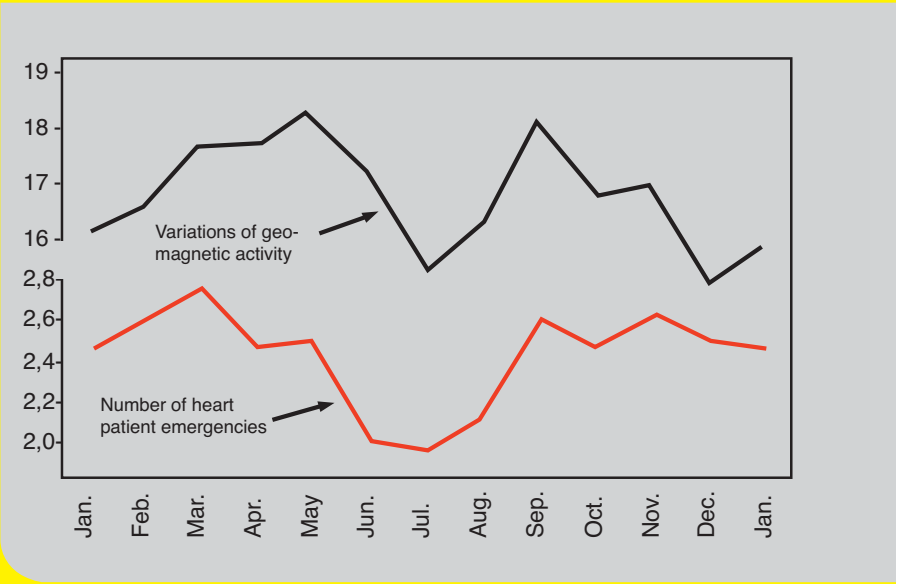

Fig. 7: *Daily emergency hospital admissions for heart attacks as monthly average (bottom curve) and geomagnetic activity (top curve)*

Malin SRC, Srivastava BJ. Correlation between heart attacks and magnetic activity. Nature 1979;277:646-648

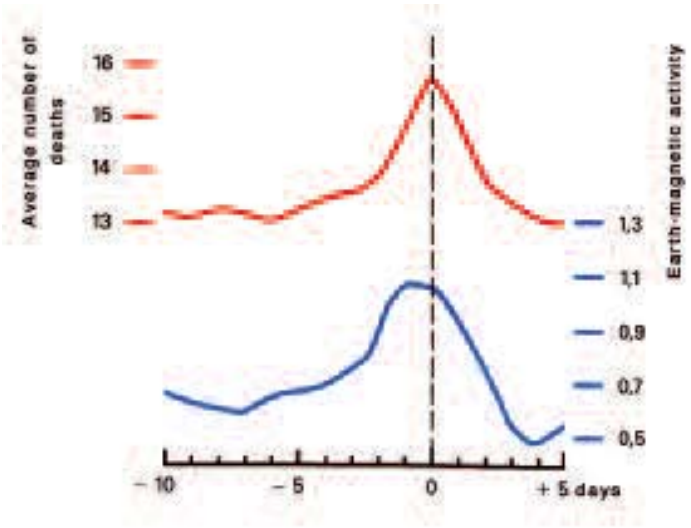

Fig. 8: *Magnetic storms (bottom) and fatalities from nervous and cardiovascular illnesses.*
Weiß 1991

Fig. 9: *Wing of a bee under a scanning electron microscope. The electrical current pattern was recorded. All the white regions have high electron mobility, whilst the darker areas are highly electrostatically charged due to low electron mobility. Discharge is very difficult.*
Warnke 1989, Copyright Ulrich Warnke

3.6 Bees transmit electrical fields

Electrical fields with high amplitudes are always in evidence when the unipolar charge accumulations creating the fields cannot be repeatedly neutralised. Charges are easily neutralised when they are highly mobile.

All land-based insects with rigid body shells (cuticula) and also animals with scales, shields, feathers and hair have used these structures to form surfaces that have excellent electrical insulating properties. These body parts have semi-conducting properties and are piezo-electric and pyro-electric – distortion and temperature changes therefore both create electrical effects. The conductivities are therefore subject to the well-known laws of semiconductor theory: temperature changes, light effects, microwave effects, changes to atmospheric ion concentration – all these parameters change the conductivity pattern.

The areas of different conductivity can be shown in a visually impressive way – demonstrated here on a bee's wing - by using a scanning electron microscope with sample current imaging.

In terms of electrostatic charging, it is also important whether the animals are in flight or on the ground. Animals having sweat, scent and adhesion glands afford excellent galvanic contact. Animals walking on hoofs, toes or claws are largely isolated from earth, however.

There is a salient point about different insects. Flies, bees and others have a glandular adhesive pad (arolium) between two toes on their feet. This adhesive pad can be folded in or folded out when walking.

When the arolium is folded in, the animals walk on their claws, insulating them electrically from the environment allowing them to get statically highly charged up. If the arolium is folded out and touches the surface on which it is walking, however, the in-

sect is instantly discharged, assuming the electrical potential of the surface. In bees, this happens just prior to taking off from a flower, in which case certain parts of the animal are discharged or obtain a different charge or sometimes even reverse polarity. Since flowers normally are at earth potential, the "arolium switch" effectively standardises the insect's potential to zero. When the bees arrive at the hive, they carry different charges that they picked up in flight and that cannot dissipate that fast (WARNKE, 1977).

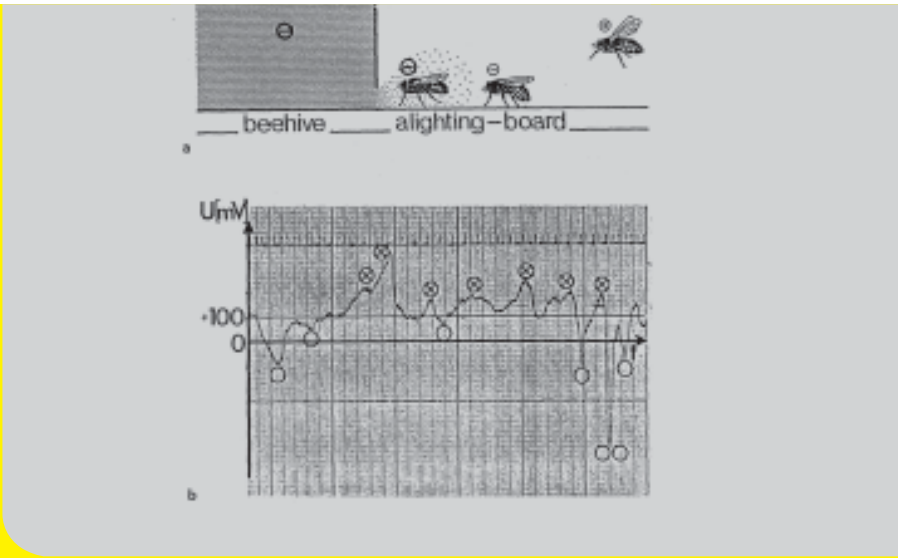

Fig. 10: *Every bee landing at the hive carries a specific charge (circle with cross) thereby changing its pattern of charge at the hive entrance, determined by the total electrical charge of the colony. Every departing bee carries with it electrical charge from the hive (circle).*
Warnke 1989, Copyright Ulrich Warnke

When two surfaces make contact on the molecular level (10 to the power of minus 10 m), positive and negative charges are separated at the point of contact through charge transfer. Many such points are activated in a short space of time by friction. Frictional electricity is one of man's oldest observations and has lent its name to the entire electrical discipline (electron: Greek for amber). It is therefore surprising that we thus far hardly spared a thought for the significance of electricity in animals.

Especially in flight, animals could become statically highly charged through friction between air molecules and body tissue – up to electrical field strengths in excess of 1 000 V/cm.

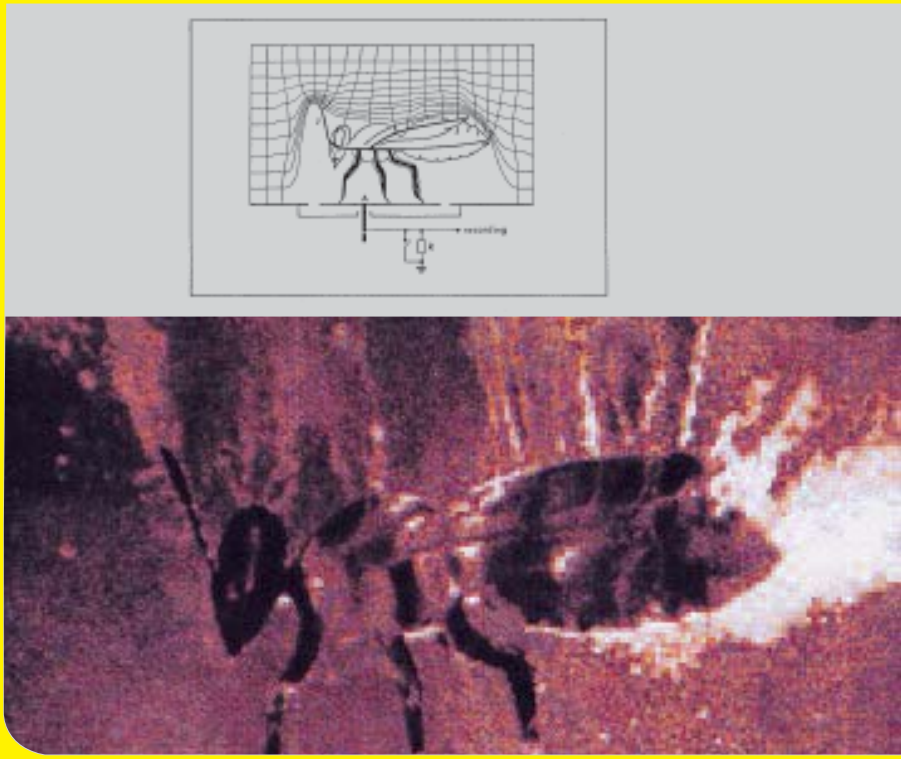

Fig. 11: *A bee in an electrical field; top: a construction, bottom: an experiment. It is shown how the field strength increases around certain surface structures.*
Warnke 1989, Copyright Ulrich Warnke

Fig. 12: *Bee in flight in an electric field. The fields around the antennae are particularly strong.*
Warnke 1986, Copyright Ulrich Warnke

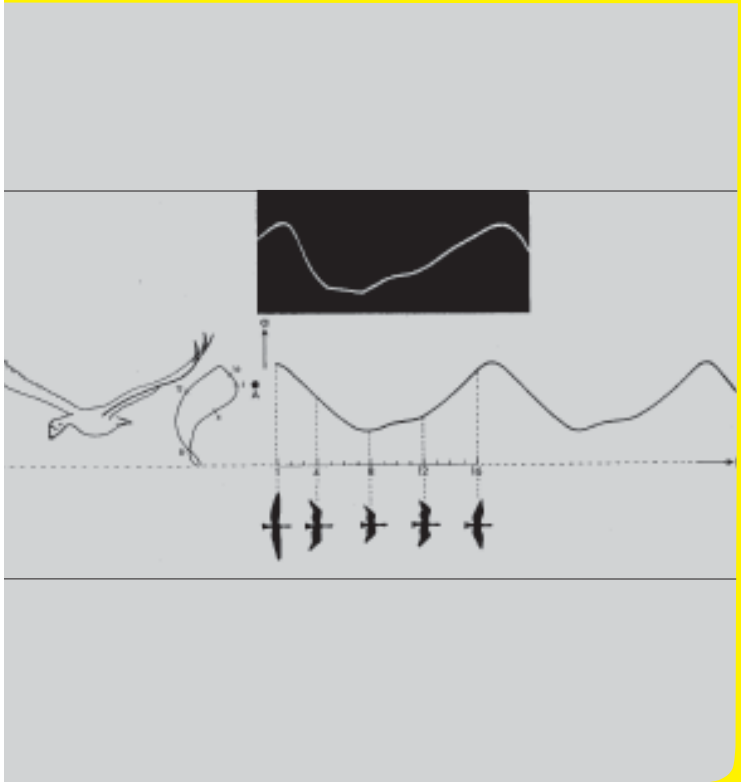

Fig. 13: *Wing movement and the electrical field – with reference to the wing – are in phase.*
Warnke 1989, Copyright Ulrich Warnke

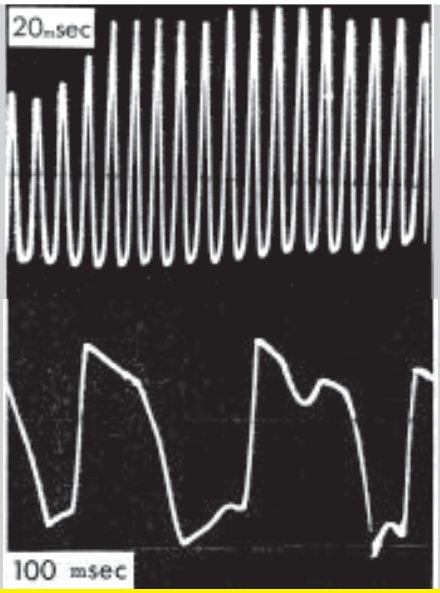

Fig. 14: *Oscillogram of the alternating electrical field around bees (top) and pigeons (bottom) in a wind tunnel.*
Warnke 1989, Copyright Ulrich Warnke

To increase these field strengths, animals have various aids such as protruding spikes on insect wings, but especially the field focussing effect of insects' antennae is measurable, developing appreciable Coulomb forces.

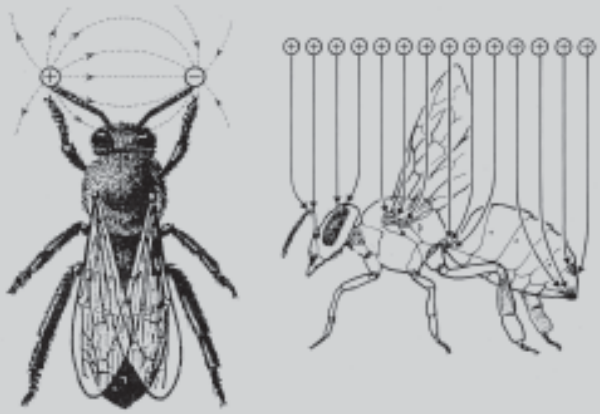

Fig. 14.1: *Representation of a measurable "dipole effect" on the antennae of the honeybee. Bees are able to change the polarity of their antennae at will (e.g. from positive to negative charge) – within a second. The dotted lines are an indication of the forces in the field.*
Warnke 1989, Copyright Ulrich Warnke

3.7 Effects of technically generated fields on bees

We investigated the reaction of bees to artificially created electrical fields in the laboratory (WARNKE 1975, 1976, WARNKE et al. 1976) and found the following: 50 Hz AC fields with field strengths of 110 V/cm cause significant restlessness of the bees in their enclosure. The colony temperature increases greatly. The defence of the social territory is uncontrollably increased to the point where individuals in a colony stab one other to death. They no longer recognise one other.

After a few days in the field, the bees tear their brood from the cells; no new brood is reared. Honey and pollen are also depleted and then no longer collected. Bees that were newly established in their hives shortly before the start of the experiment always abandon the hive again and disappear when the electrical field is switched on. Bees that have lived in their hive for a long time, plug all the cracks and holes with propolis, including the entrance. This otherwise only happens in winter in a cold draught.

Since an acute lack of oxygen develops when the cracks and the entrance are plugged, the bees attempt to introduce air by intensive fanning. In this process, the wing muscles generate temperatures high enough to melt the wax. The animals attempt to fight the temperature increase by more fanning. In the end, the colony burns itself out. This implies the death of all members of the colony – which we could obviously prevent in future.

With very sensitive colonies, the reaction signal was measurable from field strengths of 1 V/cm and frequencies between 30 Hz and 40 kHz. When the field is switched on, the animals suddenly move their wings and buzz at frequencies of 100–150 Hz (WARNKE 1973, 1976, WARNKE et al. 1976).

With signals in the frequency range of 10 to 20 kHz, the aggressiveness was increased and the homing ability much reduced even though the natural meteorological and electromagnetic environment was intact in the flight space (WARNKE, 1973).

Fig. 15: *Wing section of bees enlarged with scanning electron microscope. Observe the special structures serving to focus the electrical field.*
Warnke 1989, Copyright Ulrich Warnke

Scientists from the University of Koblenz-Landau conducted several experiments, looking at different aspects and questions, to measure the homing behaviour of bees (Apis mellifera carnica) as well as the development of mass and area of the combs under the influence of electromagnetic radiation (KUHN et al. 2001, 2002, STEVER et al. 2003, 2005, HARST et al. 2006).

They recorded an increase in agility, an increased swarming drive and no winter clustering when under the influence of EM radiation of cordless telephones.

In other experiments with base station fields of the DECT cordless telephones (1 880-1 900 MHz, 250 mW EIRP, 100 Hz pulsed, 50 m range, permanent exposure), the weight and area development of the colonies was slower compared to the colonies that were not exposed to a field.

The homing ability of the bees was tested from five days after the DECT telephones were introduced. There were significant differences in the return times of the colonies that were in the field and those that were not. No more than six of the bees exposed to the field ever returned – sometimes none returned. With the bees not exposed to a field, there were returning bees at any point in time of the experiment.

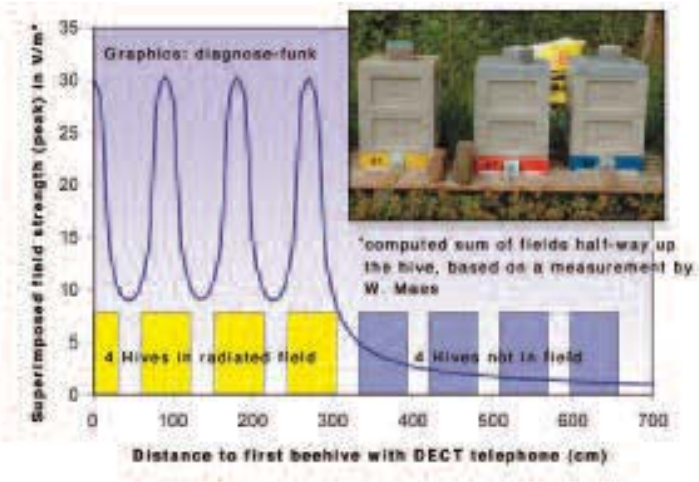

Fig. 16: *Estimated diagnosis radio field strength in the four beehives with and four without DECT telephone installations at the University Koblenz-Landau. The beehives were not electromagnetically screened, implying that the control colonies were also subjected to some field strength.*
Diagnosefunk, http://www.diagnose-funk.ch/impressum.php

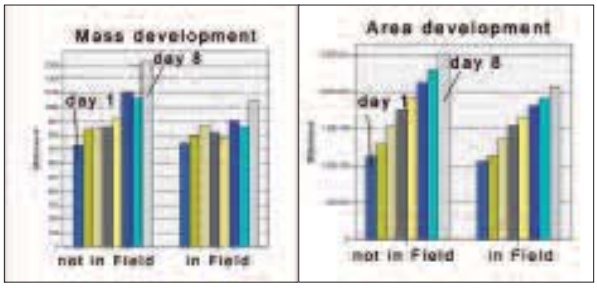

Fig. 18: *Mass and surface development of combs of bees in and outside of a field.*
Harst et al. 2006

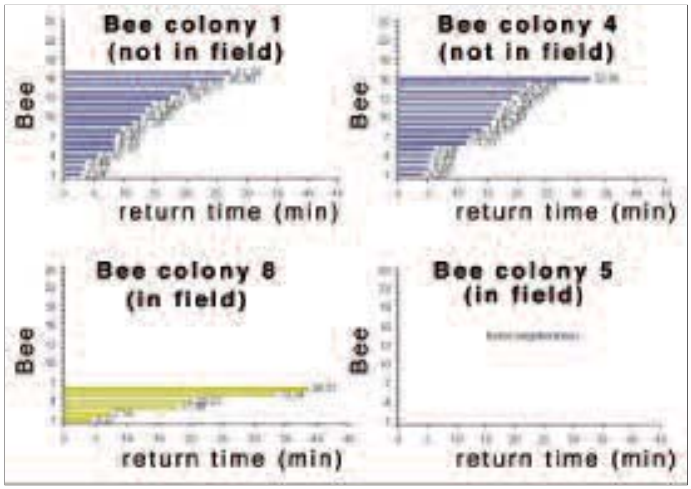

Fig. 17: *Top left and right: return times of bees not subjected to a field; bottom: return times and non-return when subjected to a field. Of the bees from hives not exposed to a field, 40% returned in total, of those subjected to a field only 7% returned.*

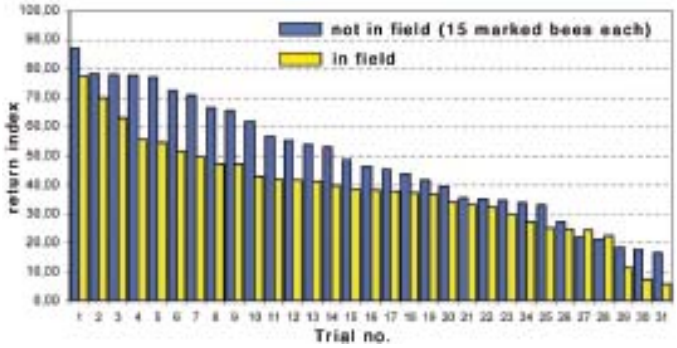

Fig. 19: *Significant difference in the homing behaviour of bees subjected to a field and others. A higher index indicates more returned bees and/or shorter return times.*
Harst et al. 2006

Two earlier NASA financed studies by one of their working groups found neither an increased fatality rate of bees in high frequency fields (2.45 GHz, CW) nor diminished orientation (WESTERDAHL et al. 1981a/b).

3.8 The highly sensitive region for interference of bees

If a new food source is discovered within 80-100 m, the bee performs a circular dance on the comb in the hive. If the food source is further away, communication is by means of a waggle dance. This waggle dance of the honeybee communicates information on the direction and distance of the new food source relative to the hive. In this dance, the returning worker bee initially traces a straight line and then dances sideways and down in a semi-circle. She then again starts along the straight and dances a semi-circle downwards again, but to the opposite side. The distance to the food source is given by the number of deflections of the abdomen on the straight (waggling). These waggles can also be measured in the form of electrical and magnetic alternating fields.

The distance to the food source is registered by reference to optical features of the landscape over which the bees are flying. The information on the direction to the food source is given by the angle between the straight line to the food source and the azimuth of the sun in each case. This angle is conveyed in the darkness of the hive via the direction of the dance with respect to the vertical (gravitational vector).

All this can be proven. The credit for discovering this evolved strategy of bee communication goes to the Austrian Karl von Frisch (FRISCH von, 1967). But we know in the meantime that the communication processes are associated with far more complicated mechanisms.

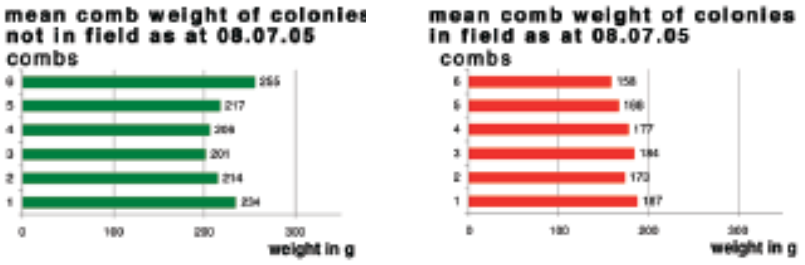

Fig. 20: *Starting with the same comb mass, the average values of the total mass of the colonies subjected to a field and those that were not, were 1326g and 1045g at the end of the test. The difference is therefore 281g (21.1%)*
Harst et al. 2006

Fig. 21: The waggle dance of the bees generates electrical oscillating fields.
Warnke 1989, Copyright Ulrich Warnke

Apart from the position of the sun, the bees can also identify polarisation of the light. And in case of overcast skies, the positions of permanent landmarks are memorised (DYER, 1981).

Navigation to the food sources and back to the hive makes use of other physical quantities, however: these are exactly those quantities that have existed on the surface of the earth for millions of years –taking us back to our subject. How does the bee know the azimuth of the sun at any given moment?

She needs this information to recognise the time of day. And she needs to know about time because many flowers only open at a particular time of day and because navigation is coded via the position of the sun.

The answer to this question illustrates how finely nature has analysed the naturally occurring energies and forces, making these available to the organism. The higher the sun in the sky, the more the atmosphere heats up. The higher the atmospheric temperature, the faster the atmospheric molecules move. The faster the molecules, the more energetic the collisions between them. The larger the collision forces, the larger the air volume and the more intense the turbulences manifesting themselves also as eddies. These eddies ultimately also affect the ionosphere. The increased movement of ions in the ionosphere generates huge electrical currents. These directional electrical mass-flow currents in turn generate strong magnetic fields.

These magnetic fields reach the earth's surface and have a typical diurnal pattern – analogous to the described effect of solar radiation. They are characteristic diurnal magnetic field variations, superimposed on the largely uniform magnetic field of the earth. Exactly these variations can be measured by the bees. And they use these measurements to calculate the azimuth of the sun and the time of day.

In the experiments on navigation and orientation, this magnetic field component is recognised as a so-called "precision error" in the performance of the waggle dance. The expression "precision error" was created when a deviation of the dance direction from the principle described above was noticed, but the influence of the magnetic field was as yet unknown. Since a few decades we now know: the reason lies in the consideration of the magnetic field variation which modulates the direction angle of the waggle dance (KIRSCHVINK, 1981). The "remaining precision error" in the dance disappears if the entire magnetic field is compensated to 0-4%.

The maximum sensitivity of the bee to earth's magnetic variations is around 26 nT. It must be emphasised here already that the system is particularly sensitive in the naturally existing physical range. Significantly amplifying the magnetic field compared to the normal biological range, causes a stronger variation in direction communication. If the field is amplified to 10-times that of the earth's magnetic field, the colony swarms, away from its hive.

The question of how bees sense these magnetic field variations has been investigated in a number of studies (GOULD et al. 1978, 1980, GOULD 1986, FRIER et al. 1996, HSU et al. 1994, KALMIJN et al. 1978, KIRSCHVINK 1992, KIRSCHVINK et al. 1981, 1991, 1997, WALKER et al. 1985, 1989 a/b/c, COLLETT et al. 1994).

To summarise, it may be said that (HSU et al. 2007): The construction of combs and the homing capability of bees change if the bees are subjected to magnetic fields superimposed on the earth's magnetic field. Bees in free flight can sense extremely slight variations of the magnetic field intensity - in the range of 26 nT. They can be trained to magnetic anomalies, but only provided the changes remain stable for a longer period.

Many experiments proved that an accumulation of bio-magnetite particles (Fe_3O_4) serves as receptor of the magnetic field. These iron granules are arranged in a band in the abdomen of the bee. They have a diameter of only about 0.5 µm and are located in special cells, the trophocytes. Magnetite has the effect of amplifying the magnetic variations. If 30% of the intensity of the horizontal earth field component is modulated, the activity of the neurons in the ganglion of the abdomen changes (SCHIFF, 1991).

Apart from super-paramagnetic magnetite, FeO-OH was also found in the abdomen. Magnetic material was also shown to be present in the antennae, head and claws of stingless bees.

The iron granulates are enclosed in small vesicles, touched by a cell framework. As in higher organisms, microscopic filaments (micro-tubules) serve as the cell framework. The vesicles also contain some phosphorus and calcium together with the iron. The density of the iron granules is 1.25g/cm³, that of the Fe_3O_4 magnetite is 5.24gIcm³.

Where does the magnetic material come from? Most of the iron originates from pollen (approx. 0.16 µg/mg) (BOYAIN-GOITIA et al. 2003). If an additional magnetic field is applied to the bee, the size and shape of the biomagnetic granula changes (HSU et al. 2007). These changes are detected by the micro-tubules and micro filaments, and the trophocytes thereafter secrete more Ca^{2+}. The fat cells of the bee also show this effect, but much less so than the trophocytes. It has been known for a long time that cells secrete Ca^{2+} under the influence of a weak magnetic field; macrophages, for instance (FLIPO et al. 1998), astrocytoma cells (PESSINA et al. 2001, ALDI-NUCCI 2000) and chrome-affine cells (MORGADO-VALLE et al. 1998).

It is also known that the Ca^{2+} secretion can be triggered by many different cell changes such as changes to the structure of membranes, changes to the electrical membrane and cell surface potential and changes to the structure and distribution of protein within the membrane. The magnetic field can stimulate two mechanisms for increasing the Ca^{2+} content in the cells: firstly by opening Ca^{2+} channels and by increased flow of external molecules into the cell; secondly by an increased release of Ca^{2+} from storage inside the cell (IKEHARAA et al. 2005, PETERSEN 1996). This explains the increased accumulation of Ca^{2+} in fat cells.

The magnetite mechanism amplifies the effects tremendously (SCHIFF, 1991). The property of the granules, to expand in an external magnetic filed, turns them into magnetic field sensors (TOWNE et al. 1985). The affected micro filaments make contact with the cell membrane (HSU et al. 1993, 1994), affecting signal transfer into the cell.

If the colchicine and latrunculin B toxic substances, known to shut down the micro-tubules and micro filaments, are administered, then an additionally applied magnetic field will not increase the Ca^{2+} in the cells.

A model of the magnetic field orientation is therefore as follows: If the bee flies parallel to the magnetic field lines, the magnetic granule vesicles will expand; if she flies vertically to the field lines, the granules contract. This change of shape is sensed by the cyto-framework and communicated to the membrane.

That is where Ca^{2+} channels are correspondingly opened or closed. This signal transfer results in a

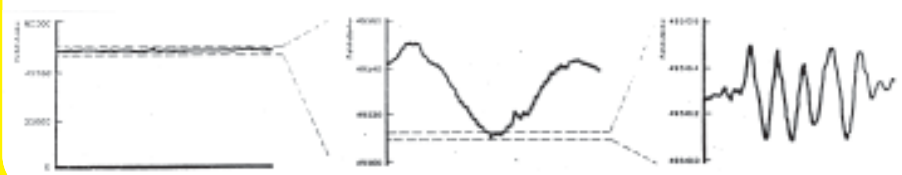

Fig. 22: *Variations in earth's magnetic field: Sensitivity of the measurements increased a 1000 times in each case. Diurnal rhythms and micro-pulsations are visible, utilised by bees and other organisms for orientation in space and time.*
Warnke 1978

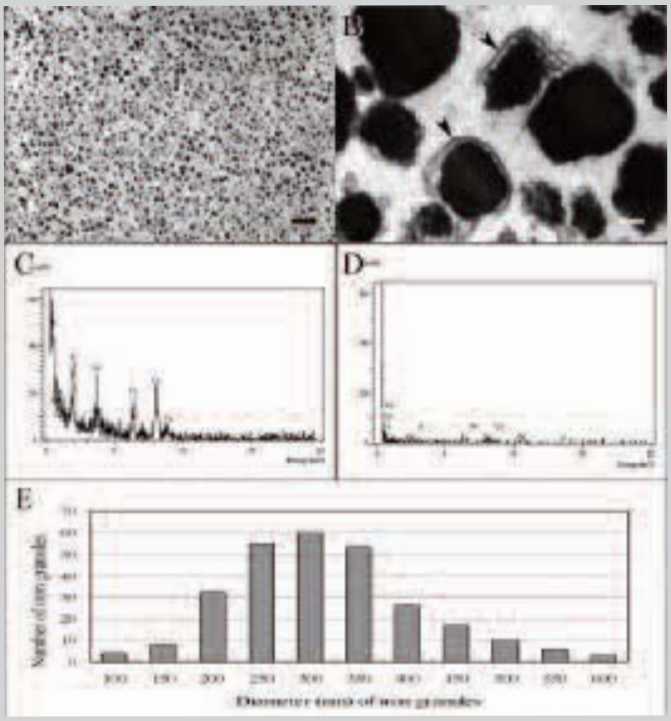

Fig. 23:
A) Iron granules in the trophocytes of the honeybee (bar: 1 µm)
B) Iron granules enclosed in lipid membranes (bar: 100 nm)
C) and D) Energy dispersing radiation analysis of the granules; they contain calcium, phosphorus and iron.
E) Histogram of the granule sizes.

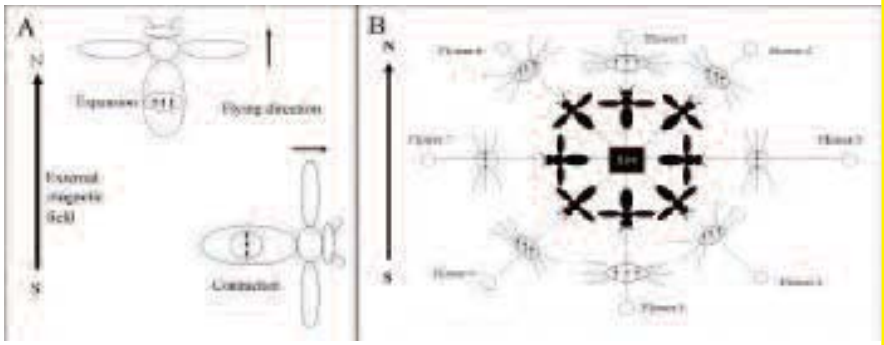

Fig. 24: Schematic of the magnetic field orientation of a bee through use of the magnetic granules.

magnetic field map for the duration of a flight, that can be used for orientation – particularly also for returning home, by reversing the time sequence of the magnetic field (RILEYet al. 2005, MENZEL et al. 2005). It is extraordinary that, in this process, variations of 26 nT can be sensed against the background of earth's 45 000 nT.

This model explains:

1. *The flight from the hive to the food source must be in a straight line. Bees navigate by means of a memory map (RILEY et al. 2005, MENZEL et al. 2005).*
2. *During the known circular orientation flights, the magnetic field is mapped over 360°. It is known that the orientation flight is indispensable for successful return to the hive (BECKER 1958, CAPALDI et al. 2000, WINSTON 1987). Nature arranged this similarly to the pigeons, who also circle several times before flying to wards their goal.*

3.9 Constant change in the magnetic environment makes learning impossible for the bees

Bees learn the patterns of the landscape they fly over and also use the magnetic field to differentiate. This is always the case when other orientation aids such as sunlight are covered by clouds. The optical patterns are therefore also associated with a magnetic coordinate (FRIER et al. 1996).

Bees may be conditioned to magnetic deviations from the normal earth magnetic field (WALKER et al. 1989a); they can also be trained to recognise small changes in the earth's magnetic field (WALKER et al. 1989b). It is a prerequisite that the change in the magnetic field remains constant over the learning period. If the field varies continuously, learning becomes impossible.

But this is exactly the situation the bees find themselves in, with wireless communication fields. The magnetic component is continuously changing – during the day and at night.

3.9.1 HAARP changes the natural diurnal variation of the magnetic fields

The information on the HAARP project is thanks to Guy Cramer (USA); it was made available to me by Joris Everaert (Belgium).

HAARP (High-frequency Active Auroral Research Project) is the abbreviation for a military project of the US Air Force and Navy. 180 towers have been erected in an uninhabited area near the city of Gakona in Alaska, together constituting an antenna complex. The frequency is around 2.5-10 MHz and the power is extremely high at 3 million Watt ("high power, high frequency phased array radio transmitter"). This is the strongest technical transmitter on earth. Its effectiveness is increased by linking the antenna array with another antenna array in Alaska, via HIPAS (High Power Auroral Stimulation). The transmitters communicate with submarines deep in the ocean and scan the horizon as a type of deep earth radar.

But the frequencies are also absorbed by the ionosphere. They heat up certain layers, creating ion turbulences by day, that are modulated onto the earth magnetic field as unnatural magnetic fields. This masks the regular effects the sun has on the ionosphere. As such, the bees lose an orientation that served them for millions of years as a reliable indicator of the time of day – encoded in the regular variations of the magnetic field changes as the sun rises and the ionosphere temperature rises.

The effects of the HAARP transmitter activity should be further investigated especially in Canada, the USA and Europe. Since the disappearance of the bees was first documented in precisely these countries, a causal relationship can no longer be excluded. The following simultaneous events tend to confirm this: In 2006, the increase of the transmitting power from 960 000 Watt to four times that power (3 600 000 Watt), was approved for the first time. Exactly in this year, reports originated in all the "scanned" transmission regions of the disrupted homing ability of bees.

Another disruptive effect may play a role. Through the irregular heating of the ionosphere, the air at great heights begins to "glow", with visible frequencies in the near infrared region (630 nm) and the associated magnetic field can be detected at the earth's surface (PEDERSEN et al. 2003, RODRIGUEZ et al. 1998).

Since the bees use not only the UV component of sunlight for orientation, but also the longer infrared wavelengths (EDRICH et al. 1979, VAN DER GLAS 1977) the new light in the sky may also be a new disrupting stimulus to them.

Fig. 25: *HAARP location and construction.*

3.10 Disrupted NO system damages learning ability, olfactory orientation and the immune system

In following, we will further detail the significance of the (NO) system and the consequences of its disruption – in other experimental animals and particularly also in humans. The salient fact is that the NO system is affected by magnetic and electromagnetic oscillations and may in the worst case become totally disrupted - finally destroying molecular functions.

As in mammals, nitric oxide (NO) normally acts as a carrier of information in insects as well. The synthesis and excretion of NO is particularly high in the insect brain. In bees, NO plays a role in the ability to smell and in learning processes (MÜLLER, 1997).

As proven in humans, if the NO system of bees is disrupted through the effect of technical magnetic fields, they lose the ability to orientate themselves by smell and the vital learning programme also becomes defunct. But since NO also materially controls the immune system, disruptions to the NO household always affect the immune defences of the organism as well.

Dennis van Engelsdorp of the American Association of Professional Apiculturists (University of Pennsylvania), in his report on the investigation into the disappearance of bees, says:

"We have never seen so many different viruses together. We also found fungi, flagellates and other micro-organisms. This multiplicity of pathogens is confusing." It is also striking that the excretion organs of the bees are affected. Dennis van Engelsdorp suspects that a weakened immune system may be behind the mysterious phenomena (VAN ENGELSDORP 2007). But he rightly asks: "Are these agents the causative stress factor or the consequences of a totally different stress?"

Diana Cox-Foster, a member of the CCD working group, says: *"It is very alarming that the deaths are associated with symptoms that have never been described before".* It appeared that the immune system of the animals had collapsed and some bees suffered from five or six infections simultaneously. But dead bees are nowhere to be found (Spiegel 12/2007).

3.11 Birds sense high frequency transmitters

Birds also sense high frequency transmitters very clearly and belong to the group of animal species that reacts very sensitively to electromagnetic fields. They absorb the impinging energy particularly intensively via the feathers of their wings (CHOU et al. 1985, VAN DAM et al. 1970, BIGUDEL-BLANCO et al. 1975 a/b).

How sensitively and promptly they react can be demonstrated by an example. Chicks exposed to a high power microwave field flee within seconds (TANNER, 1966). Investigations have, in particular, also shown how strongly microwave radiated fields affect the behaviour within a flock (WASSERMANN et al. 1984). It has repeatedly been observed that flocks of migratory birds split up when nearing a power station, to circumvent the station as if avoiding an invisible obstacle, only to re-unite again in flight afterwards. Technical disturbances in the frequency range of natural sferics, but with higher amplitudes, cause massive loss of orientation in migrating birds. The V-formation of cranes, for instance, is disrupted as they fly over transmitter stations. This phenomenon is particularly pronounced over water surfaces parallel to the flight path, which reflect electromagnetic waves.

Researchers have for a long time been pondering on how flocks of birds and also insect swarms and schools of fish stay together. It is surprising, for instance, that large flocks of starlings in an area of an estimated 500 m^2 or more, packed with birds, can perform complex flying manoeuvres within 5 milliseconds. But how can the animals, each at a different location in the flock, receive and react to signals in a short time? Transmission by sound would require more time and visual observation of a lead animal is blocked by other animals.

A hypothesis that the flying manoeuvres were coordinated by electromagnetic signals therefore appeared reasonable. Such a signal, propagating at approximately the speed of light, could reach all individuals at the same time and independent of their position. This hypothesis appears more plausible when taking into consideration that the flying animals are highly electrostatically charged.

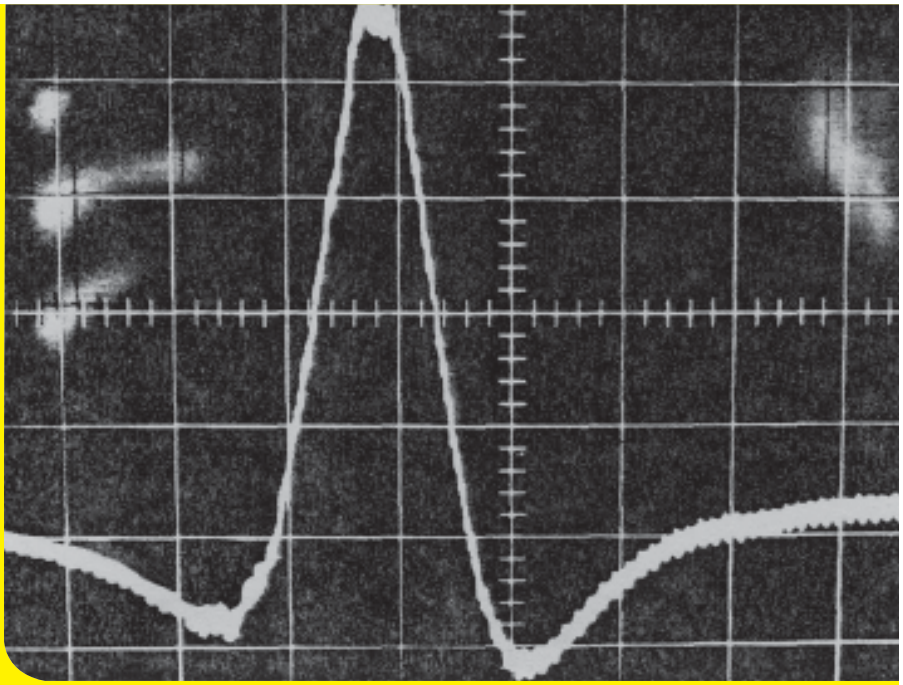

Fig. 26: *Electrical field of a passing flock of birds. The small superimposed oscillation is interpreted as interference by the beat of individual wings.*
Warnke 1989, Copyright Ulrich Warnke

We were able to record by oscilloscope that the electrical field caused by the aggregation of animals resulted in a predominantly positive overall electrostatic field. The figure also shows the very small wing beat modulation compared to the total electrical field. This modulation can be explained as a "beat" resulting from all the individual wing beats.

This beat frequency is always smaller than the wing beat frequency of an individual. The maximum beat amplitude is always much larger than the individual wing beat amplitude, however. The measured values are dependent on meteorological conditions and the geometry around the measurement.

These data allow us to conclude that flocks of small birds flying at a height of about 40 metres are electrically charged to more than 6 000 Volt. We can only speculate about the type of coded signals given for direction changing manoeuvres. It appears that each individual bird has a set beat frequency and amplitude that is corrected immediately it weakens, by changing the direction of flight.

There are presently two theories explaining the typical wedge-shaped flight formation of larger birds:

One of these assumes unhindered contact and simultaneously minimum danger of collision. The other relates aerodynamic advantage to energy economy. The first theory is based on experience with formation flying of military aircraft; the second is based mainly on calculations.

Both theories leave a couple of questions unanswered, however. How sensitive is the system to cross-winds? When a critical wind speed is exceeded – should turbulences behind the wings not distort the formation or even break up the flock? Why do the members of the flock not permanently remain in the minimum energy zone? And why is there never a formation in reverse – open to the front? Can the recognisable geometric particularities of the total formation, considering species-specific bird size and typical distances, be explained by wing-induced updrafts?

In the following, our theory of biologically sensible formations, published 25 years ago, is repeated. It describes a functional system of nature that is largely immune to meteorological interference parameters. Electrical and magnetic external fields can, however, completely destroy the formation by superposition on the biological system's own fields.

The system we are discussing allocates a position to each animal, but also considers all the flying members of the formation. It could also be identified by the analysis of formations filmed in nature. Let us inspect some facts in more detail.

Bird species flying in formation generally maintain a typical order, even in the case of only two birds flying:

The second bird flies laterally displaced behind the first. The electrical force relationships in space are in agreement with the electrical forces determined experimentally and depicted schematically in Fig 27. The highest field strengths are at the bill, the tail and the wing tips. Referring to the bird at the back, the bill-head region is charged in the alternating field of the wings of the first bird, creating an increased force field. Simultaneously, however, the wingbeat of the bird at the back induces charges in the tail region or the extremities facing backwards and resting against the body of the first bird. There is therefore a force field between these body parts as well. The respective induced charges are coupled - as shown in the model – by the electrical field. The balancing charges of opposite polarity, released from the former equilibrium, are free to move. They generate an effective new and measurable field. The bird under consideration, i.e. the second one, therefore not only received induced charges from the first bird but also indirectly - i.e. via the tail end of the first bird – originating from itself. The field strength diminishes approximately as the square of the distance from the inducing charges. The magnitude of the active forces is therefore a function of the distances. Each bird is connected to every other bird via electrical fields of a certain amplitude and direction. These fields can be calculated for each species of bird – yielding the typical formation.

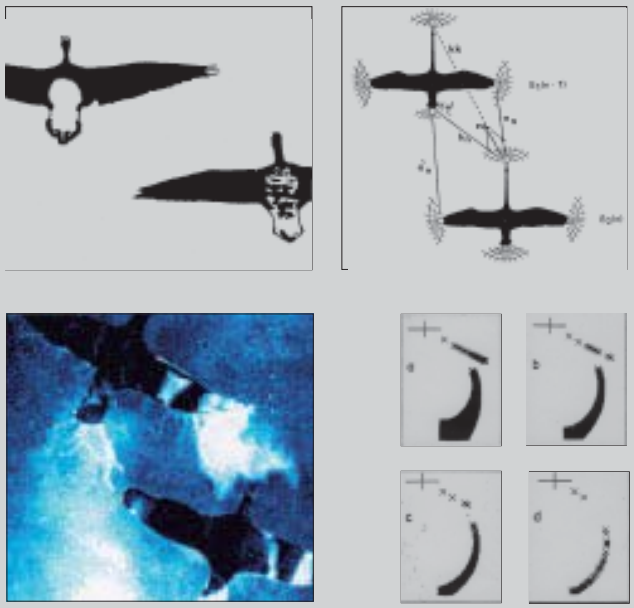

Fig. 27: *Birds use electrical fields for formation flying. Top left: Two geese in formation flight. Bottom left: Experimental model to visualise the electrical field forced between these birds. Top right: Vector diagram of the field distribution. Bottom right: Calculation of the position of the bird behind with reducing degrees of freedom a-d.*
Warnke 1989, Copyright Ulrich Warnke

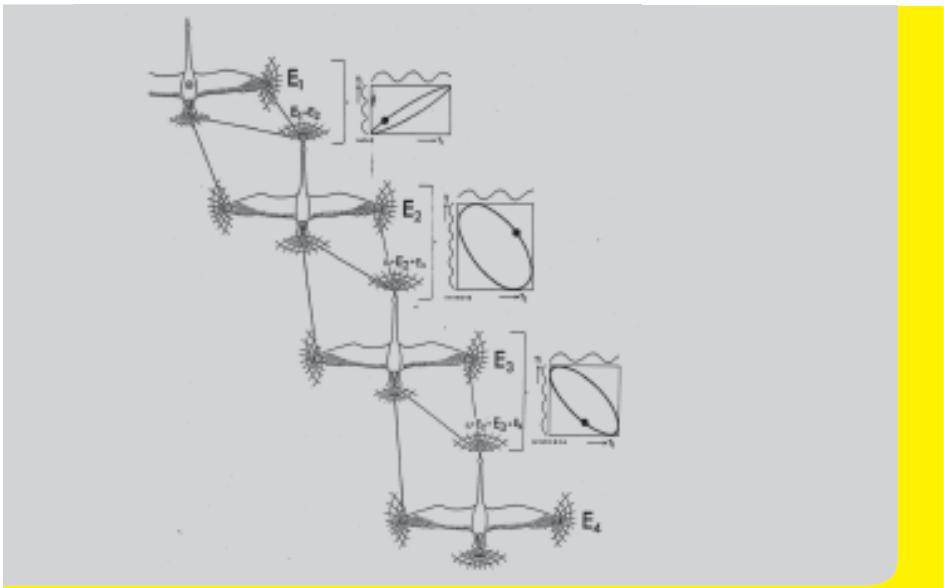

Fig. 28: *V-formations can be constructed by means of an equation that I developed on the basis of physical laws. Comparisons with photographs of natural bird formations show that the assumptions are correct: The formations are given by the Coulomb forces between birds that are electrically charged in flight.*
Warnke 1989, Copyright Ulrich Warnke

It is significant that long necked birds in particular, tend to fly in formation. Their long neck offers the advantage that the detectors in the head region – such as the highly sensitive mechanoreceptors, which also respond to the electrical field forces, can receive signals in flight largely free from the interference of their own body. Observations of their flight behaviour show that the head region compensates for all the movements of the body itself, thereby not having any own oscillations.

Electromagnetic fields therefore have a role to play in formation flying of birds as well. They serve as orientation and navigation aid and determine the position of a single animal in the flock. Depending especially on wing width, wing span and body length, our observations and calculations show that the biophysical relationships influence the species-typical V-formation flying of flocks. Computer calculations of the flight order allow us to predict natural formation flights. And photographic records, vice-versa, also agree well with computer simulations.

The observations demonstrate a unique information and orientation system of the animal kingdom. But they also explain why this is destroyed by the interference of technically generated electrical and magnetic fields.

Due to interference, it would not be possible to measure the magnetic field of the earth inside a flock of birds and its periodic variations caused by the individuals. The reason lies in the moving electrical wing charges, not only generating a weak magnetic field component (induction B approx. 0.01 pT), but also inducing voltages in neighbouring matter – like an AC generator. Only the bird flying at the tip of the formation will perceive a largely undisturbed earth magnetic field component for navigation, independent of changing superpositions - provided it is sufficiently far removed from its compatriots. The remaining animals must therefore do without own navigation mechanisms and couple themselves to the birds flying in front via an electromechanical reception channel.

The birds fly straight ahead, i.e. in the desired migration direction, if the direction of the total electrical force corresponds to the direction of the connection to the head of the bird flying in front. The connecting line between heads is visible by day and can be localised by night through calls.

The recognition of direction and magnitude of the electrical total force vector is by highly sensitive mechanoreceptors at the circumferential edge of the bill. Magnetite was also found here: Through ferromagnetic resonance, magnetite is an excellent absorber of microwaves in the 0.5-10.0 GHz band. Superimposed modulations can be transformed into acoustic vibrations via the magneto-acoustic effect (KIRSCHVINK, 1996).

Correspondence of the direction of the electrical force with the head-head line assigns to each bird a prescribed position in his flock; this position can be mathematically expressed and accurately calculated. All the results of the 22 formations investigated so far confirm the theory. It may be concluded from these data that the birds' electrical characteristics have an important biological function for transfer of information (WARNKE, 1978, 1984, 1986, 1989).

3.12 Magnetite and free radicals as a magnetic compass

Artificial oscillating magnetic fields deny migrating birds the possibility to orientate themselves. The investigation covered the effect of either an electromagnetic frequency band of 0.1 – 10 MHz, or a single frequency of 7 MHz, both superimposed vertically on earth's magnetic field. These investigations again showed that not only magnetite was required for orientation and navigation but that other mechanisms such as free radicals, played an important role as well.

Because the frequencies used in the experiments correspond to the transition energy from singlet to triplet in free radicals-pairs. The animals can obviously utilise this mechanism for orientation by targeted control (RITZ et al 2004).

The following overall picture emerges: The magnetite crystals found in the bill of the animals indicate the intensity of the magnetic field. But the animals receive complementary information on the direction of orientation via the free radical levels. Using these data, they are able to know at each stage of their flight what their instantaneous location is with reference to their biological magnetic field (WILTSCHKO et al. 2005) map.

If migrating birds are subjected to a stronger magnetic impulse, they will change their direction of flight. They can even be sent in the exact opposite direction with artificial fields superimposed on earth's magnetic field. Magnetic impulses convey information on the direction of migration; generated false impulses can also corrupt the migration direction (WILTSCHKO et al. 2006).

Summary

Bees and other insects, also birds, utilise the magnetic field of the earth and electromagnetic high frequency energy such as light. Through free radicals and simultaneously reacting magnetite conglomerates they can orientate themselves and navigate. Technically generated electromagnetic oscillations in the MHz region and low frequency magnetic impulses consistently disrupt the natural orientation and navigation mechanisms they were given through evolution.

The following can be concluded from the results of studies by other working groups and from own investigations:

1. The chitin shell of bees' and birds' feathers are semi-conducting and have piezo- and pyroelectrical properties. These body parts transform pulse-modulated high frequency into mechanical acoustic oscillation frequency. One of its important functions is the dielectric sensitivity to electromagnetic fields in the microwave region.

2. The presence of magnetite particles in the nano-range was shown in the abdomen of bees and the head region of birds. Through ferromagnetic resonance, magnetite is an excellent receiver of microwave radiated fields in the 0.5 to 10.0 GHz frequency range. In this way, pulsed microwave energy is transformed into acoustical vibrations (magneto-acoustic effect).

3. It was shown that free flying bees are capable of detecting magnetostatic fluctuations and extremely low-frequency magnetic fields with very weak inductions (from 26 nT) against the background of the 30 000 – 50 000 nT magnetic field of the earth.

4. Magnetic field impulses oriented parallel to earth's magnetic field lines, with repetition frequencies in the region of 250/sec. are responsible for clear precision errors of up to +10% in the orientation dances of bees.

5. The levels of magnetic induction in today's technically distorted environment are generally between 1 nT and 170 000 nT in the low frequency region and between some nT and a few thousand nT in the high frequency region. These values therefore generally exceed the threshold sensitivity of bees for magnetic field changes.

6. In honeybees, the NO system in the antennae has a function in the sense of smell and in learning processes. Disruptions of NO production through magnetic fields and electromagnetic oscillations have thus far been proven only in mammals. Expectations are, however, that the mechanism of disruption is the same in insects. In this case, the sense of smell and learning processes in the orientation of bees would be severely impaired.

In any event, if all the scientifically proven facts are considered, it is clear why wireless communication technologies, with their overall density of superimposed electrical, magnetic and electromagnetic fields, should disrupt the orientation and navigation of many birds

4. Humans suffer functionality disorders

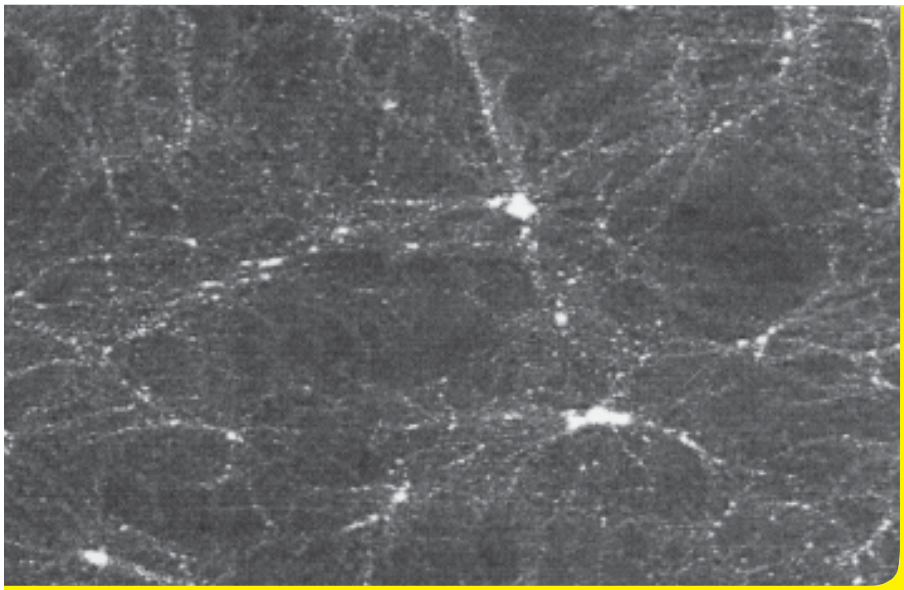

Fig. 29: *All flying organisms and also other animals, including humans, are caught up in an "impenetrable" network of electromagnetic oscillations and fields. The superpositions illustrated in this model result in points of particularly high power density or field strengths.*

Humans do not have sensory organs via which electrical and magnetic energies can be detected. But these energies nevertheless envelop humans as a tightly woven net of electromagnetic oscillations and radiating fields.

We recognised the problem in the seventies already in connection with our bee experiments and called it, in our laboratory jargon, "electrosmog". The name has established itself, also via the media.

It has in the meantime been proven that humans too can transform the specific energies and forces into information, without having a specific sensory organ to do this. But the question up to now has always been: How do they do it? And to what extent can the fields damage our health?

Let us first ask what the direct effect is on humans of the high frequency energy that is spread almost uniformly across the globe for communication purposes, and then investigate whether the subjectively frequently repeated claim that this is damaging our health can possibly be true.

This requires the following steps:

1. **Finding trends:** Do we have scientific literature causally correlating the epidemiologically recorded data on functional disorders and symptoms of disease in a human study group with the exposure to electromagnetic fields in the mobile radio and wireless communication range?

2. **Finding a causal mechanism:** Can a plausible mechanism be found that can explain functional disorders and disease systems as the result of exposure to these electromagnetic fields?

3. **Proof of health disorder and subsequent damage:** Can the function disorder as described be scientifically proven to be the result of subjectively described disease symptoms?

4. **Excluding a nocebo effect** (unfounded expectations that negatively affect health): Do we have sound scientific procedures, such as the double-blind method, showing that the symptoms of illness are not "imaginary" and are generally rapidly reversible after the physical stress fields have been "switched off"?

The answer to these four questions will determine whether subjectively described symptoms of illness can be ascribed to a collective nocebo effect or whether those responsible are required to face consequences.

4.1 On the question of finding trends

Do we have scientific literature causally correlating the epidemiologically recorded data on functional disorders and symptoms of disease of an organism with the exposure to electromagnetic fields in the mobile radio and wireless communication range?

The answer is not treated in detail here, because it has been dealt with on several occasions elsewhere (WARNKE, 2005).

To summarise, it must be noted: There is a body of differentiated scientific literature that identified a causal correlation between epidemiologically recorded data on functional disorders and symptoms of illness of the human organism, and exposure to electromagnetic

fields in the range of mobile radio and wireless communication. We therefore have an unassailable trend result.

4.2 On the effective mechanism

Can we identify a plausible effective mechanism that causally explains functional disorders and symptoms of illness as the result of exposure to electromagnetic fields?

The answer to this question does not only affect humans but analogously also birds and bees in many respects. It exposes an effective mechanism that has attracted our attention on several occasions before: The disruption of the nitrogen monoxide (NO) system. There are probably other effective mechanisms as well. But we shall only differentiate and elucidate the effective relationships of this mechanism at this point.

Nitrogen monoxide (NO) is a gas and free radical (contains unpaired electrons) that evolution has deployed as a regulator of vitality very early already – even in bacteria. This extremely important and indispensable gas is only beneficial to the organism, provided a) a certain concentration is not exceeded and b) there is no degeneration to so-called reactive nitrogens and reactive oxidative species (RNS and ROS) – i.e. no cascade-like release of newly formed free radicals and poisonous substances.

4.2.1 Disruption of the redox balance

The NO system is closely related to the so-called redox system, which is extremely important to our molecular functions. What does this mean? Every organism needs a balanced ratio of electron excess and electron deficiency. This is also called redox balance. Oxygen compounds neutralise electron charges, causing "oxidant stress". Oxidant stress is particularly intensive if free radicals and reactive oxygen species (ROS) (e.g. superoxide anion, hydrogen-peroxide) and reactive nitrosative species (RNS) (e.g. peroxinitrite) largely prevent the antioxidative processes from re-establishing an adequate electron charge.

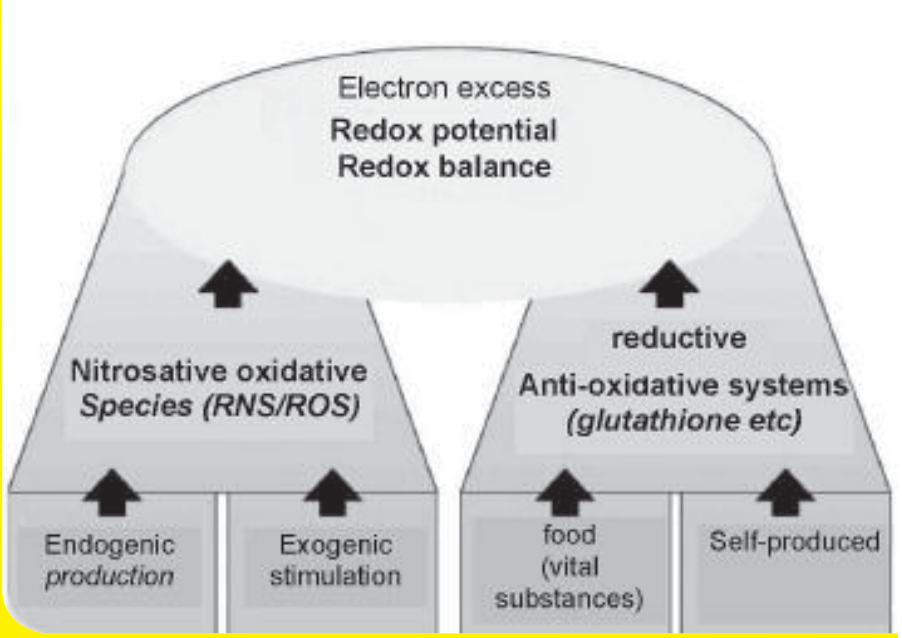

Fig. 30: *Substances with an excess of electrons are indispensible for metabolism if humans and many animals want to remain healthy. Electromagnetic oscillations destroy this electron excess and form nitrosative-oxidative species (RNS/ROS). The situation is fatal to a person if anti-oxidants are also absent in the diet.*

Shifting the redox balance towards oxidation may now result in cell damage. Oxidation may, for instance, damage unsaturated fatty acids, proteins and DNA, but particularly also the membrane – with serious consequences for heredity, energy creation and immune response.

Exposure to electrical, magnetic and electromagnetic fields disrupts the redox balance through oxidant/ nitrosative stress. This can no longer be denied in the face of many in vitro and in vivo experiments – also in humans.

Latest results on the creation of oxidant/nitrosative stress through mobile radio frequencies

Human blood cells exposed to mobile radio in standby mode show increased quantities of free radicals, resulting in lipid peroxidation (MOUSTAFA et al. 2001).

In rabbits and cells of other origin, the activity of the SOD enzyme, which neutralises free radicals, increases when exposed to mobile radio (IRMAK et al. 2002, STOPCZYK et al. 2002).

The damaging oxidative processes and NO are increased in rat brains exposed to mobile radio fields; they can be alleviated again by administering antioxidants (Ginko biloba) (ILHAN et al. 2004).

The damaging oxidative activity is increased in the skin tissue of rats exposed to mobile radio fields; this can be alleviated by administering the melatonin hormone (AYATA et al. 2004).

Acute exposure to unmodulated 930 MHz electromagnetic fields in vitro, increases the oxidant stress level in rat lymphocytes treated with iron ions (ZMYSLONY et al. 2004).

Kidney tissue of rats shows increased levels of free radicals when exposed to mobile radio fields. The damaging effects can be alleviated through various antioxidants (OZGUNER et al. 2005). The destructive effect can be neutralised by administering melatonin hormone (OKTEM et al. 2005).

Heart tissue exposed to mobile radio fields shows an increase in the activity of free radicals. This can be reduced through antioxidants (OZGUNER et al. 2005).

When exposed to mobile radio fields, eyes show an increased activity of free radicals; this can be alleviated through administering antioxidants and melatonin hormone (OZGUNER et al. 2006).

Melatonin can limit the lipid peroxidation caused by 900 MHz mobile radio fields in the hippocampus of rats, but not in the cortex (KOYLU et al. 2006).

When exposed to mobile radio fields of base stations (SAR 11.3 mW/kg), the oxidant stress level increases; the neutralising enzyme activity is simultaneously reduced (YUREKLI et al. 2006).

Compared to controls, the mobile radio signal (GSM-DTX 2W/kg) creates increased oxidative species levels in immuno-relevant human cells (LANTOW et al. 2006).

Electromagnetic high frequencies and magnetic low frequencies create stress symptoms in lymphocytes that are similar, but not identical to heat shock (BELYAEV et al. 2005).

The effect of a 890-915 MHz mobile radio field (with 217/sec. impulse rate, 2 W max. power, SAR 0.95 W/kg) was tested on guinea pigs. The setting was on 11hr 45min stand-by and 15 min talk mode. The malonaldialdehyde (MDA), Glutathion (GSH), Retinol (Vitamin A), Vitamin D3, Vitamin E und catalase enzyme activity (CAT) content in the brain tissue and in the blood was chosen as the effective indicator. The MDA level rose in the brain tissue; the GSH level and CAT activity were reduced. In the blood, the MDA levels increased, as did the Vitamin A, E and D3 levels, and the CAT activity rose. The GSH level simultaneously decreased here as well. The authors conclude from this that mobile radio produces oxidant stress in the brain tissue of test animals (MERAL et al. 2007).

These results are also confirmed for the kidney in a further study (TOHUMOGLU et al. 2007).

Stimulation of the nitrogen monoxide NO free radical by electrical, magnetic and electromagnetic fields, observed for a long time, is of importance in these effects. A chronological listing below:

Electromagnetic and magnetic radiated fields promote the production of nitrogen monoxide (NO) in organisms. A chronological literature compilation

WARNKE 1979, 1980, 1984, 1993, 1994
Weak pulsating magnetic fields create an immediate effect and stimulate NO production in humans.

MIURA et al. 1993
NO increases when a weak field of high frequency radio signals is switched on; measured directly in the brain.

LAI AND SINGH 1996
DNA destroyed through electromagnetic influence; later (2004) traced back to NO stimulation.

BAWIN et al. 1996
Magnetic fields (1 or 60 Hz, 5.6, 56, µT) had no effect when the NO synthase enzyme was pharmacologically inhibited. The effect could, on the other hand, be forced by binding NO to haemoglobin.

ADEY 1997
NO is a normal regulator of EEG rhythms and, in pathological cases, of epilepsy.

Weak magnetic fields (1 Hz, 100 µT), modulate the NO action.

KAVALIERS et al. 1998
A 60 Hz, 141 µT magnetic field affects the NO and NO synthase actions.

SEAMAN et al. 1999 and SEAMAN et al. 2002
Provided the body has sufficient supplies of nitrite, rapid increase of NO production when exposed to radio frequency pulses (SAR of 0.106 W/kg).

ENGSTRÖM et al. 2000
NO plays a role in the pathophysiology of oxidative stress, including Parkinson and Alzheimer disease through electromagnetic impulses.

YOSHIKAWA et al. 2000
A low frequency electromagnetic field increases the generation of NO.

PAREDI u.a. 2001
The production of NO also increases under exposure to the electromagnetic fields of mobile phones.

DINIZ et al. 2002
The increased proliferation of cells exposed to pulsating electromagnetic fields is caused by NO.

KIM et al. 2002
Pulsating electromagnetic fields amplify the neuronal NO synthase expression.

LAI AND SINGH 2004
Inhibitor of NO synthase (7-nitroindazol) blocks the effects of weak magnetic alternating fields (60 Hz, 10 µT).

ILHAN et al. 2004
Frequencies used by mobile radio (900 MHz) cause increased activity of NO levels, increase malondialdehyde, increase xanthin oxidase, decrease superoxide dismutase and glutathione peroxidise - thereby destroying the brain of rats. Antioxidants (Ginkgo biloba) counter this.

YARIKTAS et al. 2005
The NO level in the mucosa of the nose increases when exposed to mobile radio fields (900 MHz).

AKDAG et al. 2007
The long-term effect (2 hours per day for 10 months) of a low frequency pulsed magnetic field on rats reduces the NO production below the nominal values.

It has been known for many decades already that weak low frequency magnetic fields increase the levels of free radicals. It is therefore not necessary to quote further literature at this point.

4.2.2 Primary mechanism found: Enzymes transferring electrons are magneto-sensitive

Stimulation of free radicals – including NO – through physical fields and radiated fields is therefore scientifically and reliably proven. But viewed critically, this is no proof of damage unless the underlying primary mechanism is identified.
For this reason, we searched for a long time for a link to explain the damaging effect. And we have found it in one of the latest studies: The NADH oxidase enzyme exhibits a high – and quite reproducible – sensitivity for magnetic and electromagnetic fields of mobile phones (FRIEDMAN et al. 2007).

This sensitivity had been known for quite some time in connection with other oxidases such as cytochrome oxidase (BLANK et al. 1998, 2001 a/b). For a long time, it was believed that NADH oxidase was active only in certain cells such a phagocytes. But it was known for quite some time that it was sensitive to gravitation (NASA, 2006). In the meantime, homologues of NADH oxidase were discovered in various tissues and were collectively included in the NOX family (NOX1, NOX3, NOX4, NOX5, DUOX1 and DUOX2).

The NOX family is also responsible for a large range of pathological processes, especially neurodegeneration and heart diseases (BEDARD et al. 2007).

These oxidase enzymes are magnetically sensitive due to their capability of shepherding electrons through plasma membranes. When electrons move, an electrical current flows that in turn builds up its own magnetic field and also generates electromagnetic high frequency oscillations through acceleration and deceleration of electron movement. All these processes create sensitivity to external fields.

The electron transfer is finally responsible for the production of superoxide radicals and other reactive oxygen species (ROS). The consequences of this are far reaching in completely different areas, because radicals and ROS are very aggressive. In this way, the destruction of viruses and bacteria is promoted, the creation of proteins is forced through reinforced gene expression and finally cell proliferation is supported at the cost of cell differentiation.

Over-stimulation is a threat. It is analogous to a drug or medicine: Dosed correctly, the substance can be beneficial; but overdosing can be poisonous. This is exactly what happens with permanent exposure to magnetic and electromagnetic fields.

In detail, this process is as follows: It is a fact that the NADH oxidase enzyme also produces the superoxide anion ($O_2^{-\bullet}$) free radical. Superoxide anion is damaging to the NO budget, among other. NO may be deactivated and may subsequently degrade, negatively affecting various vital parameters (WARNHOLTZ et al. 1999).

What is new is the realisation that NADH oxidase also forces the generation of NO by stimulating the eNOS enzyme (SUZUKI et al. 2006, RACASAN et al. 2005). This stimulation of eNOS then becomes a further source of increased superoxide anion radical generation (SEINOSUKE et al. 2004). This is not the end of the list in this fatal loop of overstimulation, because the NADH oxidase system also stimulates the formation of toxic hydrogen peroxide (H202), which also increases NO production by up to 100% (LI et al. 2002). These two additional NO stimulants explain the abovementioned increased NO production under the influence of magnetic fields and electromagnetic radiated fields – also through mobile radio communication.

But this is the start of a vicious circle. Because overstimulation of the eNOS enzyme, that in the final analysis is also an agent for increased NO production, also increases superoxide anion radicals on its own (SEINOSUKE et al. 2004). Nature, however, also has a cleverly devised countermeasure against excessive and dangerous NO production threatening overproduction of a radical: The more stimulated hydrogen peroxide, which also increases the NO production, is an agent for de-activating eNOS co-factors, which finally prevents the NO production by affecting the membrane receptor (JAMES et al. 2001). Such a reduction of NO has also been found before under long-term exposure to stronger magnetic fields (AKDAG et al. 2007). Even if the NO now appears to be regulated, the damaging effects of ROS remain intact.

The real pathological effects arise afterwards. We have to consider, in addition, that both the NO and ROS, which includes superoxide anion, are important modulators of the vascular tonus and are architects of the adhesive interaction of leucocytes, platelets and endothelium. The two molecules of NO and of superoxide anion, however, have opposite effects: NO is normally beneficial in a healthy life cycle; ROS, however, prepares the system for special regulation when disruptions occur.

The functions are thereby flexibly adjusted. This allocation of functions disappears, however, under the influence of an external magnetic and electromagnetic field: NO and ROS now react together. In this event, their specific effective potential is destroyed and toxic substances are created, such as peroxinitrite (ONOO-) (MÜNZEL et al. 1999). This peroxinitrite in turn reacts with hydrogens, creating more hydrogen peroxide.

Because this mechanism is so important, we shall summarise it in one sentence: The serious pathological disruption is caused by exposure to magnetic and radiated fields resulting in the creation of additional reactive oxygen species (ROS) such as superoxide radicals and hydrogen peroxide, that combine with the increasingly produced NO to form extremely toxic peroxinitrite, that in turn reacts with hydrogens to form more hydrogen peroxide. The consequences of the pathological process are listed further down.

Many vital substances, required for functioning of the body, are rendered useless.

If the cascade of effects is disrupted, the normal and healthy effects of NO are restored (HORNIG et al. 2001).

The NADH oxidase is important in another sense as well. It is also found in the cell nucleus where it can – depending on the redox system – control the gene expression, but can also damage genes (MASUKA, 2006).

Let us therefore state in response to the question of a conclusive effective mechanism: The existing scientific literature abundantly documents disruptions of the redox

balance in organisms through reactive oxidative and nitrogenous species (ROS/RNS), causally connected to the exposure to electromagnetic fields of mobile radio and wireless communication.
An unambiguous effective damaging mechanism has therefore been found.

4.3 On the question of deterioration of health and damage

Can the functional disruptions thus explained be considered the scientifically proven reasons for the subjectively described symptoms of disease?

The proven effective mechanism is important also because it shows that the subjective ailments of many people are based on biological facts that can be explained. If you are aware of the cascades of effects described hereunder, you will better understand why "electrosmog" is damaging.

4.3.1 Functional disruptions and symptoms of disease

Electromagnetically induced excessive ROS/RNS stimulation may be differentiated into three effective phases that are passed through sequentially:
1. Stimulation of free radicals,
2. Stimulation of highly toxic peroxinitrite,
3. Stimulation of highly toxic peroxide radical.

The following processes are serious: Cell components are destroyed; the antioxidants absorbed with the food and the substances with excess electrons produced by the organism itself are spent; the harmful cholesterine increases. People feel tired, tense, battle various inflammations.

Pain is felt in places. More detail on the individual steps is given below.

First complex: Stimulation of free radicals such as superoxide O_2-° and NO leads to
- activation of protooncogenes
- damage to the mitochondria genome
- damage to the cell nucleus genome
- damage to the membranes
- oxidation of the polyene fatty acids of the membranes; release of cardiolipins (auto antibody formation)
- oxidation of SH groups, causing enzyme blocking
- activation of proteases (cell damage)
- activation of transcription factors.

Second complex: Stimulation of highly toxic peroxinitrite from superoxide anion O_2° together with NO (O_2° -+ NO = ONOO°)
NO has three times the affinity for superoxide O_2-° that O_2-° has for the neutralising superoxide dismutase; the peroxinitrite
- oxidises vitamin C
- oxidises uric acid
- oxidises cholesterine
- oxidises sulfhydryl groups (destroys thioles)
- oxidises polyene fatty acids of the membranes (initiates lipid peroxidation)
- causes DNA breaks
- activates kinases (phosphor lipase 2)
- activates polymerase (PAPP); this destroys NAD+, leading to a cellular energetic catastrophy.
NO and peroxinitrite react to form nitrogendioxide (NO_2); this deactivates superoxide dismutase (MnSOD), i.e. inhibiting the neutralising enzymes of the mitochondria (mt-Mn-SOD). These reactions alone result in massive metabolism disruptions already.

Third complex: Stimulation of highly toxic peroxide radical (HO_2°-) from superoxide and peroxinitrite with the involvement of hydrogen
Peroxide H00° has a redox potential of +1000 mV, making it highly oxidising.. An addition to the listing in complex 2, peroxide also oxidises:
- Polyene fatty acids
- Tocopherol (Vit E)
- Lycopene
- Co-enzyme Q 10

The functional disruptions are manifest in disease symptoms, as described in more detail below.

4.3.2 The "Acquired Energy Dyssymbiosis Syndrome" (AEDS)

The clinical picture of the "Acquired Energy Dyssymbiosis Syndrome" describes a deficiency of cell energy – with simultaneous derailment of the cell environment. This leads to "mitochondropathy": energy creation is blocked; the power generators for cell energy are transformed into copious sources of free radicals.

The changes have serious consequences:

1. Inflammation processes spread and release further substances that are harmful when overdosed (tumour necrosis factor TNFα and time and again nitrogen monoxide). We must also not forget that inflammations are on the increase in our industrial society and that arteriosclerosis and heart attacks – the primary cause of death – are ultimately caused by inflammations. This point of view has already been accepted among the scientifically active medical fraternity today.

2. Aerobic glycolysis (glycolysis despite the presence of oxygen) is activated as "emergency power generator" – which is in turn associated with:

- stimulation of proto-oncogenes (precursors to cancer genes)
- increased release of superoxide radicals
- lactate acidosis (excessive acidification)

3. The mitichondric genome finally mutates. But especially this pathological change can be hereditary via the female gender. It burdens the progeny for the generations to come.

Overview: Physiopathological consequences of nitrosative/oxidative stress

I. Disruption of mitochondrial activity
II. Disruption of sugar utilisation (pathological lactate acidosis)
III. Disruption of the neurotransmitter function
IV. Disruption of the cholesterine metabolism
V. Disruption of the steroid hormone synthesis (corticoids)
VI. Disruption of the haem system
VII. Generation of mutations, esp. the mitochondrial DNA (hereditary)
VIII. Disruption of apoptosis

Catalogue of symptoms and diseases (excerpt), derived from the known effective mechanisms of nitrosative/oxidative stress

- Sleep disorders
- High level of fatigue: no relaxation, recuperation times ineffective
- Psychosomatic performance lapses
- Major phases of restlessness and "panic disorder"
- Corpulence
- Chronic hypoglycemia
- Increased cholesterine and triglycerid values
- Lactate acidosis
- Fibromyalgy FMS (nitroso serotonin auto-antibody formation)
- Autoimmune diseases
- Arteriosclerosis
- M. Parkinson
- Chronic inflammation processes, especially in the nervous system, with multiple sclerosis and amyotropic lateral sclerosis
- Haem synthesis disruptions (porphyria)
- Lactose intolerance
- Pathological energy deficit PED (WARNKE, 1989)
- Chronic immune insufficiency (high infection susceptibility)
- Functional disruptions of the thyroid
- Myopathy
- Encephalopathy
- Polyneuropathy
- Enteropathy
- Cancer
- AIDS

To summarise, we can answer the question as to whether subjective reports of illness have an objective basis as follows: The redox balance is disturbed via the direct influence of weak magnetic and electromagnetic fields on the NADH oxidase. The result is oxidative/nitrosative stress. It leads to disruptions and prevention of vital functions. In the course of these processes, exactly those disease symptoms subjectively described by those affected and exposed to radiated fields, are in evidence.

Hereditary pathological changes passed on via the mother should, in particular, draw our attention to the effects that will only manifest themselves in generations to come.

4.4 On the exclusion of a nocebo effect.

Do we have scientifically designed methods, such as the "double blind" method, proving that the symptoms of disease cannot be attributed to fears but that they are generally reversible after "switching off" the physically stressing fields (unbeknown to the participants), after a short period of time?

All the scientific investigations that addressed this question reply to this question with "yes":

The various problems disappear if the influence of the radiation or the ROS/RNS formation is "switched off" (e.g. ABELIN 1999, ABELIN et al. 1995, HORNIG et al. 2001, PETROV1970, TNO study 2004).

Health is not, however, restored if the disruptions have already led to serious damage such as DNA destruction or tumours.

5. Summary

For many decades, research results showing that the natural electrical and magnetic fields and their variation are a vital precondition for the orientation and navigation of a whole range of animals, have been freely available.

What has also been known to science for many decades is that we as humans depend on this natural environment for many of our vital functions.

Today, however, this natural information and functional system of humans, animals and plants has been superimposed by an unprecedented dense and energetic mesh of artificial magnetic, electrical and electromagnetic fields, generated by numerous mobile radio and wireless communication technologies.

The consequences of this development have also been predicted by the critics for many decades and can now no longer be ignored. Bees and other insects disappear, birds avoid certain areas and are disoriented in other locations. Humans suffer from functional disorders and diseases. And those that are hereditary are passed on to the next generation as existing defects.

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Glossary (GL)

Information: This concept is generally understood in everyday life and has gained a position of central importance, especially in modern bio-sciences. "Informed society" demands to be in a position to inform itself about everything if possible, at any time and any place in the world. Analogously, it is of cardinal importance to a living organism of any kind, not only to be in a position to communicate with its environment via information carriers, but the control of its internal vital functions must also be assured, which is again possible only through the exchange of "information".

Electromagnetic (EM) fields of all kinds and magnitudes (including light, UV and infrared radiation, microwaves, etc.) were chosen by evolution as particularly suitable carriers of information because they are able to flood the living space of organisms spontaneously and fully, affording every individual immediate access to its information content.

This is available in the ordered structure of the EM fields themselves, described in physics as waves, which propagate at the speed of light with alternating electrical and magnetic field components. Because, in accordance with Faraday's law of induction (1831), the changes in a magnetic field induce changes in an electrical field.

The force/field lines of magnetic and electrical fields are in the form of vectors between positive and negative poles and we can therefore describe them as electrical or magnetic flux and a flux density orthogonal to a unit surface area, e.g. 1 m^2.

The actual information in an EM field resides – similar to acoustics – in the number of oscillations per second (=frequency) and also in the amplitude of the oscillations. If an EM field of higher frequency is interrupted at a certain rate (facilitated only through modern digital technology), low frequency pulsed high frequency radiation is created, whereby the cyclic rate can also be used for information purposes.

The traditional technical method of transmitting "information" is called modulation. In this way, a continuous low frequency carrier wave, subject to less interference during propagation in space, is overlaid (modulated) with the higher frequencies of music and voice, allowing the information to be transmitted over large distances.

EA few common physical units:

Ampere (A): current amplitude
Volt (V): electrical voltage
V / meter (E): electrical field strength
Watt:(W): power (=VA)
Joule (J): electrical energy (=W sec)
Tesla (T): magnetic induction (=V sec/m^2)

Number units

(k) Kilo ... * 1000
(M) Mega ... * 1000 000
(G) Giga ... * 1000 000 000
(T) Tera ... * 1000 000 000 000

(m) Milli ... * 0.000
(µ) Mikro ... * 0.000 000
(n) Nano ... * 0.000 000 000
(p) Pico ... * 0.000 000 000 000

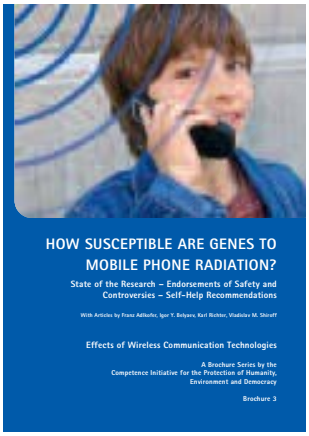
Now Brochure 3 of the Series *Effects of Wireless Communication Technologies* is also available in English:

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

2008



In their articles, the experts in biomedicine and biosciences Prof. Franz Adlkofer, Prof. Igor Y. Belyaev, and Vladislav M. Shiroff show the broad range of international research efforts that document DNA and chromosome damages as well as chronic diseases resulting from electromagnetic radiation exposures. This is about non-thermal effects well below current exposure limits. UMTS radiation turns out to be especially hazardous.

"The endorsement of safety by the German Mobile Telecommunication Research Programme regarding the health risks of mobile phone radiation is based rather on wishful thinking than facts," says Franz Adlkofer. Exposure limits that do not account for non-thermal effects or the exposure duration do not provide protection but are rather unsafe. In commissions and research programs, which are paid by the public for the protection of its health, those scientists set the tone whose main objective it is to issue endorsements of safety and support existing exposure limits. They pursue "witch hunts" against allegedly fraudulant laboratories. But obviously they do not realize that their denial of the international body of evidence is the most offensive of all scientific frauds possible. Since this turns the entire population into potential victims.

As long as this is supposed to be the "independent" research the public and environment is at the mercy of, we should not expect any protection or precaution from the government, reasons Prof. Karl Richter. It seems to be more imperative than ever before that independent scientists and responsible citizens—with the support of foundations and environmentally minded sponsors—take the organization of independent health protection projects into their own hands, as a program for self-help. The brochure provides recommendations to this end.

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

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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.