Consolidated Case Nos. 19-70123, 19-70124, 19-70125, 19-70136, 19-70144, 19-70145, 19-70146, 19-70147, 19-70326, 19-70339, 19-70341, and 19-70344

IN THE UNITED STATES COURT OF APPEALS FOR THE NINTH CIRCUIT

Sprint Corporation,

Petitioner,

v.

City of Bowie, Maryland, et al.,

Intervenors,

v.

Federal Communications Commission
and United States of America

Respondents.

On Petition for Review of Order of the
Federal Communications Commission

APPENDIX TO AMICUS BRIEF OF THE BERKSHIRE-LITCHFIELD ENVIRONMENTAL COUNCIL (BLEC) AS *AMICI CURIAE* IN SUPPORT OF PETITIONER MONTGOMERY COUNTY, MARYLAND

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EXHIBIT A – Levitt, B. B., Lai, H. (2010) Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays, Enviro. Rev. 369-395 (2010), doi:10.1139/A 10-018 (Attached)

http://www.nrcresearchpress.com/doi/pdf/10.1139/A10-018

EXHIBIT B – Prepared Remarks of FCC Chairman Tom Wheeler, 'The Future of Wireless: A Vision for U.S. Leadership in a 5G World, National Press Club, Washington, D.C. June 20, 2016 (Attached)

https://transition.fcc.gov/Daily_Releases/Daily_Business/2016/db0620/DOC-339920A1.pdf

EXHIBIT C – Comments by Don Maisch (2019) "Are community concerns over the 5G network rollout based on unfounded anxiety or valid evidence?" May 2, 2019, Between a Rock and a Hardplace (Attached)

https://betweenrockandhardplace.wordpress.com/2019/04/25/guest-blog-from-dr-don-maisch-australia-are-community-concerns-over-the-5g-network-rollout-based-on-unfounded-anxiety-or-valid-evidence/

EXHIBIT D – Comments filed by B. Blake Levitt and Henry C. Lai (2013): The Matter of Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies (ET Docket No. 013-84), and Proposed Changes in the Commission's Rules

Regarding Human Exposure to Radiofrequency Electromagnetic Fields (ET Docket No. 03-137) (Attached)

https://ecfsapi.fcc.gov/file/7520939733.pdf

EXHIBIT E – Comments filed by Starling W. Childs and B. Blake Levitt, (2016): Amendment of Part 101 to Facilitate Wireless Backhaul, GN Docket No. 14-177, IB Docket No. 15-256, RM-11664, WT Docket No. 10-112, IB Docket No. 97-95, Use of Spectrum Bands Above 24 GHz for Mobile Radio Services, et al. (Attached)

http://nebula.wsimg.com/d47146dc1eb6dede8e10446de2df0507?AccessKeyId=045114F8E0676B9465FB&disposition=0&alloworigin=1

EXHIBIT F – Comments filed by Cindy Sage, Lennart Hardell, and Martha Herbert (2013): The Matter of Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies (ET Docket No. 13-84), and Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields (ET Docket No. 03-137). FCC ET Docket No. 013-84 and ET Docket No. 03-137) (Attached)

https://ecfsapi.fcc.gov/file/7520940711.pdf

EXHIBIT G – Comments filed by Cindy Sage and David Carpenter (2013): The Matter of Reassessment of Federal

Communications Commission Radiofrequency Exposure Limits and Policies (ET Docket No. 13-84), and Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields (ET Docket No. 03-137 (Attached)

https://ecfsapi.fcc.gov/file/7520939956.pdf

EXHIBIT H – Reply comment by Cindy Sage and David Carpenter (2013): The Matter of Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies (ET Docket No. 13-84), and Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields (ET Docket No. 03-137) (Attached)

https://ecfsapi.fcc.gov/file/7520957942.pdf

EXHIBIT I – Comments filed by Cindy Sage, Lennart Hardell, and David Carpenter, (2016) *Streamlining Deployment of Small Cell Infrastructure by Improving Wireless Siting Policies* FCC Docket 16-421 (Attached)

https://bioinitiative.org/small-cell-antenna-rollout/

EXHIBIT J – Martin Pall, (2018) "5G: Great risk for EU, U.S. and International Health! Compelling Evidence for Eight Distinct

Types of Great Harm Caused by Electromagnetic Field (EMF) Exposures and the Mechanism that Causes Them." (Attached)

https://einarflydal.files.wordpress.com/2018/04/pall-to-eu-on-5g-harm-march-2018.pdf

EXHIBIT K – Three letters from Congress to FCC:

1.A. – Letter from U.S. Senators Feinstein and Blumenthal 1/30/19 on frivolous FCC lawsuits (Attached)

https://www.feinstein.senate.gov/public/_cache/files/2/6/26b80f01-7ca7-46ce-b26e-c9863a6ecbea/80446A9A6B1AEE016FE9E8C064E68C25.1.30.19-df-blumenthal-letter-to-pai-re-5g.pdf

1.B. – FCC's Response to Senators Feinstein and Blumenthal (Attached)

https://www.blumenthal.senate.gov/imo/media/doc/2018.12.17%20FCC%20Carr%20to%20Blumenthal%20and%20Eshoo%20re%20RF%20Safety.pdf

2. – Letter from Rep. DeFazio 4/15/19 on 5G health effects and RF proceeding (Attached)

https://www.eugene-or.gov/DocumentCenter/View/46057/Rep-Peter-DeFazio---Letter-to-FCC-on-5G

3. – Letter from Rep. Suozzi 4/16/19 on 5G, NTP, and RF standards (Attached)

https://docs.fcc.gov/public/attachments/DOC-357620A5.pdf

EXHIBIT L – Small Cell Photos: The San Francisco Planning Department's FAQ (2015) with photos of small cells. Some designs may have changed. (Attached)

http://default.sfplanning.org/currentplanning/wireless/FAQ_Wireless_Facilities_on_Poles.pdf

EXHIBIT M – Cucurachi, S., .Tamis, W.L.M., Vijver, M.G., .Peijnenburg, W.L.G.M, .Bolte, J.F.B., de Snoo, G.R., (2013) A review of the ecological effects of radiofrequency electromagnetic fields (RF-EMF), Elsevier Environmental International, Volume 51, January 2013, Pages 116-140. (Attached)

https://doi.org/10.1016/j.envint.2012.10.009

EXHIBIT N – Albert M. Manville, II (2016) To FCC: 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. (Attached)

https://ecfsapi.fcc.gov/file/12270470130362/Manville%207-14-%202016%20Radiation%20Briefing%20Memo-Public.pdf

EXHIBIT O.1. – (Attached)RF Guideline Issues Identified by members of the federal RF Interagency Work Group, June 1999. (Attached)

http://www.emrpolicy.org/litigation/case_law/docs/exhibit_a.pdf

EXHIBIT O.2. – RFIAWG Agency/Member List: RF Guideline Issues Identified by members of the federal RF Interagency Work Group, June 1999. (Attached)

http://www.emrpolicy.org/litigation/case_law/docs/workgroupmemberslist.pdf

EXHIBIT P – Excerpt Chart of Low Level Effects Studies from: Levitt, B.B., Lai, H. (2010) Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays, Enviro. Rev. 369-395 (2010), doi:10.1139/A 10-018 (Attached)

http://www.nrcresearchpress.com/doi/pdf/10.1139/A10-018

EXHIBIT Q – Comment on SCENIHR by Cindy Sage, Lennart Hardell, and David O. Carpenter (2015): Opinion on Potential Health Effects of Exposure to Electromagnetic Fields, Bioelectromagnetics 36:480-484 (2015). (Attached)

EXHIBIT R – Amicus Curiae Brief of the State of Connecticut in Support of Petitioner EMR Network's Petition for Writ of Certiorari, Richard Blumenthal, Attorney General of Connecticut, IN THE SUPREME COURT OF THE UNITED STATES, OCTOBER TERM, 2004, EMR NETWORK (*Petitioner)* v. FEDERAL COMMUNICATIONS

COMMISSION and UNITED STATES OF AMERICA, No. 04-1515, 2004. (Attached)

EXHIBIT S – Amicus Support Signatures (Attached)

Dated: June 17, 2019

Respectfully submitted,

/s/ Sblend A. Sblendorio

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CERTIFICATE OF SERVICE

I hereby certify that on the date below, I caused the foregoing Appendix to Amicus Brief of The Berkshire-Litchfield Environmental Council (BLEC) to be electronically filed with the Clerk of Court for the United States Court of Appeals for the Ninth Circuit using the electronic CM/ECF system. I further certify that all participants in the case are registered CM/ECF users and will be served electronically by the CM/ECF system.

Dated: June 17, 2019 *_/s/ Sblend A. Sblendorio_*
Sblend A. Sblendorio

EXHIBIT A

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 build-out of both new infrastructure as well as adaptation of pre-existing 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 (~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 ($\sim$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 ($\sim$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 (μW/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 (μW/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 (μW/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 (μW/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) behavioral 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 μW/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 μW/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 μW/cm^2. Maximum levels were between 0.000002 and 0.41 μW/cm^2 with an overall 5% of the estimated maximum above 0.1 μW/cm^2. Average levels were slightly higher in rural areas (0.005 μW/cm^2) than in urban areas (0.002 μW/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 μW/cm^2) compared with the control group with an exposure below 0.2 V/m (0.01061 μW/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 μW/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 electromagnetic 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 mentioned 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 μW/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 μW/cm^2), or 10.0 V/m (26.53 μW/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 μW/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 μW/cm^2 (range of individual means 0.0014–0.0881 μW/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 μW/cm^2) or mobile phone (0.014 μW/cm^2) were exposed more than those not owning a DECT or mobile phone (0.010 μW/cm^2). Mean values were highest in trains (0.116 μW/cm^2), airports (0.074 μW/cm^2), and tramways or buses (0.036 μW/cm^2) and were higher during daytime (0.016 μW/cm^2) than nighttime (0.008 μW/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 μW/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 station exposure contribution in self-selected volunteers (0.487 versus 0.002 μW/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 μW/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 μW/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 μW/cm^2 to as high as 0.001 μW/cm^2. At 1800 MHz, the variation of power densities was from 0.000001 to 0.01 μW/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 (~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 (~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 established, 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 μW/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 μW/cm^2 for pulsed RF exposures where they affect the general population and an indoor exposure as low as 0.01 μW/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 (~500 m) from the population, and at a height of about 150 ft (~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. However, 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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EXHIBIT B

Prepared Remarks of FCC Chairman Tom Wheeler
'The Future of Wireless: A Vision for U.S. Leadership in a 5G World'
National Press Club
Washington, D.C.
June 20, 2016

A few months ago, I found myself in a situation I never would have imagined when I became FCC Chairman. I was in Dallas, Texas; I was at the helm of an excavator; and I was using a piece of heavy machinery to dig up dirt. For those of you trying to picture this scene, yes, I was wearing a suit. I was also wearing a pair of virtual reality goggles, and I hadn't left the FCC.

While I may have been in DC physically, I am telling you that I was "AT" the site. I sat in the mock-up of an excavator, and, I had complete control sensitivity, equivalent to being there. I could be transported to a site in Texas 1,400 miles away without physically moving an inch.

Granted, remotely digging dirt in Dallas probably isn't high on the list of transformational advancements that will define the 21st century. But what if you replace the heavy machinery with a scalpel so a world-class surgeon can move from hospital to hospital without leaving her own surgery suite? Or how about students sitting in a classroom taking a virtual tour inside the human body?

Now, you've heard of such amazing things before, but making these kinds of activities possible without fat cables leading to the VR headset could not be accomplished because of three limiting factors:

1. Speed of the wireless connections: We all know the difference in the performance of a direct fiber connection compared to a wireless connection. The next generation of wireless must be like mobile fiber – and that means speeds 10 to 100 times faster than today.

2. Responsiveness: Ten thousandths of a second is an eternity in computer-to-computer connections. The surgeon's scalpel needs to be immediately responsive, not a blink later. The technical folks call this latency. It currently averages about 10 milliseconds or about one hundredth of a second. That may sound pretty fast but it's forever in computing. Latency needs to be less than one millisecond – or less than one thousandth of a second – to provide for real-time interactions.

3. Spectrum capacity: High-speed wireless broadband requires digital information racing down broad spectrum pathways. To accomplish speed and latency requires large swaths of spectrum – multiples of what is available today.

To seize the opportunities before us, we need the next generation of wireless connectivity – a fifth generation, or 5G. And if the United States is going to continue to be a world leader in wireless, we need to speed the deployment of 5G, here, on our shores.

The virtual reality example is but one sample of the effects of high-speed, low-latency connectivity and why American leadership in 5G must be a national priority. The driving force of the 21st century will be powerful processing centralized in the cloud and wirelessly connected to thin clients.

Autonomous vehicles will be controlled in the cloud. Smart-city energy grids, transportation networks, and water systems will be controlled in the cloud. Immersive education and entertainment will come from the cloud. Such futures, however, won't come to pass unless the pathway to the cloud is low-latency, ultra-fast, and secure.

If we've learned anything in the generational march through wireless connectivity, it is that we have always underestimated the innovation that would result from new generations of wireless networks.

First-generation wireless – 1G – was voice. In the early 1980s, McKinsey told AT&T there would be 900,000 cell phone subscribers by the turn of the century. Turns out there were 109 million. So they were ONLY off by a factor of roughly 100.

Second-generation – 2G – allowed both talk and text. But no one understood the power of text. From shifting the way an entire group – teenagers – communicate, to a developing-world tool for banking the unbanked, innovators seized on the new capability in unimagined ways.

Third-generation – 3G – married wireless and digital networks to open the door to connecting with another new technological development called the Internet, yet still at a stripped-down level.

Today's technology – 4G – completed the digital migration, enabling higher speeds for sophisticated applications including video. Again, greater capability led to unanticipated innovation: without 4G, there could be no WAZE … or Uber … or Snapchat … or Instagram.

Now, I've listed some examples of what 5G makes possible, but if anyone tells you they know the details of what 5G will deliver, walk the other way.

Yes, 5G will connect the Internet of Everything. If something can be connected, it will be connected in a 5G world. But with predictions of hundreds of billions of microchip-enable products from pill bottles to plant waterers, you can be sure of only one thing: the biggest IoT has yet to be imagined.

Yes, 5G will connect the unconnected and compete with the uncompetitive. Millions of Americans can't access high-speed connectivity because it's too costly to run fiber to the home. Verizon CEO Lowell McAdam has been speaking lately about using 5G connectivity to expand high-speed broadband service to rural areas. Fiber-fast wireless connectivity will deliver that long-sought goal of competitive high-speed Internet access for consumers.

But, let's stop the imagining. Here's the key – the interconnected world we live in today is the result of decisions we made a decade ago. The interconnected world of the future will be the result of decisions we must make today. That is why 5G is a national priority, and why, this Thursday, I am circulating to my colleagues proposed new rules that will identify and open up vast amounts of spectrum for 5G applications. We call it the Spectrum Frontiers proceeding, and we will vote on it July 14th.

Our 5G proposal is the final piece in the spectrum trifecta of low-band, mid-band, and high-band airwaves that will open up unprecedented amounts of spectrum, speed the rollout of next-generation wireless networks, and re-define network connectivity for years to come. I'm confident these actions will lead to a cornucopia of unanticipated innovative uses, and generate tens of billions of dollars in economic activity.

Let's revisit that spectrum strategy for a moment. Rule number one is that the technology should drive the policy rather than the policy drive the technology. And technology for 5G is not one thing, it is many things. The marriage of Moore's Law and wireless connectivity involves smart antenna systems, new more-efficient transmission formats, low-energy systems, network virtualization, and much more. And on the spectrum side, these technologies require new access to spectrum in multiple bands – the wireless future will not be a one-size-fits-all future.

So, our spectrum trifecta begins with low-band spectrum that is optimal for wide-area coverage applications. At this very moment, we are in the midst of the world's first incentive auction to make greenfield low-band spectrum available. The broadcasters have stepped up to bring their spectrum to market; shortly, the wireless industry will have the opportunity to fulfill their repeated requests for more spectrum with beachfront allocations.

Mid-band spectrum often seems the Jan Brady of the spectrum world - - the overlooked middle child. But its characteristics enable an order of magnitude increase in spectrum efficiency. The Commission's recent AWS-3 and new Citizens Broadband Radio service in the 3.5 GHz band were landmarks in using new sharing tools to open up new mid-band spectrum, and we need to continue looking for other mid-band opportunities.

And high-band spectrum will be the focus of our decision next month. These bands offer huge swaths of spectrum for super-fast data rates with low latency, and are now becoming unlocked because of technological advances in computing and antennas.

If the Commission approves my proposal next month, the United States will be the first country in the world to open up high-band spectrum for 5G networks and applications. And that's damn important because it means U.S. companies will be first out of the gate.

We will be repeating the proven formula that made the United States the world leader in 4G. It's a simple formula: Lead the world in spectrum availability, encourage and protect innovation-driving competition, and stay out of the way of technological development.

Unlike some countries, we do not believe we should spend the next couple of years studying what 5G should be, how it should operate, and how to allocate spectrum, based on those assumptions. Like the examples I gave earlier, the future has a way of inventing itself. Turning innovators loose is far preferable to expecting committees and regulators to define the future. We won't wait for the standards to be first developed in the sometimes arduous standards-setting process or in a government-led activity. Instead, we will make ample spectrum available and then rely on a private sector-led process for producing technical standards best suited for those frequencies and use cases.

Leadership in networks leads to leadership in uses, which quickly moves across borders.

A result of this national leadership is the creation of a home-field advantage, similar to what we experienced with 4G.

The main value of 5G will not be found in workshare or intellectual property. The main value of 5G by far will be in consumption rather than production. It will be in material gains and improvements in quality of life and economic opportunity.

I would also emphasize that the development of 5G is not anything like an international zero-sum game. Rather, it is a contest in which everyone can win. Our success and that of others, redounds to the benefit – literally – of everyone in the world.

We are already seeing industry gearing up to seize this opportunity. I have seen 5G hardware and firmware; the technology is here. It is also important, however, to recognize that 5G technology will be in constant evolution. It would be a mistake to think 5G can be frozen in a snapshot; it is more like a video with many new scenes, all building on each other. The systems and standards of 5G will be continually improving and evolving.

On the network side, Verizon and AT&T tell us they will begin deploying 5G trials in 2017. These efforts will, of course, help inform the standards process by putting stakes in the ground. And the first commercial deployments at scale are expected in 2020.

This timeline requires that we act to pave the way today. With the new rules I am proposing in our Spectrum Frontiers order, we take our most significant step yet down the path to our 5G future.

The big game-changer is that 5G will use much higher-frequency bands than previously thought viable for mobile broadband and other applications. Such millimeter wave signals have physical properties that are both a limitation and a strength: they tend to travel best in narrow and straight lines, and do not go through physical obstacles very well. This means that very narrow signals in an urban environment tend to bounce around buildings and other obstacles making it difficult to connect to a moving point. But it also means that the spectrum can be reused over and over again.

Brilliant engineers have developed new antennas that can aim and amplify signals, coupled with sophisticated processing, allowing a moving device to pick up all of the signals bouncing around and create one coherent connection. To make this work, 5G buildout is going to be very infrastructure intensive, requiring a massive deployment of small cells. But it also opens up unprecedented opportunities for frequency reuse and denser, more localized, networks.

The ability to use this high-frequency spectrum opens much bigger chunks of spectrum. Current blocks of licensed low-band spectrum are usually 5 to 10 MHz in width. With 5G, however, we are looking at blocks of at least 200 MHz in width. This will allow networks to carry much more traffic per user – gigabits of throughput instead of megabits. This is an order of magnitude growth in the channel capacity available to a provider, supporting, for example, simultaneously high-speed connections to mobile end users as well as "backhaul on demand" via immediate, dynamic provisioning of fixed wireless transport to the nearest fiber interconnection point, allowing faster and more flexible deployment of small cells.

The key point here is that by opening up these higher-frequency bands, we are making available more licensed spectrum for mobile than in the cumulative history of mobile spectrum allocation. And we're not done. As a part of our July 14 action, we also plan to ask for comments on opening up other high-frequency bands.

And, what we'll be considering on July 14 is not just licensed spectrum. Unlicensed will continue to play a critical role in future 5G networks. Our plan proposes making a massive 14 gigahertz unlicensed band. Consider that – 14,000 megahertz of unlicensed spectrum, with the same flexible-use rules that has allowed unlicensed to become a breeding ground for innovation.

Opening up spectrum and offering flexibility to operators and innovators is the most important thing we can do to enable the 5G revolution, but it's not the only thing.

We also need to work our way through spectrum sharing issues. Sharing is essential for the future of spectrum utilization. Many of the high-frequency bands we will make available for 5G currently have some satellite users, and some federal users, or at least the possibility of future satellite and federal users.

This means sharing will be required between satellite and terrestrial wireless; an issue that is especially relevant in the 28 GHz band. It is also a consideration in the additional bands we will identify for future exploration. We will strike a balance that offers flexibility for satellite users to expand, while providing terrestrial licensees with predictability about the areas in which satellite will locate.

However, we must reject any notion that the 5G future will be the sole province of urban areas. The 5G revolution will touch all corners of this country.

Three months ago, I indicated as directly as I am capable that it would be advantageous for the satellite and mobile industries to come together to propose realistic ideas for their coexistence in the upper bands -- and to do so quickly. Satellite and terrestrial stakeholders have suggested a range of sharing options, and the draft Spectrum Frontiers Order seeks to provide a balanced solution that addresses the needs of both parties.

I am confident we will adopt rules that will enable satellite, terrestrial, and federal operations to co-exist and thrive.

To make sure we have this connectivity with high-band spectrum will require a lot more small cells, which means a lot more antenna siting decisions by local governments. That's why it's important that the Commission has streamlined our environmental and historic preservation rules, and tightened our 'shot clock' for siting application reviews. America's local governments will play an important role in determining how we fulfill this national priority.

In addition, all these small cell sites will need to be connected, so we'll need a lot more backhaul. That's a challenge we're going to address through our proceeding on Business Data Services, the kind of dedicated access that wireless providers need to connect cell towers and antennae to their networks. These backhaul connections can be as much as 30 percent of the cost of operating a wireless network. And with the additional sites required to support use of the millimeter wave spectrum, that percentage is likely to increase, to as much as 50 percent.

In many areas, however, competition in the supply of backhaul remains limited, and that can translate into higher prices for wireless networks and then higher prices for consumers. Lack of competition doesn't just hurt the deployment of wireless networks today, it threatens as well to delay the buildout of 5G networks with its demand for many, many more backhaul connections to many, many more antennae. Before the end of this year the Commission will take up a reform proposal – supported by the nation's leading wireless carriers, save one – that will encourage innovation and investment in Business Data Services while ensuring that lack of competition in some places cannot be used to hold 5G hostage.

As we build the next-generation network, a lesson learned from our previous experience is that it must be secure. New platforms, systems, software and technologies will mean new vulnerabilities. Cybersecurity issues must be addressed during the design phase for the entire 5G ecosystem, including devices. This will place a premium on collaboration among all stakeholders. We continue to prefer an approach that emphasizes that industry develop cybersecurity standards just as we have done in wired networks.

In the spirit of the election season, I thought I'd close these remarks by referencing a campaign speech from the 60s. For a change, I don't mean the 1860s.

On July 15, 1960, John F. Kennedy strode to podium at the Los Angeles Coliseum to accept the Democratic nomination for President, and famously challenged the American people to be pioneers of a New Frontier. He spoke of harnessing the power of the technological revolution and exploring uncharted areas of science and space. JFK's vision charted a path that took us to the moon and laid the foundation for the Internet.

This July 14, the FCC will have the opportunity to take an historic step to open up yet another frontier that promises to propel our nation – and the world – forward. Once again, we are looking to the sky to unlock new discoveries and unleash American ingenuity. We are the pioneers of a new spectrum frontier. Working together, we can write the next chapter in the mobile revolution that has already transformed our lives and society. Working together, we can unleash new waves of innovation and discovery that we are yet to imagine.

EXHIBIT C

GALLERY

community concerns over the 5G network rollout based on unfounded anxiety or valid evidence?'

Posted on **April 25, 2019**

*Below is the next in a series of Guest Blogs on BRHP. The opinions expressed in this Guest Blog are of **Don Maisch** himself. Publication of these opinions in BRHP does not imply that BRHP automatically agrees with or endorses these opinions. Publication of this, and other Guest Blogs, facilitates an open debate and free exchange of opinions on wireless technology and health.*

Don Maisch is the publisher of the **EMFacts Consultancy**

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Are community concerns over the 5G network rollout based on unfounded anxiety or valid evidence?

by Don Maisch PhD

Overview

5th generation (5G) wireless technology, as the name indicates, is the next generation wireless communication network from 4G and 4G LTE. Once fully implemented it will predominantly operate in the millimetre (mm) radiofrequency band which will allow much higher data transfer necessary for driverless vehicles, the Internet of Things (IoT), faster video downloads as well as other applications, including military. The downside of 5G mmWave, however, is that the signals do not penetrate objects readily such as buildings and foliage, in comparison to the lower frequencies. This necessitates a far denser network of 5G small cell antennas which will be mounted on power poles, light poles, street furniture, bus shelters, etc. which in many cases will be close to homes, workplaces and public areas. In some cases internal antennas in buildings will also be used. This will result in higher chronic radiofrequency exposures to humans in these areas. The high number of small cells needed for an effective 5G network is causing community disquiet and that, combined with many scientific unknowns about the possible biological effects of prolonged exposure to mm waves, is resulting in increasing community opposition in Australia and internationally. As community opposition is most likely going to increase as 5G infrastructure continues to be rolled out nationally, the question arises: Is this opposition to 5G warranted or not?

5G community concerns in Australia

The Blue Mountains

On January 29, 2019, the Katoomba Council in the Blue Mountains, NSW, voted unanimously to acknowledge serious community concerns over the coming rollout of 5G technology and to investigate these 5G concerns further. Mayor Mark technology risk-phobic alarmism.

> *The most elementary test of the hypothesis that mobile phone and other electronic appliances like WiFi may give you brain cancer has repeatedly fallen at the first and most obvious hurdle. If they cause brain cancer, where are all the bodies? Ever since the nineteenth century we have seen pockets of anxiety about health from train travel, ordinary phones, radio, computer screens, electric blankets, power lines, WiFi, smart meters and wind turbines. Meanwhile life expectancy is longer than it has ever been in history. (3)*

And quoting from Chapman's blog:

> *Mobile phone alarmists are a relentless (small) lobby group who are risk-phobic about almost every new form of communication. Every time there's a new generation of cell phone or electronic technology, they crank out the same fear-mongering stuff. Cult-like, they wake every morning, to spread the word about the deadly rays they believe are being foisted on the world by the evil telecommunications industry. They follow in the hallowed footsteps of those in history who raised health alarms about railway travel, electric light, ordinary phones, radio, TV, electric blankets, computers, microwave ovens, wind turbines and solar roof cells etc. Some are also anti-vaccination (e.g.: this is one of their US queen bees). (4)*

Ryde, Sydney

In early January 2019, a group of over 100 residents of the suburb of Ryde signed a petition to have small cell 4G antennas (which will later be upgraded to accommodate 5G *infrastructure*) removed from the Ryde residential area. Unlike larger towers, small cell antennas do not need planning approval under the Federal telecommunications act. Sue Cappadonna, spokesperson for the group, said *"We don't want it here, it causes us great anxiety that this thing is going to be running 24/7". (5)*

In response, Dr. Geza Benke from Monash University's Department of Occupational and Environmental Health said that residents living near small cell boxes (antennas) had nothing to worry about. He then made a rather surprising statement that:

> *The exposure which people get from these antenna* (small cells*) is no more than you would get from a large antenna. . . over the next two years the small cell boxes would become commonplace, as they are considered a critical component of "filling in the gaps" for the high-speed 5G network…*" (6)

As "*these antenna*" can be erected without local authority and community permission on bus shelters, light poles, power poles, etc. close to homes in residential areas, it is questionable whether concerned residents would be put at ease by Benke's statement.

Responding to the above ABC News item about the Ryde community 5G concerns, Adam Verrender, a PhD Student, under the supervision of Rodney Croft at the Australian Centre for Electromagnetic Bioeffects Research (ACEBR), wrote a reply for the ABC News on January 9, 2019. His article started out with his claim that:

> *Decades of scientific research has found no evidence of any adverse health effects* [from mobile phones] *but still the public remains concerned. Even studies looking at long-term damage, such as brain cancer, have not found evidence of increased harm. (7)*

Such a *disingenuous* claim of *"no evidence"* is at odds with the decision of the International Agency for Research on Cancer (IARC) which, in 2011*, classified* radiofrequency emissions from mobile phones as a possible human carcinogen, based on the 13 nation Interphone study on mobile phone use (8).

Verrender also claimed in his article that the continuing debate over adverse health effects from "phone tower anxiety" is being *"fuelled by misinformation, scepticism and a complex psychological phenomenon known as the nocebo effect"*. As a result of this according to Verrender *"it's little wonder this contentious issue persists, particularly given wireless technologies are so pervasive".* (9)

As for evidence that any adverse effects from radiofrequency exposure, such as electro-hyper-sensitivity (EHS) are purely psychological, Verrender mentions in his article the provocation study designed by ACEBR which supported the view that a complex psychological phenomenon, the nocebo effect, could explain the condition (EHS). What he failed to mention was that the

As it stands the proposed experimental design and statistical analysis cannot be used to achieve the stated aim. The scientific and statistical shortcomings of the proposed [study] are each serious flaws in themselves and their cumulative impact and interaction render the proposal scientifically indefensible. All of them need to be corrected in a major revision of the proposal. (12)

According to Dariusz Leszczynski (13) who has studied McDonald's full critique and later versions of the ACEBR test protocol, he saw no changes and considered it as an exact repetition of the earlier design (14). Leszczynski has written extensively about the many weaknesses on provocation testing, including that designed by ACEBR, and has published an open letter on the weaknesses of EHS provocation research (15).

A sampler of growing international opposition to 5G network rollouts

In 2017 an international 5G Appeal was launched by scientists and doctors who are calling for the EU to halt the roll out of 5G due to serious potential health effects from the technology. As of April 24, 2019, 231 scientists and medical doctors have signed the appeal (16).

- **March 24**, 2019: Portland Oregon city officials in the US stated their opposition to the installation of 5G networks around the city, supported by the mayor and two commissioners. The city officials considered that 5G health risks were not well enough understood to warrant installations (17).
- **March 28**, 2019: Florence, Italy, applied the precautionary principle by refusing permission for 5G infrastructure and referring to "the ambiguity and the uncertainty of supranational bodies and private bodies (like ICNIRP)", which "have very different positions from each other, despite the huge evidence of published studies"(18).
- **March 28**, 2019: The Roman district "XII Municipality of Rome" voted against allowing 5G trials, with other districts expected to follow. Other motions to stop 5G are expected in the four regional councils, one provincial council and other municipal councils of Italy (19).
- **April 1**, 2019: Plans for a pilot project to provide high-speed 5G wireless internet in Brussels have been halted due to fears for the health of citizens, Environment Minister Céline Fremault said that "The people of Brussels are not guinea pigs whose health I can sell at a profit. We cannot leave anything to doubt" (20).
- **April 4**, 2019: The House of Representatives of the Netherlands expressed its concern over the possible health risks of radiation from the new 5G network. Political parties want to know as a matter of urgency what the dangers are before 5G is rolled out on a large scale (21).
- **April 5**, 2019: The California Supreme Court Justices unanimously upheld a 2011 San Francisco ordinance requiring telecommunications companies to get permits before placing small cell antennas on city infrastructure (22).
- **April 8**, 2019: A petition asking the German Parliament to stop the award of 5G frequencies has reached 54,643 signatures, surpassing the quorum, according to an environmental campaign group called 'Diagnose: Funk'. The German Parliament may decide to suspend the procedure to award 5G frequencies based on "scientifically justified doubts about the safety of this technology", according to the petition (23).
- **April 9**, 2019: Switzerland's 3rd largest region, Canton of Vaud adopted a resolution calling for a moratorium on 5G antennas until the publication of a report on 5G by the Swiss Federal Office for the Environment (24). Other cantons may follow with further moratoriums (25).
- **April 11**, 2019: Geneva adopted a motion for a moratorium on 5G, calling on the Council of State to request WHO to monitor independent scientific studies to determine any possible harmful effects of 5G.(26)
- **April 20**, 2019: Switzerland announced that it will monitor 5G health risks as a result of a pushback from citizens who claim that 5G emissions present dire health risks (27). Four cantons have now stopped 5G networks, Jura, Geneva, Vaud and Neuchâtel. Comprising 1.5 million people. However, the majority state-owned Swisscom defied these cantons by activating 5G stations in 102 locations by upgrading existing antennas installed for previous generations of wireless technology (28, 29).

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So, what are we to make of all this. Are there valid concerns over the rollout of 5G technology, or is this all needless worry from a misled public, as suggested by those connected with ACEBR and Prof. Simon Chapman?

Validating community concerns

This report, titled *5G Deployment: State of Play in Europe, USA and Asia*, was published in April 2019. The authors point out that the global roll out of 5G is not a short-term race and that "*5G is more complex than previous wireless technologies and should be considered as a long-term project to solve technical challenges and develop a clear business case*".

As for those "technical challenges" this is mentioned in the executive summary (excerpt):

> *As 5G is driven by the telecoms supply industry, and its long tail of component manufacturers, a major campaign is under way to convince governments that the economy and jobs will be strongly stimulated by 5G deployment. However, we are yet to see significant "demand-pull" that could assure sales. These campaign efforts are also aimed at the MNOs but they have limited capacity to invest in the new technology and infrastructure as their returns from investment in 3G and 4G are still being recouped. The notion of a "race" is part of the campaign but it is becoming clear that the technology will take much longer than earlier generations to perfect. China, for instance, sees 5G as at least a ten-year programme to become fully working and completely rolled out nationally. This is because the technologies involved with 5G are much more complex. One aspect, for example, that is not well understood today is the unpredictable propagation patterns that could result in unacceptable levels of human exposure to electromagnetic radiation.* (30)

Unpredictable propagation patterns

To visually understand what is meant by those unpredictable propagation patterns mentioned in the EC 5G report it is worthwhile examining an Ericsson PowerPoint presentation, titled *Impact of EMF limits on 5G network roll-out*.

The presentation was prepared by Christer Törnevik, Senior Expert, EMF and Health, Ericsson Research, Stockholm Sweden. The presentation was given at The International Telecommunications Union's (ITU) Workshop on 5G, EMF & Health, Warsaw, Poland on December 5, 2017.

In part, the presentation concluded that with increased human exposure levels from 5G antennas, EMF exposure compliance in some nations will be difficult. To quote: "In countries with EMF limits significantly below the international science-based ICNIRP limits the roll-out of 5G networks will be a major problem"(31).

The 5th Asian and Oceanic IRPA Regional Congress on Radiation Protection (AOCRP-5) Melbourne, Australia, May 20 – 23, 2018

At a recent scientific conference by the Australian Radiation Protection and Nuclear Safety Agency two expert presentations gave reason to pause in the rapid roll out of 5G millimetre waves. The first was by Dr. Dariusz Leszczynski, adjunct professor of biochemistry, University of Helsinki, Finland and chief editor of Frontiers in Radiation & Health, Lausanne, Switzerland. In his presentation, titled *5G Millimetre-Waves Health & Environment*, Leszczynski examined the serious limitations of biomedical research on millimetre waves but from what studies that are available, it should cause great concern. He specifically called for the urgent need for research on 5G millimetre waves because of the rapidly ongoing deployment of 5G technology (32).

Another presentation was by Dr. Andrew Wood, School of Health Sciences, Swinburne University of Technology, Melbourne. Titled '*What is the current status of research on mm-Wave frequencies'*, Wood mentioned two areas of uncertainty with 5G radiation:

- *Skin and eyes are regions of concern in regard to 5G frequencies (6-60 GHz) and beyond.*
- *Could be resonant enhancement absorption due to skin structures*.(33)

Possible effects on trees and foliage

Another possible problem specific to 5G millimeter emissions is that they can be disrupted or blocked by trees and foliage, especially after rain. This creates a potential problem for suburban streetscapes. Will residents have to choose whether they prefer a pleasant green environment or great download speeds (34)?

The potential problem of trees and 5G reception has not escaped Telstra's notice. To quote from Mike Wright, Telstra's managing director of networks:

In a September 2018 New Zealand court case the judge ruled, in relation to a property owner's trees blocking a neighbour's wi-fi reception, that *"undue interference with a wi-fi signal caused by trees could constitute an undue interference with the reasonable use and enjoyment of an applicant's land for the purposes of s335 (1)(vi) of the {property law} Act.*" Lawyer and IT specialist Rick Shera said of the case: *"This decision is interesting because it finds that, in some circumstances, neighbour A can require tree trimming, or removal, repair or alteration of a structure, on neighbour B's land, where the trees or structure unduly interfere with the neighbour A's wireless connectivity." (36)*

As 5G transmissions may be more prone to being blocked by trees than wi-fi signals what will be the legal implications if this turns out to be an issue?

An *important question*: Can 5G phased array antennas generate Brillouin precursors?

In early 2002 the New York based technical publication, *Microwave News* published an examination of a rather arcane topic: Brillouin Precursors. The issue at that time was non-ionising radiation from the phased array PAVE PAWS radar facility at Cape Cod, Massachusetts, USA. A Brillouin precursor is a very fast pulse of radiation, which when it enters the human body, may generate a burst of energy that can travel much deeper than predicted by conventional models.

In a *Microwave News* interview with Professor Kurt Oughstun (37), he explained how Brillouin precursors are generated by phased array radar antennas. When asked, "Are Brillouin precursors unique to PAVE PAWS radiation?", Oughstun replied:

> *"No – not at all. As data transmission rates continue to increase, wireless communication systems will approach closer to and may, at some time in the not-too-distant future, exceed the conditions necessary to produce Brillouin precursors in living tissue. (38)*

It must be pointed out that it is not known if Brillouin precursors would be created by 5G phased array antennas as no research has been done – so this is hypothetical. However, considering the uncertainties mentioned in the recent EC report on 5G, mentioned earlier, this possibility should be investigated:

> *One aspect, for example, that is not well understood today is the unpredictable propagation patterns that could result in unacceptable levels of human exposure to electromagnetic radiation.*

Concluding thoughts

What is apparent in this controversy is that the public's perception of risk and that of some experts defending the technology is at wide variance. The assurances of a complete absence of risk from 5G networks coming from these experts is not reflected in what is known about the many uncertainties which exist with 5G technology and speaks more about their own ignorance than that of concerned communities.

What we are seeing here is an example of what has been defined as *technological fundamentalism*. To quote from Robert Jensen:

> *Technological fundamentalists believe that the increasing use of evermore sophisticated high-energy, advanced technology is always a good thing and that any problems caused by the unintended consequences of such technology eventually can be remedied by more technology. Those who question such declarations are often said to be "anti-technology," which is a meaningless insult. All human beings use technology of some kind, whether stone tools or computers. An anti-fundamentalist position is not that all technology is bad, but that the introduction of new technology should be evaluated carefully on the basis of its effects—predictable and unpredictable—on human communities and the non-human world, with an understanding of the limits of our knowledge.(39)*

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Guest Blog: "Can 5G phased array antennas generate Brillouin precursors?" by Don Maisch
In "Mobile phones and health"

Misleading opinion on 5G small cells presented by the ABC News in Australia
In "Mobile phones and health"

Leszczynski: 'Brief Opinion on 5G and Health'
In "Mobile phones and health"

This entry was posted in **Mobile phones and health**, **Science journalism and blogging** and tagged **2011**, **4G**, **4G/LTE**, **5G**, **5G Appeal**, **ABC News**, **ACEBR**, **Adam Verrender**, **alarmism**, **Andrew Wood**, **AOCRP-5**, **ARPANSA**, **Australia**, **Australian Centre for Electromagnetic Bioeffects Research**, **Blue Mountains**, **Brillouin precursors**, **cell phone**, **cell phone radiation**, **Christer Tornevik**, **CSIRO**, **Dariusz Leszczynski**, **David McDonald**, **Don Maisch**, **EHS**, **electomagnetic sensitivity**, **electromagnetic hyper-sensitivity**, **foliage**, **Geza Benke**, **health effects**, **IARC**, **ICNIRP**, **Interphone**, **IoT**, **IRPA**, **Katoomba**, **Kurt Oughstun**, **Louis Slesin**, **Mark Greenhill**, **Melbourne**, **Microwave News**, **Mike Wright**, **millimeter waves**, **millimetre waves**, **mobile phone**, **Monash University**, **nocebo**, **PAVE PAWS**, **safety limits**, **safety standards**, **Simon Chapman**, **streetscapes**, **Sue Cappadonna**, **Swinburne University of Technology**, **Sydney**, **Sydney University**, **telecoms**, **Telstra**, **trees**, **wifi** by **dariuszleszczynski**. Bookmark the **permalink [https://betweenrockandhardplace.wordpress.com/2019/04/25/guest-blog-from-dr-don-maisch-australia-are-community-concerns-over-the-5g-network-rollout-based-on-unfounded-anxiety-or-valid-evidence/]** .

3 THOUGHTS ON "GUEST BLOG FROM DR. DON MAISCH, AUSTRALIA: 'ARE COMMUNITY CONCERNS OVER THE 5G NETWORK ROLLOUT BASED ON UNFOUNDED ANXIETY OR VALID EVIDENCE?'"

Tom Whitney
on **April 27, 2019 at 04:02** said:

Corrigendum: The 4th sentence of my Ryde paragraph should read – "The trend of replacing macro cells with small cells is analogous to the trend to replace high-wattage centre of the room light fixtures with multiple low-wattage pot lights."

Tom Whitney
on **April 27, 2019 at 00:19** said:

"Are community concerns over the 5G network rollout based on unfounded anxiety or valid evidence?" This is not a binary question that can be answered with a simple yes or no

No scientific data supports definitive answers to questions about the existence or nonexistence of health risks related to electromagnetic fields. More research to produce more reliable information is needed before any firm conclusions can be drawn. However, it can be said is that many scientists on both sides of the question agree we are dealing at most with rare diseases and an increased risk that is very small, especially compared with life's other everyday risks.

In the case of the concerns of the Blue Mountain community, they are probably unfounded anxiety. I say this because the 3.5 GHz frequency band falls between the two Wi-Fi bands and has been used in WiMAX applications for a few decades. There is no mystery as to what it can and cannot do; and there is no reason to find it any scarier than existing 3G & 4G exposure.

As for the Ryde, Sydney concerns of increased exposures from small cells: probably unfounded! As Dariusz and others have pointed out, a lot of the exposure to people comes from their own wireless device close to the body – and the amount of this exposure is controlled by the quality of the base station signal. A strong signal from a nearby transmitter means that the mobile output power will be reduced. And many small cells provide a more homogenous distribution of the signal. The trend of replacing small cells with macro cells is analogous to the trend to replace high-wattage centre of the room light fixtures with multiple low-wattage pot lights. There is every reason to believe that multiple small cells will lead to lower personal exposure.

And your "important question: Can 5G phased array antennas generate Brillouin precursors?"
Firstly, as frequency is increased the absorption is reduced. At mmWave frequencies almost all of the signal will be

dave
on **April 26, 2019 at 21:04** said:

Why is it so hard to understand that emf at certain frequencies can cause harm…we are bio electric beings and even micro volts can have an effect on the human (and animal) nervous system?Anyone overlooking possibilities of damage is very suspicious (are they punting for the industry?)

EXHIBIT D

FCC 13-39

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies	)))	ET Docket No. 13-84
	)	
Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields	)))	ET Docket No. 03-137
	)	

To: Office of the Secretary
Federal Communications Commission
Washington, DC 20554

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State of Connecticut, Litchfield County, USA

I, B. Blake Levitt, attest that my statements are true to the best of my knowledge.

I, Henry C. Lai, attest that my statements are true to the best of my knowledge.

Comments for FCC ET Docket No. 013-84 and ET Docket No. 03-137

1. My name is B. Blake Levitt. My address is 355 Lake Road, Warren. Connecticut 06777, USA.

2. I am a medical/science journalist, former *New York Times* contributor, and author of *Electromagnetic Fields, a Consumer's Guide to the Issues and How to Protect Ourselves* (Harcourt Brace, First Edition; iUniverse Back-In –Print Edition, 2007) which won a chapter Award of Excellence from the American Medical Writers Association; and Editor of *Cell Towers, Wireless Convenience? or Environmental Hazard? Proceedings of the "Cell Towers Forum," State of the Science, State of the Law* (Safe Goods/New Century Publishing, 2001). I am also the co-author, with Dr. Henry C. Lai, of *Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays,* published in Environmental Reviews/NRC Research Press, 2010 (Environ Rev: 18: 369-295 doi:10.1139/A10-018).[1] I have published widely on the health and environmental effects of low-level nonionizing radiation for over 20 years for both the lay and professional reader. I have also consulted nationally for municipalities struggling with safer cell tower and infrastructure siting after passage of The Telecommunications Act of 1996 (TCA) which restricted local and state rights regarding the ability to take radiofrequency radiation (RF) into consideration in telecommunications tower/antenna array siting. I am also on the Executive Committee of The Berkshire-Litchfield Environmental Council (BLEC), a 501 (3)(c) non-profit organization that focuses on environmental issues affecting the Northwest corner of Connecticut and the Berkshires region of Massachusetts. BLEC has sponsored

[1] Levitt, B.B., Lai, H. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays, Enviro. Rev. 369-395 (2010), doi:10.1139/A 10-018 http://www.nrcresearchpress.com/doi/pdf/10.1139/A10-018

several educational forums on safe infrastructure siting and has researched in depth the environmental effects of low-level ambient RF exposures to myriad species.

3. My name is Henry C. Lai. My address is 5557, 35th Ave., NE, Seattle, Washington 98105, USA

4. I am a Research Professor Emeritus of Bioengineering in the University of Washington, Seattle, WA, USA. I have carried out research on the biological effects of nonionizing electromagnetic fields for more than 30 years and published numerous papers on the topic. I am a co-editor of the journal Electromagnetic Biology and Medicine. I was one of the "subject matter experts" interviewed for the July 2012 report "Telecommunications: Exposure and Testing Requirements for Mobile Phones Should be Reassessed" by the Government Accountability Office (GAO).

5. Background:

On March 29, 2013, the FCC issued an Order, Notice of Proposed Rulemaking (NPRM) and a Notice of Inquiry (NOI) as a single document (13-39) in response to the July 2012 report from the Government Accountability Office GAO which recommended, among other things, that the Commission:[2]

• Reassess the current FCC radiofrequency radiation (RFR) exposure limits, including its effects on human health; the costs/benefits in keeping the current limits; to seek the opinions of relevant health/safety agencies; and to change the limits if determined necessary.

• Reassess whether the current mobile phone testing requirements, given new technologies and different use patterns, do in fact result in the identification of maximum RF energy exposures, especially when mobile phones are held against the body – the head in particular -- and to update testing requirements if determined necessary.

The NPRM proposes to standardize all criteria for frequency, power density, and antenna separation in order to determine whether a facility or device should be exempt from routine evaluation for harm to the human body. This would do away with the current categorical exclusions. The NPRM also discusses distinctions between general population and occupational RFR exposure and proposes new requirements for signs and barriers at transmitter sites.

[2] "Telecommunications: Exposure and Testing Requirements for Mobile Phones Should be Reassessed." http://www.gao.gov/assets/600/592901.pdf

The NOI addresses three areas: the propriety of existing standards and policies; possible options for precautionary exposure reduction; and possible improvements to the equipment authorization process and policies as they relate to RF exposure.

The first two points address whether thermal damage (tissue-overheating), which is the current focus of FCC standards, is the only RFR risk, or whether other human health damage can be caused by chronic exposures with cumulative effects over longer periods of time.

This is the first time in 17 years that the FCC has looked at the adequacy of its thermal-based RFR-exposure standards to protect human health. The FCC is admittedly not expert in the subject and defers to other agencies and professional organizations. Nevertheless, FCC is charged by law with adopting and enforcing RF exposure safeguards. The rationale and overall model is therefore critical for biological accuracy. Toward that end, FCC has called upon better-informed agencies such as the Environmental Protection Agency (EPA) for opinions on ambient exposures, and the Food and Drug Administration (FDA) for opinions on consumer products, as well as industry groups like the International Electrical and Electronics Engineers (IEEE) which has a financial stake in relaxed regulation, as well as the knowledgeable public for input on key areas of concern. Unfortunately, programs within EPA for this kind of research and policy-making have been almost completely defunded, leaving few there to render a considered opinion; and FDA's funding has also been reduced. This, in effect, leaves industry groups with the most clout.

The FCC expresses confidence in the current thermal-only basis, but acknowledges that with the rapid proliferation of wireless devices over the years, as well as the ubiquity of antennas needed for supportive infrastructure, and the new technological designs that allow much closer-to-the-body operation and medical implantation, that a new review is in order. The GAO report expressed similar confidence in the current methodology. This is in stark opposition to the most current data, and the direction that many other countries are taking regarding precautionary approaches.

Neither these authors, nor many expert members of the international research community, harbor the same confidence in such narrowly defined standards, which are premised upon understanding underlying biological mechanisms. Many now think that, given the peer-reviewed literature published since 1997 that setting an exposure threshold should based mainly on the knowledge at which level biological/health effects are observed, and not on the mechanism of the effects. Most of that research has come from outside of the U.S, including the recent classification of RF fields as a 2B (possible) carcinogen by the International Agency for Research on Cancer (IARC) at the World Health Organization

(WHO).[3] Indeed hundreds of studies have found biological/health effects at orders of magnitude below the current FCC thresholds. The changes regarding SAR allowances for the pinna (ear), as well as possible new setbacks from products and infrastructure, and potential new classifications that would supplant categorical exclusions, go nowhere near far enough in protecting public health and, in some areas, may serve to increase exposures to the general population.

6. FCC Comments from NPRM and NOI:

> ¶16. In this *Order*, we adopt rules explicitly permitting licensees and grantees to demonstrate that they comply with the Commission's RF exposure rules based on specific absorption rate (SAR) in lieu of maximum permissible exposure (MPE) for fixed and mobile transmitters. Providing an additional option for parties to demonstrate that they comply with the RF exposure limits could reduce those parties' expenses in some cases. Additionally, in the *Order*, we classify the outer ear as an extremity based on similarities to other parts of the body such as the hands and feet, which are already classified as extremities. This reclassification of the outer ear as an extremity is consistent with health agency comment and industry standards and should eliminate unnecessary compliance costs that could occur under alternative evaluation schemes.
>
> Accordingly, in the *Notice*, we requested comment on classifying the pinna (outer ear) as an extremity, to which less stringent exposure criteria would apply. While we received comments both for and against this classification, we amend section 1.1310 of our rules to subject the pinna to the same RF exposure limit currently applicable to hands, wrists, feet, and ankles.
>
> ¶44.
> *Background*. Our localized SAR limit for the general population is 1.6 W/kg as averaged over any one gram cube of tissue, except for extremities, explicitly defined in our existing rules as the hands, wrists, feet, and ankles, where the limit is 4 W/kg as averaged over any ten gram cube of tissue.78
> (For occupational exposure, the localized SAR limit is 8 W/kg as averaged over any one gram cube of tissue, except for within the extremities where it is limited to 20 W/kg as averaged over any ten gram cube of tissue.) In the *Notice*, 79 we referred to deliberations by the

[3] http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf

> IEEE of a standard revision that would treat the pinna of the human ear also as an extremity for the purpose of SAR evaluation.80 We invited comment on whether we should consider adopting such a revision once approved by the IEEE .In the meantime, IEEE revisions characterizing the pinna as an extremity have been issued in IEEE Standards C95.1b-2004 and C95.1-2005. We note that classification of the pinna is only relevant to evaluation of localized SAR and not MPE. The MPE limits were derived under the assumption of whole body exposure, and control of localized SAR is implicit in their derivation.

¶45.
Comments. Ericsson and Motorola both supported those revisions, and Motorola recommended that the Commission adopt it by reference in a separate rulemaking…. This revision has now been adopted by the IEEE as Amendment 2 to IEEE Std. C95.1 (IEEE Std. C95.1b-2004).
The pinna is the external part of the ear that extends away from the skull, consisting primarily of cartilage.

7. Author Comments:

Our comments are mainly on the validity and adequacy of the current guidelines in the protection of the general public exposed to radiofrequency radiation (RFR). Reclassification of the pinna as an extremity is of secondary importance. However, we do not agree with such a reclassification.

There are two major situations of radiofrequency field exposure: 1) near-field exposure, in which the source is close to the body and only part of the body is exposed and the pattern of energy absorption is relatively stationary; and 2) far-field exposure in which the source is away at a distance greater than two wavelengths of the radiation, the whole body is exposed and the pattern of energy absorption is more variable as the object moves in the field. The main cause of near-field exposure is in the use of cell phones or other wireless communication devices when the radiation is concentrated to the head of the user. In the far-field situation, the main sources are RF-transmission towers in the vicinity, e.g., radio and TV towers, cell phone base stations, and wireless emitters and radars. The FCC regulates both near- and far-field exposures.

The current RF exposure guidelines need a major overhaul but under no circumstance should be made more lenient. The guidelines are based on limited and obsolete scientific data and illogical rationale. It can be misleading to discuss the exposure standards based on thermal v. non-thermal effects. It is very difficult to scientifically differentiate between RF-induced thermal and non-thermal biological effects. An increase in tissue temperature does not necessarily imply that an effect being observed is thermal in nature only. Guidelines should be based mainly on the exposure levels (SAR or power density) at which biological effects have been consistently observed, not the mechanism of the effects.

While expanding the Commission's RF exposure rules to be based on specific absorption rate (SAR) is broadening toward a more biologically based standard rather than a doseimetry based model such as the maximum permissible exposure (MPE), SAR should not be used in lieu of MPE for fixed and mobile transmitters. Because of complex numerous variables, SAR is almost impossible to determine in the field and should not be used for ambient exposures.

Computational models for SAR calculation can be quit reliable, however. [4] Because of this, we recommend that FCC require manufacturers to provide state-of-the-art data on their phones, posted both on the FCC's website and made available to consumers at point-of-sale. Although SAR is the most biologically relevant, MPE has been used as a surrogate to determine SAR. The main emphasis for far-field exposures should remain on an MPE model, simply because it is easier to measure, control and mitigate when necessary. SAR is far too complex for a field model for infrastructure exposures and is therefore unreliable. It could actually make the standards less clear and enforceable as industry could easily hide behind specious SAR models and increase the power output of transmitters.

8. Specific Absorption Rate (SAR):

When a cell phone is held close to the head, the radiofrequency energy penetrates the head and is absorbed by body tissues. Depending on various physical factors, energy absorption is not uniform. High and low energy deposition areas are formed. The amount of energy absorption is measured by the specific absorption rate (SAR) which is the rate of energy absorbed by a unit mass of tissue, generally expressed in W/kg. Energy distribution can be calculated using computer simulation. Guidelines are set by limiting the peak SAR. In order to do that, the amount of tissue for peak SAR consideration has to be defined. In the present standards, the limiting SAR is defined by 1 or 10 gm of tissue, i.e., the SAR within 1 or 10 gm of brain/head tissue should not exceed a certain value. In the IEEE guideline, the peak SAR in the head is not to exceed 1.6 W/kg averaged over 10 g of tissue. The proposed FCC guideline of SAR of 1.6 W/kg over 1 gm of tissue is the near-field (partial body) exposure situation. This was derived from an erroneous rationale. The rationale was that the

[4] In fact, it was just such computerized SAR calculation that caused concern for the reliability of cell phone industry claims about power density and which lead to the reclassification of the pinna as an 'extremity.' Om Ghandi's and Neils Kuster's calculations showed that some cell phones exceeded the 4W/kg limit. That was why cell phone manufacturers came to recommend holding the phone a few inches away from the head. Without reclassification, some cell phone manufacturers would have had to pull their models from the market.

0.4 W/kg guideline was a whole body exposure situation (i.e., an animal's behavior was disrupted when it's whole body was exposed to 4 W/kg), and when part of the body is exposed, as in the case of cell phone use, that part of the body should be able to take more radiation. Thus, the guideline for partial body exposure was increased 4 times to 1.6 W/kg. There is no evidence that the partial body can tolerate more energy deposition than the whole body. The opposite may be true. Up to 300,000 brain cells (neurons and glial cells) can be contained within 1 cu mm of brain tissue. Genetic damage in one single cell, as caused by exposure to RFR from a cell phone, is enough to lead to cancer.

The current FCC guidelines for the SAR are based on narrow data from one set of experiments carried out in the 1980's[5] [6] which showed behavioral disruption in animals after exposure to RFR at a whole body SAR of 4 W/kg. These studies have not been independently replicated, yet are enshrined in the standards. Many other experiments since then have shown behavioral and other physiological effects in animals and humans at a SAR lower than 4 W/kg but no changes to the guidelines have been made.[7] This point ties directly into the reclassification of the pinna (ear) as an extremity, which would allow cell handset exposures to increase to 4W/kg from the current 1.6 W/kg averaged over one gram of tissue.

As examples, Table I below lists a group of low-intensity *in vitro* studies reported in the literature. 'Low intensity' is defined as a SAR less than 0.1 W/kg, which is 1/40 of the biologically effective SAR used in the setting of present RF guidelines. In addition, since cell phones are the major source of near-field exposure and modulations may have a significant role in eliciting biological effects, only studies using cell phone frequencies and modulations were considered. (It should be noted that signals used in these studies could only partially match the modulations of cell phone signals.) An additional criterion is that SARs are provided in these studies. There are 17 papers that satisfied these criteria listed in Table 1. The biological effects reported by these studies included: genetic effects, cell proliferation, membrane chemistry, protein damage, calcium metabolism, stress protein production, immunological changes, and DNA damage. The average SAR of these 17 studies is 0.029 W/kg (range 0.07 – 0.000021 W/kg). The duration of exposure ranged from 15 min to 72 hours.

Table 2 is a list of in vivo animal studies. There are 12 studies that fit the criteria. Animal species of these studies included mouse, rat and hamster. Endpoints studied included

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[5] de Lorge, J., and Ezell, C.S. 1980. Observing-responses of rats exposed to 1.28- and 5.62-GHz microwaves. Bioelectromagnetics, 1(2): 183–198, 1980.

[6] de Lorge, J.O. 1984. Operant behavior and colonic temperature of Macaca mulatta exposed to radiofrequency fields at and above resonant frequencies. Bioelectromagnetics, 5(2): 233–246, 1984.

[7] Lai, H. Biological effects of radiofrequency radiation from wireless transmission towers. In *"Cell Towers: Wireless Convenience? OrEnvironmental Hazard?"* Levitt, B.B. (ed.), New Century Publishing, East Canaan, CT, 2001, pp. 65-74, 2001.

effects on: testosterone and insulin levels, DNA double strand breaks, reproductive system, metabolism, memory functions, blood-brain barrier, embryonic kidney development, immune system, and free radical formation. The average SAR of these 13 studies is 0.015 W/kg.

It is very obvious from the data presented in the tables that recent studies do not support the use of 4 W/kg SAR as the basis of exposure limits.

Table 1. In vitro studies (800-2000 MHz) (n = 17); Average = 0.029 W/kg (range 0.07 – 0.000021 W/kg, median 0.025 W/kg)

		SAR (W/kg)	Effect reported
Belyaev et al.(2005)	915 MHz, GSM, 24 & 48 hr	0.037	Genetic changes in human white blood cells
Belyaev et al.(2009)	915 MHz, 1947 MHz; GSM, UMTS 24 & 72 hr	0.037	DNA repair mechanism in human white blood cells
Capri et al.(2004)	900 MHz, GSM 1 hr/day, 3 days	0.07	Cell proliferation and membrane chemistry
De Pomerai et al. (2003)	1 GHz 24 & 48 hr	0.015	Protein damages
Dutta et al. (1984)	915 MHz, sinusoidal AM at 16 Hz	0.05	Increase in calcium efflux in human neuroblastoma cells
Ivaschuk et al. (1997)	836.55 MHz, TDMA 20 min	0.026	Transcript levels for c-jun were altered in nerve growth factor-treated PC12 rat pheochromocytoma cells
Kwee et al. (2001)	960 MHz, GSM 20 min	0.0021	Hsp-70 stress protein increased in transformed human epithelial amnion cells
Makova et al. (2005)	915 and 905 MHz, GSM 1 hr	0.037	chromatin conformation in human white blood cells affected
Marinelli et al. (2004)	900 MHz CW 2 - 48 hr	0.0035	Cell's self-defense responses triggered by DNA damage.
Pavicic et al. (2008)	864 and 935 MHz, CW, 1-3 hrs	0.08	Growth affected in Chinese hamster V79 cells.
Phillips et al. (1998)	813.5625 MHz	0.0024	DNA damage in human

	(iDEN); 836.55 MHz (TDMA) 2 hr and 21 hr		leukemia cells.
Sarimov et al. (04)	895-915 MHz GSM 30 min	0.0054	Human lymphocyte chromatin affected similar to stress response.
Schwarz et al. (2008)	1950 MHz UMTS 24 hr	0.05	Genes in human fibroblasts.
Stagg et al. (1997)	836.55 MHz TDMA duty cycle 33% 24 hr	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)	900 MHz GSM 217 Hz pulses-.577 ms width 15 min	0.024	Immune activities of human white blood cells affected.
Velizarov et al. (1999)	960 MHz GSM 217 Hz square-pulse, duty cycle 12% 30 min	0.000021	Decrease in proliferation of human epithelial amnion cells.
Wolke et al. (1996)	900, 1300, 1800 MHz, square-wave modulated at 217 Hz; Also 900 MHz with CW, 16 Hz, 50 Hz and 30 KHz modulations	0.001	Calcium concentration in heart muscle cells of guinea pig.

Table 2: Non-human in vivo studies with SAR N=14, mean = 0.015 W/kg (range: 0.004 – 0.02 W/kg), median = 0.014 W/kg

		SAR (W/kg)	Effects reported
Forgacs et al. (2006)	1800 MHz, GSM- 217 Hz pulses, 576 μs pulse width; 2 hr/day, 10 days	0.018	Increase in serum testosterone.
Kesari and Behari (2009)	50 GHz; 2hr/day, 45 days	0.0008	Double strand DNA breaks observed in brain cells

Kesari and Behari (2010)	50 GHz; 2 hr/day, 45 days	0.0008	Reproductive system of male rats
Kesari et al. (2010)	2450 MHz, 50-Hz modulation, 2 hr/day, 35 days	0.11	DNA double strand breaks in brain cells.
Kumar et al. (2010a)	10 GHz, 2h/day 45 days	0.014	Cellular changes and increase in reactive oxygen species in testes
Kumar et al. (2010b)	10 GHz, 2 h/day, 45 days 50 GHz, 2h/day, 45 days	0.014 0.0008	Genetic damages in blood cells
Lerchl et al. (2008)	383 MHz (TETRA), 900 and 1800 MHz (GSM) 24 hr/day, 60 days	0.08	Metabolic changes.
Navakatikian and Tomashevskaya (1994)	2450 MHz CW and 3000 MHz pulse-modulated 2 μs pulses at 400 Hz Single (0.5-12 hr) or repeated (15-60 days, 7-12 hr/day) exposure, CW-no effect	0.0027	Behavioral and endocrine changes, and decreases in blood concentrations of testosterone and insulin.
Nittby et al. (2007)	900 MHz GSM 2hr/wk, 55wk	0.0006	Reduced memory functions.
Perssson et al. (1997)	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.
Pyrpasopoulou et al. (2004)	9.4 GHz GSM (50 Hz pulses, 20 μs pulse length) 1-7 days postcoitum	0.0005	Exposure during early gestation affected kidney development.
Salford et al. (2003)	915 MHz GSM 2 hr	0.02	Nerve cell damage in brain.
Veyret et al. (1991)	9.4 GHz 1 μs pulses at 1000 pps, also with or without sinusoidal AM between 14 and 41 MHz, response only with AM modulation, direction	0.015	Functions of the immune system.

	of response depended on AM frequency		
Yurekli et al. (2006)	945 MHz GSM, 217 Hz pulse-modulation 7 hr/day, 8 days	0.0113	Free radical chemistry.

9. Pinna (Ear) as 'Extremity':

The current FCC standards are 1.6 W/kg as averaged over any one gram cube of tissue, except for extremities, specifically defined by FCC as the hands, wrists, feet, and ankles, where the limit is 4 W/kg as averaged over any ten gram cube of tissue. For occupational exposure, the localized SAR limit is 8 W/kg as averaged over any one gram cube of tissue, except for within the extremities where it is limited to 20 W/kg as averaged over any ten gram cube of tissue. (The FCC notes that classification of the pinna is only relevant to evaluation of localized SAR and not MPE. The MPE limits were derived under the assumption of whole body exposure, and control of localized SAR, is implicit in their derivation.)

We think the rationale for considering the external ear (pinna or auricle) as an extremity should be re-examined more carefully. The auricle is simply not an 'extremity.' Just a casual look at the Medline comes up with some alarming information. First, it is very obvious that the auricle is histologically different from the arms and legs. There are no bone, tendon, and skeletal muscle.

Let us first consider the possible thermal effect on the auricle while using a cell phone. The 'rationale document' states very well that the auricle can probably handle the heat load. But, it fails to consider individuals who cannot thermo-regulate very well. This is not uncommon. For example, the micro-circulation of the auricle is controlled by, among other neurotransmitter systems, the adrenergic and serotonergic systems [Li et al, 1998, 2000; White et al., 1985; see references below]. People who take alpha-2 agonists for hypertension, beta-agonists for asthma, and serotonin-agonists for psychiatric depression would be vulnerable to thermal damage to the auricle when using a cell phone. Should customers who use these therapeutic drugs have additional warnings when using cell phones?

In addition, Oftedal et al (2000) recently reported that "…sensations of warmth on the ear and behind/around the ear, burning sensations in the facial skin and headaches were most commonly reported by cell phone users."

Cancer of the auricle is not uncommon [e.g., Hayter et al., 1996; Moriyama et al., 2000; Silva et al., 2000; Worley et al., 1999], because the auricle does not consist mainly of post-mitotic cells like the arms and legs. And that the question of whether RFR can cause genetic damage is far from settled.

Thirdly, the auricle, different from the arms and legs, is innervated by the vagus nerve. The vagus also innervates many other vital organs in the body, including, for example, the heart, GI-tract, and reproductive organs. Vagus reflexes are well known [Engel, 1979; Gupta et al., 1986]. Stimulating the auricle can affect these organs. Two important case reports include stoppage of the heart [Prasad et al., 1984] and epilepsy [Santanelli et al., 1985] triggered by stimulation of the auricle in humans.

Reclassification of the pinna as an extremity was a mistake. Such reclassification now allows the SAR to increase from 1.6 W/kg (averaged over 1 gm of tissue) to 4 W/kg (averaged over 10 gm of tissue) which will allow the emission power density of cell phone handsets to increase. Also, this reclassification does not take into consideration that many people – especially the young – now text rather than put a cell phone directly to the head. An increase to the higher SAR with the accompanying allowable increase in cell phone emissions, will create much stronger RFR exposures to the eyes since screens are small and now typically held close to the face for viewing purposes. The eye is a highly conductive aqueous saline organ – the exact opposite of cartilage. One study reported an increased risk of melanoma of the eye[8] with cell phone exposures but the same authors were not able to replicate their own work.[9] This area warrants close follow-up. The reclassification is inviting adverse effects to the ear, the brain, the eyes, and potentially other systems in the body.

There has been no clear rationale by FDA or FCC or IEEE for treating the ear as an extremity. Other than facilitating higher power output for potentially better operation of the handsets which is only in industry's favor, there is no real public advantage and possible public health endangerment. It is obvious why the IEEE, as an industry group with no medical training, would push for this reclassification but a complete mystery why the FDA went along with it.

10. Blanket Exemptions -- Cumulative Effects Not Considered, Smart Grid/Metering Case in Point:

FCC proposes to standardize compliance via adopting thresholds of power, distance and frequency for routine environmental evaluation. Below the threshold of one milliwatt (1

[8] Stang A, Anastassiou G, Ahrens W, Bromen K, Bornfeld N, Jöckel KH. The possible role of radiofrequency radiation in the development of uveal melanoma. Epidemiology. 12(1):7-12, 2001.
[9] Stang A, Schmidt-Pokrzywniak A, Lash TL, Lommatzsch PK, Taubert G, Bornfeld N, Jöckel KH. Mobile phone use and risk of uveal melanoma: results of the risk factors for uveal melanoma case-control study. J Natl Cancer Inst. 101(2):120-123, 2009.

mW) of power or less, services or devices would be exempt, continuing the blanket exemption for the most popular and ubiquitous consumer products today, as well as those to be developed in the future. Yet no cumulative exposure criterion is set for radiating sources for myriad products operating simultaneously. Exemptions are taken one product or service at a time and with this ruling, FCC will continue that policy without setting levels for the sum of effects from different sources and cumulative effects over time, such as DNA damage in the genome that become larger with repeated exposure.

There has been an exponential increase for both low-level RFR fixed transmitters like wifi, and voluntary personal portable/mobile devices. This is in addition to involuntary exposures from accompanying infrastructure like cell towers with multiple providers, antennas mounted on/in existing structures, and DAS systems which bring RFR much closer to the population. There is an increasing new layer of RF with smart grid/metering -- an involuntary direct RF delivery system into homes and businesses. In addition, there has been a large increase in the use of implantable medical devices such as cardiac pacemakers, insulin pumps and deep brain stimulators for Parkinsons Disease, among others, that are susceptible to interference from near-and-far field RFR. And there are increasing uses of implantable RFID devices, too. Both personal environments and large ambient environmental RFR levels have risen dramatically in the last 20 years, and continue to do so.

In the 2010 paper that we published in *Environmental Reviews* [10] -- one of the peer-reviewed publications of Canada's privately owned National Research Council Press -- we included a chart of 59 peer-reviewed studies showing various biological effects at low intensity RFR exposures far below current FCC standards (see Table 3 below). This was the first paper to specifically explore the data on biological effects now common in most urban and suburban settings. All of the works cited apply to what FCC now categorically excludes. Works cited, for instance, would apply to smart grid/metering technology and wifi routers placed on desk tops near a user's head. Such devices therefore cannot be considered benign, despite adherence to FCC guidelines for exemption. In the case of smart meters, RF couples with domestic wiring and travels throughout a building. Because of such coupling with conductive material, no distance from the transmitting source would be effective regulation here. And peak exposures during the device's duty cycle, which is the most pertinent exposure parameter, is time-averaged away. This is not protective of public health.

The listed exposure levels at which biological/health effects have been observed are much lower than the FCC's SAR of 4 W/kg, and actually include levels that one would

[10] Levitt, B. B., Lai, H., Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays, Enviro. Rev. 369-395 (2010), doi:10.1139/A 10-018 http://www.nrcresearchpress.com/doi/pdf/10.1139/A10-018

encounter in modern urban/suburban environments today. Furthermore, exposure to smart meter RF, for example, is chronic and unavoidable.

In the very least, FCC should call for a thorough assessment of the smart meter buildout until the emission levels from access points are known, setbacks for access points are recommended from nearby residences/businesses, and a better assessment of cumulative exposures from meters, access points, and wireless components placed on or in appliances themselves -- both singly and in multiples working simultaneously -- can be determined.

We recommend that FCC also advise EPA, FCC, DOE and the legislature that more extensive assessment of smart-grid/metering is needed before this buildout proceeds further. Some of the studies in the chart below are comparable to such exposures.

Table 3. A list of studies reporting biological effects at low intensities of RFR. These papers gave either SAR (W/kg) or power density (μW/cm^2) of exposure.

		SAR (W/kg)	Power density (μW/cm^2)	Effects reported
Belyaev et al. (2005) (in vitro)	915 MHz, GSM 24 & 48 hr	0.037		Genetic changes in human white blood cells
Belyaev et al. (2009) (in vitro)	915 MHz, 1947 MHz GSM, UMTS 24 & 72 hr	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 or 50-Hz AM, 14 days, 5, 10, 20 min per day, CW- no effect		26	DNA damage in human glial cells
Capri et al. (2004) (in vitro)	900 MHz, GSM 1 hr/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)	People lived close to AM radio and radar installations for more than one year		10	People lived and worked near AM radio antennae and radar installations showed deficits in psychological and short-term memory tests.
De Pomerai et al. (2003) (in vitro)	1 GHz 24 & 48 hr	0.015		Protein damages
D'Inzeo et al.	10.75 GHz CW	0.008		Operation of acetylcholine-related ion-channels in

(1988) (in vitro)	30-120 sec			cells. These channels play important roles in physiological and behavioral functions.
Dutta et al. (1984) (in vitro)	915 MHz, sinusoidal AM at 16 Hz	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 hr 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; 2hr/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
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. (1999) (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- not included)	900 MHz, GSM- 217 Hz pulses, 577 μs pulse width; 45 min; narcoleptic patients	0.06		Improved cognitive functions.
Kesari and Behari (2009a) (in vivo) (rat whole body)	50 GHz; 2hr/day, 45 days	0.0008		Double strand DNA breaks observed in brain cells
Kesari and Behari (2009b) (in vivo) (rat whole body)	50 GHz; 2hr/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)	383 MHz (TETRA),	0.08		Metabolic changes.

(in vivo) (hamster whole body)	900 and 1800 MHz (GSM) 24 hr/day, 60 days			
Magras and Xenos (1999) (in vivo) (mouse whole body)	'Antenna park'-TV and FM-radio, Exposure over several generations		0.168	Decrease in reproductive function.
Makova et al. (2005) (in vitro)	915 and 905 MHz, GSM 1 hr	0.037		Chromatin conformation in human white blood cells.
Mann et al. (1998) (in vivo) (human whole body)	900 MHz GSM pulse-modulated at 217 Hz, 577 μs width, 8 hr		20	A transient increase in blood cortisol.
Marinelli et al. (2004) (in vitro)	900 MHz CW 2 - 48 hr	0.0035		Cell's self-defense responses triggered by DNA damage.
Navakatikian and Tomashevskaya (1994) (in vivo) (rat whole body)	2450 MHz CW and 3000 MHz pulse-modulated 2 μs pulses at 400 Hz Single (0.5-12hr) or repeated (15-60 days, 7-12 hr/day) exppsure, CW-no effect	0.0027		Behavioral and endocrine changes, and decreases in blood concentrations of testosterone and insulin.
Nittby et al. (2007) (in vivo) (rat whole body)	900 MHz GSM 2hr/wk, 55wk	0.0006		Reduced memory functions.
Novoselova et al. (1999) (in vivo) (mouse whole body- wavelength in mm range)	From 8.15 -18 GHz, 1 sec sweep time-16 ms reverse, 5 hr		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 sec sweep time-16 ms reverse, 1. 5 hr/day, 30 days		1	Decreased tumor growth rate and enhanced survival.
Pavicic et al. (2008) (in vitro)	864 and 935 MHz, CW, 1-3 hrs	0.08		Growth affected in Chinese hamster V79 cells.
Panagopoulos et al. (2010) (in vivo) (fly whole body)	GSM 900 and 1800 6 min/day, 5 days		1 - 10	Reproductive capacity and induced cell death.
Panagopoulos and Margaritis (2010a) (in vivo) (fly whole body)	GSM 900 and 1800 6 min/day, 5 days		10	'Window' effect of GSM radiation on reproductive capacity and cell death.
Panagopoulos and Margaritis (2010b) (in vivo) (fly whole body)	GSM 900 and 1800 1- 21 min/day, 5 days		10	Reproductive capacity of the fly decreased linearly with increased duration of exposure.
Pérez-Castejón et al. (2009) (in vitro)	9.6 GHz , 90% AM, 24 hrs	0.0004		Increased proliferation rate in human astrocytoma cancer cells.

Perssson 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 (iDEN); 836.55 MHz (TDMA) 2 hr and 21 hr	0.0024		DNA damage in human leukemia cells.
Polonga-Moraru et al. (2002) (in vitro)	2.45 GHz 1hr		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. (2008a) (in vivo) (tomato whole body)	900 MHz		7	Gene expression and energy metabolism.
Roux et al. (2008b) (in vivo) (plant whole body)	900 MHz		7	Energy metabolism.
Salford et al. (2003) (in vivo) (rat whole body)	915 MHz GSM 2 hr	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, 30 min, effect only observed at 16-Hz modulation	0.00015		Calcium movement in the heart.
Schwarz et al. (2008) (in vitro)	1950 MHz UMTS 24 hr	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.
Stagg et al. (1997) (in vitro)	836.55 MHz TDMA duty cycle 33% 24 hr	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 15 min	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-	0.000021		Decrease in proliferation of human epithelial amnion cells.

	pulse, duty cycle 12% 30 min			
Veyret et al. (1991) (in vivo) (mouse whole body)	9.4 GHz 1 □s pulses at 1000 pps, also with or without sinusoidal AM between 14 and 41 MHz, response only with AM modulation, 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, square-wave modulated at 217 Hz; Also 900 MHz with 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 hr/day, 8 days	0.0113		Free radical chemistry.

11. Chronic Exposures, Cumulative Effects, Different Waveforms:

Another important consideration in the setting of RFR exposure guidelines is the effect of **chronic/repeated exposure**. There is not much data on the biological effects of chronic RFR exposure, although some exist. (A list of chronic exposure studies can be found in sections 6 and 9 of http://www.bioinitiative.org/table-of-contents/). There are research data showing that the effects of chronic low level exposures are different than those of acute short-term thermal exposures. A set of similar experiments[11],[12] to those of de Lodge et al[3,4] was carried out in the 1980's to study the effects of repeated RFR exposures. The researchers concluded:

[11] D'Andrea, J.A., DeWitt, J.R., Emmerson, R.Y., Bailey, C., Stensaas, S., and Gandhi, O. P.,Intermittent exposure of rat to 2450-MHz microwaves at 2.5 mW/cm^2: behavioral and physiological effects, Bioelectromagnetics 7:315-328, 1986.

[12] D'Andrea, J.A., DeWitt, J.R., Gandhi, O. P., Stensaas, S., Lords, J.L., and Nielson, H.C.,Behavioral and physiological effects of chronic 2450-MHz microwave irradiation of the rat at 0.5 mW/cm^2, Bioelectromagnetics 7:45-56, 1986.

"…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)**."

It appears that chronic exposure sensitized the animals to RFR. Therefore, it is insufficient to apply a guideline based on acute exposure (i.e., the data of de Lodge et al.) to a chronic exposure situation such as would be experienced with smart grid/metering technology and most others that are now categorically excluded.

An important question is whether RFR's biological effects are cumulative? There are studies that indicate RFR effects can accumulate with repeated exposures[13]. This is an important consideration in light of so many wireless devices in our midst today. No agency takes chronic exposure or cumulative effects into consideration. Each device or new technology is considered a stand-alone. Therefore, today's true exposures are unknown. This is especially troubling with smart grid/metering's peak exposures during the duty cycle and RFR emissions from 'access points' in the larger grid network. These points have significantly higher duty cycles in order to co-ordinate the signals from thousands of meters.

Another important consideration in the setting of guidelines for RFR exposure is the **waveform characteristics of the field**. There are many reports indicating that the waveform of RFR significantly alters its effectiveness in causing biological effects. Wave characteristics should be factored into the setting of new RFR exposure guidelines, since RFRs in the human environment today are of many different waveforms and characteristics.

And another important consideration is waveforms' specific effects. The following are some examples of reports regarding waveform specificity. (A more extensive list of studies showing waveform-specific biological effects can be found in sections 6 and 9 of http://www.bioinitiative.org/table-of-contents/).

- Campisi et al. (2010) reported increases in free radical activity and DNA fragmentation in brain cells after acute exposure to a 50-Hz amplitude-modulated 900-MHz RFR, whereas a continuous-wave 9000-MHz field produced no effect.
- Franzellitti et al. (2010) showed increased DNA strand breaks in trophoblasts after exposure to a 217-Hz modulated 1.8 GHz-RFR, but a continuous-wave field of the same carrier frequency was without effect.
- Tkalec et al (2013) reported that AM-modulated (1 KHz sinusoidal) 900-MHz RFR is more potent than non-modulated field in causing DNA damage in coelomocytes of exposed earthworms.

[13] Lai, H. Biological effects of radiofrequency radiation from wireless transmission towers. In *"Cell Towers: Wireless Convenience? Or Environmental Hazard?"* Levitt, B.B. (ed.), New Century Publishing, East Canaan, CT, 2001, pp. 65-74, 2001.

- Luukkonen et al. (2009) reported a continuous-wave 872-MHz RFR increased chemically-induced DNA strand breaks and free radicals in human neuroblastoma cells, whereas a GSM-modulated 872-MHz field had no significant effect.
- Zhang et al. (2008) found that gene expression in rat neurons is more sensitive to intermittent than continuous exposure to a 1.8 GHz-RFR.
- López-Martín et al. (2009) found that GSM and unmodulated RFR caused different effects on c-Fos gene expression in the rat brain.
- Croft et al. (2010) reported that 2G, but not 3G, cell phone radiation affected resting EEG.
- Hung et al. (2007) showed that 2, 8, 217 Hz-modulated RFR differentially affected sleep.
- Lopez-Martin et al. (2009) reported that modulated and non-modulated RFR had different effects on gene expression in the brain.
- Nylund et al. (2010) found that different carrier-frequencies (900 MHz verses 1800 MHz) had different effects on protein expression.
- Schmid et al. (2012) concluded that "modulation frequency components (of a RFR) within a physiological range may be sufficient to induce changes in sleep EEG".

Clearly there are more complex factors affecting biological processes with RFR exposures than just SAR and MPE. FCC needs to take waveforms and other transmission factors such as modulation into consideration when setting standards, especially in light of newer systems with far more complicated signaling characteristics.

11. Increasing Ambient Exposures: Humans and Wildlife

Today's wireless applications are raising ambient background levels with no FCC, EPA or other regulatory oversight. New additions to the mix include smart grid/metering creating low-level blanket exposures at ground level, and 3G/4G networks offering endless "apps," TV/music/video downloads, e-books, photos, voice, WiMax Internet connectivity and texting, all via cell phones and tablets. Then there are universal GPS systems close to a user's head (on a close lateral level with the eye) when mounted on a car dashboard. GPS works off of distant satellites and requires stronger signal emission. There is also a host of RF/radar devices built into automobiles today to detect animals on the road or park a vehicle without engaging the driver.

WiMax, already being build out, is ubiquitous wireless internet connectivity intended especially for rural communities that are now low RF areas. WiMax alone will introduce a new blanket of RFR with some systems capable of transmitting in a 12,000 square mile radius with a 62-mile reach from one antenna. The military and Homeland Security has also exponentially increased their use of wireless technology. All of these technologies use extremely complex signals that carry a lot of information. Given the data cited above in Table 3 regarding biological effects at very low intensities, we can no longer afford a presumption of safety with ever-increasing background levels.

RF is a form of energetic air pollution that requires far more regulation by FCC and other agencies, particularly the EPA and the U.S. Fish and Wildlife Service (USFWS). But there is no funding available to study, much less regulate RF at these agencies.

Prior to the telecom buildout in the early 1990's, baseline ambient RFR data was gathered in 1980 by the EPA in the largest multi-region survey ever performed. This data can be used to compare with today's rising exposures, yet no agency has continued to gather information, nor has this early study been updated in the U.S. EPA researchers, Richard Tell and Edwin Mantiply (1980)[14], assessed background levels of broadcast signal field intensity RFR for three years and obtained data at 486 locations distributed throughout 15 large cities. The data collectively represented 14,000 measurements of very high frequency (VHF) and ultra high frequency (UHF) radiation used in TV broadcast in ambient environments and they estimated exposure at 47,000 census districts within the metropolitan boundaries of those cities. At the time, ground-based broadcast signals from TV, AM radio and the then-increasing FM radio transmissions were the only exposures. There were no cellular services and very little satellite transmission at that time.

The study found that 20 percent of the total U.S. population was exposed to time-averaged VHF and UHF broadcast radiation at a median level of 0.0005 microwatts per centimeter squared (μW/cm2). The data suggested that only 1 percent of the population, or about 441,000 people, were potentially exposed to levels greater than 1μW/cm2 – the safety limit recommended by the USSR which was 1000 times more stringent than the U.S. safety guidelines back then. The data seemed reassuring for the general population at that time. Much has changed since then.

One European survey was reported on in Microwave News in 2000.[15] It found that background RFR levels in several cities had increased 10 times over the previous two decades. Changes in U.S. cities were thought to be comparable. In the European report, the primary cause was mobile phone technology. The short piece read:

> **Urban Electrosmog Increasing**
>
> RF/MW radiation levels in urban areas are approximately ten times higher than they were 20 years ago—and most of the increase is due to wireless communications, according to Dr. Yngve Hamnerius of Chalmers University of Technology in Göteborg, Sweden.

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[14] Tell, R. A., Mantiply, E. D., Population Exposure to VHF and UHF Broadcast Radiation in the United States, Proceedings of the IEEE, Vol. 68, NO 1, January 1980.

[15] Urban Electrosmog Increasing, Microwave News, Vol. XX No.4, July/august 2000, p. 3. http://microwavenews.com/news/backissues/j-a00issue.pdf

Hamnerius measured radiation levels in the 30 MHz-2 GHz frequency range at 26 sites across Sweden with varying levels of urbanization. In cities, the median power density was 0.05 μW/cm2, with a 61% average contribution from GSM base stations. In rural environments, the radiation levels were about 1,000 times lower with the largest contribution coming from television broadcasters, which account for 48% of the total.

Hamnerius contrasted his results with those of Richard Tell and Edwin Mantiply in the late 1970s, when both were at the U.S. Environmental Protection Agency in Las Vegas. Their survey of 12 large American cities showed that the median exposure of the population was 0.005 W/cm2 (see *Radio Science, 17,* pp.39S-47S, 1982).

The following is a list of RF-levels measured in other countries.

- Amoako et al. (2009)- Ghana- 900-1800 MHz- 0.001 $\mu W/cm^2$
- Dode et al. (2011)- Brazil- cell tower- 0.04 - 40.78 $\mu W/cm^2$
- Dhami (2011)-India-10 MHz-8 GHz- 1.148 $\mu W/cm^2$
- Firlarer et al. (2003)- Turkey- GSM900 MHz - 3 $\mu W/cm^2$
- Frei et al. (2009)- Switzerland- 12 different bands from FM (88 MHz- 108 MHz) to W-LAN (2.4-2.5 GHz) - 0.013 $\mu W/cm^2$
- Henderson et al. (2006)- Australia- 870-1200 MHz- 0.8 $\mu W/cm^2$
- Joseph et al. (2008)- Belgium – FM, GSM900, GSM1800 and UMTS- 0.07 $\mu W/cm^2$
- Kim et al. (2010)- Korea- CDMA800 and CDMA1800- 0.6 $\mu W/cm^2$
- Thuroczy et al. (2006)- Hungary- 9 bands between 80-2200 MHz- 0.025 $\mu W/cm^2$
- Viel et al. (2009) - France- 12 bands: FM to mobile phone- 0.6 $\mu W/cm^2$

Although cellular service did not exist when the EPA survey was done, cell service now functions in the UHF bands and higher frequencies. So today's exposures are broadly comparable to background levels noted in that EPA review, which can be used as a baseline. When the U.S. switched to digital TV in 2008, it freed up spectrum "white space" previously used for analog TV transmission. That spectrum space is now allocated for 4G wireless Internet and both the VHF and UHF bands will be used in the upcoming ubiquitous WiMax service in rural areas.

The advent of digital technology, which simulates pulsed waves, significantly changed communications signaling characteristics, allowing for a second universal transmission system to be built on top of the old analog signals. This not only doubled overall environmental RFR exposures, it introduced a completely new kind. It was the introduction of digital technology that facilitated the reshuffling of various RF bands in the 'limited real estate' of the electromagnetic spectrum. This reshuffling continues at FCC today with new upcoming airwave auctions. There is never enough spectrum to satisfy society's desire to use it. As a consequence, we have now filled in most of the lower nonionizing bands with commercial, private, and military use; split the signals; digitized them; and are now branching into higher frequencies such as infrared to be used in communications.

There is virtually no research to indicate that this is safe for either humans or wildlife but other species are highly sensitive in ways that humans are not. Some infrared frequencies are visible to other species. For instance, birds see the color red in ways that we do not and steady red lights atop towers are attractants at night. Red steady lighted towers are known to kill many more birds that white flashing lights.[16]

Birds' feathers are also known to have piezoelectric properties and are capable of conducting EMF/RF deep within bird body cavities. And birds are known to be sensitive to RFR. [17],[18]

According to Albert M. Manville, II, Ph.D., Senior Wildlife Biologist, Division of Migratory Bird Management at the U.S. Fish and Wildlife Service[19]:

> " The effects of radiation from communication towers on nesting and roosting wild birds are yet unstudied in U.S., although in Europe, Balmori (2005) found strong negative correlations between levels of tower-emitted microwave radiation and bird breeding, nesting, and roosting in the vicinity of electromagnetic fields in Spain. He documented nest and site abandonment, plumage deterioration, locomotion problems, and death in House Sparrows, White Storks, 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 of the cellular phone towers. Balmori and Hallberg (2007) and Everaert and Bauwens (2007) found similar strong negative correlations among male House Sparrows. Under laboratory conditions, T. Litovitz (pers. comm.) and De Carlo *et al.* (2002) raised troubling concerns about impacts of low-level, non-thermal radiation from the standard 915 MHz cell phone frequency

[16] Manville, A.M., Anthropogenic-related Bird Mortality Focusing on Steps to Address Human-caused Problems – a White Paper for the Anthropogenic Panel, 5th International Partners in Flight Conference, August 27, 2013, Snowbird, Utah

[17] Tanner, J.A. Effect of Microwave Radiation on Birds, *Nature* 210, 636 (07 May 1966);doi:10.1038/210636a0

[18] Tanner, J.A., Romero-Sierra, C., Davie, S.J. Non-thermal Effects of Microwave Radiation on Birds, *Nature* 216, 1139 (16 December 1967); doi:10.1038/2161139a0

[19] Albert M. Manville, II, Ph.D., Senior Wildlife Biologist, Division of Migratory Bird Management (DMBM), U.S. Fish and Wildlife Service, 4401 N. Fairfax Dr.–MBSP 4107 Arlington, VA 22203; 703/358-1963; albert_manville@fws.gov

> on domestic chicken embryos – with lethal results (Manville 2009). Given the findings of the studies mentioned above, field studies should be conducted in North America to validate potential impacts of communication tower radiation – both direct and indirect – to birds and potentially other animals. However, these have yet to be performed." (See References section for Manville citations.)

Dr. Manville is also on the Radio Frequency Inter-Agency Work Group (RFIAWG) and has worked closely with the FCC on towers and bird-death mitigation.

Birds are not the only species of fauna and flora affected. RFR can induce electric and magnetic fields in living tissue. While a complete literature review is beyond the scope of these comments, a selected sampling of both ELF and RFR exposures noted in wildlife includes:

- Alfonso Balmori[20] found that sparrows and other bird species abandoned areas where RF backgrounds were highest due to the presence of cell phone base stations. Other species affected included bats, invertebrates, insects, domestic animals, trees and bushes.
- Ioannis Magras and Thomas Zenos,[21] found increased rates of infertility and growth abnormalities in test animals at some distance from antenna parks where exposure levels were well below standards. By the fifth generation, test animals were permanently infertile.
- Andrea De Carlo, Nicole White, Fuling Guo, Peter Garret, and Theodore Litovitz[22] found decreases in the production of heat shock proteins in chick embryos. Heat shock proteins help maintain the conformation of cellular proteins during periods of stress. A decrease in their production diminishes cellular protection in a way that could lead to cancer and other diseases.
- Atsuko Kobayashi and Joseph Kirchvink[23] found myriad species contain the magnetic crystal magnetite and rely on it for critical activities in mating, direction-finding, and migratory patterns, among other things. Magnetite couples with external EMF/RF couples a million times more efficiently than any other known biological material.

[20] Balmori, A.M., The Effects of Microwave Radiation on the Wildlife, Preliminary Results, Valloid, Spain, 2003.
[21] Magras, I., Zenos, T., RF Radiation-Induced Changes in the Prenatal Development of Mice, Bioelectromagnetics 18:455-461, 1997).
[22] DeCarlo, A., White, N., Guo, F., Garret,G. Litivitz, T., Chronic Electromagnetic Field Exposure Decreases HSP70 Levels and Lowers Cytoprotection, Journal of Cellular Biochemistry 84:447-454, 2002.
[23] Kobayashi, A., Kirchvink, J.,Magnetoreception and Electromagnetic Field Effects: Sensory Perception of the Geomagnetic Field in Animals and Humans," Electromagnetic Fields, Biological Interactions and Mechanisms, Ed: Martin Blank, Advances in Chemistry Series 250, 1995, p 367-394.

- W. Loscher and G. Kas,[24] found severe behavioral anomalies in dairy cows near TV and RF-transmitting towers. Effects included lower milk production, excitability, birth defects, mastitis and others.
- A. Belyavskaya[25] found that plant roots exposed to extremely low magnetic fields exhibited a strong cytochemical reaction in root cells after exposure.

Other species are affected by increasing ambient backgrounds, perhaps even more so than humans due to their different physiologies. Effects seen in the literature for both *in vitro* and *in vivo* research include habitat loss and abandonment, infertility, adverse reproductive outcomes, cellular stress, and chemical changes, among others. And there are plausible mechanisms for biological action with the presence of magnetite in all species studied. Yet there are no guidelines at any regulatory agency to protect the environment, even though the FCC standards are considered – erroneously in our opinion – to include "environmental" exposures. There are glaring holes in this presumption.

Cellular communication infrastructure, though orders of magnitude lower in power density than broadcast facilities, are vastly more ubiquitous and placed much closer to the human population and wildlife in both urban and rural areas. The increasing advent of technologies like WiMax now affects formerly low RFR environments. Broadband-over-Powerlines will add to the rural exposures. We are doing this with no understanding of the broader consequences.

The rise in ambient RF levels is the single biggest environmental alteration within the last 20 years. Follow-up of the Tell and Mantiply/EPA study and the Hamnerius survey are imperative given today's increasing ambient RF levels.

12: Assessing Outdoor Far-Field Exposures:

Assessing outdoor exposures can be particularly difficult for a variety of factors. One question involves how best to capture field exposure data, e.g. through computer estimates or actual dosimetry measurements? 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 couples with the environment once transmitted. Complicated factors and numerous variables come into play, such as orientation toward the transmitting source, species, size,

[24] Loscher, W., Kas G;, Conspicuous behavioral abnormalities in a dairy cow herd near TV and Radio transmitting antenna, Prakt. Tierarzt [Practical Veterinary Surgeon], 79:5, 437-444, 1998.
[25] Belyavskaya, N.A., Ultrastructure and Calcium Balance in Meristem Cells of Pea Roots Exposed to Extremely Low Magnetic Fields, Elsevier Sciences, Ltd. Pergamon, Adv. Space Res. Vol. 28, No. 4, pp. 645-450, 2001.

physical composition, genetics, presence of metal objects and topography, to name a few.[26] In human populations, the wearing of personal dosimetry devices appears promising for capturing cumulative exposure data.[27] But attaching RF devices to wildlife is ill-advised despite the frequent use of radio collars and RFID chips by biologists to study wildlife. Deadly sarcomas have been observed in tissue around RFID chips imbedded in domestic pets, for instance.[28] While RFID chips are supposed to be passive until called upon to give up information by a device, these sarcomas are an alarm signal that RFID's are: 1) malfunctioning; and 2) the low-level fields caused by the batteries may be affecting tissue. Radio collars attached typically at the head to wildlife transmit constantly and work off of satellites, thus requiring stronger emissions.

One study that indicates the increasing background levels of mobile phone infrastructure was done on humans in 2009 using personal dosimetry devices to examine the total exposure levels of RFR in the Swiss urban population[29]. What they found was startling. Nearly a third of the test subjects' cumulative exposures were from cell tower 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 such infrastructure. But this study showed that the general population moves in and out of these particular fields with more regularity than previously thought. That assessment would apply to wildlife, too.

In the study, a sample of 166 volunteers from Basel, Switzerland, agreed to wear personal exposure meters (called exposimeters). Frei et al found that nearly one third of total exposures came from cell phone base stations. Participants carried an exposimeter for 1 week and also completed an activity diary. Results found a mean weekly exposure to all RF and/or EMF sources was 0.013 milliwatts per square centimeter (mW/cm2). Exposure was mainly from mobile phone base stations (32.0%); mobile phone handsets (29.1%); and domestic digital enhanced cordless telecommunications (DECT) phones (22.7%). Mean values were highest in trains (0.116 mW/cm2), airports (0.074 mW/cm2), and tramways or buses (0.036 mW/cm2) and were higher during the daytime (0.016 mW/cm2) than the nighttime (0.008 mW/cm2).

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[26] Levitt, B. B., Lai, H. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays, Enviro. Rev. 369-395 (2010), doi:10.1139/A 10-018 http://www.nrcresearchpress.com/doi/pdf/10.1139/A10-018

[27] Radon, K., Spegel, H., Meyer, N., Klein, J., Brix, J., Wiedenhofer,A., Eder, H., Praml, G., Schulze, A., Ehrenstein, V., von Kries,R., and Nowak, D. 2006. Personal dosimetry of exposure to mobiletelephone base stations? An epidemiological feasibilitystudy comparing the Maschek dosimeter prototype and Antennessa SP-090 system. Bioelectromagnetics, **27**(1): 77–81.doi:10.1002/bem.20175.

[28] Lewan, Todd. Chip Implants Linked to Animal Tumors, The Associated Press Saturday, September 8, 2007; 2:04 PM

[29] Frei, P., Mohler, E., Neubauer, G., Theis, G., Burgi, A., Frohlich, J., Braun-Fahrlander, C., Bolte, J., Egger, M., and Roosli, M. Temporal and spatial variability of personal exposure to radio frequency electromagnetic fields. Environ. Res 109(6):779–785. doi:10.1016/j.envres.2009.04.015.

Another surprising finding of this study implied that at the belt, backpack, or in close vicinity to the body in test subjects, the mean base station contribution corresponded to about 7 min of mobile phone use. In other words, ambient exposure from infrastructure was a significant contributor beyond one's personal choice to use individual devices.

RF field strength falls off rapidly with distance from the transmitting source, but predicting actual exposures based on simple distance from antennas using standardized computer formulas is inadequate. Actual exposure metrics can be far more complex in both urban and rural areas, to humans and wildlife alike. 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 or wildlife species 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, architectural composition, the presence of trees, soil type, and topographical features such as mountains and rock formations.[30] Power density levels can be 1-to-100 times lower inside a building, for instance, depending on construction materials. Exposures can differ greatly depending on numerous factors, such as orientation toward the generating source, as well as the presence of conductive mediums like water, or minerals in soil containing salt, iron and copper. Exposures can be twice as high in upper floors as in lower floors, as found by Anglesio et al.[31] This would apply to birds/bats/bees and other insects receiving higher exposures when flying at a lateral plane with transmitting antennas atop a tower or mounted on other structures.

Although distance from a transmitting source has been shown to be an unreliable determinant for accurate exposure predictions, it is nevertheless useful in general ways. For instance, it has been shown that radiation levels from a tower with 15 non-broadcast radio systems will fall off to natural background levels at approximately 1500 feet, or approximately 500 meters.[32] This would be in general agreement with the lessening of symptoms in human populations living near cell towers at a distance over 1000 ft (300

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[30] Kasevich, R.S., Brief Overview of the Effects of Electromagnetic Fields on the Environment; Cell Towers, Wireless Convenience? or Environmental Hazard? Proceedings of the "Cell Towers Forum," State of the Science, State of the Law, Safe Goods/New Century Publishing, 2001, pp.170-175.

[31] Anglesio, L., Benedetto, A., Bonino, A., Colla, D., Martire, F., Saudino Fusette, S., and d'Amore, G. 2001. Population exposureto electromagnetic fields generated by radio base stations: evaluation of the urban background by using provisional model andinstrumental measurements. Radiat. Prot. Dosimetry, **97**: 355–358. PMID:11878419. 2001.

[32] Rinebold, J.M., Centralized Siting of Telecommunications Faciulities: Cell Towers, Wireless Convenience? or Environmental Hazard? Proceedings of the "Cell Towers Forum," State of the Science, State of the Law Safe Goods/New Century Publishing, 2001, pp. 133.

meters) found by Santini et al[33], Abdel-Rassoul et al, [34]Hutter etc al ,[35] Navarro et al,[36] and Oberfield et al.[37]

Unfortunately, there is very little far-field distance-to-safety ratios research for wildlife as this has not been studied with that focus in mind. What little EMF/RF field research on wildlife has been conducted, has been focused on behavior, mortality and reproductive outcomes.

13. Conclusion: The following are suggestions to FCC in updating the RFR exposure standards:

- Use both SAR and MPE but not interchangeably.
- Post SAR's on the FCC's website, on products, and at point-of-sale.
- Take waveform specifics and modulation into consideration.
- Increase tower/antenna array monitoring for compliance with FCC standards.
- Institute large setbacks from tower installations, 1500' minimum for cell towers at 150' in height. Lower height DAS systems should be discouraged unless large setbacks from dwellings/business can be attained.
- Tell Congress that the EPA should be refunded for EMF/RF research and standards setting/review; and that USFWS should have research appropriations to specifically study RFR effects on wildlife.
- Decrease MPE's – FCC is supposed to regulate the airwaves and enforce safety. Assisting industry is secondary.
- Reduce categorical exclusions based solely on power density. Ubiquity of exposures, such as from smart grid/metering, also count.
- Set limits for chronic exposures from multiple sources and cumulative effects.
- Make clear that FCC standards as currently written are for human exposures only and do not include wildlife or protect the environment.
- Take a Precautionary Approach
- Institute more field measurement and less computation.

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33 Santini, R., Santini, P., Danze, J.M., Le Ruz, P., and Seigne, M. 2002. Enqueˆte sur la sante´ de riverains de stations relais de te´le´-phonie mobile : Incidences de la distance et du sexe. Pathol. Biol. **50**: 369–373. doi:10.1016/S0369-8114(02)00311-5.

34 Abdel-Rassoul, G., El-Fateh, O.A., Salem, M.A., Micgael, A., Farahat,F., and Salem, E. 2007. Neurobehavioral effects among inhabitantsaround mobile phone base stations. Neurotoxicology,**28**(2): 434–440. doi:10.1016/j.neuro.2006.07.012.

35 Hutter, H.-P., Moshammer, H., Wallner, P., and Kundi, M. 2006.Subjective symptoms, sleeping problems, and cognitive performancein subjects living near mobile phone base stations. Occup.Environ. Med. **63**(5): 307–13.doi:10.1136/oem.2005.020784.

36 Navarro, A.E., Sequra, J., Portole´s, M., and Go´mez-Perretta de Mateo,C. 2003. The microwave syndrome: a preliminary study inSpain. Electromagn. Biol. Med. **22**(2-3): 161–169. doi:10.1081/JBC-120024625.

37 Oberfeld, G., Navarro, A.E., Portoles, M., Maestu, C., and Gomez-Perretta, C. 2004. The microwave syndrome – further aspects ofa Spanish study. *In* Proceedings of the 3rd International Workshopon Biological Effects of Electromagnetic Fields, Kos, Greece, 4–8 October 2004.

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Appendix A Attached:

Levitt, B.B., Lai, H. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays, Enviro. Rev. 369-395 (2010), doi:10.1139/A 10-018 http://www.nrcresearchpress.com/doi/pdf/10.1139/A10-018

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Balmori, A. 2010. Mobile phone mast effects on common frog (Rana temporaria) tadpoles: the city turned into a laboratory. Electromagn. Biol. Med. 29: 31-35.

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EXHIBIT E

July 12, 2018

To:
Thomas Wheeler, Chairman, Federal Communications Commission
Washington, D.C. 20554

Electronic copies to:

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Re: **Proceedings 14-177, 15-256, 10-112, and 97-95**

From:
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Background on The Berkshire-Litchfield Environmental Council:

The Berkshire-Litchfield Environmental Council (BLEC) is a 501 (3)(c) non-profit organization that focuses on environmental issues affecting the Northwest Corner of Connecticut and the Berkshires region of Massachusetts. BLEC addresses diverse environmental subjects, including a proposed/failed hydroelectric pumped storage power plant, water and air contamination, land preservation, zoning controls, vernal pools protection, the environmental effects of radio frequency radiation associated with the siting of telecommunications infrastructure, and industrial-scale wind turbines. Our focus is historically on the environmental effects of infrastructure. Founded in 1970, BLEC has over 500 members and holds educational forums on emerging environmental issues with speakers from federal agencies and researchers from around the world.

BLEC President, Starling W. Childs, a lecturer at the Yale School of Forestry and President of EECOS Inc. Environmental Consultants -- a land-use planning/scientific assessment group specializing in innovative farm and forest management and creative development designs -- has been a consultant to wind projects throughout the east coast.

BLEC Communications Director, B. Blake Levitt, is a decades-long member of the science press, former *New York Times* contributor, and award winning author of two books on the health and environmental effects of nonionizing radiation,[1] which includes the radiofrequencies of the electromagnetic spectrum used in all wireless technology.

With a focus on the health/environmental effects of infrastructure, BLEC is qualified to comment on the current FCC proposal on the 5G network.

Introduction:

The Federal Communications Commission (FCC) is about to vote on the expedited buildout of the 5G communications network, endorsed by Chairman Thomas Wheeler who has gone on record saying he wants the U.S. to be "…first out the gate," adding that "…Turning innovators loose is far preferable to expecting committees and regulators to define the future."

There are problems with that logic, most notably the fact that the FCC is a licensing and engineering entity that <u>relies</u> on other agencies for guidance outside of FCC's range of expertise. FCC is the first to point out that it is not a health or environmental agency, yet it is lauding innovators over those very regulators who know far more about this. That makes little sense. Would deference to those other agencies slow down the 5G buildout? Probably, but the entire 5G concept is still very theoretical and untested. There is time to get this right.

The buildout of a whole new wireless network, utilizing unusual wave propagation characteristics in new/untested technology, with unknown global consequences far into the future and that would create another ubiquitous layer of radiofrequency radiation (RF) – a biologically active exposure -- in frequencies not now in widespread use <u>mandates</u> a careful, thorough approach.

It appears to be getting the exact opposite.

At a time when other industrialized countries are calling for caution regarding wireless exposures, the U.S. is going in the opposite direction as evidenced by Chairman Wheeler's enthusiasm for 5G, which appears to preclude any in-depth review.

Most of the concerns today are in the health and environmental categories when it comes to the effects of wireless technologies. Radiofrequency radiation is a highly biologically active

[1] *Electromagnetic Fields, A Consumer's Guide to the Issues and How to Protect Ourselves,* by B. Blake Levitt, first edition, Harcourt Brace, 1996, second edition, iUniverse, 2011; and editor of *Cell Towers – Wireless Convenience? or Environmental Hazard? Proceedings of the "Cell Towers Forum, State of the Science/State of the Law,* first edition, Safe Goods/New Century Publishing, 2001, second edition, iUniverse 2010.

exposure across a range of frequencies. The 5G system is designed at present to function in the Super High Frequency (SHF) and the Extremely High Frequency (EHF) gigahertz (GHz) ranges between 3 GHz and 300 GHz, at intensities below current FCC exposure limits, but that should instill no confidence. The current FCC standards are for acute high-intensity, short-term exposures capable of heating tissue. Most exposures today are long-term, low-intensity but a systematically growing body of evidence finds those to be as biologically active, if not more so (see below) than the thermal effects regulated today. The 5G system, which will require literally millions of new antennas mounted everywhere, is exactly the kind of exposure that most alarms both scientists and citizens alike.

In light of the newly released $28-million multi-year study by The National Toxicology Program (NTP) at the National Institutes of Health (NIH), which found a causal relationship between RF in cell phone frequencies and malignant brain cancers (glioma), as well as benign nerve tumors (schwannomas) of the heart in male rats,[2] The Berkshire-Litchfield Environmental Council strongly recommends that the FCC apply the brakes and not move forward until all of the current biological information is taken into consideration, biologically based standards enacted, and the appropriate agencies consulted. To do otherwise is a severe overreach of FCC's traditional role in responsibly managing the nation's airwaves. The current proposal throws all caution to the wind.

What is 5G?

5G stands for "Fifth Generation" and is a massively complex network made up of both cloud-based wireless transceivers and ground-based fiberoptic wired systems that will enable full buildout of the "Internet of Things," including driverless cars, interconnectivities between cell phones and 'smart' homes and businesses, and faster telecom services and entertainment to businesses and consumers among myriad applications yet-to-be-imagined. There are serious concerns at all levels of government and in many private sectors about such massive interconnectivity regarding cybersecurity, safety, and privacy -- concerns that may be irreconcilable given how technology basically functions in an interconnected world.

Spectrum allocated for 5G is spread across a range of frequencies between the Super High Frequency (SHF) and the Extremely High Frequency (EHF) bands between 3 GHz and 300 GHz. These are also known as the millimeter bands. Current cell technology functions in the Ultra High Frequency (UHF) bands between 300 megahertz (MHz) and 3 GHz. 5G may end up functioning close to the lower regions of the laser frequencies visible to other species. These upper ranges are in fact the only area of the nonionizing bands of the electromagnetic spectrum that is relatively untouched. Most others are completely filled in.

The FCC is looking between 24 GHz and 90 GHz for 5G. Samsung Electronics has already demonstrated a 28 GHz system.

The FCC also plans to open up multiple wide areas of other bands for 5G too. This is the first time since the advent of telecommunication in the 1990's that the FCC has opened this

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[2] http://ntp.niehs.nih.gov/results/areas/cellphones/index.html

much spectrum – more than the 1-through-4G systems combined. 5G makes use of digitized millimeter waves that function best in narrow beams/bands that do not wrap well around obstacles like buildings, is easily deflected and has poor penetration ability. But new antenna designs have overcome those limitations and can now aim and process the radiation into coherent signals that easily penetrate buildings, people, everything. According to Chairman Wheeler, 5G will require millions of new antennas, as well as hundreds of billions of microchips, and will be an economic multiplier with tens of billions of dollars in economic activity. He calls 5G "infrastructure intensive" [3] and the system(s) will presumably fall under the same restrictions of the Telecommunications Act of 1996 that prohibited states and communities from taking the "environment effects" of radiofrequency radiation into consideration in infrastructure siting if the emissions are within FCC limits.

Toward the 5G initiative, the FCC last year also enacted rules that gave distributed antenna systems (DAS) – a precursor of how 5G will operate in combination with fiberoptic cable -- expedited review at the local level for both environmental effects and historical significance, which now cannot be taken into consideration. These are historically sacrosanct tools that local governments use to determine suitability for any proposal, not just telecomm infrastructure.

That this buildout will bring increasing levels of RF to the living environment is a given at a time when there are serious concerns in many countries about just such exposures. Yet Chairman Wheeler has expressed contempt toward other countries that have elected to study 5G's effects before buildout. In the U.S., the approach is the opposite. Chairman Wheeler expressly says that technology should drive policy, not the other way around. While China, Japan, and North Korea have agreed to cooperate, the EU has actually put up 50 million Euros to study 5G <u>before</u> implementation. The U.S., therefore, will be the first nation on earth to give total license to the companies that stand to profit most, with virtually no scrutiny for safety. Chairman Wheeler sees the FCC's role as making spectrum available but thereafter to let technology take it from there. As such, 5G will basically be unregulated. And since he is averse to "micromanaging" technological development, that means we are missing a critical opportunity to make recommendations or requirements for safer devices and infrastructure. Chairman Wheeler also says that an increase in unlicensed RF uses will also play a critical role in 5G. That means even less regulation for devices, apart from the infrastructure.

These are huge missed opportunities, given what is known – and continuing to emerge -- about the health and environmental exposures of radiofrequency radiation. Examples include:

. The International Agency for Research on Cancer (IARC) at the World Health Organization (WHO) classified RF as a 2B (possible) human carcinogen in 2011.[4] The NTP study not only reinforces that classification but appears to indicate a reclassification of RF to a 2A (probable) carcinogen, or even to Group 1 (known) carcinogen for humans in the not too distant future.

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[3] "The Future of Wireless: A vision for the U.S. Leadership in a 5G World," Thomas Wheeler, FCC Chairman, National Press Club, Washington, D.C. June 20, 2016. **www.c-span.org**/.../fcc-chair-**tom-wheeler**-delivers-remarks-**5g**-networks

[4] http://www.iarc.fr/en/media-centre/pr/2011/pdfs/pr208_E.pdf

. In 2015, 220 scientists who had published in peer-reviewed journals from 41 nations signed the International Scientists Appeal[5] to the United Nations and the WHO to coordinate their classifications of both low frequency electromagnetic fields (EMFs) and RF as 2B carcinogens in a manner that would strengthen WHO's own standards recommendations. It was a dramatic way to warn the august international public health entities that there is grave concern for the increasing ambient exposures from technology. Their warnings included everything from cell phones, infrastructure, wifi, 'smart' meter/grid technology and devices like baby monitors to commercial broadcast uses. This warning *de facto* would extend to 5G, and because of its nascent global ubiquity and potential consequences, 5G may warrant a WHO recommendation of its own.

. The BioInitiative report, edited by Cindy Sage and David O. Carpenter, MD, updated in 2012, is a treasure trove of experts and papers on the health and environmental effects by those who have done the work, including nearly 2000 papers from 29 international scientists – Ph.Ds and MDs -- from over 10 countries including 10 from the U.S. Their conclusions note that the continued unfettered rollout of wireless technologies jeopardizes global health and recommends stricter biologically based standards, lower exposure limits, and certainly a more cautious, science-based approach – the exact opposite of Chairman Wheeler's technophoria and market/based embrace of 5G.

The above are only a handful of examples of the professional concerns today.

The question is: What do all of these people know that Chairman Wheeler doesn't, all the while he waives concerns aside in favor of free-market ideology? Does this serve the public good?

Health Concerns are Real: Problems at the FCC

That there are potential adverse health and environmental effects from nonionizing radiation has been known since the advent of radar used in WW2 aboard U.S. ships when cataracts, numerous cancers and infertility were observed in U.S. Navy midshipmen and radar technicians. Since that time, and especially within the last 15 years, the use of wireless technologies has exploded – all without a clear understanding of the biological implications and without adequate regulatory controls. Ambient nonionizing radiation exposures are the fastest growing environmental exposures today. In fact, it has become a hidden variable in all research.

The FCC has standards in place but they only regulate for acute, short term, high-intensity exposures capable of heating tissue the way a microwave oven cooks food. Although a safety margin is built into the standards, any biological effects below that thermal threshold are simply unregulated. In addition, the FCC categorically excludes from review any device or application that falls below a certain power density threshold which most wireless products do. That means that there is no true regulatory oversight of just about all of the wireless products in use today with the exception of cell phones which have to meet a threshold for a specific

[5] https://www.**emfscientist**.org

absorption rate (SAR) of energy deposited in tissue. The FCC is currently reviewing the adequacy of cell phone and RF exposure limits but there is intense pressure to make the current inadequate standards even more lenient.

One primary criticism of how the FCC functions is that they time-average exposures rather than regulate for peak exposures, which is the most important biological metric. Smart meters, for instance, during the duty cycle, put out a peak burst of RF that has been found to exceed FCC limits by orders of magnitude. (Cell phone manufacturers tell consumers not to hold a functioning cell phone against the body or it too may exceed FCC limits.) Yet that peak is averaged away into the duty cycle's lower exposures and essentially disappears into what is deemed "safe." That is like saying that a bullet passing through flesh is "safe" because it comes out the other side and moves more slowly by the time is passes through bone, blood and tissue. The FCC standards are based on a dosemitry model of how to make communications systems work with the least amount of transmitted power necessary, not on true biological models regarding the consequences to living systems in the path of technology. The proposed 5G network will contain peak exposures of its own that will also be lost in the background noise of how FCC regulates.

In addition, the FCC standards – and indeed no state or federal regulatory entity – regulates for cumulative exposures from myriad sources all functioning together. RF power density and categorical exclusion are considered one product at a time. The 5G network will add a whole new layer of ambient RF exposure that does not now exist.

It is the unregulated, long-term, low-level, chronic exposures that are increasing exponentially today from all manner of wireless devices, such as cell phones, wifi, cordless domestic phones, myriad screen 'apps,' wireless security systems, baby monitors, and now 'smart' grid/meters. Add to this ambient exposures from all of the infrastructure, such as cell towers and myriad antenna arrays to support 1G, 2G, 3G, 4G and soon the 5G network creating ubiquitous internet connectivity and it is easy to understand why many governments and health agencies outside the US are calling for a precautionary approach before further buildout.

What's more, man-made radiation creates very different kinds of exposures -- with unusual signaling characteristics like digital pulsing, phased array and saw-tooth waveforms, and at much higher power intensities than anything found in nature. RF is actually a form of energetic air pollution. Myriad species are known to be fantastically sensitive to low-level energy[6] and may be affected by these increasing background levels. No federal or state agency has standards to protect wildlife from RF. 5G could approach frequency bands that are actually visible to avian species.

What the Studies Show:

[6] For a list of studies on wildlife and RF, see http://www.livingplanet.be/emranimals.htm

Below is a chart compiled by Levitt and Lai[7] of biological effects at extremely low intensities comparable to 5G infrastructure. These exposures cannot be considered biologically inactive. Scores of studies have found otherwise, despite industry assurances.

Table I. A list of studies reporting biological effects at low intensities of RFR. These papers gave either SAR (W/kg) or power density (uW/cm^2) of exposure.

		SAR (W/kg)	Power density (uW/cm^2)	Effects reported
Belyaev et al. (2005) (in vitro)	915 MHz, GSM 24 & 48 hr	0.037		Genetic changes in human white blood cells
Belyaev et al. (2009) (in vitro)	915 MHz, 1947 MHz GSM, UMTS 24 & 72 hr	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 or 50-Hz AM, 14 days, 5, 10, 20 min per day, CW- no effect		26	DNA damage in human glial cells
Capri et al. (2004) (in vitro)	900 MHz, GSM 1 hr/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)	People lived close to AM radio and radar installations for more than one year		10	People lived and worked near AM radio antennae and radar installations showed deficits in psychological and short-term memory tests.
De Pomerai et al. (2003) (in vitro)	1 GHz 24 & 48 hr	0.015		Protein damages
D'Inzeo et al. (1988) (in vitro)	10.75 GHz CW 30-120 sec	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	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 hr to 7 days direction of response depended on exposure duration		1	Change in immunological functions.

[7] *Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays,* B. Blake Levitt and Henry Lai, Environ. Rev. **18**: 369–395 (2010) doi:10.1139/A10-018 Published by NRC Research Press. http://electromagnetichealth.org/electromagnetic-health-blog/levitt-lai/

Forgacs et al. (2006) (in vivo) (mouse whole body)	1800 MHz, GSM- 217 Hz pulses, 576 s pulse width; 2hr/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
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. (1999) (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- not included)	900 MHz, GSM- 217 Hz pulses, 577 s pulse width; 45 min; narcoleptic patients	0.06		Improved cognitive functions.
Kesari and Behari (2009a) (in vivo) (rat whole body)	50 GHz; 2hr/day, 45 days	0.0008		Double strand DNA breaks observed in brain cells
Kesari and Behari (2009b) (in vivo) (rat whole body)	50 GHz; 2hr/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 (TETRA), 900 and 1800 MHz (GSM) 24 hr/day, 60 days	0.08		Metabolic changes.
Magras and Xenos (1999) (in vivo) (mouse whole body)	'Antenna park'-TV and FM-radio, Exposure over several generations		0.168	Decrease in reproductive function.
Makova et al. (2005) (in vitro)	915 and 905 MHz, GSM 1 hr	0.037		Chromatin conformation in human white blood cells.
Mann et al. (1998) (in vivo) (human whole body)	900 MHz GSM pulse-modulated at 217 Hz, 577 s width, 8 hr		20	A transient increase in blood cortisol.
Marinelli et al. (2004) (in vitro)	900 MHz CW 2 - 48 hr	0.0035		Cell's self-defense responses triggered by DNA damage.
Navakatikian and Tomashevskaya (1994) (in vivo) (rat whole body)	2450 MHz CW and 3000 MHz pulse-modulated 2 s pulses at 400 Hz	0.0027		Behavioral and endocrine changes, and decreases in blood concentrations of testosterone and insulin.

	Single (0.5-12hr) or repeated (15-60 days, 7-12 hr/day) exppsure, CW-no effect			
Nittby et al. (2007) (in vivo) (rat whole body)	900 MHz GSM 2hr/wk, 55wk	0.0006		Reduced memory functions.
Novoselova et al. (1999) (in vivo) (mouse whole body-wavelength in mm range)	From 8.15 -18 GHz, 1 sec sweep time-16 ms reverse, 5 hr		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 sec sweep time-16 ms reverse, 1. 5 hr/day, 30 days		1	Decreased tumor growth rate and enhanced survival.
Pavicic et al. (2008) (in vitro)	864 and 935 MHz, CW, 1-3 hrs	0.08		Growth affected in Chinese hamster V79 cells.
Panagopoulos et al. (2010) (in vivo) (fly whole body)	GSM 900 and 1800 6 min/day, 5 days		1 - 10	Reproductive capacity and induced cell death.
Panagopoulos and Margaritis (2010a) (in vivo) (fly whole body)	GSM 900 and 1800 6 min/day, 5 days		10	'Window' effect of GSM radiation on reproductive capacity and cell death.
Panagopoulos and Margaritis (2010b) (in vivo) (fly whole body)	GSM 900 and 1800 1- 21 min/day, 5 days		10	Reproductive capacity of the fly decreased linearly with increased duration of exposure.
Pérez-Castejón et al. (2009) (in vitro)	9.6 GHz , 90% AM, 24 hrs	0.0004		Increased proliferation rate in human astrocytoma cancer cells.
Perssson 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 (iDEN); 836.55 MHz (TDMA) 2 hr and 21 hr	0.0024		DNA damage in human leukemia cells.
Polonga-Moraru et al. (2002) (in vitro)	2.45 GHz 1hr		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 □s pulse length) 1-7 days postcoitum	0.0005		Exposure during early gestation affected kidney development.
Roux et al. (2008a) (in vivo) (tomato whole body)	900 MHz		7	Gene expression and energy metabolism.
Roux et al. (2008b) (in vivo) (plant whole body)	900 MHz		7	Energy metabolism.

Salford et al. (2003) (in vivo) (rat whole body)	915 MHz GSM 2 hr	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, 30 min, effect only observed at 16-Hz modulation	0.00015		Calcium movement in the heart.
Schwarz et al. (2008) (in vitro)	1950 MHz UMTS 24 hr	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.
Stagg et al. (1997) (in vitro)	836.55 MHz TDMA duty cycle 33% 24 hr	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 15 min	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 □s pulses at 1000 pps, also with or without sinusoidal AM between 14 and 41 MHz, response only with AM modulation, 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, square-wave modulated at 217 Hz; Also 900 MHz with CW, 16 Hz, 50 Hz and 30 KHz modulations	0.001		Calcium concentration in heart muscle cells of guinea pig.
Yurekli et al. (2006)	945 MHz GSM, 217	0.0113		Free radical chemistry.

(in vivo) (rat whole body)	Hz pulse-modulation 7 hr/day, 8 days			

Although many of the above studies were conducted across of range of frequencies lower than 5G, such studies demonstrate that vanishingly low-levels of RF affects every aspect of biological function. This is a body of work that we ignore at our own peril, especially with the deployment of a new infrastructure intended to penetrate every inch of living space.

Conclusion:

If the FCC votes to approve Chairman Wheeler's proposal, it waives aside an enormous amount of research, spanning decades, that indicates we need to be more prudent in our approach to technology. It would simply bypass what we already know and that other areas of the world take into consideration.

We cannot, and should not, endorse this proposal without at least including a request for new research appropriations by unbiased, independent government agencies, as well as a recommendation to refund the agencies that FCC relies upon to help them make such determinations – the EPA, NIH and the U.S. Fish & Wildlife Service. There are safe ways to live with and encourage technology, but this carte blanche 5G tech-friendly proposal is not it. The FCC is supposed to manage the airwaves for the common good. Throwing the doors open to an unknown technology that could essentially go unregulated other than via spectrum allocation, is not what the public wants from the FCC, which has been given oversight for RF safety. Approval would not reflect well on the agency. We can do better than this. There is time to be careful. We need a much clearer idea of where this is headed, and what the consequences may be, before moving forward.

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EXHIBIT F

FCC 13-39

Before the Federal Communications Commission

Washington, D.C. 20554

In the Matter of

Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies	)))	ET Docket No. 13-84
	)	
Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields	))	ET Docket No. 03-137

To: Office of the Secretary
Federal Communications Commission , Washington, DC 20554

As officially presented in the Federal Register/ Vol. 78, No. 107 / Tuesday, June 4, 2013 / Proposed Rules. Federal Communications Commission, 47 CFR Parts 1, 2, 15, 24, 25, 27, 73, 90, 95, 97, and 101 [ET Docket Nos. 03–137 and 13–84; FCC 13–39], Reassessment of Exposure to Radiofrequency Electromagnetic Fields Limits and Policies, Federal Communications Commission

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1. New, biologically-based public exposure standards should be developed under the direction of experts in the biological effects and adverse health effects of chronic exposures to radiofrequency electromagnetic radiation (RFR), drawing upon the substantial international body of scientific and public health literature, and not be limited to individuals in electrical and electronic engineering.

2. A rapidly accumulating body of scientific evidence of harm to health and well-being constitute warnings that adverse health effects can occur with prolonged exposures to very low-intensity EMF at biologically active frequencies or frequency combinations.

3. The BioInitiative 2012 Report reports biological effects at exposure levels significantly below the 2007 recommended goal of 0.1 uW/cm2. Since 2007, five new studies of base-station level RFR at intensitites ranging from less than 0.001 uW/cm2 to 0.05 uW/cm2 report headaches, concentration difficulties and behavioral problems in children and adolescents; and sleep disturbances, headaches and concentration problems in adults. Exhibit A presents some representative studies (peer-reviewed and published in reputable scientific journals) that report biological effects and adverse health effects at levels that are clearly non-thermal (low-intensity). New biologically-based public exposure limits are critically needed in light of the vast rollout of wireless technologies that expose billions of people globally to elevated, artificial RFR (particularly pulsed RFR) in daily life. These studies are representative of several thousand studies over four decades that constitute emerging scientific evidence of risk to very low-intensity RFR with chronic exposure.

4. As new studies are completed and published on the effects of chronic, low-intensity RFR exposure across populations (from cell towers and wireless devices, for example) the results indicate adverse health impacts occur from on-going disruption of normal metabolism, endocrine function, male fertility parameters, fetal brain development, immune function, mental abilities, electrophysiology, and neural synchrony. Disruption of basic neural function due to artificial EMF/RFR exposures can disrupt weak-field effects that are necessary to guide non-linear biological oscillations and other cellular communications necessary for normal biological functioning, and result in unacceptable burdens on human health.

5. Evidence for Damage to Sperm and Reproduction

Evidence for damage to sperm and male reproduction parameters include adverse effects on sperm quality, motility and pathology in men who use and particularly those who wear a cell phone, PDA or pager on their belt or in a pocket (Agarwal et al, 2008; Agarwal et al, 2009; Wdowiak et al, 2007; De Iuliis et al, 2009; Fejes et al, 2005; Aitken et al, 2005; Kumar, 2012). Other studies conclude that usage of cell phones, exposure to cell phone radiation, or storage of a mobile phone close to the testes of human males affect sperm counts, motility, viability and structure (Aitken et al, 2004; Agarwal et al, 2007; Erogul et al, 2006). Animal studies have demonstrated oxidative and DNA damage, pathological changes in the testes of animals, decreased sperm mobility and viability, and other measures of deleterious damage to the male germ line (Dasdag et al, 1999; Yan et al, 2007; Otitoloju et al, 2010; Salama et al, 2008; Behari et al, 2006; Kumar et al, 2012). There are fewer animal studies that have studied effects of cell phone radiation on female fertility parameters. Panagopoulous et al (2012) report decreased ovarian development and size of ovaries, and premature cell death of ovarian follicles and nurse cells in *Drosophila melanogaster*. Gul et al (2009) reported rats exposed to stand-by level RFR (phones on but not transmitting calls) had a decrease in the number of ovarian follicles in pups born to these exposed dams. Magras and Xenos (1997) reported irreversible infertility in mice after five (5) generations of exposure to RFR at cell phone tower exposure levels of less than one microwatt per centimeter squared (µW/cm2). See www.bioinitiative.org Section 18 for references.

HUMAN SPERM AND THEIR DNA ARE DAMAGED

Human sperm are damaged by cell phone radiation at very low intensities (0.00034 – 0.07 µW/cm2). Many new studies in the last decade report sperm damage in humans and animals, leading to substantial concerns for fertility, reproduction and health of the offspring (unrepaired de novo mutations in sperm). Exposure levels are similar to those resulting from wearing a cell phone on the belt, or in the pants pocket, or using a wireless laptop computer on the lap. Sperm lack the ability to repair DNA damage.

6. Evidence for Brain Tumors

Based on epidemiological studies there is a consistent pattern of increased risk for glioma and acoustic neuroma associated with use of mobile phones and cordless phones. The evidence comes mainly from two study centres, the Hardell group in Sweden and the Interphone Study Group. No consistent pattern of an increased risk is seen for meningioma. A systematic bias in the studies that explains the results would also have been the case for meningioma. The different risk pattern for tumor type strengthens the findings regarding glioma and acoustic neuroma. Meta-analyses of the Hardell group and Interphone studies show an increased risk for glioma and acoustic neuroma. Supportive evidence comes also from anatomical localisation of the tumor to the most exposed area of the brain, cumulative exposure in hours and latency time that all add to the biological relevance of an increased risk. In addition risk calculations based on estimated absorbed dose give strength to the findings. See www.bioinitiative.org Section 11 for references.

- There is reasonable basis to conclude that RF-EMFs are bioactive and have a potential to cause health impacts.
- There is a consistent pattern of increased risk for glioma and acoustic neuroma associated with use of wireless phones (mobile phones and cordless phones) mainly based on results from case-control studies from the Hardell group and Interphone Final Study results.
- Epidemiological evidence gives that RF-EMF should be classified as a human carcinogen.
- The existing FCC/IEE and ICNIRP public safety limits and reference levels are not adequate to protect public health based on evidence for brain tumors and RFR exposure.
- New public health standards and limits are needed.

7. Evidence for Adverse Fetal and Neonatal Effects

Effects on the developing fetus from in-utero exposure to cell phone radiation have been observed in both human and animal studies since 2006. Sources of fetal and neonatal exposures of concern include cell phone radiation (both paternal use of wireless devices worn on the body and maternal use of wireless phones during pregnancy). Sources include exposure to whole-body RFR from base stations and WI-FI, use of wireless laptops, use of incubators for newborns with excessively high ELF-EMF levels resulting in altered heart rate variability and reduced melatonin levels in newborns, fetal exposures to MRI of the pregnant mother, and greater susceptibility to

leukemia and asthma in the child where there have been maternal exposures to ELF-EMF. Divan et al (2008) found that children born to mothers who used cell phones during pregnancy develop more behavioral problems by the time they have reached school age than children whose mothers did not use cell phones during pregnancy. Children whose mothers used cell phones during pregnancy had 25% more emotional problems, 35% more hyperactivity, 49% more conduct problems and 34% more peer problems (Divan et al, 2008). Aldad et al (2012) showed that cell phone radiation significantly altered fetal brain development and produced ADHD-like behavior in the offspring of pregnant mice. Exposed mice had a dose-dependent impaired glutamatergic synaptic transmission onto Layer V pyramidal neurons of the prefrontal cortex. The authors conclude the behavioral changes were the result of altered neuronal developmental programming in utero. Offspring mice were hyperactive and had impaired memory function and behavior problems, much like the human children in Divan et al (2008). Fragopoulou et al (2012) reports that brain astrocyte development followed by proteomic studies is adversely affected by DECT (cordless phone radiation) and mobile phone radiation.
See www.bioinitiative.org Section 19 and 20 for references.

Fetal (in-utero) and early childhood exposures to cell phone radiation and wireless technologies in general may be a risk factor for hyperactivity, learning disorders and behavioral problems in school.

8. Evidence for Effects on Autism (Autism Spectrum Disorders)

"*Autism spectrum disorder (ASD), the fastest-growing complex neurodevelopment disorder, continues to rise in its prevalence, now affecting up to 1 in 50 children in the USA, and averaging 1% globally, according to the latest CDC report. More children will be diagnosed with ASD this year than with AIDS, diabetes & cancer combined in the USA.* ***ASD costs the nation $137 billion a year and this debt is expected to increase in the next decade.*** *Hence, ASD has become a huge healthcare burden and global threat, categorized by the CDC as a national public health crisis*." (Special Issue on Autism, North American Journal of Medicine and Science, Vol 6, Issue 3, July 2013, Harvard Medical School).

Several thousand scientific studies over four decades point to serious biological effects and health harm from EMF and RFR. These studies report genotoxicity, single-and double-strand DNA damage, chromatin condensation, loss of DNA repair capacity in human stem cells, reduction in free-radical scavengers (particularly melatonin), abnormal gene transcription, neurotoxicity, carcinogenicity, damage to sperm morphology and function, effects on behavior, and effects on brain development in the fetus of human mothers that use cell phones during pregnancy. Cell phone exposure has been linked to altered fetal brain development and ADHD-like behavior in the offspring of pregnant mice.

Many disrupted physiological processes and impaired behaviors in people with ASDs closely resemble those related to biological and health effects of EMF/RFR exposure. Biomarkers and indicators of disease and their clinical symptoms have striking similarities. At the cellular and molecular level many studies of people with ASDs have identified oxidative stress and evidence of free-radical damage, as well as deficiencies of antioxidants such as glutathione. Elevated intracellular calcium in ASDs can be associated with genetic mutations but more often may be downstream of inflammation or chemical exposures. Lipid peroxidation of cell membranes, disruption of calcium metabolism, altered brain wave activity and consequent sleep, behavior and immune disfunction, pathological leakage of critical barriers between gut and blood or blood and brain may also occur. Mitochondria may function poorly, and immune system disturbances of various kinds are common. Changes in brain and autonomic nervous system electrophysiology can be measured and seizures are far more common in ASCs than in the population at large. Sleep disruption and high levels of stress are close to universal in ASCs. All of these phenomena have also been documented to result from or be modulated by EMF/RFR exposure. Reducing or removing EMF and wireless RFR stressors from the environment is a reasonable precautionary action given the overall weight of evidence for a link to ASDs. The FCCs thermal safety limits do not address low-intensity (non-thermal) effects. The evidence is now overwhelming that limiting exposures to those causing thermal injury alone does not address the much broader array of risks and harm now clearly evident with chronic exposure to low-intensity (non-thermal) EMF/RFR. The now well-documented genotoxic impacts of EMF/RFR, placed in parallel with the huge rise in reported cases of ASCs as well as with the de novo mutations associated with some cases of ASCs (as well as other conditions), make it urgent to address the issue of (environmental) acquired as well as inherited genetic damage. With the rising numbers people with ASCs and other childhood health and developmental disorders, and with emerging evidence that EMF/RFR is a preventable environmental exposure of consequence to ASCs; public safety limits must be rethought in terms of fetal, neonatal and childhood neurological and electrophysiological development. The evidence is sufficient to warrant new public exposure standards benchmarked to low-intensity (non-thermal) exposure levels causing biological disruption and strong, interim precautionary practices are advocated. See www.bioinitiative.org Section 20 for references.

9. FCC Dockets 13-84, 03-137 and 13-39 propose to significantly relax rather than tighten exposure standards, in stark contrast to what the scientific evidence suggests is needed to protect public health from RFR. IEEE/FCC public safety limits remain unchanged and are still inadequate and obsolete with respect to prolonged, low-intensity NIER exposures.

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Exhibit A

Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure (Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities (Pages 1 – 11)

http://www.bioinitiative.org/rf-color-charts/ DOWNLOAD RF Color Charts

Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

Power Density (Microwatts/centimeter2 - uW/cm2)		Reference
As low as (10^{-13}) or 100 femtowatts/cm2	Super-low intensity RFR effects at MW reasonant frequencies resulted in changes in genes; problems with chromatin conformation (DNA)	Belyaev, 1997
5 picowatts/cm2 (10^{-12})	Changed growth rates in yeast cells	Grundler, 1992
0.1 nanowatt/cm2 (10^{-10}) or 100 picowatts/cm2	Super-low intensity RFR effects at MW reasonant frequencies resulted in changes in genes; problems with chromatin condensation (DNA) intensities comparable to base stations	Belyaev, 1997
0.00034 uW/cm2	Chronic exposure to mobile phone pulsed RF significantly reduced sperm count,	Behari, 2006
0.0005 uW/cm2	RFR decreased cell proliferation at 960 MHz GSM 217 Hz for 30-min exposure	Velizarov, 1999
0.0006 - 0.0128 uW/cm2	Fatigue, depressive tendency, sleeping disorders, concentration difficulties, cardio- vascular problems reported with exposure to GSM 900/1800 MHz cell phone signal at base station level exposures.	Oberfeld, 2004
0.0009 uW/cm2	RFR induced 10%-40% increase in DNA synthesis in glioma cells (brain)	Stagg, 1997
0.003 - 0.02 uW/cm2	In children and adolescents (8-17 yrs) short-term exposure caused headache, irritation, concentration difficulties in school.	Heinrich, 2010
0.003 to 0.05 uW/cm2	In children and adolescents (8-17 yrs) short-term exposure caused conduct problems in school (behavioral problems)	Thomas, 2010
0.005 uW/cm2	In adults (30-60 yrs) chronic exposure caused sleep disturbances, (but not significantly increased across the entire population)	Mohler, 2010
0.005 - 0.04 uW/cm2	Adults exposed to short-term cell phone radiation reported headaches, concentration difficulties (differences not significant, but elevated)	Thomas, 2008
0.006 - 0.01 uW/cm2	Chronic exposure to base station RF (whole-body) in humans showed increased stress hormones; dopamine levels substantially decreased; higher levels of adrenaline and nor-adrenaline; dose-response seen; produced chronic physiological stress in cells even after 1.5 years.	Buchner, 2012
0.01 - 0.11 uW/cm2	RFR from cell towers caused fatigue, headaches, sleeping problems	Navarro, 2003

Stress proteins, HSP, disrupted immune function	Brain tumors and blood-brain barrier
Reproduction/fertility effeccts	Sleep, neuron firing rate, EEG, memory, learning, behavior
Oxidative damage/ROS/DNA damage/DNA repair failure	Cancer (other than brain), cell proliferation
Disrupted calcium metabolism	Cardiac, heart muscle, blood-pressure, vascular effects

Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

Power Density (Microwatts/centimeter2 - uW/cm2)		**Reference**
0.01 - 0.05 uW/cm2	Adults (18-91 yrs) with short-term exposure to GSM cell phone radiation reported headache, neurological problems, sleep and concentration problems.	Hutter, 2006
0.005 - 0.04 uW/cm2	Adults exposed to short-term cell phone radiation reported headaches, concentration difficulties (differences not significant, but elevated)	Thomas, 2008
0.015 - 0.21 uW/cm2	Adults exposed to short-term GSM 900 radiation reported changes in mental state (e.g., calmness) but limitations of study on language descriptors prevented refined word choices (stupified, zoned-out)	Augner, 2009
0.05 - 0.1 uW/cm2	RFR linked to adverse neurological, cardio symptoms and cancer risk	Khurana, 2010
0.05 - 0.1 uW/cm2	RFR related to headache, concentration and sleeping problems, fatigue	Kundi, 2009
0.07 - 0.1 uW/cm2	Sperm head abnormalities in mice exposed for 6-months to base station level RF/MW. Sperm head abnormalities occurred in 39% to 46% exposed mice (only 2% in controls) abnormalities was also found to be dose dependent. The implications of the pin-head and banana-shaped sperm head. The occurrence of sperm head observed increase occurrence of sperm head abnormalities on the reproductive health of humans living in close proximity to GSM base stations were discussed."	Otitoloju, 2010
0.38 uW/cm2	RFR affected calcium metabolism in heart cells	Schwartz, 1990
0.8 - 10 uW/cm2	RFR caused emotional behavior changes, free-radical damage by super-weak MWs	Akoev, 2002
0.13 uW/cm2	RFR from 3G cell towers decreased cognition, well-being	Zwamborn, 2003
0.16 uW/cm2	Motor function, memory and attention of school children affected (Latvia)	Kolodynski, 1996
0.168 - 1.053 uW/cm2	Irreversible infertility in mice after 5 generations of exposure to RFR from an 'antenna park'	Magras & Zenos, 1997
0.2 - 8 uW/cm2	RFR caused a two-fold increase in leukemia in children	Hocking, 1996
0.2 - 8 uW/cm2	RFR decreased survival in children with leukemia	Hocking, 2000
0.21 - 1.28 uW/cm2	Adolescents and adults exposed only 45 min to UMTS cell phone radiation reported increases In headaches.	Riddervold, 2008

Stress proteins, HSP, disrupted immune function	Brain tumors and blood-brain barrier
Reproduction/fertility effeccts	Sleep, neuron firing rate, EEG, memory, learning, behavior
Oxidative damage/ROS/DNA damage/DNA repair failure	Cancer (other than brain), cell proliferation
Disrupted calcium metabolism	Cardiac, heart muscle, blood-pressure, vascular effects

Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure
(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

Power Density (Microwatts/centimeter2 - uW/cm2)		Reference
0.5 uW/cm2	Significant degeneration of seminiferous epithelium in mice at 2.45 GHz, 30-40 min.	Saunders, 1981
0.5 - 1.0 uW/cm2	Wi-FI level laptop exposure for 4-hr resulted in decrease in sperm viability, DNA fragmentation with sperm samples placed in petri dishes under a laptop connected via WI-FI to the internet.	Avendano, 2012
1.0 uW/cm2	RFR induced pathological leakage of the blood-brain barrier	Persson, 1997
1.0 uW/cm2	RFR caused significant effect on immune function in mice	Fesenko, 1999
1.0 uW/cm2	RFR affected function of the immune system	Novoselova, 1999
1.0 uW/cm2	Short-term (50 min) exposure in electrosensitive patients, caused loss of well-being after GSM and especially UMTS cell phone radiation exposure	Eltiti, 2007
1.3 - 5.7 uW/cm2	RFR associated with a doubling of leukemia in adults	Dolk, 1997
1.25 uW/cm2	RFR exposure affected kidney development in rats (in-utero exposure)	Pyrpasopoulou, 2004
1.5 uW/cm2	RFR reduced memory function in rats	Nittby, 2007
2 uW/cm2	RFR induced double-strand DNA damage in rat brain cells	Kesari, 2008
2.5 uW/cm2	RFR affected calcium concentrations in heart muscle cells	Wolke, 1996
2 - 4 uW/cm2	Altered cell membranes; acetycholine-induced ion channel disruption	D'Inzeo, 1988
4 uW/cm2	RFR caused changes in hippocampus (brain memory and learning)	Tattersall, 2001
4 - 15 uW/cm2	Memory impairment, slowed motor skills and retarded learning in children	Chiang, 1989
5 uW/cm2	RFR caused drop in NK lymphocytes (immune function decreased)	Boscolo, 2001
5.25 uW/cm2	20 minutes of RFR at cell tower frequencies induced cell stress response	Kwee, 2001
5 - 10 uW/cm2	RFR caused impaired nervous system activity	Dumansky, 1974
6 uW/cm2	RFR induced DNA damage in cells	Phillips, 1998

Stress proteins, HSP, disrupted immune function	Brain tumors and blood-brain barrier
Reproduction/fertility effeccts	Sleep, neuron firing rate, EEG, memory, learning, behavior
Oxidative damage/ROS/DNA damage/DNA repair failure	Cancer (other than brain), cell proliferation
Disrupted calcium metabolism	Cardiac, heart muscle, blood-pressure, vascular effects

Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

Power Density (Microwatts/centimeter2 - uW/cm2)		Reference
8.75 uW/cm2	RFR at 900 MHz for 2-12 hours caused DNA breaks in leukemia cells	Marinelli, 2004
10 uW/cm2	Changes in behavior (avoidance) after 0.5 hour exposure to pulsed RFR	Navakatikian, 1994
10 - 100 uW/cm2	Increased risk in radar operators of cancer; very short latency period; dose response to exposure level of RFR reported.	Richter, 2000
12.5 uW/cm2	RFR caused calcium efflux in cells - can affect many critical cell functions	Dutta, 1989
13.5 uW/cm2	RFR affected human lymphocytes - induced stress response in cells	Sarimov, 2004
14.75 uW/cm2	RFR increased biomarker for cell division in glioma brain tumor cells	Stagg, 1997
20 uW/cm2	Increase in serum cortisol (a stress hormone)	Mann, 1998
28.2 uW/cm2	RFR increased free radical production in rat cells	Yurekli, 2006
37.5 uW/cm2	Immune system effects - elevation of PFC count (antibody producing cells	Veyret, 1991
45 uW/cm2	Pulsed RFR affected serum testosterone levels in mice	Forgacs, 2006
50 uW/cm2	Cell phone RFR caused a pathological leakage of the blood-brain barrier in 1 hour	Salford, 2003
50 uW/cm2	An 18% reduction in REM sleep (important to memory and learning functions)	Mann, 1996
60 uW/cm2	RFR caused structural changes in cells of mouse embryos	Somozy, 1991
60 uW/cm2	Pulsed RFR affected immune function in white blood cells	Stankiewicz, 2006
60 uW/cm2	Cortex of the brain was activated by 15 minutes of 902 MHz cell phone	Lebedeva, 2000
65 uW/cm2	RFR affected genes related to cancer	Ivaschuk, 1999
92.5 uW/cm2	RFR caused genetic changes in human white blood cells	Belyaev, 2005
100 uW/cm2	Changes in immune function	Elekes, 1996
100 uW/cm2	A 24.3% drop in testosterone after 6 hours of CW RFR exposure	Navakatikian, 1994

Stress proteins, HSP, disrupted immune function	Brain tumors and blood-brain barrier
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Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

Power Density (Microwatts/centimeter2 - uW/cm2)		**Reference**
120 uW/cm2	A pathological leakage in the blood-brain barrier with 915 MHz cell RF	Salford, 1994
500 uW/cm2	Intestinal epithelial cells exposed to 2.45 GHz pulsed at 16 Hz showed changes in intercellular calcium.	Somozy, 1993
500 uW/cm2	A 24.6% drop in testosterone and 23.2% drop in insulin after 12 hrs of pulsed RFR exposure.	Navakatikian, 1994

STANDARDS		
530 - 600 uW/cm2	Limit for uncontrolled public exposure to 800-900 MHz	ANSI/IEEE and FCC
1000 uW/cm2	PCS STANDARD for public exposure (as of September 1,1997)	FCC, 1996
5000 uW/cm2	PCS STANDARD for occupational exposure (as of September 1, 1997)	FCC, 1996
BACKGROUND LEVELS		
0.003 uW/cm2	Background RF levels in US cities and suburbs in the 1990s	Mantiply, 1997
0.05 uW/cm2	Median ambient power density in cities in Sweden (30-2000 MHz)	Hamnierius, 2000
0.1 - 10 uW/cm2	Ambient power density within 100-200' of cell site in US (data from 2000)	Sage, 2000

Stress proteins, HSP, disrupted immune function	Brain tumors and blood-brain barrier
Reproduction/fertility effeccts	Sleep, neuron firing rate, EEG, memory, learning, behavior
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Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

SAR (Watts/Kilogram)		Reference
0.000064 - 0.000078 W/Kg	Well-being and cognitive function affected in humans exposed to GSM-UMTS cell phone frequencies; RF levels similar near cell sites	TNO Physics and
0.00015 - 0.003 W/Kg	Calcium ion movement in isolated frog heart tissue is increased 18% (P<.01) and by 21% (P<.05) by weak RF field modulated at 16 Hz	Schwartz, 1990
0.000021 - 0.0021 W/Kg	Changes in cell cycle; cell proliferation (960 MHz GSM mobile phone)	Kwee, 1997
0.0003 - 0.06 W/Kg	Neurobehavioral disorders in offspring of pregnant mice exposed in utero to cell phones - dose-response impaired glutamatergic synaptic transmission onto layer V pyramidal neurons of the prefrontal cortex. Hyperactivity and impaired memory function in offspring. Altered brain development.	Aldad, 2012
0.0009 W/Kg	Changes in brain glial cells with TDMA 836.55 MHz frequency	Stagg, 1997
0.0016 - 0.0044 W/Kg	Very low power 700 MHz CW affects excitability of hippocampus tissue, consistent with reported behavioral changes.	Tattersall, 2001
0.0021 W/Kg	Heat shock protein HSP 70 is activated by very low intensity microwave exposure in human epithelial amnion cells	Kwee, 2001
0.0024 - 0.024 W/Kg	Digital cell phone RFR at very low intensities causes DNA damage in human cells; both DNA damage and impairment of DNA is reported	Phillips, 1998
0.0027 W/Kg	Changes in active avoidance conditioned behavioral effect is seen after one-half hour of pulsed radiofrequency radiation	Navakatikian, 1994
0.0035 W/Kg	900 MHz cell phone signal induces DNA breaks and early activation of p53 gene; short exposure of 2-12 hours leads cells to acquire greater survival chance - linked to tumor agressiveness.	Marinelli, 2004
0.0095 W/Kg	MW modulated at 7 Hz produces more errors in short-term memory functioin on complex tasks (can affect cognitive processes such as attention and memory)	Lass, 2002
0.001 W/Kg	750 MHz continuous wave (CW) RFR exposure caused increase in heat shock protein (stress proteins). Equivalent to what would be induced by 3 degree C. heating of tissue (but no heating occurred)	De Pomerai, 2000

Stress proteins, HSP, disrupted immune function	Brain tumors and blood-brain barrier
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Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

SAR (Watts/Kilogram)		**Reference**
0.001 W/Kg	Statistically significant change in intracellular calcium concentration in heart muscle cells exposed to RFR (900 MHz/50 Hz modulation)	Wolke, 1996
0.0021 W/Kg	A significant change in cell proliferation not attributable to thermal heating. RFR induces non-thermal stress proteins (960 MHz GSM)	Velizarov, 1999
0.004 - 0.008 W/Kg	915 MHz cell phone RFR caused pathological leakage of blood-brain barrier. Worst at lower SAR levels and worse with CW compared to Frequency of pathological changes was 35% in rats exposed to pulsed radiation at 50% to continuous wave RFR. Effects observed at a specific absorption (SA) of > 1.5 joules/Kg in human tissues	Persson, 1997
0.0059 W/Kg	Cell phone RFR induces glioma (brain cancer) cells to significantly increase thymidine uptake, which may be indication of more cell division	Stagg, 1997
0.014 W/Kg	Sperm damage from oxidative stress and lowered melatonin levels resulted from 2-hr per day/45 days exposure to 10 GHz.	Kumar, 2012
0.015 W/Kg	Immune system effects - elevation of PFC count (antibody-producing cells)	Veyret, 1991
0.02 W/Kg	A single, 2-hr exposure to GSM cell phone radiation results in serious neuron damage (brain cell damage) and death in cortex, hippocampus, and basal ganglia of brain- even 50+ days later blood-brain barrier is still leaking albumin (P<.002) following only one cell phone exposure	Salford, 2003
0.026 W/Kg	Activity of c-jun (oncogene or cancer gene) was altered in cells after 20 minutes exposure to cell phone digital TDMA signal	Ivaschuk, 1997
0.0317 W/Kg	Decrease in eating and drinking behavior	Ray, 1990
0.037 W/Kg	Hyperactivity caused by nitric oxide synthase inhibitor is countered by exposure to ultra-wide band pulses (600/sec) for 30 min	Seaman, 1999
0.037 - 0.040 W/Kg	A 1-hr cell phone exposure causes chromatin condensation; impaired DNA repair mechanisms; last 3 days (longer than stress response) the effect reaches saturation in only one hour of exposure; electro- sensitive (ES) people have different response in formation of DNA repair foci, compared to healthy individuals; effects depend on carrier frequency (915 MHz = 0.037 W/Kg but 1947 MHz = 0.040 W/Kg)	Belyaev, 2008

Stress proteins, HSP, disrupted immune function	Brain tumors and blood-brain barrier
Reproduction/fertility effeccts	Sleep, neuron firing rate, EEG, memory, learning, behavior
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Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

SAR (Watts/Kilogram)		**Reference**
0.05 W/Kg	Significant increase in firing rate of neurons (350%) with pulsed 900 MHz cell phone radiation exposure (but not with CW) in avian brain cells	Beason, 2002
0.09 W/Kg	900 MHz study of mice for 7 days, 12-hr per day (whole-body) resulted in significant effect on mitochondria and genome stability	Aitken, 2005
0.091 W/Kg	Wireless internet 2400 MHz, 24-hrs per day/20 weeks increased DNA damage and reduced DNA repair; levels below 802.11 g Authors say "findings raise questions about safety of radiofrequency exposure from Wi-Fi internet access devices for growing organisms of reproductive age, with a potential effect on fertility and integrity of germ cells" (male germ cells are the reproductive cells=sperm)	Atasoy, 2012
0.11 W/Kg	Increased cell death (apoptosis) and DNA fragmentation at 2.45 GHz for 35 days exposure (chronic exposure study)	Kesari, 2010
0.121 W/Kg	Cardiovascular system shows significant decrease in arterial blood pressure (hypotension) after exposure to ultra-wide band pulses	Lu, 1999
0.13 - 1.4 W/Kg	Lymphoma cancer rate doubled with two 1/2-hr exposures per day of cell phone radiation for 18 months (pulsed 900 MHz cell signal)	Repacholi, 1997
0.14 W/Kg	Elevation of immune response to RFR exposure	Elekes, 1996
0.141 W/Kg	Structural changes in testes - smaller diameter of seminiferous	Dasdag, 1999
0.15 - 0.4 W/Kg	Statistically significant increase in malignant tumors in rats chronically exposed to RFR	Chou, 1992
0.26 W/Kg	Harmful effects to the eye/certain drugs sensitize the eye to RFR	Kues, 1992
0.28 - 1.33 W/Kg	Significant increase in reported headaches with increasing use of hand-held cell phone use (maximum tested was 60 min per day)	Chia, 2000
0.3 - 0.44 W/Kg	Cell phone use results in changes in cognitive thinking/mental tasks related to memory retrieval	Krause, 2000
0.3 - 0.44 W/Kg	Attention function of brain and brain responses are speeded up	Preece, 1999
0.3 - 0.46 W/Kg	Cell phone RFR doubles pathological leakage of blood-brain barrier permeability at two days (P=.002) and triples permeability at four days (P=.001) at 1800 MHz GSM cell phone radiation	Schirmacher, 2000

Stress proteins, HSP, disrupted immune function	Brain tumors and blood-brain barrier
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Disrupted calcium metabolism	Cardiac, heart muscle, blood-pressure, vascular effects

Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

SAR (Watts/Kilogram)		Reference
0.43 W/Kg	Significant decrease in sperm mobility; drop in sperm concentration; and decrease in seminiferous tubules at 800 MHz, 8-hr/day, 12 weeks, with mobile phone radiation level on STANDBY ONLY (in rabbits)	Salama, 2008
0.5 W/Kg	900 MHz pulsed RF affects firing rate of neurons (Lymnea stagnalis) but continuous wave had no effect	Bolshakov, 1992
0.58 - 0.75 W/Kg	Decrease in brain tumors after chronic exposure to RFR at 836 MHz	Adey, 1999
0.6 - 0.9 W/Kg	Mouse embryos develop fragile cranial bones from in utero 900 MHz The authors say "(O)ur results clearly show that even modest exposure (e.g., 6 min daily for 21 days" is sufficient to interfere with the normal mouse developmental process"	Fragopoulou, 2009
0.6 and 1.2 W/Kg	Increase in DNA single and double-strand DNA breaks in rat brain cells with exposure to 2450 MHz RFR	Lai & Singh, 1996
0.795 W/Kg	GSM 900 MHz, 217 Hz significantly decreases ovarian development and size of ovaries, due to DNA damage and premature cell death of nurse cells and follicles in ovaries (that nourish egg cells)	Panagopoulous, 2012
0.87 W/Kg	Altered human mental performance after exposure to GSM cell phone radiation (900 MHz TDMA digital cell phone signal)	Hamblin, 2004
0.87 W/Kg	Change in human brainwaves; decrease in EEG potential and statistically significant change in alpha (8-13 Hz) and beta (13-22 Hz) brainwave activity in humans at 900 MHz; exposures 6/min per day for 21 days (chronic exposure)	D'Costa, 2003
0.9 W/Kg	Decreased sperm count and more sperm cell death (apoptosis) after 35 days exposure, 2-hr per day	Kesari, 2012
< 1.0 W/Kg	Rats exposed to mobile phone radiation on STANDBY ONLY for 11-hr 45-min plus 15-min TRANSMIT mode; 2 times per day for 21 days showed decreased number of ovarian follicles in pups born to these pregnant rats. The authors conclude "the decreased number of follicles in pups exposed to mobile phone microwaves suggest that intrauterine exposure has toxic effects on ovaries."	Gul, 2009
0.4 - 1.0 W/Kg	One 6-hr exposure to 1800 MHz cell phone radiation in human sperm cells caused a significant dose response and reduced sperm motility and viability; reactive oxygen species levels were significantly increased after exposure to 1.0 W/Kg; study confirms detrimental effects of RF/MW to human sperm. The authors conclude "(T)hese findings have clear implicatiions for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and wellbeing of their offspring."	De Iuliis, 2009

Stress proteins, HSP, disrupted immune function	Brain tumors and blood-brain barrier
Reproduction/fertility effeccts	Sleep, neuron firing rate, EEG, memory, learning, behavior
Oxidative damage/ROS/DNA damage/DNA repair failure	Cancer (other than brain), cell proliferation
Disrupted calcium metabolism	Cardiac, heart muscle, blood-pressure, vascular effects

Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

SAR (Watts/Kilogram)		**Reference**
1.0 W/Kg	Human semen degraded by exposure to cell phone frequency RF increased free-radical damage.	De Iuliis, 2009
1.0 W/Kg	Motility, sperm count, sperm morphology, and viability reduced in active cell phone users (human males) in dose-dependent manner.	Agarwal, 2008
1.0 W/Kg	GSM cell phone use modulates brain wave oscillations and sleep EEG	Huber, 2002
1.0 W/Kg	Cell phone RFR during waking hours affects brain wave activity. (EEG patterns) during subsequent sleep	Achermann, 2000
1.0 W/Kg	Cell phone use causes nitric oxide (NO) nasal vasodilation (swelling inside nasal passage) on side of head phone use	Paredi, 2001
1.0 W/Kg	Four-fold increase in eye cancer (uveal melanoma) in cell phone users	Stang, 2001
1.0 W/Kg	Increase in headache, fatigue and heating behind ear in cell phone users	Sandstrom, 2001
1.0 W/Kg	Significant increase in concentration difficulties using 1800 MHz cell phone compared to 900 MHz cell phone	Santini, 2001
1.0 W/Kg	Sleep patterns and brain wave activity are changed with 900 MHz cell phone radiation exposure during sleep	Borbely, 1999
1.4 W/Kg	GSM cell phone exposure induced heat shock protein HSP 70 by 360% (stress response) and phosphorylation of ELK-1 by 390%	Weisbrot, 2003
1.46 W/Kg	850 MHz cell phone radiation decreases sperm motility, viability is significantly decreased; increased oxidative damage (free-radicals) significantly decreased; increased oxidative damage (free-radicals)	Agarwal, 2009
1.48 W/Kg	A significant decrease in protein kinase C activity at 112 MHz with 2-hr per day for 35 days; hippocampus is site, consistent with reports that RFR negatively affects learning and memory functions	Paulraj, 2004
1.0 - 2.0 W/Kg	Significant elevation in micronuclei in peripheral blood cells at 2450 MHz (8 treatments of 2-hr each)	Trosic, 2002
1.5 W/Kg	GSM cell phone exposure affected gene expression levels in tumor suppressor p53-deficient embryonic stem cells; and significantly increased HSP 70 heat shock protein production	Czyz, 2004

Stress proteins, HSP, disrupted immune function	Brain tumors and blood-brain barrier
Reproduction/fertility effeccts	Sleep, neuron firing rate, EEG, memory, learning, behavior
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Reported Biological Effects from Radiofrequency Radiation at Low-Intensity Exposure

(Cell Tower, Wi-Fi, Wireless Laptop and 'Smart' Meter RF Intensities)

SAR (Watts/Kilogram)		Reference
1.8 W/Kg	Whole-body exposure to RF cell phone radiation of 900-1800 MHz 1 cm from head of rats caused high incidence of sperm cell death; deformation of sperm cells; prominent clumping together of sperm cells into "grass bundle shapes" that are unable to separate/swim. Sperm cells unable to swim and fertilize in normal manner.	Yan, 2007
2.0 W/Kg	GSM cell phone exposure of 1-hr activated heat shock protein HSP 27 (stress response) and P38 MAPK (mutagen-activated protein kinase) that authors say facilitates brain cancer and increased blood-brain barrier permeability, allowing toxins to cross BBB into brain	Leszczynski, 2002
2 W/Kg	900 MHz cell phone exposure caused brain cell oxidative damage by increasing levels of NO, MDA, XO and ADA in brain cells; caused statistically significant increase in 'dark neurons' or damaged brain cells in cortex, hippocampus and basal ganglia with a 1-hr exposure for 7 consecutive days	Ilhan, 2004
2.6 W/Kg	900 MHz cell phone exposure for 1-hr significantly altered protein expression levels in 38 proteins following irradiation; activates P38 MAP kinase stress signalling pathway and leads to changes in cell sie and shape (shrinking and rounding up) and to activation of HSP 27, a stress protein (heat shock protein)	Leszczynski, 2004
2.0 - 3.0 W/Kg	RFR accelerated development of both skin and breast tumors	Szmigielski, 1982
2 W/Kg	Pulse-modulated RFR and MF affect brain physiology (sleep study)	Schmidt, 2012

STANDARDS		
0.08 W/Kg	IEEE Standard uncontrolled public environment (whole body)	IEEE
0.4 W/Kg	IEEE Standard controlled occupational environment (whole body)	IEEE
1.6 W/Kg	FCC (IEEE) SAR limit for 1 gram of tissue in a partial body exposure	FCC, 1996
2 W/Kg	ICNIRP SAR limit for 10 grams of tissue	ICNIRP, 1996

Stress proteins, HSP, disrupted immune function	Brain tumors and blood-brain barrier
Reproduction/fertility effeccts	Sleep, neuron firing rate, EEG, memory, learning, behavior
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Disrupted calcium metabolism	Cardiac, heart muscle, blood-pressure, vascular effects

Exhibit B

Reference List
Reported Biological Effects from Radiofrequency Radiation (RFR) at Low-Intensity Exposure Levels

(Cell Tower, WI-FI, Wireless Laptop, Wireless Utility Meters 'smart meters')

http://www.bioinitiative.org/bibliography/ DOWNLOAD REFERENCE LIST (PDF)

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EXHIBIT G

FCC 13-39

Before the Federal Communications Commission

Washington, D.C. 20554

In the Matter of

Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and	))	ET Docket No. 13-84
Policies	)	
	)	
Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency	)	ET Docket No. 03-137
Electromagnetic Fields	)	

To: Office of the Secretary
Federal Communications Commission , Washington, DC 20554

As officially presented in the Federal Register/ Vol. 78, No. 107 / Tuesday, June 4, 2013 / Proposed Rules. Federal Communications Commission, 47 CFR Parts 1, 2, 15, 24, 25, 27, 73, 90, 95, 97, and 101 [ET Docket Nos. 03–137 and 13–84; FCC 13–39], Reassessment of Exposure to Radiofrequency Electromagnetic Fields Limits and Policies, Federal Communications Commission

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BioInitiative 2007 Report Conclusions

1) The 2007 BioInitiative Report conclusively established that low-intensity (non-thermal) bioeffects and adverse health effects of non-ionizing electromagnetic radiation (NIER) at levels significantly below existing public exposure standards.

2) The International Committee on Non-Ionizing Radiation Protection (ICNIRP) and the Institute for Electrical and Electronic Engineers/Federal Communications Commission (IEEE/FCC) public safety limits are inadequate and obsolete with respect to prolonged, low-intensity NIER exposures, based on an expert group's review of more than 2000 peer-reviewed and published scientific studies and reviews.

3) New, biologically-based public exposure standards are urgently needed to protect public health world-wide.

4) It is not in the public interest to wait.

5) The BioInitiative 2007 Report recommends a 0.1 microwatt per square centimeter limit for outdoor exposure for combined AM, FM, TV and wireless frequencies.

Background: The BioInitiative Report is an internationally acclaimed scientific and public health report on potential health risks of electromagnetic fields and radiofrequency/microwave radiation. In 2007, the BioInitiative Working Group, an international collaboration of prestigious scientists and public health experts from Columbia University and the University at Albany (New York), University of Washington (Seattle), the Karolinska Institute, Umea University and Orebro University Hospital (Sweden), the European Environmental Agency (Denmark) Medical University of Vienna (Austria) and Zhejiang University School of Medicine, (China) released a 650-page report citing more than 2000 studies that document health effects of EMFs from all sources. It is incorporated by reference in this filing.

The BioInitiative Report was produced for publication to the broadest possible audience, hence placed on the Web. Much of the BioInitiative Report content, including updated chapters and new chapters was published in a special two-volume issue of the journal Pathophysiology (August 2009, Pathophysiology 16: 2,3).

It documented that chronic exposure to electromagnetic fields (EMF) is associated in some scientific studies with increased health risks that vary from impaired learning, headaches, mental confusion, skin rashes, tinnitus and disorientation to a variety of cancers, and neurological diseases like amyotrophic lateral sclerosis (ALS) and Alzheimer's. Sources of concern may include but are not limited to power lines, cell and cordless phones, cell towers, WI-FI, WiMax and wireless internet.

Strong concern was voiced by scientists and public health and environmental policy experts, that the deployment of technologies that expose billions of people worldwide to new sources of EMF may pose a pervasive risk to public health. Such exposures did not exist before the age of industry and information. Prolonged exposure appears to disrupt biological processes that are fundamental to plant, animal and human growth and health. Life on earth did not evolve may pose a pervasive risk to public health. Such exposures did not exist before the age of industryand information. Prolonged exposure appears to disrupt biological processes that are fundamental to plant, animal and human growth and health. Life on earth did not evolve with biological protections or adaptive biological responses to these EMF exposures. A rapidly accumulating body of scientific evidence of harm to health and well- being constitute warnings that adverse health effects can occur with prolonged exposures to very low-intensity EMF at biologically active frequencies or frequency combinations.

BioInitiative 2012 Report Conclusions

1) The 2012 BioInitiative Report was prepared by 29 international experts studying more than 1800 new peer-reviewed scientific studies published since 2007 and concluded again that exposure to EMF and radiofrequency radiation (RFR) produces biological effects and adverse health effects at levels significantly below existing public exposure standards; and substantially below levels identified in 2007.

2) The scientific evidence for health harm in 2012 is stronger and more consistent than in 2007; and the levels of exposure at which biological effects and adverse health impacts are reported to occur are far lower than in 2007.

3) ICNIRP and IEEE/FCC public safety limits remain unchanged and are still inadequate and obsolete with respect to prolonged, low-intensity NIER exposures. Worse, FCC Dockets 13-84, 03-137 and 13-39 propose to significantly relax rather than tighten exposure standards, in stark contrast to what the scientific evidence suggests is needed to protect public health from RFR.

4) Specific absorption rate (SAR) as a measure of compliance with new biologically-based exposure limits should be abandoned. Setting public safety limits based on heating is an unsuitable starting point for developing new standards that properly address chronic exposures to very low-intensity RFR. SAR should not be applied to new biologically-based public exposure standards since by definition SAR is a measure of tissue heating, and the biological effects of NIER are by definition, not due to a heating mechanism. It makes no sense to continue misapplying existing thermal concepts of biological harm, time-averaging and metrics for thermal heating as a basis for detecting and preventing harm from new wireless technologies in the face of strong evidence of harm without measureable heating.

5) New, biologically-based public exposure standards should be developed under the direction of experts in the biological effects and adverse health effects of chronic exposures to electromagnetic fields, drawing upon the substantial international body of scientific and public health literature, and not be limited to individuals in electrical and electronic engineering.

6) The agency to develop new biologically-based public exposure standards should be chosen to avoid the conflicts present now where the FCC acts both as the auctioneer to promote sale and use of radiofrequency radiation spectrum and works to actively enable the telecommunications

and electronics industries to develop and market new technologies through FCC compliance testing (Grants of Authorization). At the same time the FCC is charged with adopting effective

public health limits (for which it admits it has no health expertise) and for enforcing compliance with FCC public safety limits (for which it has a dismal and ineffective track record).

7) Immediate precautionary actions are urgently needed. New safety standards will take time to be developed and implemented. Societies in the interim need to begin making changes to reduce exposures now from wireless technologies (communications, data transmission, transportation, surveillance, environmental and medical monitoring, medical implants, etc.) in the interim.

8) It is not in the public interest to wait. The continued rollout of wireless technologies and devices puts global public health at risk from unrestricted wireless commerce unless new and far lower exposure limits and strong precautionary warnings for their use are implemented. Many millions of people, including the most vulnerable populations (the fetus, young children, the ill, the elderly and those with extreme sensitivity to exposures) who are affected by second-hand wireless radiation exposures must have better protection.

9) The cost of doing nothing is unacceptable. Substantial evidence for health risks from chronic exposure to wireless technologies cannot be dismissed in 2012, and if we do nothing, it will simply worsen rates of chronic diseases, disability and premature mortality.

10) The BioInitiative 2012 Report reports biological effects at exposure levels significantly below the 2007 recommended goal of 0.1 uW/cm2. Since 2007, five new studies of base-station level RFR at intensitites ranging from less than 0.001 uW/cm2 to 0.05 uW/cm2 report headaches, concentration difficulties and behavioral problems in children and adolescents; and sleep disturbances, headaches and concentration problems in adults. If these results are confirmed to be due to RFR exposure exposure standards may need to be set at even lower levels in the future, as new and better studies are completed.

Background: The BioInitiative 2012 Report concludes that the evidence for health risks from electromagnetic fields (EMFs) generated by wireless technologies have substantially increased since 2007. A review of over 1800 new scientific studies indicates current guidelines are inadequate to protect the public from chronic exposure to very low-intensity (non-thermal) electromagnetic fields and radiofrequency radiation (EMF and RFR). It is incorporated by reference in this filing.

The 2012 BioInitiative Report was prepared by 29 authors from ten countries, ten holding medical degrees (MDs), 21 PhDs, and three MsC, MA or MPHs. Among the authors are three former Presidents of the Bioelectromagnetics Society and five full members of BEMS. One distinguished author is the Chair of the Russian National Committee on Non-Ionizing Radiation. Another is a Senior Advisor to the European Environmental Agency. Full titles and affiliations of authors is in Section 25 of the BioInitiative Report at www.bioinitiative.org

In twenty-four technical chapters, the BioInitiative Working Group authors discuss the content and implications of about 1800 new studies since 2007. Overall, these new studies report abnormal gene transcription (Section 5); genotoxicity and single-and double-strand DNA damage (Section 6); stress proteins because of the fractal RF-antenna like nature of DNA (Section 7); chromatin condensation and loss of DNA repair capacity in human stem cells (Sections 6 and 15); reduction in free-radical scavengers - particularly melatonin (Sections 5, 9, 13, 14, 15, 16 and 17); neurotoxicity in humans and animals (Section 9); carcinogenicity in humans (Sections 11, 12, 13, 14, 15, 16 and 17); serious impacts on human and animal sperm morphology and function (Section 18); effects on the fetus, neonate and offspring (Section 18 and 19); effects on brain and cranial bone development in the offspring of animals that are exposed to cell phone radiation during pregnancy (Sections 5 and 18); and findings in autism spectrum disorders consistent with EMF/RFR exposure effects. Global precautionary actions that have been taken in countries around the world, and recommended by medical and research experts are documented in Section 22. Use of the Precautionary Principal and it's relevance are presented in Section 23. Key scientific evidence and public health policy recommendations are in Section 24.

See Appendix A for specific conclusions and findings of the BioInitiative 2012 Report, and see the Report at www.bioinitiative.org

Recommendations to the FCC

The FCC review of health and safety standards for radiofrequency radiation as presented (Federal Register/ Vol. 78, No. 107 / Tuesday, June 4, 2013 / Proposed Rules. Federal Communications Commission, 47 CFR Parts 1, 2, 15, 24, 25, 27, 73, 90, 95, 97, and 101 [ET Docket Nos. 03–137 and 13–84; FCC 13–39], Reassessment of Exposure to Radiofrequency Electromagnetic Fields Limits and Policies, Federal Communications Commission) does not begin to properly address the current scientific evidence that conclusively demonstrates biological effects and some adverse health effect of EMF and RFR exposures at low-intensity (non-thermal) exposure levels. The BioInitiative Reports (2007 and 2012) should define the discussion range for new chronic exposure limits; and not be drawn from re-examination of existing thermal standards.

In fact, these proposed rules and regulations relax rather than tighten exposure levels in the face of overwhelming scientific evidence that an entirely new paradigm for developing safety standards is warranted, and in fact, overdue. For example, declaring the pinna of the ear (the earlobe) to be an extremity, so as to allow a huge increase in allowable SAR exposure [(5)] at the head (affecting the brain including the auditory and other cranial nerves, the eye and salivary glands in the cheek) is reckless and unsupported by any legitimate expert review of the available evidence. [(1,2,3)] The FCC has not considered the special biology of the developing fetus, the young child, people of small stature, people with medical implants for serious chronic diseases and chronic pain in these proposed rule changes. These changes avoid making exposure-relevant reductions keyed to scientific benchmarks established in hundreds of in peer-reviewed, published studies reporting low-intensity (non-thermal) effects of chronic (prolonged) exposures now common in public life.

The new FCC public exposure limits must take into account the variable conductivity and permittivity of tissues of various ages and developmental stages and aging of humans, and the exquisite sensitivity of the human reproductive cells.

1) SUPPORT DEVELOPMENT OF NEW, BIOLOGICALLY-BASED PUBLIC SAFETY LIMITS BY A QUALIFIED AGENCY OR PROFESIONAL ORGANIZATION:

The FCC'S thermal-based public safety MPEs and the SAR approach are useful to prevent tissue heating and damage; but not useful to protect the public against chronic exposures (as opposed to acute exposures) biologically active non-thermal, low-intensity NIER.

2) RECOGNIZE THE WHO IARC CLASSIFICATION OF RFR:

The WHO IARC classified RF radiation as a Group 2B Possible Human Carcinogen; it joins the IARC classification of ELF-EMF (Extremely Low Frequency Electromagnetic Fields) as a Group 2B Possible Human Carcinogen, which the FCC has also ignored. The evidence for carcinogenicity for RFR was primarily from cell phone/brain tumor studies but IARC applies this classification to all RFR exposures.

3) ADOPT SPECIFIC LANGUAGE ENDORSING THE PRECAUTIONARY PRINCIPLE:

The Commission should address and incorporate appropriate precautionary, public-health based measures to take into account the recent World Health Organization International Agency for Research on Cancer (IARC) classification of RFR as a Possible Human Carcinogen before subjecting widespread national populations to a preventable toxic exposure.

4) DEFINE BIOLOGICAL EFFECT AS HARMFUL INTERFERENCE WITH BIOLOGICAL ORGANISMS

A definition of biological effects should key to such effects that can reasonably be presumed to result in adverse health effects from exposure to RFR including but not limited to DNA damage; immune, blood-brain barrier, and calcium channel disruption; disturbed circadian rhythms; hormone dysregulation; degraded cognition and sleep; disrupted autonomic regulation; desynchronization of neural activity and other biological consequences of acute or chronic exposure to low-intensity NIER as documented in the BioInitiative 2007 and 2012 Reports.

5) RECLASSIFICATION OF THE PINNA SHOULD BE DEFERRED:

A reclassification of the pinna should be delayed by the FCC in all open dockets pertaining to completion of the FCC's review of RFR health effects and proposed FCC compliance testing rule changes. New studies show adverse effects without relaxing this limit. [1,2,3,4]. Lin. [5] gives an answer to the FCC's question asking on page 79 "*We request comment on the significance, if any, of the differences between these standards. For example, we request comment on whether using an averaging mass of 10 grams over a contiguous layer of tissue would yield a significantly different SAR value than that averaged over a 1-gram cube and whether that difference would be consistently higher or lower, particularly with enough consistency to be able to establish a definable relationship between the measurement methods*". See footnote to reference (5)

6) NEPA ASSESSMENT FOR FINAL RULES – APPENDIX A AND B

The Commission should require a NEPA assessment for Final Rules (App. A) and Proposed Rules (App. B). Proposed Rules in Appendix B, in particular, have the potential to adversely affect human health and environmental resources.

7) COMPLIANCE TESTING REQUIREMENTS

a) **Medical and Metal Implants**: Metal detectors in the 9 kHz range are not covered by current FCC rules and should be addressed with respect to the public with disabilities (medical and metal implants). People with deep brain stimulators for Parkinson's disease are unable to pass through metal detectors because evidence exists that such exposures can shut down the electrodes in these devices, and such exposures are now preventing people with deep brain stimulators from normal activities (shopping, air travel, hospitals and health care facilities, attendance at public meetings and events, etc).

b) **Distance Exemptions**: More realistic provisions must be developed regarding distancing from RFR transmitters (wireless devices, wireless access points and routers, baby monitors, wireless utility meters, etc) for infants and children who cannot reasonably be expected to observe FCC rules for 20 cm or 40 cm separation. The basis for exemptions from routine evaluations (Appendix C – fixed, mobile or portable RF sources) assumes conservative derivations or worst-case predictions leading to "*minimal likelihood for the exposure limits for the general public to be exceeded*" based on faulty logic about what can be expected with regard to the general public knowing or being able to avoid breaching an arbitrary 20 cm or 40 cm distances.

c) **Compliance Testing**: Realistic assumptions about operation of wireless utility meter devices ('smart meters') should be mandatory in FCC testing and issuance of Grants of Authorization. FCC testing labs ignore the obvious two-antenna or three-antenna design of wireless utility meters, yet issue 'Conditions' for compliance that specify "*this compliance test is issued with the condition that the antenna may not operate in conjunction with other antennas*". The FCC cannot reasonably issue Grants of Authorization based on lab testing that ignores typical construction of the device, and how in common practice it is installed and operated.

d) **Cumulative Effects**: Cumulative effects of RFR exposures from multiple wireless devices and environmental exposures are not sufficiently addressed, measured or tested under current or proposed FCC rules. The 2008 NAS Report on Research Needs for Wireless Device summarizes deficiencies for wireless effects on children, adolescents and pregnant women; wireless personal computers and base station antennas; multiple element base station antennas under highest radiated power conditions; hand-held cell phone compliance testing; and better dosimetric absorbed power calculations using realistic anatomic models for both men, women and children of different height and ages. Realistic assessments of cumulative RFR exposures need to be addressed, taking into account the high variability in environmental situations; and safety buffers below 'effects levels' need to be built into new FCC public safety limits.

e) **100% Duty Cycle**: FCC OET 65 should make clear that a 100% duty cycle will continue to be required in calculations of power density 'where the public cannot be excluded'.

f) **Time-Averaging vs Pulsed RFR**: New public exposure limits for pulsed RFR are needed, rather than specifying compliance limits based on time-averaged fields. Many new wireless devices and exposures create pulsed RFR for users; such exposures are linked to biological disruption effects and adverse health impacts. Time-averaging is biologically inappropriate where such measurements effectively camouflage exposures by mathematical dilution. Positive assertions of safety of pulsed RFR exposures that are characterized only by time-averaging have been shown to be unsupportable.

8. **Basis for Biologically-based Public Exposure Limits**: Recommendations for new, biologically-based public exposure standards should not be derived from existing FCC/IEEE C95.1 thermal standards, which have other useful purposes but which are obsolete with respect to low-intensity, chronic exposure to new wireless technologies.

Respectfully submitted:

Cindy Sage, Co-Editor **David O. Carpenter, MD, Co-Editor**

The 2007 and 2012 BioInitiative Reports at www.bioinitiative.org are incorporated by reference.

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1. BioInitiative Working Group, Cindy Sage and David O. Carpenter, Editors. BioInitiative Report: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF) at www.bioinitiative.org, August 31, 2007.

2. BioInitiative Working Group, Cindy Sage and David O. Carpenter, Editors. BioInitiative Report: A Rationale for Biologically-based Public Exposure Standards for Electromagnetic Radiation at www.bioinitiative.org, December 31, 2012.

3. Yaniv Hamzany, Raphael Feinmesser, Thomas Shpitzer, Aviram Mizrachi, Ohad Hilly, Roy Hod, Gideon Bahar, Irina Otradnov, Moshe Gavish, Rafael M. Nagler. Is Human Saliva an Indicator of the Adverse Health Effects of Using Mobile Phones? *Antioxidants & Redox Signaling*, 2013; 18 (6): 622 DOI: 10.1089/ars.2012.4751

4. J.C. Lin. Cellular Mobile Phone Radiation and Intracranial Tumors. Health Effects. IEEE Microwave Magazine, June 2007.

5. J.C Lin. Update of IEEE Radio Frequency Exposure Guidelines. Health Effects. IEEE Microwave Magazine, April 2006. Footnote below.

"First and foremost, for the first time in its history, the new IEEE standard instituted an exclusion for the pinnae or the external ears by relaxation of the above-mentioned basic SAR restriction from 2 W/kg to 4 W/kg. This choice segregates tissues in the pinnae apart from all other tissues of the human head. Of equal significance is the basic restriction for localized exposure at 2 W/kg in terms of SAR averaged over any 10 g of tissue. The SAR value has been increased from 1.6 W/kg averaged over any 1 g of tissue to 2 W/kg over any 10 g of tissue. Aside from the numerical difference between the SARs, the volume of tissue mass used to define the SARs in the new standard was increased from 1 g to 10 g. ***The increase in tissue mass can have a profound influence on the actual quantityof RF energy allowed to be deposited in tissue by the new exposure standard.*** *It has been well established that the distribution of absorbed microwave energy is nonuniform, and it varies greatly from point to point inside a body.* ***An averaging volume that is as large as 10 g would tend to artificially flatten out the SAR distribution, whether it is computed or measured.*** *And the smoothing tends to substantially reduce the resulting SAR value.* ***Thus, a 10-g SAR at 2 W/kg could be equivalent to 1-g SARs of 5 W/kg or higher. Simply put, the absorbed energy averaged over a defined tissue mass of 10 g is inherently low compared to a 1-g SAR."*** *(emphasis added)*

EXHIBIT H

FCC 13-39

Before the Federal Communications Commission

Washington, D.C. 20554

In the Matter of

Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies	))))	ET Docket No. 13-84
Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields	))	ET Docket No. 03-137

To: Office of the Secretary
Federal Communications Commission , Washington, DC 20554

As officially presented in the Federal Register/ Vol. 78, No. 107 / Tuesday, June 4, 2013 / Proposed Rules. Federal Communications Commission, 47 CFR Parts 1, 2, 15, 24, 25, 27, 73, 90, 95, 97, and 101 [ET Docket Nos. 03–137 and 13–84; FCC 13–39], Reassessment of Exposure to Radiofrequency Electromagnetic Fields Limits and Policies, Federal Communications Commission

Reply filed by: Cindy Sage, MA and David O. Carpenter, Co-Editors, BioInitiative Reports 2007 and 2012.

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We have read comments submitted by the parties on 03-137 and 13-84, and submit the following Reply:

There is a broad consensus that new, biologically-based public safety limits for chronic exposure are warranted, given the scientific and public health evidence for health risks from low-intensity radiofrequency radiation exposures from wireless technology applications.

The existing FCC public safety limits are inadequate to protect public health given the proliferation of RF-emitting devices now in common usage.

We do not see a "broad consensus to adopt the Basic Restriction in IEEE C95.1-2005" for SAR and substituting a 10-gm tissue volume for the current 1-gm tissue volume for calculating SAR - except across the associated industry and corporate interests where it would be expected that these parties would promote the status quo regardless of impacts to public health.

Willful disregard by industries and regulators since at least 2007 of this scientific and public health evidence for health harm is no justification to keep existing and inadequate FCC public safety limits.

There is no reasonable basis for time-averaging and spatially averaging measured values as the sole basis for protection against health impacts of chronic exposure. Pulsed radiofrequency health impacts require the development of protective safety limits that control chronic exposure to peak exposures, not time-averaged exposures.

The biologically-relevant time period during which pulsed RF causes disruption of key biological processes should be the basis for determining acceptable safety limits. If biological systems register pulsed RF as a continuous insult (e.g., by expression of stress proteins or HSP, or by disruption of normal electrophysiology or neural synchrony, or by oxidative damage or mitochrondrial function disruption as examples) then the biologically relevant time period that cell membranes, cells and tissues respond to pulsed RF as a continuous insult must define the safety limit.

Some parties have commented 'RF levels in some places already exceed new recommendations by the BioInitiative Working Group and others. There is no justification that today's levels of RF must be tolerated because the wireless industry created them already; RF levels common today are creating intolerable health problems and should be rolled back. The evidence for health risks comes directly from thousands of published scientific and public health studies that increasing RF levels are producing 'epidemiologically-visible' health harm across very large populations of exposed people.

Regulators need to rethink safety limits now, even if it means rolling back 'RF exposure levels now commonly measured' to levels below those reported to cause biological effects and adverse health effects. It is precisely why this FCC process has been convened: to re-evaluate the RF health impacts and sufficiency of existing safety limits, and to change them in accord with the damage to health that is now established from the rollout of wireless technologies and the RF exposures they create. And, remember, corporate decisions to roll out wireless technologies over early scientific and public health objections and early evidence of health risk was simply a calculated risk. It was demonstrated at least as early as 2007 that the evolving evidence was sufficient to look for alternatives to wireless in communications and data transmission. Market decisions that ignored such possible health risks do not today deserve to be rewarded at the expense of public health. Further, it is not in the public interest to continue to market technologies that will worsen out-of-control US healthcare costs.

CTIA comments that *"CTIA strongly supports the Commission's decision in the First R&O to classify the pinna as an extremity based on the expert determinations of the FDA and of the IEEE, and the Commission's conclusion that this specification has no practical effect on human exposure to RF energy permitted by the FCC's rules."* There is no justification for this conclusion since placing a wireless transmitting device (e.g., a cell or cordless phone) against the pinna of the ear also exposes the highly sensitive brain and eyes to excessive pulsed RF. which has already resulted in increased risk for malignant brain tumors, acoustic neuromas, parotid gland tumors and some reports of uveal melanoma. Reclassifying the pinna of the ear as an extremity will greatly increase RF exposures not just within the pinna, but also critical tissues and organs in proximity - the brain, the skin, the eyes, the underlying nerves, blood vessels, salivary glands and tissues. It is already demonstrated that EXISTING RF exposures are linked to increased risk of some cancers. Reclassifying the pinna of the ear as an extremity is an extreme way to make legal what the industry needs to deploy new and more powerful cell phones and other wireless devices; and to cover themselves from liability where cell phones today don't always comply with existing SAR limits in the manner they are commonly used by consumers.

Utility Telecom Commission (UTC) argues for a categorical exemption for routine RF testing for wireless utility meters.

> *"Specifically with regard to categorical exclusion, the Commission should clarify that low power fixed transmitters -- such as those that utilities and other CII use for advanced metering infrastructure (AMI), multiple address systems (MAS) and supervisory control and data acquisition (SCADA) – are categorically excluded from routine evaluation. These devices operate at low power and typically only transmit when they are polled by the associated master station or network node. As such, they pose little or no risk of exceeding the RF exposure limits, especially when a time average measurements are conducted. Similarly, bidirectional amplifiers that are used to extend coverage within a building should also be categorically excluded, due to their low power and minimal risk of causing excessive RF exposure.15 Alternatively, the power limits proposed for categorical exclusion in Section 1. 1307(b)(1)(ii) should be revised upward to clearly encompass bi-directional amplifiers. Finally, and consistent with the Commission's Report and Order, any new rules should not require licensees to conduct routine evaluations for devices that were licensed before the rules go into effect.16"*

We oppose UTCs request for a categorical exclusion of these facilities from routine RF evaluation. UTC ignores the evidence that such meters emit RF pulses far more frequently because they are 'hand-shaked' every few seconds by the mesh networks to which they are tied (about <u>90% more transmissions</u> than estimated for 'polling' alone), and not just when 'polled' for information (about 10% of transmissions based on testimony by PG&E to the California Public Utilities Commission for the OWS NIC514).

UTC also ignores the evidence that wireless utility meters <u>can violate existing FCC safety limits</u> when the 100% duty cycle requirement for 'uncontrolled public access' is properly applied within FCC OET 65 Equations 6 and 10 (Sage, 2011). UTC errs in assuming that "*they pose little or no risk of exceeding the RF exposure limits*". Further, diluting the RF exposure of millisecond bursts by time-averaging makes a mockery of testing procedures. Pulsed RF has biological effects from millisecond RF bursts that last longer than the interval between these RF emissions; thus the biological insult is continuous (chronic exposure). Time-averaging simply gives the appearance of diluting these biologically-important exposures to extinction.

These devices are frequently placed within mere centimeters of occupied space in family homes, and in businesses that have inside electric meters on walls close to where patrons (including their children) spend time. Considering that perhaps 2-3% of wireless utility meters (electric meters) are completely accessible and closer than 20-40 cm (uncontrolled public access by definition) and there are likely to be 300 to 400 million ‘smart meters’ installed; this would mean about 6 million to 12 million meters would place people in situations where there are significant RF exposures, there is no warning signage, there is complete access to touch or place the face close to the meter (to read the digital output information) and depending on whether it is one meter, or a bank of meters mounted together – this situation demands both routine environmental testing for every meter type, and it demands that the distancing exclusions be eliminated from the FCC’s proposed actions.

We also oppose the proposed new standardized measures for separation distance that could exempt many of these devices,

Distance Exemptions: More realistic provisions must be developed regarding distancing from RFR transmitters (wireless devices, wireless access points and routers, baby monitors, wireless utility meters, etc) for infants and children who cannot reasonably be expected to observe FCC rules for 20 cm or 40 cm separation. The basis for exemptions from routine evaluations (Appendix C – fixed, mobile or portable RF sources) assumes conservative derivations or worst- case predictions leading to “*minimal likelihood for the exposure limits for the general public to be exceeded*” based on faulty logic about what can be expected with regard to the general public knowing or being able to avoid breaching an arbitrary 20 cm or 40 cm distances.

Compliance Testing: Realistic assumptions about operation of wireless utility meter devices (‘smart meters’) should be mandatory in FCC testing and issuance of Grants of Authorization. FCC testing labs ignore the obvious two-antenna or three-antenna design of wireless utility meters, yet issue ‘Conditions’ for compliance that specify “*this compliance test is issued with the condition that the antenna may not operate in conjunction with other antennas*”. The FCC cannot reasonably issue Grants of Authorization based on lab testing that ignores typical construction of the device, and how in common practice it is installed and operated.

Cumulative Effects: Cumulative effects of RFR exposures from multiple wireless devices and environmental exposures are not sufficiently addressed, measured or tested under current or proposed FCC rules. The 2008 NAS Report on Research Needs for Wireless Device summarizes deficiencies for wireless effects on children, adolescents and pregnant women; wireless personal computers and base station antennas; multiple element base station antennas under highest radiated power conditions; hand-held cell phone compliance testing; and better dosimetric absorbed power calculations using realistic anatomic models for both men, women and children of different height and ages. Realistic assessments of cumulative RFR exposures need to be addressed, taking into account the high variability in environmental situations; and safety buffers below 'effects levels' need to be built into new FCC public safety limits.

100% Duty Cycle: FCC OET 65 should make clear that a 100% duty cycle will continue to be required in calculations of power density 'where the public cannot be excluded'.

CTIA's comments dispute and distort the basis, intent and result of the World Health Organization IARC classification of RF as a Group 2B Possible Human Carcinogen. CTIA recklessly disregards human health with its twisted representation of the IARC classification. If anything CTIA's arrogant attempt to downplay the IARC classification is the real distortion of fact here, not that IARC's work has left the issue "*vulnerable to distortion by alarmists*". IARC could have reviewed the science on RF health impacts and voted it a Group 4 (Not a Carcinogen) if what CTIA maintains is that wireless RF is safe. They did not. IARC could have voted RF as a Group 3 (Insufficient Evidence) but they did not. IARC found there to be sufficient scientific evidence to classify RF as a Group 2B Possible Human Carcinogen, and all the dancing around CTIA does to undermine this in the eyes of the Commission is a cynical dodge favoring the industry members for whom CTIA is chief lobby.

IEEE's justification for reclassifying the pinna of the ear is based on thermal injury alone, and this is an outdated and irrelevant measure of health harm (IEEE C95.1-2005).

The Mobile Manufacturers Forum comment on proposed reclassification of the pinna of the ear as an extremity "*just as for hands, wrists and limbs where there are no major organs subject to RF exposure*" defies belief. Clearly, has MMF no knowledge of basic physiology to say that the human eyes, brain, skin, glands of the throat and neck, and interconnecting nerves are not 'major organs'?

In a spectacular gaff, a staff representative for Hammett and Edison, Inc recently testified in a municipal proceeding on behalf of AT&T (September 2013) that "boiled vegetables" are a Group 2B Possible Human Carcinogen. It would be a laughable mistake except when one considers that the 'expert' in question who misspoke represents one of the most active engineering firms that represents dozens of site applications for major telecom siting companies. But it is another demonstration that engineering firms often do not have the biological or health credentials and knowledge to make rules on health risks and safety limits, nor do they accurately depict the recent IARC classification. Rather, they issue the oft-heard dismissal that the 300+ listed Group 2B carcinogens also include pickled vegetables, coffee and talcum - rendering any other listings like RF a trivial issue by association. But, usually they trivialize it more accurately.

Hatfield and Dawson Engineers commented that "*(B)oth the IEEE and NCRP guidelines were developed by scientists and engineers with a great deal of experience and knowledge in the area of RF biological effects*". Nothing could be further from the truth in this matter. Engineers are not experts in biology, and certainly have failed to recommend RF public safety limits and maximum permissible exposures in line with established biological effects and related health harm from low-intensity, chronic RF exposures in all prior IEEE C95.1 proceedings that use 'thermal injury' as a basis for defining permissible exposures for the public.

Motorola Solutions Inc. comments support the existing FCC standards. It is another example where industry is telling the FCC they like the existing (and inadequate) safety standards just as they are – although they probably did not intend the irony here.

> "*(A)s the Commission reviews its RF exposure policies, it should begin from the understanding that the current system is working. The Commission's policies have enabled the rapid development and widespread adoption of wireless technologies in the United States in a manner that is safe and sustainable.*"

The current system is working well <u>for industry</u>. The current system has enabled <u>the rapid development and widespread adoption of wireless technologies</u> for industry benefit - to keep on track with wireless marketing strategies. The current FCC limits suit the industry, and now the industry wants bigger exclusions and higher exposure limits to keep rolling out new wireless technologies.

The current system is NOT WORKING for consumers who suffer health harm from wireless technologies, nor is it working for Americans whose health care costs are already exorbitant and who are suffering from the inavailability of medical insurance. The current system is <u>not sustainable and certainly not safe</u>. This is a positive assertion of safety of wireless devices from Motorola Solutions. It is contradicted by Motorola's own RF health warnings on cell phones that they issued for years in the fine print of cell phone owners' manuals.

CTIA has commented that "(*B)y continuing a pro-competitive, deregulatory environment for wireless service and directing the FCC to promulgate uniform RF emission standards, the 1996 Telecommunications Act codified the policy goals underlying the Commission's current RF regime. When adopting the current standards, the Commission noted that it sought to balance public safety with the goal of fostering wireless deployment, thus reflecting the directives of the 1996 Act. The growth of the wireless industry since 1996 attests to the Commission's success in striking the right balance.*"

In fact, the scientific evidence is more than sufficient in 2007, and certainly in 2012 (www.bioinitiative.org) that the Commission has not struck the right balance between uncontrolled wireless rollout and health impacts resulting for Americans, particularly for children. The increased risk for cancers, neurological diseases, memory and learning impairment in children, and other serious medical problems associated with wireless technologies and chronic exposure to low-intensity RF are now clearly available to the Commission.

Respectfully submitted:

Cindy Sage, MA and David O. Carpenter, MD

EXHIBIT I

BioInitiative 2012

A Rationale for Biologically-based Exposure Standards for Low-Intensity Electromagnetic Radiation

Report Updated in 2014 and 2017

Comment to the FCC on Docket 16-421 on Streamlining for Small Cell (Antenna) Rollout By Relaxing the Rules for Siting

February 1st, 2017

The FCC is proposing to 'streamline' the permitting process for small wireless facilities, without completing its investigation of RF health effects of low-intensity radio frequency radiation. This fact alone argues against the FCC speeding and easing the approval of millions of new 'small cell' wireless antenna sites under **Docket 16-421**. It also argues against permitting thousands of new satellite RF sources (Boeing **Docket No. 16-1244,** SAT-LOA-20160622-00058). Health consequences have not been identified nor been factored into public safety limits. This is particularly true for the new 5G wireless technologies using millimeter wave frequencies (~28 GHz to ~71 GHz) that will be transmitted by small cells in the future. It is also the responsibility of the FCC to formally recognize and act to reduce the health impacts of wireless infrastructure. The FCC proposal only speaks to promoting and expediting new RF sources under the guise of preventing *'unnecessarily time-consuming and costly siting review processes*" while ignoring the duty to adopt new public safety limits that are biologically relevant.

Read More (PDF)

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FCC 16-421

Before the Federal Communications Commission

Washington, D.C. 20554

In the Matter of

STREAMLINING DEPLOYMENT OF SMALL CELL	*)*	FCC Docket 16-421
INFRASTRUCTURE BY IMPROVING	*)*	
WIRELESS FACILITIES SITING POLICIES	*)*	

To: Office of the Secretary
Federal Communications Commission, Washington, DC 20554

Date: 6 February 2017

Comment filed by: Cindy Sage, MA, Lennart Hardell, MD, PhD and David O. Carpenter on behalf of the BioInitative Working Group.

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The BioInitiative Working Group Comment on
FCC Docket 16-421 - STREAMLINING DEPLOYMENT OF SMALL CELL INFRASTRUCTURE BY IMPROVING WIRELESS FACILITIES SITING POLICIES

The FCC is proposing to streamline the process for small wireless facility permitting, without completing its investigation of RF health effects of low-intensity radiofrequency radiation (Docket No. 13-39, Docket No 13-84 - In the Matter of Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies and Docket No. 03-137 Regarding Human Exposure to Radiofrequency Electromagnetic Fields). This fact alone argues against the FCC speeding and easing the approval of millions of new 'small cell' wireless antenna sites under **Docket 16-421**. It also argues against permitting thousands of new satellite RF sources (Boeing **Docket No. 16-1244,** SAT-LOA-20160622-00058).

Health consequences have not been identified nor been factored into public safety limits. This is particularly true for the new 5G wireless technologies using millimeter wave frequencies (~28 GHz to ~71 GHz) that will be transmitted by small cells in the future. Adey (1993) warns:

> *"Biomolecular and cell research in this spectral region has been meager. There may be special significance to biomolecular interactions with millimeter wave EM fields. At frequencies within the range 10-1,000 GHz, resonant vibrational or rotational interactions, not seen at lower frequencies, may occur with molecules or portions of molecules."*
> *" Grundler and Kaiser (1992) have shown that growth appears finely "tuned" to applied field frequencies around 42 GHz, with successive peaks and troughs at intervals of about 10 MHz. In recent studies, they noted that the sharpness of the tuning increases as the intensity of the imposed field decreases; but the tuning peak occurs at the same frequency when the field intensity is progressively reduced. Moreover, clear responses occur with* ***incident fields as weak as 5 picowatts/cm2." (emphasis added)***

New public safety limits taking into account non-thermal, low-intensity effects of chronic exposure to 900 MHz to the low GHz frequencies are vitally needed but the FCC has failed to complete this step. There is no basis for the FCC to make a positive assertion of safety of existing RF levels to which the public is perpetually exposed. Certainly unaddressed health concerns should stop the FCC from expediting new wireless technologies facilitating new small cell siting and satellite RF sources. The existing FCC public safety limits are grossly inadequate to protect public health from the body burden of the existing proliferation of RF-emitting devices and the wireless infrastructure supporting them, let alone from new RF sources that will make the situation worse for public health. There is a broad consensus that new, biologically-based public safety limits for chronic exposure are warranted, given the scientific and public health evidence for health risks from low-intensity radiofrequency radiation exposures from wireless technology applications (BioInitiative 2007 and 2012 Reports, accessed at www.bioinitiative.org).

The 2008 NAS Report on Research Needs for Wireless Device summarizes deficiencies for wireless effects on children, adolescents and pregnant women; wireless personal computers and base station antennas; multiple element base station antennas under highest radiated power conditions; hand-held cell phone compliance testing; and better dosimetric absorbed power calculations using realistic anatomic models for both men, women and children of different height and ages. Realistic assessments of cumulative RF exposures need to be addressed, taking into account the high variability in environmental situations; and safety buffers below 'effects levels' need to be built into new FCC public safety limits. The FCC has failed to do so. Instead the agency has sold off new spectrum, fails to complete its open reviews on RF health effects, and now proposes to fast-track application procedures for new RF sources.

The FCC ignores studies establishing human health harm at currently permissible exposure levels. The National Toxicology Program under the National Institutes of Health has completed the largest-ever animal study on cell phone radiation and cancer. The relationship between radiofrequency radiation and cancer is clearly established. Dr. John Bucher, Associate Director of the NTP and the lead researcher on this study confirmes that the exposure of 1.5 W/Kg is lower than currently allowed for the public, including children, under FCC public safety limits. Testing on rats is standard in predicting human cancers.

The NTP results confirm that cell phone radiation exposure levels within the currently allowable safety limits are the "likely cause" of brain and heart cancers in these animals. Tumors called schwannomas were induced in the heart. Hyperplastic lesions and glial cell neoplasms of the heart and brain observed in male rats are considered likely the result of whole-body exposures to GSM- or CDMA-modulated RFR. One in twelve (12) male rats developed either malignant cancer (glioma) and rare heart tumors. Pre-cancerous lesions were observed that can lead to cancer. The NTP says it is important to release these completed findings now given the implications to global health. No cancers occurred in the control group. The animal study confirms prior findings in epidemiological studies of an increased risk for glioma and acoustic neuroma among people that use wireless phones, both cell phones and cordless phones (DECT). Acoustic neuroma is a type of Schwannoma, so interestingly this study confirms findings in humans of increased risk for glioma and acoustic neuroma. This supports upgrading the risk in humans to Group 1, the agent is carcinogenic to humans. The NTP evidence has filled the gap on animal toxicity of RF, and has greatly strengthening the evidence of risk for humans. It is sufficient to reclassify cell phone radiation as a known cancer-causing agent, and confirms the inadequacy of existing public safety limits.

The FCC needs to consider mounting evidence that even Wi-Fi level exposures are reported to cause DNA damage, brain damage and heat-shock protein (Dushmukh et al, 2017). The authors report statistically significant effects of subchronic low level microwave radiation (MWR) on cognitive function, heat shock protein 70 (HSP70) level and DNA damage in brain of Fischer rats. Experiments performed on male Fischer rats exposed to microwave radiation for 90 days at three different frequencies: 900, 1800, and 2450 MHz. Animals were exposed to microwave radiation at 900 MHz and specific absorption rate (SAR) 0.0005953 W/kg; animals exposed to 1800 MHz at SAR 0.0005835 W/kg and animals exposed to 2450 MHz at SAR 0.0006672 W/kg. <u>These exposures are roughly equivalent to 1.5 to 2 uW/cm2.</u> All the animals were tested for cognitive function using elevated plus maze and Morris water maze at the end of the exposure period and subsequently sacrificed to collect brain tissues. HSP70 levels were estimated by ELISA and DNA damage was assessed using alkaline comet assay. Results showed microwave exposure at 900-2450 MHz with SAR values as mentioned above lead to decline in cognitive function, increase in HSP70 level and DNA damage in brain. They conclude that low level microwave exposure at frequencies 900, 1800, and 2450 MHz may lead to hazardous effects on brain.

Evidence from microRNA studies at Wi-Fi intensities report damage, i.e., modulation of microRNA is presented by Dasdag et al. (2015a, 2015b) in new studies on 900 MHz cell phone radiation and 2450 MHz Wi-Fi levels of exposure. Dasdag et al. (2015b) report that very low intensity Wi-Fi exposures over a year-long period (24 hrs per day) at 141.4 uW/Kg (whole body SAR) and a maximum SAR of 7127 uW/Kg lowered activity of microRNAs in the brain of adult rats. Van den Hove et al. (2014) previously reported miR-107 as epigenetically-regulated miRNA linked to Alzheimer's disease and correlated with changes in neuronal development and neuronal activity.

The scientific evidence is more than sufficient in 2007, and certainly in 2012 (www.bioinitiative.org) that the Commission has not struck the right balance between uncontrolled wireless rollout and health impacts resulting for Americans, particularly for children. The increased risk for cancers, neurological diseases, memory and learning impairment in children, and other serious medical problems associated with wireless technologies and chronic exposure to low-intensity RF are now clearly available to the Commission.

The FCC should not approve streamlining the process for small wireless cell rollout, nor expedite any other approval process for siting of wireless facilities, nor grant exemptions for any RF source or low-power device or enabling network. The incremental increase in daily RF exposure already exceeds human health tolerance. Cumulative effects of RF exposures from multiple wireless devices and environmental exposures are not addressed at all; nor measured or tested under current or proposed FCC rules.

Respectfully submitted:

Cindy Sage, MA, Lennart Hardell, MD, PhD and David O. Carpenter, MD

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EXHIBIT J

5G: Great risk for EU, U.S. and International Health! Compelling Evidence for Eight Distinct Types of Great Harm Caused by Electromagnetic Field (EMF) Exposures and the Mechanism that Causes Them

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<u>Preface</u>

The document that follows was, in its original form, sent to many of the authorities of the European Union, in conjunction with other documents sent to the same people by a group of European scientists. It was in response two documents that were, in turn, written by Mr. Ryan and Dr. Vinciūnas responding to a large group of European and other international scientists expressing great concern about the safety of 5G. I was asked by the leaders of the group of scientists to write my own response to those two documents. Mr. Ryan made the statement that "There is consistent evidence presented by national and international bodies (International Commission on Non Ionising Radiation Protection - ICNIRP, Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) that exposure to electromagnetic fields does not represent a health risk, if it remains below the limits set by Council Recommendation 1999/519/EC1." In fact, that is <u>not</u> either the ICNIRP or SCENIHR position – their position, and similar positions have been taken by the U.S. FCC, FDA and the National Cancer Institute, is that the evidence is inconsistent or conflicting and therefore, in their view, no conclusions can be drawn. Some of these organization have also stated that there is no known mechanism by which effects can be produced. What is shown below is that there is a vast amount of evidence in the independent scientific literature that conflicts with both the conclusion about lack of demonstrated effects and the conclusion about lack of mechanism.

The European Commission, according to the Ryan and Vinciūnas documents and the U.S. National Cancer Institute, according to their web site, are both depending on the SCENIHR 2015 document to make judgments about EMF effects. Consequently, the reliability of SCENIHR 2015 is an essential element in determining the reliability of both of their assessments.

The document that is presented below, differs from the document that was emailed to EU authorities in three different ways: 1. The original document was sent as an email with multiple attachments. In this document attachments are simply provided as citations. The current document is a stand-alone document. 2. Some material is inserted to discuss positions taken by the U.S. FCC, FDA and National Cancer Institute, so as to be particularly relevant to the U.S. situation. 3. Substantial additional evidence is also provided.

The revised document contains six chapters followed by a citation list for the entire document:

Chapter 1: Eight Extremely Well-Documented Effects of Non-Thermal EMF Exposures: Role of Pulsations, Other Factors that Influence EMF Effects

Chapter 2: How Each Such EMF Effect Is Directly Produced via Voltage-Gated Calcium Channel Activation: Role of the Voltage Sensor in Producing the Extraordinary Sensitivity to EMF Effects

Chapter 3. Strong Evidence for Cumulative and Irreversible EMF Effects

Chapter 4. EMFs Including Wi-Fi May Be Particularly Damaging to Young People

Chapter 5: The Importance of the SCENIHR 2015 Document and the Many Omissions, Flaws and Falsehoods in That Document

Chapter 6: The Great Risks of 5G: What We Know and What We Don't Know

<u>Chapter 1. Eight Extremely Well-Documented Effects of Non-Thermal EMF Exposures: Role of Pulsations, Other Factors that Influence EMF Effects</u>

Both the earlier Ryan document and the more recent Arūnas document each fail to pay any attention to the extensive scientific literature that has been accumulated on non-thermal electromagnetic field (EMF) effects. The scientific consensus of independent scientists based on information accumulated over the last 7 decades is just the opposite of what each of them states. I am copying into this document, at the end of Chapter 1, a series of 8 extremely well-documented effects of such EMF exposure, together with a list of review articles, most of them being peer reviewed articles published in well respected journals in the PubMed database, *that have each reviewed a body of evidence demonstrating the existence of each such effect*.

What are the effects produced by non-thermal exposures to microwave frequency EMFs, where we have an extensive scientific literature? Each of the following effects has been documented in from 11 to 35 reviews, listed at the end of Chapter 1.

1. Three types of cellular DNA attacks, producing single strand breaks in the cellular DNA, double strand breaks in cellular DNA and oxidized bases in cellular DNA. Each of these DNA changes have roles in cancer causation and in producing the most important mutational changes in humans and other animals. Double stranded DNA breaks produce chromosomal breaks, rearrangements, deletions and duplications and copy number mutations; they also produce gene amplification, an important mechanism in cancer causation. Single strand breaks in cellular DNA cause aberrant recombination events leading to copy number mutations. Oxidized bases leading to point mutations. When these occur in somatic cells, they can each have roles in causing cancer. When these occur in germ line cells (and they have be shown to occur in sperm following EMF exposures), they cause the three most important types of mutations in future generations, chromosomal mutations, copy number mutations and point mutations. (19 different reviews documenting these types of cellular DNA damage)
2. A wide variety of changes leading to lowered male fertility, lowered female fertility, increased spontaneous abortion, lowered levels of estrogen, progesterone and testosterone, lowered libido (16 reviews). Human sperm count has dropped to below 50% of what used to be considered normal throughout the technologically advanced countries of the world [1]. Reproductive rates have fallen below replacement levels in every technologically advanced country of the world, with a single exception. These include every EU country, the U.S., Canada, Japan, South Korea, Taiwan, Singapore, Australia and New Zealand. Reproduction averages in these countries is about 73% of replacement levels according to 2015 or 2016 data. A study on mouse reproduction [2] showed that radio/microwave frequency EMF exposure at doses well within our current safety guidelines produced substantial dose-dependent decreases in reproduction within the first set of litters; further exposure produced dose-dependent complete or almost complete sterility that was found to be largely irreversible. When we have a technology that is universally present in these technologically advanced countries, that we know impacts reproduction, and reproduction has already dropped well below replacement levels, and we may be facing a catastrophic and irreversible decline in reproduction and there are more and more plans to expose us still further, don't you think that we should take note of the science? Mr. Ryan and Dr. Vinciūnas seem to be saying not at all. (Please note that the U.S. FCC and FDA also completely ignore this existential threat)
3. Neurological/neuropsychiatric effects (23 reviews). My own paper on this [3] and two earlier reviews cited in it found that there are whole series of repeatedly found EMF effects which have also become extremely widespread complaints in our technologically advanced societies, namely: sleep disturbance/insomnia; fatigue/tiredness; headache; depression/depressive symptoms; lack of concentration/attention/cognitive dysfunction; dizziness/vertigo; memory changes; restlessness/tension/anxiety/stress/agitation; irritability. These findings are not just based on

epidemiological findings but are also based on profound impacts of EMFs, at levels well within our safety guidelines, on brain structure and function and also on the mechanism of non-thermal EMF action discussed below. When we have these neuropsychiatric effects becoming more and more common in technologically advanced societies all over the world, and *we know each of these is caused EMF exposures*, shouldn't we take note of this relationship?

4. Apoptosis/cell death (13 reviews). The two most important consequences of large increases in apoptosis (programmed cell death) are in causation of the neurodegenerative diseases and lowered reproduction although there are others.

5. Oxidative stress/free radical damage (17 reviews). Oxidative stress has roles in all or almost all chronic diseases. It is reported to have essential roles in producing the reproductive effects and the attacks on cellular DNA and may also have roles in producing the neurological effects and some of the cancer-causing effects shown to be produced here by EMF exposures.

6. Widespread endocrine (that is hormonal) effects (11 reviews). The steroid hormone levels drop with EMF exposure, whereas other hormone levels increase with initial exposure. The neuroendocrine hormones and insulin levels often drop with prolonged EMF exposure, possibly due to endocrine exhaustion.

7. Increases in intracellular calcium ([Ca2+]i) levels following EMF exposure (14 reviews). Calcium signaling also increases following EMF exposure.

8. Cancer causation (35 reviews). Brain cancer, salivary cancer, acoustic neuromas and two other types of cancer go up with cell phone use. People living near cell phone towers have increased cancer rates. Other types of EMFs are also implicated. Short wave radio, radio ham operators and people exposed to radar all are reported to have increased cancer incidence. Perhaps most telling, heavy-long term cell phone users have the highest incidence of brain cancer and have predominantly cancer increases on the ipsilateral side of the head (the side they use their cell phones), as opposed to the contralateral side. I have an in press paper [7], focused not on whether EMFs cause cancer but rather on ***how*** they can cause cancer. The paper shows that "downstream effects" of the main target of the EMFs in the cells of our bodies, can cause cancer in 15 different ways, including increases in cancer initiation, promotion and progression. Progression effects include both tissue invasion and metastasis. Each of these cancer causation effects are caused via mechanisms produced by downstream effects of the main non-thermal EMF mechanism, as discussed in Chapter 2.

9. Therapeutic effects of such EMFs. Such EMFs when focused on a specific region of the body where there is some dysfunction and when used at specific intensities, can have therapeutic effects. In my 2013 paper [4], I cited 12 different reviews where EMF stimulation of bone growth was used therapeutically. There are something like 4000 papers on various therapeutic effects. Strangely, the telecommunications industry does not acknowledge these therapeutic effects, preferring rather to maintain the fiction that there are no non-thermal effects.

There is another set of reviews, 12 in this case, with each showing that pulsed EMFs are, in most cases, much more biologically active than are non-pulsed EMFs. This is particularly important because all wireless communication devices communicate via pulsations, making them potentially much more dangerous. It follows from this that if you wish to study the effects of Wi-Fi, cell phones, cordless phones, cell phone towers, smart meters or 5G, you had better study the real thing or at least something that pulses very much like the real thing. There are many studies that don't do this, but falsely claim to be genuine Wi-Fi, cell phone or cordless phone studies. Other factors that influence the occurrence of non-thermal EMF effects include the frequency being used, the polarization of the EMFs and the cell type being studied [4,5,8-11]. Furthermore there are intensity "windows" that produce maximum biological effects, such that both lower and higher intensities produce much less effect [5,8,9]. These window effect studies clearly show that dose-response curves are both non-linear and non-monotone, such that it is difficult or impossible to predict effects based on relative intensity even when all other factors are the same. The role of each of these factors is completely ignored by ICNIRP, SCENIHR, the U.S. FCC, FDA and National Cancer Institute as well as by many other industry-friendly groups. When each of these organizations concludes that "results are inconsistent" they are comparing studies based on superficial similarities but not on these demonstrated causal factors. What is being observed, therefore, is genuine biological heterogeneity, not inconsistency. It has been known since the beginning of modern science in the 16th century that how you do your studies is important in determining what results are obtained. How is it possible that ICNIRP, SCENIHR, the U.S. FCC, FDA and National Cancer Institute have forgotten this important fact?

The primary literature studies demonstrating roles of pulsation, frequency, polarization, cell type and intensity windows in determining biological effects are entirely dependent on having genuine effects to study. None of these studies could have been done without an effect to study. Consequently, the claims that there are no well-documented EMF effects are nonsense, based not only on the eight extremely well-documented effects summarized above, but also on the entire literature demonstrating the role of pulsation, frequency, polarization, cell type and intensity windows.

Now I haven't said anything about how these non-thermal EMF effects are produced. I am taking much of Chapter 2 from a recent paper [11].

Reviews each showing important health-related non-thermal effects of microwave frequency electromagnetic fields (EMFs).

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Specific effects and reviews each reporting the effect in multiple primary literature studies:

Cellular DNA damage: Single strand and double strand breaks in cellular DNA and oxidized bases in cellular DNA, leading to chromosomal and other mutational changes:

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Lowered fertility, including tissue remodeling changes in the testis, lowered sperm count and sperm quality, lowered female fertility including ovarian remodeling, oocyte (follicle) loss, lowered estrogen, progesterone and testosterone levels (that is sex hormone levels), increased spontaneous abortion incidence, lowered libido:

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23. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.

Apoptosis/cell death (an important process in production of neurodegenerative diseases that is also important in producing infertility responses):

1. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised. https://scholar.google.com/scholar?q=Glaser+naval+medical+microwave+radio-frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)
2. Tolgskaya MS, Gordon ZV. 1973. Pathological Effects of Radio Waves, Translated from Russian by B Haigh. Consultants Bureau, New York/London, 146 pages.
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7. Yakymenko I, Sidorik E. 2010 Risks of carcinogenesis from electromagnetic radiation and mobile telephony devices. Exp Oncol 32:729-736.

8. Yakimenko IL, Sidorik EP, Tsybulin AS. 2011 [Metabolic changes in cells under electromagnetic radiation of mobile communication systems]. Ukr Biokhim Zh (1999). 2011 Mar-Apr;83(2):20-28.
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12. Asghari A, Khaki AA, Rajabzadeh A, Khaki A. 2016 A review on Electromagnetic fields (EMFs) and the reproductive system. Electron Physician. 2016 Jul 25;8(7):2655-2662. doi: 10.19082/2655.
13. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.

Oxidative stress/free radical damage (important mechanisms involved in almost all chronic diseases; direct cause of cellular DNA damage):

1. Raines, J. K. 1981. Electromagnetic Field Interactions with the Human Body: Observed Effects and Theories. Greenbelt, Maryland: National Aeronautics and Space Administration 1981; 116 p.
2. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.
3. Hazout A, Menezo Y, Madelenat P, Yazbeck C, Selva J, Cohen-Bacrie P. 2008 [Causes and clinical implications of sperm DNA damages]. Gynecol Obstet Fertil ;36:1109-1117
4. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.
5. Desai NR, Kesari KK, Agarwal A. 2009 Pathophysiology of cell phone radiation: oxidative stress and carcinogenesis with focus on the male reproductive system. Reproduct Biol Endocrinol 7:114.
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17. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.

Endocrine, that is hormonal effects:

1. Glaser ZR, PhD. 1971 Naval Medical Research Institute Research Report, June 1971. Bibliography of Reported Biological Phenomena ("Effects") and Clinical Manifestations Attributed to Microwave and Radio-Frequency Radiation. Report No. 2 Revised. https://scholar.google.com/scholar?q=Glaser+naval+medical+microwave+radio-frequency+1972&btnG=&hl=en&as_sdt=0%2C38 (Accessed Sept. 9, 2017)
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10. Asghari A, Khaki AA, Rajabzadeh A, Khaki A. 2016 A review on Electromagnetic fields (EMFs) and the reproductive system. Electron Physician. 2016 Jul 25;8(7):2655-2662. doi: 10.19082/2655.
11. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.

Increased intracellular calcium: intracellular calcium is maintained at very low levels (typically about 2 X 10-9 M) except for brief increases used to produce regulatory responses, such that sustained elevation of intracellular calcium levels produces many pathophysiological (that is disease-causing) responses).

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7. Pall, ML. 2013. Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. J Cell Mol Med 17:958-965. doi: 10.1111/jcmm.12088.
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Pulsed EMFs are, in most cases much more biologically active than are non-pulsed EMFs. This is important because all wireless communication devices communicate via pulsations and because the "smarter" the devices are, the more they pulse because the pulsations convey the information. What should be obvious is that you cannot study such pulsation roles if there were no biological effects produced by such EMFs. *The pulsation studies alone tell us that there are many such EMF effects.*

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Cancer causation by EMF exposures:

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Each of these reviews, typically cite from 5 to over 100 primary literature citations, each showing that non-thermal EMF exposures produce the effect under which they are listed. It follows from this, that there are not only 11 or more reviews documenting each of these effects, but there is also a massive primary literature documenting these effects as well. It follows from this that the ICNIRP, FCC and International Safety Guidelines, which are entirely based only on thermal effects are inadequate and there have been petitions and other statements of international groups of scientists expressing great concern about this. *It follows that the ICNIRP, FCC and International safety guidelines are completely unscientific and cannot be relied upon to protect our safety.*

<u>Chapter 2: How Each Such EMF Effect Is Produced via Voltage-Gated Calcium Channel Activation: Role of the Voltage Sensor in Producing the Extraordinary Sensitivity to EMF Effects</u>

The Pall, 2013 [4] study showed that in 24 different studies (there are now a total of 26 [5]), effects of low-intensity EMFs, both microwave frequency and also lower frequency EMFs, could be blocked by calcium channel blockers, drugs that are specific for blocking voltage-gated calcium channels (VGCCs). There were 5 different types of calcium channel blockers used in these studies each thought to be highly specific, each structurally distinct and each binding to a different site on the VGCCs. *In studies where multiple effects were studied, all studied effects were blocked or greatly lowered by calcium channel blockers*. These studies show that EMFs produce diverse non-thermal effects via VGCC activation in many human and animal cells and even in plant cells where some similar calcium channels are involved [6]. Furthermore, many different effects shown to be produced in repeated studies by EMF exposures, including the effects discussed above, can each be produced by downstream effects of VGCC activation, via increased intracellular calcium $[Ca2+]i$, as discussed below.

Various EMFs act via VGCC activation, as shown by calcium channel blocker studies. These include microwave frequency EMFs, nanosecond pulse EMFs, intermediate frequency EMFs, extremely low frequency EMFs and even static electrical fields and static magnetic fields.

It is important to discuss why the VGCCs are so sensitive to activation by these low-intensity EMFs. Each of the VGCCs have a voltage sensor which is made up of 4 alpha helixes, each designated as an S4 helix, in the plasma membrane. Each of these S4 helixes has 5 positive charges on it, for a total of 20 positive charges making up the VGCC voltage sensor [5,8]. Each of these charges is within the lipid bilayer part of the plasma membrane. The electrical forces on the voltage sensor are extraordinarily high for three distinct reasons [5,8]. 1. The 20 charges on the voltage sensor make the forces on voltage sensor 20 times higher than the forces on a single charge. 2. Because these charges are within the lipid bilayer section of the membrane where the dielectric constant is about $1/120^{th}$ of the dielectric constant of the aqueous parts of the cell, the law of physics called Coulomb's law, predicts that the forces will be approximately 120 times higher than the forces on charges in the aqueous parts of the cell. 3. Because the plasma membrane has a high electrical resistance whereas the aqueous parts of the cell are highly conductive, the electrical gradient across the plasma membrane is estimated to be concentrated about 3000-fold. The combination of these factors means that comparing the forces on the voltage sensor with the forces on singly charged groups in the aqueous parts of the cell, the forces on the voltage sensor are approximately $20 \times 120 \times 3000 = 7.2$ million times higher [5,8]. The physics predicts, therefore, extraordinarily strong forces activating the VGCCs via the voltage sensor. It follows that the biology tells us that the VGCCs are the main target of the EMFs and the physics tells us why they are the main target. *Thus the physics and biology are pointing in exactly the same direction*.

We have, then, very strong arguments that the EMFs act directly on the voltage-sensor to activate the VGCCs. There are several other types of evidence, each providing important evidence supporting this view:

1. In a study published by Pilla [12], it was found that pulsed EMFs produced an "instantaneous" increase in calcium/calmodulin-dependent nitric oxide synthesis in cells in culture. What this study [12] showed was that following EMF exposure, the cells in culture, must have produced a large increase in [Ca2+]i, this in turn produced a large increase in nitric oxide synthesis, the nitric oxide diffused out of the cells and out of the aqueous medium above the cells into the gas phase, where the nitric oxide was detected by a nitric oxide electrode. This entire sequence occurred in less than 5 seconds. This eliminates almost any conceivable indirect effect, except possibly via plasma membrane depolarization. Therefore, it is likely that the pulsed EMFs are acting directly on the voltage sensors of the VGCCs and possibly the voltage-gated sodium channels, to produce the [Ca2+]i increase.

2. There are also additional findings pointing to the voltage sensor as the direct target of the EMFs. In addition to the VGCCs, there are also voltage-gated sodium, potassium and chloride channels, with each of these having a voltage sensor similar to those found in the VGCCs. Lu et al [13] reported that voltage gated sodium channels, in addition to the VGCCs were activated by EMFs. Tabor et al [14] found that Mauthner cells, specialized neurons with special roles in triggering rapid escape mechanisms in fish, were almost instantaneously activated by electrical pulses, which acted via voltage-gated sodium channel activation to subsequently produce large [Ca2+]i increases. Zhang et al [15] reported that in addition to the VGCCs, potassium and chloride channels were each activated by EMFs, although these other voltage-gated ion channels had relatively modest roles, compared with the VGCCs, in producing biological effects. Each of these three studies [13-15] used specific blockers for these other voltage-gated ion channels to determine their roles. The Tabor et al [14] study also used genetic probing to determine the role of the voltage-gated sodium channels. Lu et al [13] also used whole cell patch clamp measurements to measure the rapid influx of both sodium and calcium into the cell via the voltage-gated channels following EMF exposure. Sodium influx, particularly in electrically active cells, acts in the normal physiology to depolarize the plasma membrane, leading to VGCC activation such that the voltage-gated sodium channels may act primarily via indirect activation of the VGCCs. In summary then, we have evidence that in animal including human cells, seven distinct classes of voltage-gated ion channels are each activated by EMF exposures: From Ref. [4], four classes of voltage-gated ion channels were shown from calcium channel blocker studies, to be activated by EMFs, L-type, T-type, N-type and P/Q –type VGCCs. In this paragraph we have evidence that three other channels are also activated, voltage-gated sodium channels, voltage-gated potassium channels and voltage-gated chloride channels. Furthermore the plant studies strongly suggest that the so called TPC channels, which contain a similar voltage sensor, are activated in plants allowing calcium influx into plants to produce similar EMF-induced responses [6]. In summary, then we have evidence for eight different ion channels being activated by EMF exposure, four classes of VGCCs, one class each of voltage-gated sodium, potassium and chloride channels and also one class of plant channel, with each of these channels having a similar voltage-sensor regulating its opening. One can put those observations together with the powerful findings from the physics, that the electrical forces on the voltage-sensor are stunningly strong, something like 7.2 million times stronger than the forces on the singly charged groups in the aqueous phases of the cell. Now you have a stunningly powerful argument that the voltage sensor is the predominant direct target of the EMFs.

3. The most important study on this subject, was published by Tekieh et al [16]. It showed that microwave frequency EMFs directly activate the VGCCs in isolated membranes. A variety of microwave frequencies were used in these studies and each such frequency produced VGCC activation in a completely cell-free system. This study clearly shows that the EMF activation of the VGCCs is direct and not due to some indirect regulatory effect.

How then does the estimated sensitivity of the voltage-sensor, about 7.2 million times greater forces than the forces on singly charged groups, compare with previous estimates of levels of EMF exposure needed to produce biological effects? The ICNIRP 2009 [17] safety guidelines allowed for 2 to 10 W/m^2 exposure, depending upon frequency. In contrast, the Bioinitiative Working Group 2007 [18] proposed a precautionary target level of 3 to 6 $\mu W/m^2$ or about a million-fold lower, using a safety factor of 10. If one uses a more commonly used safety factor of 50 to 100, then the 7.2 million-fold sensitivity of the voltage-sensor, predicted by the physics, falls right in the middle of the Bioinitiative Working Group 2007 calculations. So again, it can be argued that the physics and the biology are pointing in the same direction, in this case pointing to the same approximate range of sensitivity.

You may be wondering why I am spending so much time and space going through each of these studies. The answer is that a well over a trillion dollar (or trillion euro) set of industries, the telecommunications industry, has been putting out propaganda for over two decades, arguing that there cannot be a mechanism of action of these non-thermal EMFs to produce biological effects; and that these EMFs are too weak to do anything and that there only thermal effects are documented. It is essential to dot every **i** and cross every **t** with regard to the main mechanism of action of non-thermal effects. That is exactly what has been done here.

How Can the Diverse Effects of Such EMF Exposures Be Produced by VGCC Activation?

Fig. 1 How EMFs Act via VGCC Activation to Produce Various Effects

The mechanisms by which various effects can be generated by VGCC activation are outlined in Fig. 1. Going across the top of Fig. 1, it can be seen that increased intracellular calcium [Ca2+]i can increase nitric oxide (NO) synthesis, stimulating the NO signaling pathway (going to the right from top, center), to produce therapeutic effects. NO (very top) can also bind to cytochromes and inhibit their activity. NO binding to the terminal oxidase in the mitochondria inhibits energy metabolism and lowers, therefore, ATP. NO binding to cytochrome P450s, lowers synthesis of steroid hormones, including estrogen, progesterone and testosterone. The P450 lowering also lowers detoxification and vitamin D activity. Most of the pathophysiological effects are produced by the peroxynitrite/free radical/oxidative stress pathway center to lower right (Fig. 1) and also by excessive calcium signaling pathway (slightly left of center, Fig. 1). Some of the ways these are thought to produce various well-established EMF effects are outlined in Table 1.

Table 1. How Eight Established Effects of Wi-Fi and Other EMFs Can Be Produced by VGCC Activation

EMF effect	**Probable mechanism(s)**
Oxidative stress	Produced by elevated levels of peroxynitrite and the free radical breakdown products of peroxynitrite and its CO_2 adduct. Four studies of EMF exposure, cited in [4] showed that oxidative stress following exposure was associated with major elevation of 3-nitrotyrosine, a marker of peroxynitrite, thus confirming this interpretation. Two other studies each found 3-nitrotyrosine elevation, both following 35 GHz exposures [19,20].
Lowered male/female fertility, elevated spontaneous abortion, lowered libido	Both the lowered male fertility and lowered female fertility are associated with and presumably caused by the oxidative stress in the male and female reproductive organs. Spontaneous abortion is often caused by chromosomal mutations, so the germ line mutations may have a causal role. Lowered libido may be caused by lowered estrogen, progesterone and testosterone levels. It seems likely that these explanations may be oversimplified. One additional mechanism that may be important in producing lowered fertility is that VGCC activation and consequent high [Ca2+]i levels is known to have a key role in avoiding polyspermy. Consequently, if this if triggered before any fertilization of an egg has occurred, it may prevent any sperm from fertilizing and egg.
Neurological/ neuropsychiatric effects	Of all cells in the body, the neurons have the highest densities of VGCCs, due in part to the VGCC role and [Ca2+]i role in the release of every neurotransmitter in the nervous system. Calcium signaling regulates synaptic structure and function in 5 different ways, each likely to be involved here.

	Oxidative stress and apoptosis are both thought to have important roles. Lowered sleep and increased fatigue are likely to involve lowered nocturnal melatonin and increased nocturnal norepinephrine.
Apoptosis	Apoptosis can be produced by excessive Ca2+ levels in the mitochondria and by double strand breaks in cellular DNA; it seems likely that both of these mechanisms are involved following EMF exposure. A third mechanism for triggering apoptosis, endoplasmic reticulum stress (see bottom row in this Table), may also be involved.
Cellular DNA damage	Cellular DNA damage is produced by the free radical breakdown products of peroxynitrite directly attacking the DNA [7].
Changes in non-steroid hormone levels	The release of non-steroid hormones is produced by VGCC activation and [Ca2+]i elevation. The immediate effects of EMF exposures is to increase hormone release and to raise, therefore, hormone levels. However many hormone systems become “exhausted” as a consequence of chronic EMF exposures. The mechanism of exhaustion is still uncertain, but it may involve oxidative stress and inflammation.
Lowered steroid hormone	Steroid hormones are synthesized through the action of cytochrome P450 enzymes; activity of these hormones is inhibited by binding of high levels of nitric oxide (NO) leading to lowered hormone synthesis.
Calcium overload	Produced by excessive activity of the VGCCs; secondary calcium overload is produced by oxidative stress activation of TRPV1, TRPM2 and possibly some other TRP receptors, opening the calcium channel of these receptors.
Heat shock protein induction	There is a large literature showing that excessive [Ca2+]i induces very large increases in heat shock proteins. This is thought to be produced by complex calcium signaling changes involving the endoplasmic reticulum, mitochondria and the cytosol and also involving excessive [Ca2+]i producing increasing protein misfolding [21-23]. It should be noted that some calcium is essential for proper protein folding in the endoplasmic reticulum such that only excessive calcium leads to misfolding and consequent endoplasmic reticulum stress.

Each of the seven established EMF effects, discussed above, can be generated through the mechanisms outlined in Fig. 1, as shown by Table 1. An eighth, heat shock protein induction can also be so explained (Table 1). Several other such effects, including EMF causation of cataracts, breakdown of the blood-brain barrier, lowered nocturnal melatonin as discussed earlier [5]. The primary mechanism for therapeutic effects was discussed in [4,24,25]. Each of these also shown to be generated via such VGCC downstream effects. Fifteen mechanisms for EMF cancer causation are described in ref [7]; these are far too complex to describe in this document so the reader is referred to ref [7].

It can be seen, in summary, that we are far beyond the issue whether there are non-thermal EMF effects. Rather many researchers have identified many established effects of EMF exposure. The main direct targets of non-thermal EMF exposure, the VGCCs have also been identified and how these get activated by EMF exposure acting on the VGCC voltage-sensor has also been determined. And finally we have identified how a wide variety of these effects can be generated via downstream effects produced by such VGCC activation.

Our current safety guidelines are based only on heating (thermal) effects. Heating is produced predominantly by forces on singly charged groups in the aqueous phases of the cell but the forces on the voltage sensor are approximately 7.2 million times higher. Therefore, our current safety guidelines are allowing us to be exposed to EMFs that are approximately 7.2 million times too strong. That 7.2 million figure is somewhat similar to the estimate given by the Bioinitiative Report and by the Building Biologists, based on completely different considerations.

It should be obvious, that non-thermal EMFs:

1. Attack our nervous systems including our brains leading to widespread neuropsychiatric effects and possibly many other effects. This nervous system attack is of great concern.
2. Attack our endocrine (that is hormonal) systems. In this context, the main things that make us functionally different from single celled creatures are our nervous system and our endocrine systems – even a simple planaria worm needs both of these. Thus the consequences of the disruption of these two regulatory systems is immense, such that it is a travesty to ignore these findings.
3. Produce oxidative stress and free radical damage, which have central roles in all common chronic diseases.
4. Attack the DNA of our cells, producing single strand and double strand breaks in cellular DNA and oxidized bases in our cellular DNA. These in turn produce both cancer and mutations in germ line cells with germ line mutations producing mutations impacting future generations.
5. Produce elevated levels of apoptosis (programmed cell death), events especially important in causing both neurodegenerative diseases and infertility.
6. Lower male and female fertility, lowered sex hormones, lowered libido, increased levels of spontaneous abortion and, as already stated, attacks on the DNA in sperm cells.
7. Produce excessive intracellular calcium $[Ca2+]i$ and increased calcium signaling.
8. Act in the cells of our bodies via 15 different mechanisms to cause cancer.

By attacking all of these important systems in the body, EMFs attack everything we care about including our health (in many ways), our reproductive systems, the integrity of our genomes and our ability to produce healthy offspring.

There are 77 different reviews listed at the end of Chapter 1, with each documenting the existence of one or more of these various non-thermal EMF effects. What, then, do the two organization reports that the EU authorities and U.S. authorities rely upon, ICNIRP and SCENIHR 2015, have to say about these independent reviews. The answer is absolutely nothing! Neither one of them uses any of these independent reviews to assess EMF effects. This whole area is discussed in much more detail in Chapter 5, below.

Chapter 3. Strong Evidence for Cumulative and Irreversible EMF Effects

Two questions that must be raised about the effects of these low-intensity EMFs producing biological effects is are they cumulative and are they reversible? I am aware of several different types of evidence for cumulative effects and also for irreversible effects.

Three of the human occupational exposure studies from the 1970's reviewed in the Raines, National Aeronautics and Space Administration (NASA) study [26], showed that effects increased substantially with increasing time of exposure to a particular type and intensity of EMF. While these three studies each show cumulative effects but they provide no data on possible irreversibility of these neurological/neuropsychiatric effects. However the largest review of such occupational exposures (Hecht [28]) does provide substantial evidence on the cumulative nature and irreversibility of these neurological/neuropsychiatric effects.

Hecht [28] reviewed 60 different studies of occupational exposures that were done between 1960 and 1990 in the Soviet Union and East Germany. These were occupational exposure studies of over 3500 people, who were exposed to microwave frequency EMFs at intensities of less than 1/1000[th] of our safety guidelines. These studies [28] found that these EMFs produced neuropsychiatric effects similar to those found in my much more recent study [3], listed in Chapter 1 as well as on cardiac effects. Neither the neuropsychiatric findings nor the cardiac findings were unique however. Similar neuropsychiatric effects have been found to be caused by low intensity EMF exposures [27,29-34]. Cardiac effects have also been found in humans [26,29,30,32,34,35] similar to those found by Hecht [28].

Hecht [28] reports that exposures at those very low intensities for up to 3 years produced increased sympathetic nervous system activity, apparently in response to the EMF stress, following the classic stress sequence described by Hans Selye in 1953. No other effects were apparent during this circa 3 year period. However longer exposure produced observable neurological/neuropsychiatric and cardiac effects as well as other effects which were initially modest. Exposures of 3 to 5 years typically produced effects that could be largely reversed after 2 to 3 years in a no-EMF exposure environment. Hecht states that "if detected early, effective therapy is possible." However longer than 4 to 5 years exposures produced more severe effects which did not reverse when the persons were subsequently put into a no-EMF exposure environment. These and other effects continued to worsen with 10 years of exposure or longer. This cumulative nature of such EMF exposures was noted in two earlier reviews cited by Hecht et al [36,37]. These studies, then, provide very large amounts of evidence both for the cumulative nature of these neuropsychiatric effects, as well as the apparent irreversibility of these effects as they become more severe. Hecht also notes that "decline in health status increasingly amplifies EMF effects." This a pattern of increasing apparent sensitivity produced by previous exposure is similar to that described in the Western literature on electromagnetic hypersensitivity (EHS), something that Hecht recognizes [28]. EHS something that is discussed very briefly below in this section.

There are strong similarities between the Hecht [28] findings on microwave frequency EMFs in humans and the impacts of such EMFs on cellular and organ histology in rodents, as were reviewed in Tolgskaya and Gordon [38] and discussed in Pall [3]. In rodents, initially non-thermal exposures over periods of 1 to 2 months produced modest changes in structure of the brain and of the neurons. When such exposures ceased, most of the structural changes disappeared – that is the changes were largely reversible when the animals were place back into a no-EMF environment. However more months of exposure produced much more severe impacts on brain and neuronal structure and these were irreversible [38, 3]. More recent, Western country and other country studies cited in [3], provide much further support for brain impacts similar to those found in Soviet and also other country brain studies reviewed by Tolgskaya and Gordon[38]. Tolgskaya and Gordon [38.3] also reported findings that in histological studies, the nervous system was the most sensitive organ in the body, followed closely by effects on the heart and the testis, although many other organs were also impacted. Thus, the Tolgskaya and Gordon review [38,3] provides very important support for the findings of neurological/neuropsychiatric effects, the cardiac effects, discussed immediately above and below, and the reproductive effects discussed in Chapter 1. By comparing the animal studies with the human studies, one can see the striking similarities, with the major difference being that the effects in rodents are much more rapid than the effects on humans. Given the much higher metabolic rates in rodents and much lower life spans in rodents, the timing difference is not surprising. With regard to the issues of cumulative nature and irreversibility, both rodent and human studies provide strong support for both neurological and neuropsychiatric effects showing both cumulative nature and irreversibility and show a similar pattern of cumulative effects with the cardiac effects.

What are the cardiac effects discussed briefly above, that are produced by non-thermal microwave frequency EMF exposures? The effects include tachycardia (rapid heartbeat) where some people with apparent EHS, on blinded exposure to cordless phone radiation have instantaneous tachycardia, an effect that is also essentially instantaneously reversible on cessation of exposure [28,35,36]. So tachycardia can be an almost instantaneous response to EMFs and it is sometimes also found with arrhythmia. Prolonged exposures produce both arrhythmias and bradycardia (slow heart beat) [26-30,32]. Similar EMF cardiac effects were seen in animal studies, with the earliest of these going back to the late 1960s. Arrhythmias, especially when they are accompanied by bradycardia, are often associated with sudden cardiac death. We are having an epidemic of young, apparently healthy athletes dying in the middle of an athletic competition of apparent sudden cardiac death, which may, therefore be possibly caused by EMF exposures [39]. Some of these individuals have been saved from death [39] and subsequently found to be suffering from bradycardia and arrhythmias. Another type of cardiac effect is that when apparent EHS people are exposed to Wi-Fi, cell phone, cell phone tower or smart meter radiation, they are reported to suffer from heart palpitations. Each of these four types of cardiac effects, tachycardia, arrhythmias, bradycardia and heart palpitations involve aberrations in the electrical control of the heartbeat. How can these be produced?

The heartbeat is controlled by pacemaker cells in what is called the sino-atrial node of the heart. Those pacemaker cells have been shown to have very high densities of the T-type VGCCs which may make these cells particularly susceptible to direct effects of the EMFs (recall that EMFs act via VGCC activation). The T-type and the L-type types of VGCCs have essential roles in controlling the heartbeat. It follows that EMF exposures, acting directly on the pacemaker cells of the heart, can produce tachycardia responses. Furthermore, gene mutations in a VGCC gene that produce increased VGCC activity can produce both tachycardia and arrhythmia in young babies carrying those mutations; these young children die of sudden cardiac death at a very young age. How then do we get bradycardia? Bradycardia is produced when heart failure impacts the sino-atrial node, such that the dysfunction involved in heart failure, which is very complex, produces dysfunction of the pacemaker cells of the heart, producing bradycardia [40]. It follows from this that EMF-produced bradycardia and chronic arrhythmias are likely to be caused by heart-failure-like changes that particularly impact the sino-atrial node of the heart, including the tissue remodeling found in heart failure. This model has been confirmed by the findings of Liu et al [41], who found that pulsed microwave frequency EMF produced tissue remodeling that specifically impacted the sino-atrial node of the heart with remodeling changes similar to thoe found in heart failure [40]. Because heart failure develops in a cumulative fashion and is based on current medicine at least, an irreversible process involving tissue remodeling and a large number of other biochemical and physiological changes [41], it seems likely, therefore, that the EMF effects on the heart are both cumulative and irreversible.

You will recall, from the discussion at the beginning of Chapter 1, that there are 16 reviews documenting that EMF produces lowered fertility and that these act via diverse mechanisms. These include tissue remodeling changes in the testis, lowered sperm count and sperm quality, lowered female fertility including ovary remodeling and oocyte apoptosis, lowered estrogen, progesterone and testosterone levels (that is sex hormone levels), increased spontaneous abortion incidence, and lowered libido. We already have sperm count drops to below 50% of normal in every technologically advanced country on earth. We also have fertility drops to well below replacement levels in every technologically advanced country on earth, with one exception. Clinical observations argue that while there are sometimes technical fixes that allow some reproduction, infertility appears to be inherently irreversible. The Magras and Xenos [2] in mice, also discussed in Chapter 1 shows that radiofrequency radiation exposures well below our safety guidelines, produce immediate drops in mouse reproduction in the first litter. Further exposures to the same EMF levels produced a crash in reproduction essentially to zero, a crash that appeared to be essentially irreversible.

We don't know that humans will behave similarly to mice, although we do know that the EMFs produce the diverse effects on human reproduction listed in the previous paragraph. My prediction is that even if exposures level off where they are now, we will start seeing crashes in reproduction within about 5 years. If we go ahead with 5G, that crash may be almost instantaneous.

Mutation accumulation produced by cellular DNA damage is likely to be both cumulative and irreversible, as well, because later mutations are highly unlikely to reverse previously occurring mutations. It has been estimated that all we need to have is an increase in germ line mutation of 2 ½ to 3-fold, to become over time, extinct from the very high levels of mutations in each newborn. From the high levels of DNA damage produced in human sperm from common EMF exposures, we may be already well above that level.

It follows from this that we already face four existential threats produced by microwave frequency EMF exposures to the survival of every technologically advanced society on earth:

1. Cumulative and irreversible neurological/neuropsychiatric effects.
2. Cumulative and irreversible reproductive effects.
3. Cumulative and irreversible cardiac effects, leading to sudden cardiac death.
4. DNA effects in germ line, including sperm cells, leading to major impacts on our gene pool and high mutation frequencies.

Any one of these can destroy us on its own and with the ever increasing exposures and especially the vast increases in exposure that the 5G rollout will inevitably produce, that destruction is likely to be imminent. These don't even take into consideration the cancer effects, the hormonal effects or other effects produced by increased oxidative stress or increased apoptotic cell death. There is extraordinary evidence for each of these effects of EMF exposure which I have documented in 8 of these effects with the massive numbers of reviews documenting each of them.

The following information is derived from an abstract that I used for a talk at the Neuroscience 2016 meeting in Los Angeles, a meeting that was focused on Alzheimer's disease and similar dementias. The discussion here raises the question of whether Alzheimer's and other dementias may be still another set of irreversible diseases where cumulative effects of microwave frequency EMFs may have important causal roles. Dementias and other types of neurological deaths have had unexplained rapid recent increases [42-44]. The parallel between these increases and the increases in cell phone and other EMF exposures suggested that such exposures may cause dementia increases [45]. Reports show people circa age 30 developing Alzheimer's or other very early onset dementias and even younger people are reported to develop digital dementias, dementias caused by heavy use of digital devices [46-48]. One of the questions being raised here, is whether digital dementias are caused, at least in part, by the EMF exposures produced by these digital devices and the Wi-Fi fields involved in their usage, rather than solely by such things as screen time, as is often assumed. As you have seen in chapter 2, microwave and lower frequency EMFs act via activation of the VGCCs, leading to increases in intracellular calcium ([Ca2+]i) and downstream effects including increased Ca2+ signaling, NO, superoxide, peroxynitrite, free radicals, oxidative stress, NF-kappaB and mitochondrial dysfunction. Each of these downstream effects have been shown to have important roles in causing Alzheimer's disease and other neurodegenerative diseases [49-51]. These all suggest plausible mechanisms for action for EMFs causing Alzheimer's disease. Furthermore the amyloid-beta protein (Aβ) which has an specific causal role in AD is produced in increasing amounts by elevated [Ca2+]i, and small Aβ aggregates form Ca2+ channels in the plasma membrane and aggregates also raise [Ca2+]i via increased VGCC and RYRr activity, suggesting a vicious cycle between Aβ and [Ca2+]i in Alzheimer's disease. This argues that increased intacellular calcium levels, produced by the EMFs increases Aβ and increased Aβ increases intracellular calcium, quite possibly the central mechanism in causing Alzheimer's disease.

Five rodent studies support an EMF role in Alzheimer's disease. A series of short pulses of EMFs in young rats, produced the following in the equivalent of middle aged rats: elevated brain Aβ and oxidative stress; lowered cognition and memory [52.53]. 900 MHz exposures produces oxidative stress, increased Aβ and lowered miR-107, all found in AD brains [52-55]. There are many animal studies showing roles for [Ca2+]i through both VGCCs and RYRs in causing Alzheimer's disease in rodent models; these include studies with calcium channel blockers and studies of transgenic mice with varying VGCC and RYR expression. Very low EMF exposures can produce, however, protective responses [56,57]; this is not surprising because EMF therapy is thought to act via NO signaling and protein kinase G (see Fig.1, Chapter 2) and this pathway is reported to protect from Alzheimer's disease. Epidemiological studies have shown that exposure of humans of 50/60 Hz EMFs, which also act via VGCC activation, can cause elevated AD incidence [58,59]. However we have no similar studies for exposures to microwave/radiofrequency EMFs. In conclusion, a wide range of studies support the view that low intensity microwave frequency exposures acting via VGCC activation and [Ca2+]i, can produce increases in Aβ and other causal factors of Alzhimer's disease in humans and in animals and EMFs have been shown to produce Alzheimer's effects in rats.

These various findings on EMFs and Alzheimer's disease, the increasingly early onset of dementias and the occurrence of digital dementias, all suggest we may have another very high level threat caused by EMF exposures, possibly involving cumulative EMF effects and leading to severe, irreversible brain damage.

Chapter 4 EMFs Including Wi-Fi May Be Particularly Damaging to Young People

Most arguments that have been made that microwave frequency EMFs may be much more damaging to young children have centered on the much smaller skulls and skull thickness in young children, increasing the exposure of their brains to EMFs [60, 61]. However there are other arguments to be made. EMFs have been shown to be particularly active in producing effects on embryonic stem cells [62-71]. Because such stem cells occur at much higher cell densities in children, with stem cell densities the highest in the fetus and decreasing with increasing age [62, 63], impacts on young children are likely to be much higher than in adults. The decreased DNA repair and increased DNA damage following EMF exposure, in conjunction with the increased cell division in young children, strongly suggest that young children may be increasingly susceptible to cancer following such exposures [62-64, 71]. Two reviews discussed in the next chapter provide further evidence on higher cancer susceptibility of children. EMF action on stem cells may also cause young children to be particularly susceptible to disruption of brain development [66,71], something that may be relevant to autism causation. It is my belief that the role of [Ca2+]i in synapse development is also relevant to the possible EMF causation of autism. The Hecht review of Soviet occupational exposure studies [28] reports that "younger persons show a greater sensitivity to electromagnetic fields than adults." These are all very problematic issues and we cannot rule out the possibility that there are other problematic issues as well. Redmayne and Johansson [72] reviewed the literature showing that there are age-related effects, such that young people are more sensitive to EMF effects. It follows from these various findings that the placement of Wi-Fi into schools around the country and the not uncommon placing of cell phone towers on schools may well both be a high level threats to the health of our children as well being a threat to teachers and any very sensitive fetuses teachers may be carrying, as well. Mr. Barrie Trower, a retired military intelligence expert from the U.K. has been going around the world, at his expense, speaking against Wi-Fi in schools. His knowledge on this is based in part on classified information which he is unable to discuss, but has given him great concern.

<u>Chapter 5: The Importance of the SCENIHR 2015 Document and the Many Omissions, Flaws and Falsehoods in That Document</u>

One thing that I think we can all agree upon, is that the SCENIHR 2015 [73] document is an important document. The reason for its importance is that previous industry-friendly documents, and there have been many of them, have only reviewed very limited amounts of the literature on EMF effects. Consequently all of these other documents are open to the criticism that they have cherry picked what little data they have chosen to discuss. SCENIHR 2015 [73] has a reference list of almost 48 pages in length, going from page 233 to 280. So it appears that SCENIHR 2015 may have done a much more thorough and defensible review of the literature. Our assessement of SCENIHR 2015 [73] is important because of the confidence expressed in this document both by Mr. Ryan and Dr. Vinciūnas and also by the U.S. National Cancer Institute. The question that is being raised here is whether SCENIHR 2015 is thorough and defensible or not.

<u>The Speit/Schwarz Controversy: How SCENIHR Has Put Out Seven Falsehoods in Support of the Industry Progaganda Position</u>

I am going to start by discussing a single particularly important issue. At the end of Table 5 there is a claim that a 2013 study by Speit et al [74] was unable to replicate the findings of a 2008 study published by Schwarz et al [75]. In Table 5 they state further that Speit el al found "No effect on DNA integrity (MN) and DNA migration (comet); Repetition study of Schwarz et al, 2008." What is called loss of DNA integrity here, measured by formation of micronuclei (MN), is caused by the formation of double strand breaks in cellular DNA. The comet assay measures single strand breaks in cellular DNA. Schwarz et al [75] found strong evidence that there were large increases in both single strand and double strand breaks in cellular DNA following very low intensity exposures to a cell phone-like pulsed radiation, but SCENIHR claims that Speit et al [74] were unable to repeat the earlier study. Elsewhere (p.89, bottom) SCENIHR states that "By using the same exposure system and the same experimental protocols as the authors of the original study, they failed to confirm the results. They did not find any explanation for these conflicting results (Speit et al, 2013)." A careful examination of both [74] and [75] finds the following: 1. Speit et al [74] used a lymphocytic cell line, HL-60; Schwarz et al [75] studied human fibroblasts. This is a big difference because, as we have already said, different cell types behave differently. 2. Speit used 1800 MHz radiation; Schwarz used 1950 MHz radiation (the frequency of UMTS, also called 3G). Again we have a potentially important difference because effects are influenced by the frequency used. 3. Speit used a continuous wave EMF; Schwarz used a highly pulsed EMF, with high levels of both KHz and MHz pulsations to mimic the pulsation pattern of 3G cell phones. This is expected to produce very large differences between the two studies. 4. Speit used a reverberation exposure chamber; Schwarz did not use any exposure chamber. This could be another very large difference between the two studies, a difference that will be discussed toward the end of this chapter. 5. So where did the claim come from that Speit was trying to repeat the Schwarz study? Speit says in their paper that they were trying to repeat another study (not Schwarz) that was described in a report but was never published. 6. Speit does not even cite the Schwarz et al [75] paper, so obviously they did not intend to repeat Schwarz. We have then SCENIHR 2015 stating three multifaceted falsehoods that Speit et al [74] tried to repeat the earlier studies of Schwarz et al [75], that they were unable to repeat those Schwarz studies and that they used identical methodology to that used by Schwarz et al [75]. In addition to those three are four underlying falsehoods – namely that the two studies used very different methodologies, notably differing in the cell type studied, differing in the frequency used, differing widely in the in pulsations used and differing in the use of an exposure chamber. Each of these falsehoods are SCENIHR's not Speit's, *each of them can be easily seen to be false by even a superficial reading of these two papers*.

As you might guess, there is a major story behind all of this. The very low intensity exposure used in the Schwarz et al [75] study produced large numbers of DNA breaks, larger than that produced by 1600 chest X-rays. This conclusion can be made by comparing the results of Schwarz et al [75] with the earlier study of Lutz and Adlkofer [76]. From this comparison, it seems clear that non-ionizing radiation similar to 3G radiation can be much more dangerous to the DNA of our cells than is similar energy of ionizing radiation. When this was found, the industry went into attack mode, attacking the two Professors who collaborated in [75], Prof. Franz Adlkofer in Germany and Prof. Hugo Rüdinger in Austria. The first couple of years of these attacks have been described in some detail on pp 117-131 in Dr. Devra Davis' book Disconnect [77]. Before the SCENIHR 2015 document was drafted, it was clear that the publishers who had published Adlkofer's and Rüdinger's work, not just the Schwarz et al [75] study but other papers by the same research group, had long since rejected the industry propaganda claims. In addition. Adlkofer had won a lawsuit in the German courts against his main accuser. He has subsequently since won a second such lawsuit. The last paragraph on p.89 in SCENIHR 2015 is word for word industry propaganda. What is clear is that SCENIHR is wittingly or unwittingly serving as a propagandist for the industry in and that process, SCENIHR has no difficulty in putting forth seven obvious, individually important falsehoods.

One question that needs to be raised is how is it possible for microwave frequency EMFs to produce much more cellular DNA damage than a comparable energy level of ionizing radiation? Both ionizing radiation and microwave/lower frequency EMFs act via free radicals to attack the DNA. If you examine Fig. 2, Chapter 2, you will see how low intensity microwave frequency EMFs can act (circa p. 14). The free radicals that attack the DNA are breakdown products peroxynitrite.. The sequence of events leading to those free radicals starts, of course with the extraordinarily high sensitivity of the VGCC voltage sensor to the electrical forces of the EMFs that open the VGCC calcium channels. Following that there are three steps in the process leading to peroxynitrite elevation *each of which have high levels of amplification*. The first of these is that when the VGCC channels are open, they allow the influx of about a million calcium ion per second into the cell. The second amplification is that elevated intracellular calcium [Ca2+]i activates the synthesis of both nitric oxide (NO) and superoxide. The third amplification is that the formation of peroxynitrite is proportional to the product of nitric oxide concentration *times* the superoxide concentration. When you have three sequential amplification mechanisms, you can get a very large response, in this case free radical attack on cellular DNA, from a very small initial signal. That is where much of the existential crises are coming are from, with EMFs threatening the survival of every technologically advanced country on earth.

Going back to falsehoods perpetrated by SCENIHR regarding Speit/Schwarz, here are two possible interpretations for those seven falsehoods. One is that SCENIHR is simply an industry propaganda organ. The second is that we have a group of scientists SCENIHR who are largely incompetent and that it is just coincidence that these seven falsehoods serve the industry propaganda case. Either of these interpretations completely destroy the claims of confidence in SCENIHR that Mr. Ryan and Dr. Vinciūnas made in the documents they wrote that were referred to in the Preface of this document.

I have written here more than another 20 pages critiquing the SCENIHR 2015 [73] document. If you are already convinced that the SCENIHR claims that there are no established non-thermal EMF effects are false and that we have eight extremely well documented effects (Chapter 1) and that we have detailed mechanisms of how these effects are produced (Chapter 2), then I suggest you skip to the summary of this

Chapter 5 starting on p. 44 and then go on to the consider 5G in Chapter 6. If, however, you are not so convinced, you need to read the intervening 20 plus pages..

22 Reviews on EMF Effects, 20 of Which Are Ignored by SCENIHR, Two of Which Are Discussed in [73] but Essentially Dismissed

Now let's go on to consider how SCENIHR 2015 [73] considers the many independent reviews, listed in Chapter 1, which disagree with them and also fall into the 2009 through 2013 period that SCENIHR claims to have thoroughly considered. See Table 2.

Table 2: 2009 to 2013 Reviews that Should Have Been Cited and Discussed in SCENIHR 2015

Citation	Brief Summary	What does SCENIHR 2015 say about it?
[78] Khurana VG, Teo C, Kundi M, Hardell L, Carlberg M. 2009 Cell phones and brain tumors: a review including the long-term epidemiologic data. Surg Neurol 72:205-214.	Meta-analysis study of cell phone usage and brain cancer. The results indicate that using a cell phone for > or = 10 years approximately doubles the risk of being diagnosed with a brain tumor on the same ("ipsilateral") side of the head preferred for cell phone use. The data achieve statistical significance for glioma and acoustic neuroma but not for meningioma. CONCLUSION: The authors conclude that there is adequate epidemiologic evidence to suggest a link between prolonged cell phone usage and the development of an ipsilateral brain tumor.	Nothing. Review is not cited and not discussed.
[79] Desai NR, Kesari KK, Agarwal A. 2009 Pathophysiology of cell phone radiation: oxidative stress and carcinogenesis with focus on the male reproductive system. Reproduct Biol Endocrinol 7:114.	This review identifies the plasma membrane as a target of RF-EMW. In addition, the effects of RF-EMW on plasma membrane structures (i.e. NADH oxidase, phosphatidylserine, ornithine decarboxylase) and voltage-gated calcium channels are discussed. We explore the disturbance in reactive oxygen species (ROS) metabolism caused by RF-EMW and delineate NADH oxidase mediated ROS formation as playing a central role in oxidative stress (OS) due to cell phone radiation (with a focus on the male reproductive system). This review also addresses: 1) the controversial effects of RF-EMW on mammalian cells and sperm DNA as well as its effect on apoptosis, 2) epidemiological, in vivo animal and in vitro studies on the effect of RF-EMW on male reproductive system.	Nothing. Review is not cited and not discussed.
[80] Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.	Effects of cell phone exposure on the cardiovascular system, sleep and cognitive function, as well as localized and general adverse effects, genotoxicity potential, neurohormonal secretion and tumour induction. The proposed mechanisms by which cell phones adversely affect various aspects of human health, and male fertility in particular, are explained, and the emerging molecular techniques and approaches for elucidating the effects of mobile phone radiation on cellular physiology using high-throughput screening techniques, such as metabolomics and microarrays, are discussed. A novel study is described, which is looking at changes in semen parameters, oxidative stress markers and sperm DNA damage in semen samples exposed in vitro to cell phone radiation.	Nothing. Review is not cited and not discussed.
[81] Ruediger HW.	101 publications are exploited which have studied	Nothing.

2009 Genotoxic effects of radiofrequency electromagnetic fields. Pathophysiology. 16:89-102.	genotoxicity of radiofrequency electromagnetic fields (RF-EMF) in vivo and in vitro. Of these 49 report a genotoxic effect and 42 do not. In addition, 8 studies failed to detect an influence on the genetic material, but showed that RF-EMF enhanced the genotoxic action of other chemical or physical agents. Variation in results may in part be explained by the different cellular systems and from the variety of analytical methods being used. Taking altogether there is ample evidence that RF-EMF can alter the genetic material of exposed cells in vivo and in vitro and in more than one way. This genotoxic action may be mediated by microthermal effects in cellular structures, formation of free radicals, or an interaction with DNA-repair mechanisms.	Review is not cited and not discussed.
[82] Phillips JL, Singh NP, Lai H. 2009 Electromagnetic fields and DNA damage. Pathophysiology 16:79-88.	A major concern of the adverse effects of exposure to non-ionizing electromagnetic field (EMF) is cancer induction. Since the majority of cancers are initiated by damage to a cell's genome, studies have been carried out to investigate the effects of electromagnetic fields on DNA and chromosomal structure. Additionally, DNA damage can lead to changes in cellular functions and cell death. Single cell gel electrophoresis, also known as the 'comet assay', has been widely used in EMF research to determine DNA damage, reflected as single-strand breaks, double-strand breaks, and crosslinks. Studies have also been carried out to investigate chromosomal conformational changes and micronucleus formation in cells after exposure to EMF. This review describes the comet assay and its utility to qualitatively and quantitatively assess DNA damage, reviews studies that have investigated DNA strand breaks and other changes in DNA structure, and then discusses important lessons learned from our work in this area.	Nothing. Review is not cited and not discussed.
[83] Davanipour Z, Sobel E. 2009 Long-term exposure to magnetic fields and the risks of Alzheimer's disease and breast cancer: Further biological research. Pathophysiology 16:149-156.	Extremely low frequency (ELF) and radio frequency (RF) magnetic fields (MFs) pervade our environment. Whether or not these magnetic fields are associated with increased risk of serious diseases, e.g., cancers and Alzheimer's disease, is thus important when developing a rational public policy. Our objective was to provide an unbiased review of the current knowledge and to provide our general and specific conclusions. RESULTS: The evidence indicates that long-term significant occupational exposure to ELF MF may certainly increase the risk of both Alzheimer's disease and breast cancer. There is now evidence that two relevant biological processes (increased production of amyloid beta and decreased production of melatonin) are influenced by high long-term ELF MF exposure that may lead to Alzheimer's disease. There is further evidence that one of these biological processes (decreased melatonin production) may also lead to breast cancer. Finally, there is evidence that exposures to RF MF and ELF MF have similar biological consequences. CONCLUSION: It is important to mitigate ELF and RF MF exposures through equipment design changes and environmental placement of electrical equipment.	Nothing. Review is not cited and not discussed.
[84] Yakymenko I,	Latest epidemiological data reveal a significant increase in	Nothing.

Sidorik E. 2010 Risks of carcinogenesis from electromagnetic radiation and mobile telephony devices. Exp Oncol 32:729-736.	risk of development of some types of tumors in chronic (over 10 years) users of mobile phone. It was detected a significant increase in incidence of brain tumors (glioma, acoustic neuroma, meningioma), parotid gland tumor, seminoma in long-term users of mobile phone, especially in cases of ipsilateral use (case-control odds ratios from 1.3 up to 6.1). Two epidemiological studies have indicated a significant increase of cancer incidence in people living close to the mobile telephony base station as compared with the population from distant area. These data raise a question of adequacy of modern safety limits of electromagnetic radiation (EMR) exposure for humans. For today the limits were based solely on the conception of thermal mechanism of biological effects of RF/MW radiation. Meantime the latest experimental data indicate the significant metabolic changes in living cell under the low-intensive (non-thermal) EMR exposure. Among reproducible biological effects of low-intensive MWs are reactive oxygen species overproduction, heat shock proteins expression, DNA damages, apoptosis. Practical steps must be done for reasonable limitation of excessive EMR exposure, along with the implementation of new safety limits of mobile telephony devices radiation, and new technological decisions, which would take out the source of radiation from human brain.	Review is not cited and not discussed.
[85] Carpenter DO. 2010 Electromagnetic fields and cancer: the cost of doing nothing. Rev Environ Health 25:75-80.	Concern of health hazards from EMFs has increased as the use of cell phones and other wireless devices has grown in all segments of society, especially among children. While there has been strong evidence for an association between leukemia and residential or occupational exposure to ELF EMFs for many years, the standards in existence are not sufficiently stringent to protect from an increased risk of cancer. For RF EMFs, standards are set at levels designed to avoid tissue heating, in spite of convincing evidence of adverse biological effects at intensities too low to cause significant heating. Recent studies demonstrate elevations in rates of brain cancer and acoustic neuroma only on the side of the head where individuals used their cell phone. Individuals who begin exposure at younger ages are more vulnerable. These data indicate that the existing standards for radiofrequency exposure are not adequate. While there are many unanswered questions, the cost of doing nothing will result in an increasing number of people, many of them young, developing cancer.	Nothing. Review is not cited and not discussed.
[86] Giuliani L, Soffritti M (Eds). 2010 NON-THERMAL EFFECTS AND MECHANISMS OF INTERACTION BETWEEN ELECTROMAGNETIC FIELDS AND LIVING MATTER, RAMAZZINI INSTITUTE EUR. J. ONCOL. LIBRARY	Contains entire articles on: 1. Influence of mobile phone radiation on cognitive function. 2. Impact of DECT cordless phone radiation on heart rate variability and on the autonomic nervous system. 3 & 4. Two articles on the impact of radiofrequency radiation on the blood-brain barrier. 5 & 6. Two articles on microwave/radiofrequency radiation and cancer causation. 7. Epidemiological studies of EMF impact on human reproduction.	Nothing. Review is not cited and not discussed.

Volume 5, National Institute for the Study and Control of Cancer and Environmental Diseases "Bernardino Ramazzini" Bologna, Italy 2010, 400 page monograph.		
[87] Khurana, V. G., Hardell, L., Everaert, J., Bortkiewicz, A., Carlberg, M., Ahonen, M. 2010 Epidemiological evidence for a health risk from mobile phone base stations. Int. J. Occup. Environ. Health 16, 263-267.	We identified a total of 10 epidemiological studies that assessed for putative health effects of mobile phone base stations (cell phone antennae). 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.	Nothing. Review is not cited and not discussed.
[88] Levitt, B. B., Lai, H. 2010. Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays. Environ. Rev. 18, 369-395. doi.org/10.1139/A10-018	Both anecdotal reports and some epidemiology studies, reviewed in this study, 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. Cardiac effects were also reported. Symptoms reported 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.	Nothing. Review is not cited and not discussed.
[89] Kang N, Shang XJ, Huang YF. 2010 [Impact of cell phone radiation on male reproduction]. Zhonghua Nan Ke Xue 16:1027-1030.	With the popularized use cell phones, more and more concern has been aroused over the effects of their radiation on human health, particularly on male reproduction. Cell phone radiation may cause structural and functional injuries of the testis, alteration of semen parameters, reduction of epididymal sperm concentration and decline of male fertility. This article presents an overview on the impact of cell phone radiation on male reproduction.	Nothing. Review is not cited and not discussed.
[90] Yakymenko, I., Sidorik, E., Kyrylenko, S., Chekhun, V. 2011. Long-term exposure to microwave radiation provokes cancer growth: evidences from radars and mobile communication systems. Exp. Oncol. 33(2), 62-70.	The carcinogenic effect of MW irradiation is typically manifested after long term (up to 10 years and more) exposure. Nevertheless, even a year of operation of a powerful base transmitting station for mobile communication reportedly resulted in a dramatic increase of cancer incidence among population living nearby. In addition, model studies in rodents unveiled a significant increase in carcinogenesis after 17-24 months of MW exposure both in tumor-prone and intact animals. To that, such metabolic changes, as overproduction of reactive oxygen species, 8-hydroxi-2-deoxyguanosine formation, or	Nothing. Review is not cited and not discussed.

	ornithine decarboxylase activation under exposure to low intensity MW confirm a stress impact of this factor on living cells. We also address the issue of standards for assessment of biological effects of irradiation. It is now becoming increasingly evident that assessment of biological effects of non-ionizing radiation based on physical (thermal) approach used in recommendations of current regulatory bodies, including the International Commission on Non-Ionizing Radiation Protection (ICNIRP) Guidelines, requires urgent reevaluation. We conclude that recent data strongly point to the need for re-elaboration of the current safety limits for non-ionizing radiation using recently obtained knowledge. We also emphasize that the everyday exposure of both occupational and general public to MW radiation should be regulated based on a precautionary principles which imply maximum restriction of excessive exposure.	
[91] Yakimenko IL, Sidorik EP, Tsybulin AS. 2011 [Metabolic changes in cells under electromagnetic radiation of mobile communication systems]. Ukr Biokhim Zh (1999). 2011 Mar-Apr;83(2):20-28.	Review is devoted to the analysis of biological effects of microwaves. The results of last years' researches indicated the potential risks of long-term low-level microwaves exposure for human health. The analysis of metabolic changes in living cells under the exposure of microwaves from mobile communication systems indicates that this factor is stressful for cells. Among the reproducible effects of low-level microwave radiation are overexpression of heat shock proteins, an increase of reactive oxygen species level, an increase of intracellular Ca2+, damage of DNA, inhibition of DNA reparation, and induction of apoptosis. Extracellular-signal-regulated kinases ERK and stress-related kinases p38MAPK are involved in metabolic changes. Analysis of current data suggests that the concept of exceptionally thermal mechanism of biological effects of microwaves is not correct. In turn, this raises the question of the need to revaluation of modern electromagnetic standards based on thermal effects of non-ionizing radiation on biological systems.	Nothing. Review is not cited and not discussed.
[92] Gye MC, Park CJ. 2012 Effect of electromagnetic field exposure on the reproductive system. Clin Exp Reprod Med 39:1-9. doi.org/10.5653/cerm.2012.39.1.1 . Clin Exp Reprod Med 39:1-9. doi.org/10.5653/cerm.2012.39.1.1	The safety of human exposure to an ever-increasing number and diversity of electromagnetic field (EMF) sources both at work and at home has become a public health issue. To date, many *in vivo* and *in vitro* studies have revealed that EMF exposure can alter cellular homeostasis, endocrine function, reproductive function, and fetal development in animal systems. Reproductive parameters reported to be altered by EMF exposure include male germ cell death, the estrous cycle, reproductive endocrine hormones, reproductive organ weights, sperm motility, early embryonic development, and pregnancy success. At the cellular level, an increase in free radicals and [Ca(2+)]i may mediate the effect of EMFs and lead to cell growth inhibition, protein misfolding, and DNA breaks. The effect of EMF exposure on reproductive function differs according to frequency and wave, strength (energy), and duration of exposure. In the present review, the effects of EMFs on reproductive function are summarized according to the types of EMF, wave type, strength, and duration of exposure at cellular and organism levels.	Nothing. Review is not cited and not discussed.

[93] La Vignera S, Condorelli RA, Vicari E, D'Agata R, Calogero AE. 2012 Effects of the exposure to mobile phones on male reproduction: a review of the literature. J Androl 33:350-356.	The use of mobile phones is now widespread. A great debate exists about the possible damage that the radiofrequency electromagnetic radiation (RF-EMR) emitted by mobile phones exerts on different organs and apparatuses. The aim of this article was to review the existing literature exploring the effects of RF-EMR on the male reproductive function in experimental animals and humans. Studies have been conducted in rats, mice, and rabbits using a similar design based upon mobile phone RF exposure for variable lengths of time. Together, the results of these studies have shown that RF-EMR decreases sperm count and motility and increases oxidative stress. In humans, 2 different experimental approaches have been followed: one has explored the effects of RF-EMR directly on spermatozoa and the other has evaluated the sperm parameters in men using or not using mobile phones. The results showed that human spermatozoa exposed to RF-EMR have decreased motility, morphometric abnormalities, and increased oxidative stress, whereas men using mobile phones have decreased sperm concentration, decreased motility (particularly rapid progressive motility), normal morphology, and decreased viability. These abnormalities seem to be directly related to the duration of mobile phone use.	Nothing. Review is not cited and not discussed.
[94] Biointiative Working Group, David Carpenter and Cindy Sage (eds). 2012 Bioinitiative 2012: A rationale for biologically-based exposure standards for electromagnetic radiation. http://www.bioinitiative.org/participants/why-we-care/	Sections on EMF effects: SECTION 4: EVIDENCE FOR INADEQUACY OF THE STANDARDS SECTION 5: EVIDENCE FOR EFFECTS ON GENE AND PROTEIN EXPRESSION SECTION 6: EVIDENCE FOR GENOTOXIC EFFECTS – RFR AND ELF DNA DAMAGE SECTION 7: EVIDENCE FOR STRESS RESPONSE (STRESS PROTEINS) SECTION 8: EVIDENCE FOR EFFECTS ON IMMUNE FUNCTION SECTION 9: EVIDENCE FOR EFFECTS ON NEUROLOGY AND BEHAVIOR SECTION 10: EFFECTS OF EMF FROM WIRELESS COMMUNICATION UPON THE BLOOD-BRAIN BARRIER SECTION 11: EVIDENCE FOR BRAIN TUMORS AND ACOUSTIC NEUROMAS SECTION 12: EVIDENCE FOR CHILDHOOD CANCERS (LEUKEMIA) SECTION 13: EVIDENCE FOR EFFECTS ON MELATONIN: ALZHEIMER'S DISEASE AND BREAST CANCER SECTION 14: EVIDENCE FOR BREAST CANCER PROMOTION SECTION 15: EVIDENCE FOR DISRUPTION BY THE MODULATING SIGNAL SECTION 16: PLAUSIBLE GENETIC AND METABOLIC MECHANISMS FOR BIOEFFECTS OF VERY WEAK ELF MAGNETIC FIELDS ON LIVING TISSUE	Nothing. Review is not cited and not discussed.

	SECTION 17 EVIDENCE BASED ON EMF MEDICAL THERAPEUTICS SECTION 18: FERTILITY AND REPRODUCTION EFFECTS OF EMF SECTION 19: FETAL AND NEONATAL EFFECTS OF EMF SECTION 20: FINDINGS IN AUTISM CONSISTENT WITH EMF AND RFR	
[4] Pall, ML. 2013. Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects. J Cell Mol Med 17:958-965. doi: 10.1111/jcmm.12088.	The direct targets of extremely low and microwave frequency range electromagnetic fields (EMFs) in producing non-thermal effects have not been clearly established. However, studies in the literature, reviewed here, provide substantial support for such direct targets. Twenty-three studies have shown that voltage-gated calcium channels (VGCCs) produce these and other EMF effects, such that the L-type or other VGCC blockers block or greatly lower diverse EMF effects. Furthermore, the voltage-gated properties of these channels may provide biophysically plausible mechanisms for EMF biological effects. Downstream responses of such EMF exposures may be mediated through Ca(2+) /calmodulin stimulation of nitric oxide synthesis. Potentially, physiological/therapeutic responses may be largely as a result of nitric oxide-cGMP-protein kinase G pathway stimulation. A well-studied example of such an apparent therapeutic response, EMF stimulation of bone growth, appears to work along this pathway. However, pathophysiological responses to EMFs may be as a result of nitric oxide-peroxynitrite-oxidative stress pathway of action. A single such well-documented example, EMF induction of DNA single-strand breaks in cells, as measured by alkaline comet assays, is reviewed here. Such single-strand breaks are known to be produced through the action of this pathway. Data on the mechanism of EMF induction of such breaks are limited; what data are available support this proposed mechanism. Other Ca(2+) -mediated regulatory changes, independent of nitric oxide, may also have roles. This article reviews, then, a substantially supported set of targets, VGCCs, whose stimulation produces non-thermal EMF responses by humans/higher animals with downstream effects involving Ca(2+) /calmodulin-dependent nitric oxide increases, which may explain therapeutic and pathophysiological effects.	This was cited. Sole statement is: “(see Pall, 2013 for a review of studies suggesting effects through voltage-gated calcium channels).” None of the important implications listed on the left are used in any way in the rest of the SCENIHR 2015 document See text for further discussion..
[95] Nazıroğlu M, Yüksel M, Köse SA, Özkaya MO. 2013 Recent reports of Wi-Fi and mobile phone-induced radiation on oxidative stress and reproductive signaling pathways in females and males. J Membr Biol 246:869-875.	The aim of the study was to discuss the mechanisms and risk factors of EMR changes on reproductive functions and membrane oxidative biology in females and males. It was reported that even chronic exposure to EMR did not increase the risk of reproductive functions such as increased levels of neoantigens abort. However, the results of some studies indicate that EMR induced endometriosis and inflammation and decreased the number of follicles in the ovarium or uterus of rats. In studies with male rats, exposure caused degeneration in the seminiferous tubules, reduction in the number of Leydig cells and testosterone production as well as increases in luteinizing hormone levels and apoptotic cells. In some cases of male and female infertility, increased	This was listed on p.285 under ***Literature identified but not cited.*** SCENIHR chose not to cite or discuss this paper, although they had identified it.

	levels of oxidative stress and lipid peroxidation and decreased values of antioxidants such as melatonin, vitamin E and glutathione peroxidase were reported in animals exposed to EMR. In conclusion, the results of current studies indicate that oxidative stress from exposure to Wi-Fi and mobile phone-induced EMR is a significant mechanism affecting female and male reproductive systems.	
[96] Ledoigt G, Belpomme D. 2013 Cancer induction molecular pathways and HF-EMF irradiation. Adv Biol Chem 3:177-186.	The response of cells to different types of electromagnetic fields can be induced by low-level (athermal) high frequency (HF) electromagnetic fields (EMFs) exposure associated with mobile phone technologies. There are many examples of biological effects involving the epigenome. EMFs could trigger protein activation mediated by ligands, such as Ca2+, that alter the conformation of binding proteins, especially the NADPH plasmic membrane oxidase, so inducing increased formation of reactive oxygen species (ROS) that may alter proteomic functions. Classical anti-apoptotic and procarcinogenic signaling pathways that are commonly found activated in human malignancies and in inflammation mainly involve the tran-scription factor NF-κB. The microenvironment that exists during chronic inflammation can contribute to cancer progression. The data support the proposition that long term HF-EMF exposure associated with improper use of cell phones can potentially cause cancer.	Nothing. Review is not cited and not discussed.
[97] Hardell L, Carlberg M. 2013 Using the Hill viewpoints from 1965 for evaluating strengths of evidence of the risk for brain tumors associated with use of mobile and cordless phones. Rev Environ Health 28:97-106. doi: 10.1515/reveh-2013-0006.	BACKGROUND: Wireless phones, i.e., mobile phones and cordless phones, emit radiofrequency electromagnetic fields (RF-EMF) when used. An increased risk of brain tumors is a major concern. The International Agency for Research on Cancer (IARC) at the World Health Organization (WHO) evaluated the carcinogenic effect to humans from RF-EMF in May 2011. It was concluded that RF-EMF is a group 2B, i.e., a "possible", human carcinogen. Bradford Hill gave a presidential address at the British Royal Society of Medicine in 1965 on the association or causation that provides a helpful framework for evaluation of the brain tumor risk from RF-EMF. METHODS:All nine issues on causation according to Hill were evaluated. Regarding wireless phones, only studies with long-term use were included. In addition, laboratory studies and data on the incidence of brain tumors were considered. RESULTS: The criteria on strength, consistency, specificity, temporality, and biologic gradient for evidence of increased risk for glioma and acoustic neuroma were fulfilled. Additional evidence came from plausibility and analogy based on laboratory studies. Regarding coherence, several studies show increasing incidence of brain tumors, especially in the most exposed area. Support for the experiment came from antioxidants that can alleviate the generation of reactive oxygen species involved in biologic effects, although a direct mechanism for brain tumor carcinogenesis has not been shown. In addition, the finding of no increased risk for brain tumors in subjects using the	Nothing. Review is not cited and not discussed. The Hill criteria are THE well-accepted way of analyzing biological plausiblility of epidemiological evidence. It is unacceptable for SCENIHR not to consider this review when attempting to analyze epidemiological evidence of EMF cancer causation.

	mobile phone only in a car with an external antenna is supportive evidence. Hill did not consider all the needed nine viewpoints to be essential requirements. CONCLUSION:Based on the Hill criteria, glioma and acoustic neuroma should be considered to be caused by RF-EMF emissions from wireless phones and regarded as carcinogenic to humans, classifying it as group 1 according to the IARC classification. Current guidelines for exposure need to be urgently revised.	
[98] Hardell L, Carlberg M, Hansson Mild K. 2013 Use of mobile phones and cordless phones is associated with increased risk for glioma and acoustic neuroma. Pathophysiology 2013;20(2):85-110.	The International Agency for Research on Cancer (IARC) at WHO evaluation of the carcinogenic effect of RF-EMF on humans took place during a 24-31 May 2011 meeting at Lyon in France. The Working Group consisted of 30 scientists and categorised the radiofrequency electromagnetic fields from mobile phones, and from other devices that emit similar non-ionising electromagnetic fields (RF-EMF), as Group 2B, i.e., a 'possible', human carcinogen. The decision on mobile phones was based mainly on the Hardell group of studies from Sweden and the IARC Interphone study. We give an overview of current epidemiological evidence for an increased risk for brain tumours including a meta-analysis of the Hardell group and Interphone results for mobile phone use. Results for cordless phones are lacking in Interphone. The meta-analysis gave for glioma in the most exposed part of the brain, the temporal lobe, odds ratio (OR)=1.71, 95% confidence interval (CI)=1.04-2.81 in the ≥10 years (>10 years in the Hardell group) latency group. Ipsilateral mobile phone use ≥1640h in total gave OR=2.29, 95% CI=1.56-3.37. The results for meningioma were OR=1.25, 95% CI=0.31-4.98 and OR=1.35, 95% CI=0.81-2.23, respectively. Regarding acoustic neuroma ipsilateral mobile phone use in the latency group ≥10 years gave OR=1.81, 95% CI=0.73-4.45. For ipsilateral cumulative use ≥1640h OR=2.55, 95% CI=1.50-4.40 was obtained. Also use of cordless phones increased the risk for glioma and acoustic neuroma in the Hardell group studies. Survival of patients with glioma was analysed in the Hardell group studies yielding in the >10 years latency period hazard ratio (HR)=1.2, 95% CI=1.002-1.5 for use of wireless phones. This increased HR was based on results for astrocytoma WHO grade IV (glioblastoma multiforme). Decreased HR was found for low-grade astrocytoma, WHO grades I-II, which might be caused by RF-EMF exposure leading to tumour-associated symptoms and earlier detection and surgery with better prognosis. Some studies show increasing incidence of brain tumours whereas other studies do not. It is concluded that one should be careful using incidence data to dismiss results in analytical epidemiology. The IARC carcinogenic classification does not seem to have had any significant impact on governments' perceptions of their responsibilities to protect public health from this widespread source of radiation.	This paper is cited and discussed very briefly. See text for discussion.
[99] Davis DL, Kesari S, Soskolne CL, Miller AB,	Mobile phones are two-way microwave radios that also emit low levels of electromagnetic radiation. Inconsistent results	Nothing. Review is not

Stein Y. 2013 Swedish review strengthens grounds for concluding that radiation from cellular and cordless phones is a probable human carcinogen. Pathophysiology 20:123-129.	have been published on potential risks of brain tumors tied with mobile phone use as a result of important methodological differences in study design and statistical power. Some studies have examined mobile phone users for periods of time that are too short to detect an increased risk of brain cancer, while others have misclassified exposures by placing those with exposures to microwave radiation from cordless phones in the control group, or failing to attribute such exposures in the cases. In 2011, the World Health Organization, International Agency for Research on Cancer (IARC) advised that electromagnetic radiation from mobile phone and other wireless devices constitutes a "possible human carcinogen," 2B. Recent analyses not considered in the IARC review that take into account these methodological shortcomings from a number of authors find that brain tumor risk is significantly elevated for those who have used mobile phones for at least a decade. Studies carried out in Sweden indicate that those who begin using either cordless or mobile phones regularly before age 20 have greater than a fourfold increased risk of ipsilateral glioma. Given that treatment for a single case of brain cancer can cost between $100,000 for radiation therapy alone and up to $1 million depending on drug costs, resources to address this illness are already in short supply and not universally available in either developing or developed countries. Significant additional shortages in oncology services are expected at the current growth of cancer. No other environmental carcinogen has produced evidence of an increased risk in just one decade. Empirical data have shown a difference in the dielectric properties of tissues as a function of age, mostly due to the higher water content in children's tissues. High resolution computerized models based on human imaging data suggest that children are indeed more susceptible to the effects of EMF exposure at microwave frequencies. If the increased brain cancer risk found in young users in these recent studies does apply at the global level, the gap between supply and demand for oncology services will continue to widen. Many nations, phone manufacturers, and expert groups, advise prevention in light of these concerns by taking the simple precaution of "distance" to minimize exposures to the brain and body. We note that brain cancer is the proverbial "tip of the iceberg"; the rest of the body is also showing effects other than cancers.	cited and not discussed.

Of these 22 reviews, 19 are found in the PubMed database, the most widely used medical database in the world, so there is no excuse for not discussing these 19, but only two of them were discussed (see below). With regard to the eight different types of effects that I consider established non-thermal EMF effects, each of them were reviews in multiple studies described in Table 2 as follows: Cancer 12 reviews [78,82,83,84,85,86,87,90,94,96,97,98]; Oxidative stress/free radicals 8 reviews [79,80,84,90,92,93.95,96]; Cellular DNA damage 10 review [4,79,80,81,82,84,90,91,92,94]; Apoptosis/cell death 3 reviews [79,82,91]; Lowered fertility 7 reviews [80,86,89,92,93,94,95]; Neurological/neuropsychiatric effects 4 reviews [80,87,88,94]; Calcium overload 4 reviews [4,91,92,96]; Endocrine effects 2 reviews [92,95]. It is not clear why so many important reviews on effects are not found in SCENIHR 2015 [73]. What is perhaps surprising, is that these reviews also document many other effects, none of which are clearly acknowledged by SCENIHR. These include stress responses; breakdown of the blood-brain barrier; fetal and neonatal effects; therapeutic effects; Alzheimer's disease; increased nitric oxide; endometriosis; changes in protein levels (proteomics) and changes in gene expression; NF-kappaB elevation; increased suicide; changes in protein kinase activity including ERK and p32MAPK; mechanisms associated with oxidative stress including elevated NADPH/NADH oxidase increased lipid peroxidation and decreased enzymatic antioxidant activity, increased ornithine decarboxylase; and autism. It can be seen from this that the SCENIHR 2015 document seems to be systematically avoiding considering substantial bodies of evidence regarding a very large range of repeatedly reported EMF effects, each of which challenges the SCENIHR position that no effects are established.

Three specific issues regarding apparent cancer causation by EMFs need to be discussed here. Five of these reviews each review a body of evidence showing that cancer rates are higher on the side of the head where people use their cell phones and cordless phones, the ipsilateral side, as opposed to the opposite side of the head, called the contralateral side [78,84,85,98,99]. These are very important studies because they are not likely to be affccted by how complete the reporting data are, or whether there are affects produced by chemicals, ionizing radiation or other EMFs; each of these factors should not be specific for the side of the head impacted. The contralateral side of the head serves as a control that can be compared with the ipsilateral side of the head. What is strange about the SCENIHR 2015 document, is that it avoids discussing all of these data presented in these five reviews. That is even true for [98] which is discussed very briefly in SCENIHR 2015. Only one body of evidence from [98] is discussed in SCENIHR 2015 but several others are not discussed, including the two bodies of evidence which each find statistically significant rises in ipsilateral cancer as compared with contralateral cancer. The ipsilateral findings produce very strong arguments that cell phones and/or cordless phones do cause brain cancer. The best evidence suggests that both cell phones and cordless phones do cause cancer. What does SCENIHR 2015 say about ipsilateral cancer? The document states, on p. 74 that "ORs for glioma were higher in subjects who reported phone use mostly on the same side of the head (ipsilateral) as their tumour than for use on the opposite side (contralateral). For meningioma, ORs for temporal lobe tumours were slightly lower than for other locations, while a similar pattern as for glioma of higher ipsilateral ORs compared to contralateral ORs was seen." On p. 76, SCENIHR states that "Afterwards, in an attempt to quantify the relationship, Interphone and the Hardell studies were analysed in a meta-analytical approach (Hardell et al., 2013a), an OR of 1.71 (CI: 1.04-2.81) was found for temporal glioma among ipsilateral mobile phone users of 10+ years of use…." On p. 77, regarding a study designed to assess the reliability of self-reported cell phone usage in young brain cancer patients, a study **not** designed to assess ipsilateral effects in patients whose cancer cases may likely have been caused by cell phone usage, the SCENIHR 2015 document states "No clear patterns were seen when comparing ipsilateral and contralateral use." That is not surprising. It can be seen from this that 2 out of 3 studies that SCENIHR discussed argue that there is increased ipsilateral cancer and argue therefore that cell phones or cordless phones do cause cancer. Furthermore, they ignore large amounts of data, cited in [78,84,85,98,99] that provide further support for this view. When SCENIHR wishes to take the opposite position from that taken in these reviews, it is incumbent on SCENIHR to cite them, to discuss the data and opinion presented in those reviews and then and only then can they argue for their position. Having failed to do those things, SCENIHR loses credibility in any argument that they are doing what they can to protect our health. The same is true for all of the other effects where they similarly fail to cite large numbers of obviously relevant reviews, each arguing for various health effects produced by EMF exposures.

Two other findings from these reviews are important in assessing EMF cancer causation. Refs. [85 and 99] each provide evidence that younger people are more susceptible to cancer causation by EMFs than are adults. SCENIHR takes the opposite view but cannot argue credibly without considering those who differ. The other finding found in [97] is that the epidemiological evidence on cancer causation by microwave frequency EMFs satisfies most of the Hill criteria. The Hill criteria are the well-accepted criteria that allow one to distinguish chance associations from causal roles in epidemiology. Because epidemiology is the main basis for the arguments that SCENIHR makes against the conclusion that EMFs cause cancer, it is essential that SCENIHR carefully examine the Hill criteria. They fail to do so. They also ignored this study where these criteria were examined and where it was concluded that the majority of the Hill criteria argue that EMFs do cause cancer. This again, undercuts any claim that SCENIHR has carefully considered critically important findings with regard to EMF health effects.

There are several places in the SCENIHR 2015 document, where they state that no mechanisms have been identified by which claimed effects of EMFs can be produced. These can be found by searching the SCENIHR 2015 document using “mechanism” as the search term. However [4] clearly states that the VGCC activation mechanism triggered by EMF exposure can produce, via this mechanism, cellular DNA damaging effects, can produce therapeutic effects and can produce oxidative stress effects. It can be seen, therefore that SCENIHR has no problem making repeated claims that have been falsified by information that they presumably have examined. It also can be seen from this, that even in the cases where SCENIHR cites and very briefly discusses a review that disagrees with them, one can have no assurance that the information is used by SCENIHR in its assessment of health impacts. The causation of cellular DNA damage by EMFs acting via VGCC activation also has important implications with regard to cancer causation. Because almost all cases of cancer start with mutagenic DNA damage in the cell destined to become a cancer cell, this shows how EMFs can initiate the process of carcinogenesis.

It is clear that the SCENIHR 2015 document neither cited nor discussed 20 out of 22 reviews that have documented non-thermal effects of EMFs. In addition, the most important findings of the two that were cited in the document were ignored in the document as well. Therefore SCENIHR has systematically avoided discussing the most important implications of reviews that fell into the time frame they purport to have studied and disagreed with SCENIHR on the existence of important effects. The question can be raised, however, as to whether the SCENIHR has done a better job in its consideration of primary literature citations. To answer that question, I am using a database of important primary literature, regarding effects of cell phone EMFs that we are commonly exposed to.

23 Genuine Cell Phone Studies, Each of Which Should Be Discussed in SCENIHR 2015, 21 of Which Are Not.

Panagopoulos et al [100] showed that whereas 46 out of 48 studies on genuine cell phone radiation showed health-related effects, the majority of studies on simulated cell phones reported no statistically significant effects. They [100] interpreted the difference of results as having been caused by the lowered pulsation rate of the “simulated” cell phone exposures. While I am sure that is part of the explanation, there may be other possible differences that are discussed later in this chapter.

Of those 48 genuine cell phone studies, 23 fell into the time frame (Jan. 2009 through Dec. 2013) reviewed in SCENIHR, 2015. Because of the importance of cell phones and therefore cell phone radiation in our lives, I am using these 23 as a database of primary literature studies that should all be covered in the SCENIHR 2015 [73] document. How many of these 23 were reviewed and cited in SCENIHR 2015? The answer is four (17%) and I will discuss how each of them were discussed below. I have inserted 17 of these into Table 3 below, but six were left out, because they are easy to summarize. These six are all Drosophila studies, none of which were discussed in SCENIHR 2015 [73] but are easy to summarize. All six Drosophila studies were focused on lowered fertility following EMF exposure, with the majority of these focused on female fertility. Four of the six found increased apoptosis following cell phone EMF exposaure and four of the six also found cellular DNA damage following exposure. These are important because of the similarities of each of these effects to effects found in mammals. They are also important because they found DNA damage in Drosophila eggs, whereas mammalian eggs no similar studies have been done because of the difficulty in doing so. In mammals there are many studies showing DNA damage in sperm following EMF exposure. This DNA damage in germ line cells is particularly importance because of the importance of mutations passed onto progeny. Two of the Drosophila studies show a clear window of effect at quite low intensity, where the effects seen were much higher those those found with either lower or higher intensities. Table 32 summarizes the other 17 genuine cell phone radiation findings that that SCENIHR 2015 [73] should be discussing, 15 of which were not discussed or cited in SCENIHR 2015.

Table 3: Genuine Cell Phone Studies that Fell into the 2009 through 2013 SCENIHR 2015 period

Citation studied	Cell Phone Effects Reported	SCENIHR comments

1. Mailankot M, Kunnath AP, Jayalekshmi H, Koduru B, Valsalan R. 2009 Radio frequency electromagnetic radiation (RF-EMR) from GSM (0.9/1.8GHz) mobile phones induces oxidative stress and reduces sperm motility in rats. Clinics (Sao Paulo) 64:561-565.	The present study was designed to evaluate the effects of RF-EMR from mobile phones on free radical metabolism and sperm quality. MATERIALS AND METHODS: Male albino Wistar rats (10-12 weeks old) were exposed to RF-EMR from an active GSM (0.9/1.8 GHz) mobile phone for 1 hour continuously per day for 28 days. Controls were exposed to a mobile phone without a battery for the same period. The phone was kept in a cage with a wooden bottom in order to address concerns that the effects of exposure to the phone could be due to heat emitted by the phone rather than to RF-EMR alone. Animals were sacrificed 24 hours after the last exposure and tissues of interest were harvested. RESULTS: One hour of exposure to the phone did not significantly change facial temperature in either group of rats. No significant difference was observed in total sperm count between controls and RF-EMR exposed groups. However, rats exposed to RF-EMR exhibited a significantly reduced percentage of motile sperm. Moreover, RF-EMR exposure resulted in a significant increase in lipid peroxidation and low GSH content in the testis and epididymis. CONCLUSION: Given the results of the present study, we speculate that RF-EMR from mobile phones negatively affects semen quality and may impair male fertility.	Listed under literature identified but not cited. SCENIHR knew about this paper but decided not to discuss it.
2. Gul A, Celebi H, Uğraş S. 2009 The effects of microwave emitted by cellular phones on ovarian follicles in rats. Arch Gynecol Obstet 280:729-733. doi: 10.1007/s00404-009-0972-9.	The aim of this study was to investigate whether there were any toxic effects of microwaves of cellular phones on ovaries in rats. METHODS: In this study, 82 female pups of rats, aged 21 days (43 in the study group and 39 in the control group) were used. Pregnant rats in the study group were exposed to mobile phones that were placed beneath the polypropylene cages during the whole period of pregnancy. The cage was free from all kinds of materials, which could affect electromagnetic fields. A mobile phone in a standby position for 11 h and 45 min was turned on to speech position for 15 min every 12 h and the battery was charged continuously. On the 21st day after the delivery, the female rat pups were killed and the right ovaries were removed. The volumes of the ovaries were measured and the number of follicles in every tenth section was counted. RESULTS: The analysis revealed that in the study group, the number of follicles was lower than that in the control group. The decreased number of follicles in pups exposed to mobile phone microwaves suggest that intrauterine exposure has toxic effects on ovaries. CONCLUSION: We suggest that the microwaves of mobile phones might decrease the number of follicles in rats by several known and, no doubt, countless unknown mechanisms.	Not cited and not discussed by SCENIHR.
3. Imge EB, Kiliçoğlu B, Devrim E, Cetin R, Durak I. 2010 Effects of mobile phone use on brain tissue from the rat and a possible protective role of vitamin C - a preliminary study. Int J Radiat Biol 86:1044-1049. doi: 10.3109/09553002.2010	To evaluate effects of mobile phone use on brain tissue and a possible protective role of vitamin C. MATERIALS AND METHODS: Forty female rats were divided into four groups randomly (Control, mobile phone, mobile phone plus vitamin C and, vitamin C alone). The mobile phone group was exposed to a mobile phone signal (900 MHz), the mobile phone plus vitamin C group was exposed to a mobile phone signal (900 MHz) and treated with vitamin C administered orally (per os). The vitamin C group was also treated with vitamin C per os for four weeks. Then, the animals were sacrificed and brain tissues were dissected to be used in the analyses of malondialdehyde (MDA), antioxidant potential (AOP), superoxide dismutase, catalase	Not cited and not discussed by SCENIHR.

.501838.	(CAT), glutathione peroxidase (GSH-Px), xanthine oxidase, adenosine deaminase (ADA) and 5'nucleotidase (5'-NT). RESULTS: Mobile phone use caused an inhibition in 5'-NT and CAT activities as compared to the control group. GSH-Px activity and the MDA level were also found to be reduced in the mobile phone group but not significantly. Vitamin C caused a significant increase in the activity of GSH-Px and non-significant increase in the activities of 5'-NT, ADA and CAT enzymes. CONCLUSION: Our results suggest that vitamin C may play a protective role against detrimental effects of mobile phone radiation in brain tissue.	
4. Sharma VP, Kumar NR. 2010 Changes in honeybee behavior under the influence of cell phone radiation. Curr Science 98: 1376-1378.	Honeybee behaviour and biology has been affected by electrosmog since these insects have magnetite in their bodies which helps them in navigation. There are reports of sudden disappearance of bee populations from honeybee colonies. The reason is still not clear. We have compared the performance of honeybees in cellphone radiation exposed and unexposed colonies. A significant ($p < 0.05$) decline in colony strength and in the egg laying rate of the queen was observed. The behaviour of exposed foragers was negatively influenced by the exposure, there was neither honey nor pollen in the colony at the end of the experiment.	Not cited and not discussed by SCENIHR.
5. Vecchio F, Babiloni C, Ferreri F, Buffo P, Cibelli G, Curcio G, van Dijkman S, Melgari JM, Giambattistelli F, Rossini PM. 2010 Mobile phone emission modulates inter-hemispheric functional coupling of EEG alpha rhythms in elderly compared to young subjects. Clin Neurophysiol 121:163-171. doi: 10.1016/j.clinph.2009.11.002.	It has been reported that GSM electromagnetic fields (GSM-EMFs) of mobile phones modulate--after a prolonged exposure--inter-hemispheric synchronization of temporal and frontal resting electroencephalographic (EEG) rhythms in normal young subjects [Vecchio et al., 2007]. Here we tested the hypothesis that this effect can vary on physiological aging as a sign of changes in the functional organization of cortical neural synchronization. METHODS: Eyes-closed resting EEG data were recorded in 16 healthy elderly subjects and 5 young subjects in the two conditions of the previous reference study. The GSM device was turned on (45 min) in one condition and was turned off (45 min) in the other condition. Spectral coherence evaluated the inter-hemispheric synchronization of EEG rhythms at the following bands: delta (about 2-4 Hz), theta (about 4-6 Hz), alpha 1 (about 6-8 Hz), alpha 2 (about 8-10 Hz), and alpha 3 (about 10-12 Hz). The aging effects were investigated comparing the inter-hemispheric EEG coherence in the elderly subjects vs. a young group formed by 15 young subjects (10 young subjects of the reference study; Vecchio et al., 2007). RESULTS: Compared with the young subjects, the elderly subjects showed a statistically significant ($p<0.001$) increment of the inter-hemispheric coherence of frontal and temporal alpha rhythms (about 8-12 Hz) during the GSM condition. CONCLUSIONS: These results suggest that GSM-EMFs of a mobile phone affect inter-hemispheric synchronization of the dominant (alpha) EEG rhythms as a function of the physiological aging. SIGNIFICANCE: This study provides further evidence that physiological aging is related to changes in the functional organization of cortical neural synchronization.	Was cited and discussed – see text.
6. Kumar NR, Sangwan S, Badotra P. 2011 Exposure to cell phone radiations produces	The present study was carried out to find the effect of cell phone radiations on various biomolecules in the adult workers of Apis mellifera L. The results of the treated adults were analyzed and compared with the control. Radiation from the cell phone	Not cited and not discussed by

biochemical changes in worker honey bees. Toxicol Int. 2011 Jan;18(1):70-2. doi: 10.4103/0971-6580.75869.	influences honey bees' behavior and physiology. There was reduced motor activity of the worker bees on the comb initially, followed by en masse migration and movement toward "talk mode" cell phone. The initial quiet period was characterized by rise in concentration of biomolecules including proteins, carbohydrates and lipids, perhaps due to stimulation of body mechanism to fight the stressful condition created by the radiations. At later stages of exposure, there was a slight decline in the concentration of biomolecules probably because the body had adapted to the stimulus.	SCENIHR.
7. Favre D. 2011 Mobile phone-induced honeybee worker piping. Apidologie 42:270-279.	Electromagnetic waves originating from mobile phones were tested for potential effects on honeybee behavior. Mobile phone handsets were placed in the close vicinity of honeybees. The sound made by the bees was recorded and analyzed. The audiograms and spectrograms revealed that active mobile phone handsets have 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.	Not cited and not discussed by SCENIHR.
8. Cammaerts MC, Debeir O, Cammaerts R. 2011. Changes in Paramecium caudatum (protozoa) near a switched-on GSM telephone. Electromagn Biol Med. 2011 Mar;30(1):57-66. doi: 10.3109/15368378.2011.566778.	The protozoan Paramecium caudatum was examined under normal conditions versus aside a switched-on GSM telephone (900 MHz; 2 Watts). Exposed individuals moved more slowly and more sinuously than usual. Their physiology was affected: they became broader, their cytopharynx appeared broader, their pulse vesicles had difficult in expelling their content outside the cell, their cilia less efficiently moved, and trichocysts became more visible. All these effects might result from some bad functioning or damage of the cellular membrane. The first target of communication electromagnetic waves might thus be the cellular membrane.	Listed under literature identified but not cited. SCENIHR knew about this paper but decided not to discuss it.
9. Çam ST, Seyhan N. 2012 Single-strand DNA breaks in human hair root cells exposed to mobile phone radiation. Int J Radiat Biol 88:420-424. doi: 10.3109/09553002.2012.666005.	To analyze the short-term effects of radiofrequency radiation (RFR) exposure on genomic deoxyribonucleic acid (DNA) of human hair root cells. SUBJECTS AND METHODS: Hair samples were collected from eight healthy human subjects immediately before and after using a 900-MHz GSM (Global System for Mobile Communications) mobile phone for 15 and 30 min. Single-strand DNA breaks of hair root cells from the samples were determined using the 'comet assay'. RESULTS: The data showed that talking on a mobile phone for 15 or 30 min significantly increased ($p < 0.05$) single-strand DNA breaks in cells of hair roots close to the phone. Comparing the 15-min and 30-min data using the paired t-test also showed that significantly more damages resulted after 30 min than after 15 min of phone use. CONCLUSIONS: A short-term exposure (15 and 30 min) 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.	Not cited and not discussed by SCENIHR.
10. Vecchio F, Tombini M, Buffo P, Assenza G, Pellegrino G, Benvenga A, Babiloni C, Rossini PM. 2012 Mobile phone emission increases inter-	It has been reported that GSM electromagnetic fields (GSM-EMFs) of mobile phones modulate - after a prolonged exposure - inter-hemispheric synchronization of temporal and frontal resting electroencephalographic (EEG) rhythms in normal young and elderly subjects (Vecchio et al., 2007, 2010). Here we tested the hypothesis that this can be even more evident in epileptic patients, who typically suffer from abnormal mechanisms	Was cited and discussed – see text.

hemispheric functional coupling of electroencephalographic α rhythms in epileptic patients. Int J Psychophysiol 84:164-171. doi: 10.1016/j.ijpsycho.2012.02.002.	governing synchronization of rhythmic firing of cortical neurons. Eyes-closed resting EEG data were recorded in ten patients affected by focal epilepsy in real and sham exposure conditions. These data were compared with those obtained from 15 age-matched normal subjects of the previous reference studies. The GSM device was turned on (45 min) in the "GSM" condition and was turned off (45 min) in the other condition ("sham"). The mobile phone was always positioned on the left side in both patients and control subjects. Spectral coherence evaluated the inter-hemispheric synchronization of EEG rhythms at the following frequency bands: delta (about 2-4 Hz), theta (about 4-6 Hz), alpha1 (about 6-8 Hz), alpha2 (about 8-10 Hz), and alpha3 (about 10-12 Hz). The effects on the patients were investigated comparing the inter-hemispheric EEG coherence in the epileptic patients with the control group of subjects evaluated in the previous reference studies. Compared with the control subjects, epileptic patients showed a statistically significant higher inter-hemispheric coherence of temporal and frontal alpha rhythms (about 8-12 Hz) in the GSM than "Sham" condition. These results suggest that GSM-EMFs of mobile phone may affect inter-hemispheric synchronization of the dominant (alpha) EEG rhythms in epileptic patients. If confirmed by future studies on a larger group of epilepsy patients, the modulation of the inter-hemispheric alpha coherence due to the GSM-EMFs could have clinical implications and be related to changes in cognitive-motor function.	
11. Al-Damegh MA. 2012 Rat testicular impairment induced by electromagnetic radiation from a conventional cellular telephone and the protective effects of the antioxidants vitamins C and E. Clinics 67:785-792	OBJECTIVE: The aim of this study was to investigate the possible effects of electromagnetic radiation from conventional cellular phone use on the oxidant and antioxidant status in rat blood and testicular tissue and determine the possible protective role of vitamins C and E in preventing the detrimental effects of electromagnetic radiation on the testes. MATERIALS AND METHODS: The treatment groups were exposed to an electromagnetic field, electromagnetic field plus vitamin C (40 mg/kg/day) or electromagnetic field plus vitamin E (2.7 mg/kg/day). All groups were exposed to the same electromagnetic frequency for 15, 30, and 60 min daily for two weeks. RESULTS: There was a significant increase in the diameter of the seminiferous tubules with a disorganized seminiferous tubule sperm cycle interruption in the electromagnetism-exposed group. The serum and testicular tissue conjugated diene, lipid hydroperoxide, and catalase activities increased 3-fold, whereas the total serum and testicular tissue glutathione and glutathione peroxidase levels decreased 3-5 fold in the electromagnetism-exposed animals. CONCLUSION: Our results indicate that the adverse effect of the generated electromagnetic frequency had a negative impact on testicular architecture and enzymatic activity. This finding also indicated the possible role of vitamins C and E in mitigating the oxidative stress imposed on the testes and restoring normality to the testes.	Listed under literature identified but not cited. SCENIHR knew about this paper but decided not to discuss it.
12. Aldad TS, Gan G, Gao X-B, Taylor HS. 2012 Fetal radiofrequency	Neurobehavioral disorders are increasingly prevalent in children, however their etiology is not well understood. An association between prenatal cellular telephone use and hyperactivity in children has been postulated, yet the direct effects of	Was cited and discussed, see text.

radiation from 800-1900 MH-rated cellular telephone affects neurodevelopment and behavior in mice. Scientific Rep 2, article 312.	radiofrequency radiation exposure on neurodevelopment remain unknown. Here we used a mouse model to demonstrate that in-utero radiofrequency exposure from cellular telephones does affect adult behavior. Mice exposed in-utero were hyperactive and had impaired memory as determined using the object recognition, light/dark box and step-down assays. Whole cell patch clamp recordings of miniature excitatory postsynaptic currents (mEPSCs) revealed that these behavioral changes were due to altered neuronal developmental programming. Exposed mice had dose-responsive impaired glutamatergic synaptic transmission onto layer V pyramidal neurons of the prefrontal cortex. We present the first experimental evidence of neuropathology due to in-utero cellular telephone radiation. Further experiments are needed in humans or non-human primates to determine the risk of exposure during pregnancy.	
13. Liu C, Gao P, Xu SC, Wang Y, Chen CH, He MD, Yu ZP, Zhang L, Zhou Z. 2013 Mobile phone radiation induces mode-dependent DNA damage in a mouse spermatocyte-derived cell line: a protective role of melatonin. Int J Radiat Biol. 2013. 89: 993-1001. doi: 10.3109/09553002.2013.811309.	A mouse spermatocyte-derived GC-2 cell line was exposed to a commercial mobile phone handset once every 20 min in standby, listen, dialed or dialing modes for 24 h. DNA damage was determined using an alkaline comet assay. RESULTS: The levels of DNA damage were significantly increased following exposure to MPR in the listen, dialed and dialing modes. Moreover, there were significantly higher increases in the dialed and dialing modes than in the listen mode. Interestingly, these results were consistent with the radiation intensities of these modes. However, the DNA damage effects of MPR in the dialing mode were efficiently attenuated by melatonin pretreatment. CONCLUSIONS: These results regarding mode-dependent DNA damage have important implications for the safety of inappropriate mobile phone use by males of reproductive age and also suggest a simple preventive measure: Keeping mobile phones as far away from our body as possible, not only during conversations but during 'dialed' and 'dialing' operation modes. Since the 'dialed' mode is actually part of the standby mode, mobile phones should be kept at a safe distance from our body even during standby operation. Furthermore, the protective role of melatonin suggests that it may be a promising pharmacological candidate for preventing mobile phone use-related reproductive impairments.	Not cited and not discussed by SCENIHR.
14. Koca O, Gökçe AM, Öztürk MI, Ercan F, Yurdakul N, Karaman MI. 2013 Effects of intensive cell phone (Philips Genic 900) use on the rat kidney tissue. Urol J. 2013 Spring;10:886-891.	To investigate effects of electromagnetic radiation (EMR) emitted by cell phones on the rat kidney tissue. MATERIALS AND METHODS: Twenty-one male Albino rats were divided into 3 groups, each comprising 7 rats. Group 1 was exposed to a cell phone in speech mode for 8 hours/day for 20 days and their kidneys were removed. Group 2 was exposed to EMR for 20 days and then their kidneys were removed after an interval of 20 days. Cell phone used in the present study was Philips Genie 900, which has the highest specific absorption rate on the market. RESULTS: Light microscopic examination of the kidney tissues obtained from the first group of rats revealed glomerular damage, dilatation of Bowman's capsule, formation of large spaces between the tubules, tubular damage, perivascular edema, and inflammatory cell infiltration. The mean severity score was 4.64 ± 1.7 in group 1, 4.50 ± 0.8 in group 2, and 0 in group 3. While there was no significant difference between group 1 and group 2 (P > .05), the mean severity scores of groups 1 and 2 were	Not cited and not discussed by SCENIHR.

	significantly higher than that of the control group (P = .001 for each). CONCLUSION: Considering the damage in rat kidney tissue caused by EMR-emitting cell phones, high-risk individuals should take protective measures.	
15. Meo SA, Al Rubeaan K. 2013 Effects of exposure to electromagnetic field radiation (EMFR) generated by activated mobile phones on fasting blood glucose. Int J Occup Med Environ Health 26:235-241. doi: 10.2478/s13382-013-0107-1.	Extensive use of mobile phones has been accompanied by a common public debate about possible adverse effects on human health. No study has been published so far to establish any association between the fastest growing innovation of mobile phone and fasting blood glucose. The aim was to determine the effects of exposure to electromagnetic field radiation generated by mobile phones on fasting blood glucose in Wistar Albino rats. MATERIALS AND METHODS: 40 Male Albino rats (Wistar Strain) were divided into 5 equally numerous groups. Group A served as the control one, group B received mobile phone radiation for less than 15 min/day, group C: 15-30 min/day, group D: 31-45 min/day, and group E: 46-60 min/day for a total period of 3 months. Fasting blood glucose was determined by using Spectrophotometer and serum insulin by Enzyme-linked Immunosorbent Assay (ELISA). The Homeostatic Model (HOMA-B) was applied for the assessment of β-cell function and (HOMA-IR) for resistance to insulin. RESULTS: Wister Albino rats exposed to mobile phone radiation for longer than 15 min a day for a total period of 3 months had significantly higher fasting blood glucose ($p < 0.015$) and serum insulin ($p < 0.01$) compared to the control group. HOMA-IR for insulin resistance was significantly increased ($p < 0.003$) in the groups that were exposed for 15-30 and 46-60 min/day compared to the control rats. CONCLUSION:The results of the present study show an association between long-term exposure to activated mobile phones and increase in fasting blood glucose and serum insulin in Albino rats.	Not cited and not discussed by SCENIHR.
16. Tsybulin O, Sidorik E, Brieieva O, Buchynska L, Kyrylenko S, Henshel D, Yakymenko I. 2013 GSM 900 MHz cellular phone radiation can either stimulate or depress early embryogenesis in Japanese quails depending on the duration of exposure. Int J Radiat Biol 89:756-763. doi: 10.3109/09553002.2013.791408.	Our study was designed to assess the effects of low intensity radiation of a GSM (Global System for Mobile communication) 900 MHz cellular phone on early embryogenesis in dependence on the duration of exposure. MATERIALS AND METHODS: Embryos of Japanese Quails were exposed in ovo to GSM 900 MHz cellular phone radiation during initial 38 h of brooding or alternatively during 158 h (120 h before brooding plus initial 38 h of brooding) discontinuously with 48 sec ON (average power density 0.25 μW/cm(2), specific absorption rate 3 μW/kg) followed by 12 sec OFF intervals. A number of differentiated somites were assessed microscopically. Possible DNA damage evoked by irradiation was assessed by an alkaline comet assay. RESULTS: Exposure to radiation from a GSM 900 MHz cellular phone led to a significantly altered number of differentiated somites. In embryos irradiated during 38 h the number of differentiated somites increased ($p < 0.001$), while in embryos irradiated during 158 h this number decreased ($p < 0.05$). The lower duration of exposure led to a significant ($p < 0.001$) decrease in a level of DNA strand breaks in cells of 38-h embryos, while the higher duration of exposure resulted in a significant ($p < 0.001$) increase in DNA damage as compared to the control. CONCLUSION: Effects of GSM 900 MHz cellular phone radiation on early embryogenesis can be either stimulating or deleterious depending on the duration of exposure.	Listed under literature identified but not cited. SCENIHR knew about this paper but decided not to discuss it.

17. Luo Q, Jiang Y, Jin M, Xu J, Huang HF. 2013 Proteomic analysis on the alteration of protein expression in the early-stage placental villous tissue of electromagnetic fields associated with cell phone exposure. Reprod Sci 20:1055-1061. doi: 10.1177/1933719112473660.	To explore the possible adverse effects and search for cell phone electromagnetic field (EMF)-responsive proteins in human early reproduction, a proteomics approach was employed to investigate the changes in protein expression profile induced by cell phone EMF in human chorionic tissues of early pregnancy in vivo. METHODS: Volunteer women about 50 days pregnant were exposed to EMF at the average absorption rate of 1.6 to 8.8 W/kg for 1 hour with the irradiation device placed 10 cm away from the umbilicus at the midline of the abdomen. The changes in protein profile were examined using 2-dimensional electrophoresis (2-DE). RESULTS: Up to 15 spots have yielded significant change at least 2- to 2.5-folds up or down compared to sham-exposed group. Twelve proteins were identified- procollagen-proline, eukaryotic translation elongation factor 1 delta, chain D crystal structure of human vitamin D-binding protein, thioredoxin-like 3, capping protein, isocitrate dehydrogenase 3 alpha, calumenin, Catechol-O-methyltransferase protein, proteinase inhibitor 6 (PI-6; SerpinB6) protein, 3,2-trans-enoyl-CoA isomerase protein, chain B human erythrocyte 2,3-bisphosphoglycerate mutase, and nucleoprotein. CONCLUSION: Cell phone EMF might alter the protein profile of chorionic tissue of early pregnancy, during the most sensitive stage of the embryos. The exposure to EMF may cause adverse effects on cell proliferation and development of nervous system in early embryos. Furthermore, 2-DE coupled with mass spectrometry is a promising approach to elucidate the effects and search for new biomarkers for environmental toxic effects.	Listed under literature identified but not cited. SCENIHR knew about this paper but decided not to discuss it.

If you look through the studies described in Table 3, you will see multiple studies in oxidative stress/free radical damage, on changes in tissue structure (sometimes called remodeling), on cellular DNA damage, on male fertility (and also one on female fertility), on behavioral changes and on neurological changes. There is also one study on insulin/type 2 diabetes (hormonal effect). It follows from this that five of the effects that were extensively documented in large numbers of reviews (Chapter 1) are further demonstrated in these studies. In addition the tissue remodeling and proteomic changes discussed in Chapter 3 are also further demonstrated here. One question that needs to be raised with regard to SCENIHR is why so many clearly important primary literature studies of cell phone radiation (perhaps the most important source of human microwave irradiation) are not discussed in SCENIHR 2015. I will discuss certain particular articles that I think are particularly important for *particular reasons*. Subsequently, I will discuss the three articles that SCENIHR does discuss.

One of the more interesting studies not discussed by SCENIHR, is #11 in Table 3. This was published by a woman scientist in Saudi Arabia. What it shows is that 15, 30 or 60 minutes per day of cell phone radiation disrupts the structure of the rat testis and also produces high levels of oxidative stress as shown by measuring 5 different markers of oxidative stress. Such studies have been done for several decades, with oxidative stress having been shown in many different organs following EMF exposures. What is particularly important in this study is that high levels of two different antioxidants, vitamin C and vitamin E, were each shown to produce substantial protection of the testis structure from the EMF effects while partially normalizing the oxidative stress elevation. What this clearly shows is that the oxidative stress causes the testis tissue disruption. So we don't just have evidence for two effects, testis disruption and oxidative stress but we have strong evidence that one causes the other. It is exactly these connections that are essential for the progression of the science!

13 is another study not discussed by SCENIHR which is also particularly important. It looks at cell phone radiation DNA damage produced in a mouse spermatocyte-derived cell line. What it finds is that DNA damage is particularly high when the cell phone is in the dialed or dialing mode, as opposed to a

listen mode. They also state that the radiation levels in the three modes correspond, at least roughly, to the DNA damage effects seen. They also show that pretreatment with melatonin (which is known to have antioxidant effects) greatly lowers the DNA damage produced by the cell phone EMF exposures. This is similar to the study discussed immediately above because it again shows that one effect, DNA damage is produced by another effect, namely oxidative stress/free radical elevation. You will recall that as discussed in Chapter 2, cellular DNA damage following EMF exposure is produced by the attacks by on the DNA by peroxynitrite derived free radicals. This study provides confirmation for that mechanism.

#14 is another study not discussed by SCENIHR which is also particularly important. It looks at the impact of cell phone radiation on kidney structure of rats, using six different measures of kidney structure. There were two groups of rats that were exposed to cell phone radiation which were both compared with each other and with normal unexposed control rats. The two exposed groups differed from each other in one group the kidney structure was assessed immediately following the 20 day exposure period. The second exposure group was also exposed for 20 days but was given 20 days subsequently with no exposure to see if the kidney structure spontaneously recovered. There was no recovery seen in the second group, showing that the kidney damage was effectively irreversible. In Chapter 3, several tissue remodeling type effects produced by EMF exposure appeared to be irreversible. Study #14 may add an additional such effect to that list.

#15 is another study not discussed by SCENIHR which is also particularly important. In this study control (unexposed) rats were compared with rats exposed to cell phone radiation for: less than 15 minutes per day, 15 to 30 minutes per day, 31 to 45 minutes per day or 45 to 60 minutes per day. Rats exposed to over 15 minutes per day of cell phone radiation showed type 2 diabetes onset-like effects, with higher fasting glucose levels and higher serum insulin levels. This appears to be, therefore a study showing important hormone dysfunction. It should be noted that the same research group has found similar changes in people living near cell phone towers [101]. Consequently, this is still another situation where findings in experimental animal studies appear to be directly applicable to humans.

Of the papers that were discussed, it is my opinion that the Aldad et al paper (#12, Table 4) is perhaps the most important. The paper starts out discussing the very large increase in ADHD that we have had in recent years, an increase which suggests that one or more environmental changes must be involved. This paper is from a distinguished laboratory, Hugh Taylor's laboratory at Yale, and was published in one of the highly respected Nature journals and the paper at this writing has been cited 89 times, showing a high level of scientific interest in it. The paper showed that prenatal exposure of pregnant mice to cell phone radiation produced three highly statistically significant changes in the adult mice. These were a decrease in measured memory function, increase in hyperactivity and increase in anxiety. They also showed that there was a dose dependent decrease in an important neurological parameter, the frequency of miniature excitatory postsynaptic currents, allowing the authors to conclude "that these behavioral changes were due to altered neuronal developmental programming." SCENIHR states the following about this study: "Neurodevelopment from a functional point of view was studied by Aldad et al. (2012) who exposed mice in utero and investigated them as adults for certain behavioural traits and electrophysiological characteristics. Exposure is poorly described but is reported to be to a muted telephone (900-1800 MHz) during the entire gestation period. After blinded investigations, the authors concluded that exposed animals displayed hyperactivity, memory deficiencies, decreased anxiety, and impaired glutamatergic transmission. Although the study employs relevant biological end-points, it cannot be used for any conclusions regarding pre-natal mobile phone exposure and functional development of the brain." SCENIHR fails to tell us why they claim the exposures were poorly described nor do they provide any reasoning on why "it cannot be used for any conclusions regarding pre-natal mobile phone exposure and development of the brain." It is hard to see how such results could be found unless there are substantial effects of pre-natal exposure. Because the study used genuine cell phone radiation, the effects seen are disturbing. It would be reasonable for SCENIHR to call for more studies of this type to see if they can be replicated. Having said that there have been five subsequent studies that I found where pre-natal mouse exposure to non-thermal EMFs produced substantial and somewhat similar adult neurological effects and or behavioral effects [102-106]. These five included exposures to Wi-Fi and to DECT (cordless phone) EMFs. It is common for SCENIHR and other industry friendly organizations to treat experimental studies as if they had the weaknesses of epidemiological studies. They don't because they can and do in these cases, directly demonstrate causation. In epidemiology, causation can be inferred but not directly demonstrated. What about epidemiological evidence with regard to EMF causation of ADHD? There are two such studies that each provide evidence for an association between prenatal cell phone exposures and development of ADHD [107,108]. SCENIHR knew about both of these, since it discusses one of them which is, in turn, based on the earlier one. Why then did SCENIHR not make the connection of those two studies with at Aldad study (#12 in Table 4)? That is of course an important failure, given that the Aldad study greatly strengthens the argument for EMF causation of ADHD.

Given the current situation where there are a total of 6 studies showing that EMFs, including cell phone, Wi-Fi and cordless phone EMFs can cause ADHD-like effects in mice and two human epidemiological studies suggesting a similar mechanism in humans and the parallel between the huge increase in ADHD and the huge increase in microwave frequency EMF exposures, is there any other type of evidence that supports a causal role for EMFs? It turns out there is. EMFs, of course, act primarily via VGCC activation and genetic polymorphism studies show that elevated VGCC activity has a role in causing ADHD [109], acting to a substantial extent prenatally. This is the way real science works. It is not the way that SCENIHR works.

The Vecchio et al 2010 paper (#5, Table 4) was discussed in SCENIHR 2015 as follows: "A study by Vecchio et al. (2010) analysed age-dependent EMF effects on alpha activity in waking EEGs in 16 older (47-84 years) and 15 younger subjects (20-37 years). Participants were exposed to a GSM signal (902.40 MHz, modulation frequencies: 8.33 and 217 Hz) for 45 min with a maximum SAR of 0.5 W/kg emitted by a commercially available mobile phone which was set using a test card in a double-blind cross-over paradigm. EEG was recorded for 5 min prior to and following exposure at 19 electrodes. The authors found an increased inter-hemispheric coherence of frontal alpha EEG activity after GSM exposure which was statistically significant for the elderly subjects but not for the young ones. This might point to a GSM-EMF related inter-hemispheric synchronization of alpha rhythms as a function of physiological aging." Another related study (#by the same research group was also cited and discussed SCENIHR 2015 [73] as follows: "Vecchio et al. (2012a) used the same study design to investigate an exposure effect in patients with epilepsy. Data from 10 patients were compared to results from 15 age- matched controls from previous studies. Patients showed a statistically significant higher inter-hemispheric coherence of temporal and frontal alpha-rhythms under exposure as compared to control subjects. According to the authors, these results might indicate a GSM exposure effect on inter-hemispheric synchronization of the dominant (alpha) EEG rhythms in epileptic patients."

What do I have to say about the two Vecchio studies? They are both based on an earlier 2007 study which showed that increased EEG coherence between the two hemispheres of the brain produced by genuine cell phone EMF exposure. What the 2010 study (#5 in Table 3) shows is that the EMF-induced increased coherence is much higher in older adults than it is in younger adults. What the 2012 study (#10 in Table 3) shows is that the EMF-induced coherence seen in people with epilepsy is also much higher than in people without epilepsy. These three studies then provide large amounts of evidence for a neurological effect of cell phone radiation that is influenced by two variables, age and epilepsy. These findings should be looked at the context of the 23 reviews, listed in Chapter 1, each showing that EMFs produce both neurological and/or neuropsychiatric impacts on the brain. Here we have still another neurological effect, one that is influenced by age and epileptic condition. There are, then three important findings in these studies. One is that while we have had quite lot of evidence showing that children are more sensitive to EMF effects than adults, this is the first clear finding, to my knowledge, that suggests that older people may be more sensitive to a neurological effect. The linkage to epilepsy should not be surprising as some EHS people are reported to have seizures triggered by very low intensity EMF exposures. Finally, the communication between the two hemispheres of the brain has been known for over half a century to be through what is called the corpus callosum, a structure deeply buried in the middle of the brain, linking the two hemispheres. These effects increasing the coherence between the two hemispheres are probably produced, therefore, through the impact of the EMFs on the corpus callosum. That implies, in turn, that the EMFs act much more deeply in the brain than the industry claims is possible.

The problem with SCENIHR is that it lives in a totally fictional universe where none of those EMF effect reviews exist or at least none of them have any relevance to the SCENIHR world. Neither of the two

Vecchio et al studies, discussed in the previous two paragraphs, are used by SCENIHR [73] to make any conclusions about EMF effects or lack thereof – they are only cited in the quote that I gave you. We know that because because the citations are by author's last name and are, therefore easily searchable. Similarly, the Aldad study discussed two paragraphs further up, was also never cited except in the quotation given. So none of these three papers are used to assess any effects of EMFs or lack of effects. The same thing is true of the two reviews from Table 2 that were cited and discussed in [73]. They also were only cited in the quoted section and are never used to assess EMF effects or the mechanism of EMF action. As previously noted, there are several statements in SCENIHR 2015 [73] regarding lack of any available mechanism to explain claimed EMF effects, something that is directly contradicted by one of those cited and discussed reviews [4]. The consequence of all of that is that we have two very large and very consequential bodies of literature, the reviews on EMF effects and the literature on cell phone radiation effects, which are entirely missing from any SCENIHR 2015 [73] conclusion.

<u>Is There Another Systematic Effort by Industry to Corrupt the Literature that Has Been Followed to Some Extent by SCENIHR?</u>

The important roles of pulsation, window effects, frequency, cell type and polarization in determining biological activity of EMFs were discussed in Chapter 1, where it was noted that SCENIHR fails to pay attention to any of these roles. That failure shows up in many places in the document. In Tables 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14 of SCENIHR 2015 [73], the discussion of each table centers on how many studies found apparent effects and how many did not. But these numbers are irrelevant to the issue of whether there are effects or not. In fact one can argue that the industry, knowing about the roles of each of these factors, could fund any number of studies designed to give apparent negative results just by manipulating these factors to minimize responses and by only studying tiny numbers of individuals to produce low statistical power. This approach closely describes the approach used in seven studies of what were claimed to be genuine Wi-Fi studies that were described by Foster and Moulder [110] in Table 4 of their paper. Those seven studies were shown [11] to all have used an EMF that was not genuine Wi-Fi, despite claims to the contrary. They all used one of two types of reverberation exposure chamber for their rodent exposures, with each type of chamber greatly lowering the polarization of the EMFs [11] and also generating some level of destructive interference from variable path lengths produced by the reverberations. Each of these changes from genuine Wi- Fi is predicted to lower effects. Foster and Moulder [110] concluded that there was no effect in any of these studies. However tiny numbers of rodents were studied, typically between 3 and 15 in each class, such that these studies have very low statistical power to conclude anything substantive.

It is not possible to conclude no effect even with large studies. At most one can cleaim that there is no statistically significant evidence of an effect. With tiny numbers, a claim of no effect is complete nonsense. This problem with "no effect" claims is documented in a section of Rothman et al., Modern Epidemiology, 3rd Edition, a highly respected source of information, cited over 19,000 times according to the Google Scholar database. It states (p. 151, bottom) that: "A common misinterpretation of significance tests is that there no difference between two observed groups because the null test is not statistically significant, in that P is greater that the cutoff for declaring statistical significance (again, usually 0.05). This interpretation confuses a descriptive issue (whether two observed groups differ) with an inference about the superpopulation. The significance test refers only to the superpopulation, not the observed groups. To say that the difference is not statistically significant means only that one cannot reject the null hypothesis that the superpopulation groups are the same; it does not imply that the two groups are the same." All such claims of "no effect" are, therefore flawed. When they are made regarding very small studies with very low statistical power, they are particularly deeply flawed.

Were these seven studies designed to fail? I don't think we can say for certain but they certainly *look* as if they may have been. They also raise the serious question about whether the industry may be corrupting the science, by using their knowledge of the roles of pulsation, window effects, frequency, cell type and polarization.

The SCENIHR 2015 document has 127 places in the 221 pages of text where the term "no effect" was found (these can be easily found by searching the document using "no effect" for the search terms (that also picks up "no effects" statements. The first two of these 127 places are used properly, to describe the null hypothesis. *Each of the other 125 should not be there*, with each of those 125 overstating the case and therefore, improperly supporting the industry propaganda case.

In any case, the only way to show that there are inconsistencies or conflicts in the EMF literature is to carefully repeat studies finding such effects, not to flood the literature with studies done under other conditions. The logic used throughout SCENIHR 2015 [73] of just counting numbers of studies is deeply flawed.

<u>Summary of Flaws in SCENIHR 2015</u>

The first set of flaws, is that SCENIHR is perfectly willing to make statements which they know or should have known are false. The most egregious example of this is the Speit/Schwarz controversy described at the beginning of this chapter where there are seven clear falsehoods *created by SCENIHR*, each of which greatly strengthens the telecommunications industry propaganda positions. There are many others, described in this chapter that are substantive, but less egregious than the Speit/Schwarz falsehoods.

There is a vast literature, both in the review literature and in the primary literature studies, that disagree strongly with the SCENIHR positions and are completely ignored by SCENIHR. In a few cases, such studies are cited and very briefly discussed by SCENIHR but then they have no impact on the assessments that SCENIHR makes in the SCENIHR 2015 document [73]. The situation here is similar to an organization that has two sets of books, the fake books that are used in public and then a genuine set of books that includes all of the data that are too inconvenient to be included in the fake set of books.

The finally, we have three additional considerations which interact with each other to produce the completely bogus logic used by SCENIHR and by other organizations that have taken positions similar those taken by SCENIHR. One of those considerations comes from our knowledge that pulsation pattern, cell type, polarization and frequency can all influence biological effects and that there are exposure windows that produce much larger effects than are seen with either lower or higher intensities. Our knowledge of these factors mean that it is possible for the telecommunications industry to foster any number of studies where it is unlikely that statistically significant evidence of effects will be seen. I have presented examples where this may have been done. SCENIHR has often falsely stated that these studies show no effects as opposed to lack of statistical significance of any effects. SCENIHR 2015 document has 125 places where such bogus claims of "no effect" are found. They repeatedly claim the literature is inconsistent but studies done under different conditions are *not* inconsistent because they are more likely to be due to genuine biological heterogeneity of responses. The false logic described here is used, in turn, to support another highly pervasive false logic. I've documented where SCENIHR has simply counted numbers of studies showing so many findings of effects and some other number of findings of "no effect." But these numbers are meaningless, when the studies are done under different conditions and where the "no effect" numbers can easily be inflated by studies designed to produce such results. They are also, of course, meaningless, when large numbers of studies that show effects are eliminated by SCENIHR by the simple process of pretending they don't exist. You can see from this, that the entire logical framework behind the SCENIHR 2015 [73] document is completely bogus.

Lastly, before going on to 5G, there is one other thing I want to state here. In 2005, Dr. Jared Diamond published a book [111] entitled "Collapse: How Societies Choose to Fail or Succeed." In it he documents how each society that "chose to fail," chose paths that had some short term gains but also had much more severe longer-term consequences. This is exactly what we have been doing with the EMFs, except that the consequences are much more severe than the collapse of one society – here all of the advanced technology societies on earth are at great risk.

<u>Chapter 6: The Great Risks of 5G: What We Know and What We Don't Know</u>

We have already discussed two issues that are essential to understanding 5G. One is that pulsed EMFs are, in most cases, much more biologically active than are non-pulsed (often called continuous wave) EMFs. A second is that the EMFs act by putting forces on the voltage sensor of the VGCCs, opening these calcium channels and allowing excessive calcium ions to flow into the cell. The voltage sensor is extraordinarily sensitive to those electrical forces, such that the safety guidelines are allowing us to be exposed to EMFs that are something like 7.2 million times too high.

The reason that the industry has decided to go to the extremely high frequencies of 5G is that with such extremely high frequencies, it is possible to carry much more information via much more pulsation than it is possible to carry with lower frequencies even in the microwave range. We can be assured, therefore, that 5G will involve vastly more pulsation than do EMFs that we are currently exposed to. It follows from that, that any biological safety test of 5G must use the very rapid pulsations including whatever very short term spikes may be present, that are to be present in genuine 5G. There is an additional process that is planned to be used in 5G: phased arrays (https://en.wikipedia.org/wiki/Phased_array). Here multiple antenna elements act together to produce highly pulsed fields which are designed for 5G, to produce increased penetration. 5G will entail particularly powerful pulsations to be used, which may, therefore, be particularly hazardous.

The only data we have, to my knowledge, used *non-pulsed EMFs in the frequency range of 5G, not genuine 5G*. Any such data tells us almost nothing useful about 5G. I take it that from their statements, that both Mr. Ryan and Dr. Vinciūnas are ready to put out 10s of millions of 5G antennae to afflict every single person in the EU with 5G radiation without even a single biological test of safety of genuine 5G. (Note: the FCC has taken an identical position' in parts of the U.S. 5G antennae are already being installed). In a world where shocking behavior has become less and less shocking, I consider their views to be genuinely shocking. The U.S. situation is mass insanity. I would have hoped that the Europeans, who think of themselves as being much more thoughtful than Americans, would have been genuinely more thoughtful.

Why does 5G need such high numbers of antennae? It is because the 5G radiation is much more absorbed as it enters various materials. The approach is to use many more antennae with one found every few houses, such that 5G can sufficiently penetrate local walls. Such absorption usually involves the interaction with electrically charged groups, such that such absorption is likely to involve placing forces on electrically charged groups. Because such forces are the way in which EMFs activate the VGCCs, it seems highly likely, therefore, that 5G radiation will be particularly active in VGCC activation.

In summary, then, 5G is predicted to be particularly dangerous for each of four different reasons: 1. The extraordinarily high numbers of antennae that are planned. 2. The very high energy outputs which will be used to ensure penetration. 3. The extraordinarily high pulsation levels. 4. The apparent high level interactions of the 5G frequency on charged groups presumably including the voltage sensor charged groups.

Now what the telecommunications industry argues is that 5G radiation will be mostly absorbed in the outer 1 or 2 mm of the body, such that they claim that we don't have to worry about the effects. There is some truth to that, but there are also some caveats that make any conclusions made from that, much more suspect. In any case, these surface effects of 5G will have especially strongly impact organisms with much higher surface to volume ratios. Consequently, I predict that many organisms will be much more impacted than we will. This includes insects and other arthropods, birds and small mammals and amphibia. It includes plants and even large trees, because trees have leaves and reproductive organs that are highly exposed. I predict there will be major ecological disasters as a consequence of 5G. This will include vast conflagrations because EMF exposures make plants much more flammable.

But let's get back to humans. The industry has also made claims that more conventional microwave frequency EMFs are limited in effect to the outer 1 cm of the body. We know that is not true, however because of the effects deep in the human brain, on the heart and on hormone systems. Perhaps the most important two studies demonstrating effects deep within the body are the studies of Professor Hässig and his colleagues in Switzerland on cataract formation in calves [112,113]. These two studies clearly show that when pregnant cows are grazing near mobile phone base stations (sometimes called cell phone towers), the calves are born with very greatly increased incidences of cataracts. It follows from these findings that even though the developing fetuses are very deep in the body of the mother and should be highly protected from the EMF exposures, they are not so protected. And because the EMF safety guidelines in Switzerland are 100 times more stringent than are the safety guidelines in most of the rest of Europe, the more general safety guidelines allow greatly excessive exposures. The claims of industry that microwave frequency EMFs only act in the outer centimeter of the body are clearly false.

How then can both conventional microwave frequency EMFs and 5G radiation act deeply within the body? You may correctly observe that the electrical effects of the EMFs activate the voltage sensor and that the direct electrical forces are rapidly attenuated in the body. So how can we get deep effects? I think the answer is that the magnetic parts of the EMFs have been known for decades to penetrate much more deeply than do the electrical parts. The magnetic fields put forces on mobile electrically charged groups dissolved in the aqueous phases of the body and small individual movements of the charged groups can regenerate electric fields that are essentially identical to the electric fields of the original EMFs, carrying the same frequency and same pulsation pattern, although with lower intensity. An example of this is given in the Lu and Ueno [114] study. Because the voltage sensor is so stunningly sensitive to electrical forces and part of the reason for that is the very high level of amplification of the electrical field across the plasma membrane, we have an almost perfect way in which to produce EMF effects deeply within our bodies.

This brings us back to the earlier point. The only way to do 5G safety testing is to do genuine 5G biological safety testing. I have published on how this can be done relatively easily at relatively low costs in any comparison with the gigantic risks that will be taken if we fail to do those tests. Those tests must be done by organizations completely independent of industry and that leaves out both ICNIRP and SCENIHR and a lot of other organizations.

Dr. Vinciūnas’ last full paragraph reads as follows: “The recourse to the EU’s precautionary principle to stop distribution of 5G products appears too drastic a measure. We need first to see how this technology will be applied and how the scientific evidence will evolve. Please be assured that the Commission will keep abreast of the scientific evidence in view of safeguarding the health of European citizens at the highest level possible and in line with its mandate.”

Article 191 defines the **Precautionary Principle** as follows:

“According to the European Commission the precautionary principle may be invoked when a phenomenon, **product or process may have a dangerous effect**, identified by a **scientific and objective evaluation**, **if this evaluation does not allow the risk to be determined with sufficient certainty**.

Recourse to the principle belongs in the general framework of **risk analysis** (which, besides risk evaluation, includes risk management and risk communication), and more particularly in the context of **risk management** which corresponds to the decision-making phase.

The Commission stresses that the precautionary principle may only be invoked in the event of a potential risk and that it can never justify arbitrary decisions.
The precautionary principle may only be invoked when the **three preliminary conditions** are met:

identification of potentially adverse effects;
evaluation of the scientific data available;
the extent of scientific uncertainty.”

We know that there is a massive literature, providing a high level of scientific certainty, for each of these pathophysiological effects caused by non-thermal EMF exposures. This is shown in from 11 to 35 reviews on each specific effect, with each review listed in Chapter 1, providing a extremely large body of evidence on the existence of each effect.

1. Attack our nervous systems including our brains leading to widespread neuropsychiatric effects and possibly many other effects. This nervous system attack is of great concern.

2. Attack our endocrine (that is hormonal) systems. In this context, the main things that make us functionally different from single celled creatures are our nervous system and our endocrine systems – even a simple planaria worm needs both of these. Thus the consequences of the disruption of these two regulatory systems is immense, such that it is a travesty to ignore these findings.
3. Produce oxidative stress and free radical damage, which have central roles in essentially all chronic diseases.
4. Attack the DNA of our cells, producing single strand and double strand breaks in cellular DNA and oxidized bases in our cellular DNA. These in turn produce cancer and also mutations in germ line cells which produce mutations in future generations.
5. Produce elevated levels of apoptosis (programmed cell death), events especially important in causing both neurodegenerative diseases and infertility.
6. Lowers male and female fertility, lowers sex hormones, lowers libido and increases levels of spontaneous abortion and, as already stated, attacks on the DNA in sperm cells.
7. Produces excessive intracellular calcium [Ca2+]i and increased calcium signaling.
8. Attacks the cells of our bodies to cause cancer. Such attacks are thought to act via 15 different mechanisms during cancer causation.

Of course, the Commission has done nothing to protect European citizens from any of these very serious health hazards and the U.S. FCC, FDA, EPA and National Cancer Institute have done nothing to protect American citizens.

The question now is what about 5G? Here we have strong suspicions of similar or more severe risk than those listed immediately above but we have no biological safety testing of genuine 5G radiation. Therefore, we have no risk analysis or risk management because we have no risk assessment whatsoever on 5G. So here we have Dr. Vinciūnas arguing that the request for precautionary principle application is premature. But it is not the request for the use of the precautionary principle that is premature, it is the Commission's claim that it has done the required risk analysis and risk assessment. This is the bizarre world that we live in.

Let me close, as follows. There have been certain points in our history where people have stood up to strong destructive forces against what often appeared to be insurmountable odds. Those people are THE most honored people in our history. The people who failed to do so are among the most despised people in our history. I am not at all sure we will have historians to record us 100 years from now or even 30 years from now, given the direction in which we are heading. But if we do, rest assured that these are the standards by which you will be judged.

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.Thank you for your consideration. Martin L. Pall, Professor Emeritus
(US) 503-232-3883 ; martin_pall@wsu.edu

EXHIBIT K.1.A.

United States Senate
WASHINGTON, DC 20510

January 30, 2019

The Honorable Ajit Pai
Chairman
Federal Communications Commission
Washington, DC 20554

Dear Chairman Pai,

As you know, reports have surfaced that Federal Communications Commission (FCC) staff may have encouraged wireless carriers to file suit against the September 2018 FCC rule on 5G small cell deployment. It has been alleged this was done with the goal of moving litigation out of the Ninth Circuit. What's worse, there are also allegations that FCC staff may have implicitly threatened licensees that were not helpful. If true, this represents an unprecedented level of coordination between an oversight agency and the entities it regulates for the express purpose of preventing a federal circuit court's review. We therefore ask you provide additional information about these cases and the FCC's role in them.

To date, our offices have heard from more than 60 towns and cities throughout California and Connecticut strongly opposing the FCC's *Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment* Declaratory Ruling and Third Report and Order (Order).[1] Once this rule goes into effect, local governments will lose the ability to make decisions regarding where and how 5G transmission devices are affixed to light poles, traffic poles, and utility poles. The rule will also take away the ability of cities and counties to receive fair and competitive compensation from wireless carriers for use of public property. Consumer advocacy groups have also expressed their opposition to the FCC's ruling, citing the unbalanced benefit it gives to carriers and decrying the lack of commitment from carriers to reinvest cost savings in rural and underserved areas.

As you know, in October 2018, two dozen cities across the country filed suit against the FCC challenging the legality of the Order. Even though additional cases filed by wireless carriers in separate jurisdictions were eventually transferred back to the Ninth Circuit, the reason for their filing in the first place remains a concern. Pressuring entities that are regulated by the FCC to file frivolous litigation in order to

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[1] Federal Communications Commission, *Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment, Accelerating Wireline Broadband Deployment by Removing Barriers to Infrastructure Investment,* WT Docket 17-79 and WC Docket 17-84, Declaratory Ruling and Third Report and Order (Sept. 27, 2018).

game the system, and potentially threatening companies if they fail to comply, would be an unacceptable abuse of power and raise serious ethical concerns. Given these concerns, please answer the following questions:

1. Did any individual employed by or otherwise affiliated with the FCC discuss challenging the Order with an FCC licensee? If so, who and what was discussed?

2. Did any individual employed by or otherwise affiliated with the FCC communicate with an FCC licensee regarding that licensee's potential or actual legal challenge of the Order? If so, who and what was discussed?

3. Did any individual employed by or otherwise affiliated with the FCC threaten or take adverse action against any FCC licensee that refused to challenge the Order in court? If so, who and what was discussed?

Please provide answers no later than **Friday, February 8th**. We appreciate your responsiveness to these questions.

Sincerely,

Dianne Feinstein
United States Senator

Richard Blumenthal
United States Senator

EXHIBIT K.1.B.

Federal Communications Commission
Washington, D.C. 20554

Brendan Carr
Commissioner

December 17, 2018

Dear Senator Blumenthal and Congresswoman Eshoo,

Thank you for your December 3, 2018, letter regarding the Senate Commerce Committee field hearing in Sioux Falls, South Dakota. I appreciated the chance to spend time outside of Washington, D.C., and hear directly from community leaders who are eager to see next-generation broadband deployed across the country. I welcome the chance to respond to your letter, which touches on topics discussed at the hearing.

Local governments are critical partners in building wireless infrastructure. As an order the Commission adopted in September affirms, localities play an important role in reviewing the placement of wireless facilities, applying reasonable aesthetic requirements that reflect the surroundings, and charging fees that allow localities to recover their costs. At the same time, Congress has prohibited localities from regulating wireless infrastructure based on radio frequency emissions, stating that, "No State or local government or instrumentality thereof may regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions." 47 U.S.C. § 332(c)(7)(B)(iv).

As indicated in my remarks, federal agencies that are experts in these health and safety issues monitor and evaluate the relevant science and stay up-to-date on scientific and medical studies. I also indicated that these experts consistently take new information into account.

The FCC sets the radiofrequency emissions limits for cell phones and other electronic equipment, relying on the scientific and medical expertise of our sister federal agencies. As Dr. Jeffrey Shuren, Director of the FDA's Center for Devices and Radiological Health, recently explained, "The Food and Drug Administration is charged with ensuring cell phones—and any radiation-emitting electronic product—are safe for the public to use. Our scientific expertise and input, along with other health agencies, are used by the [FCC] to set the standards for exposure limits of radiation from cell phones . . . ."[1]

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[1] Statement from Jeffrey Shuren, M.D., J.D., Director of the FDA's Center for Devices and Radiological Health, on the National Toxicology Program's report on radiofrequency energy exposure (November 1, 2018), https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm624809.htm.

The FCC indeed has set RF exposure limits. And those limits do not stop at 6 GHz. Rather, the FCC's rules apply up to 100 GHz.[2]

Your letter references a recent report from the National Toxicology Program (NTP). On February 2, prior to my remarks in Sioux Falls, the NTP released a draft report on radiofrequency energy exposure. After reviewing the draft report, Dr. Shuren of the FDA confirmed his agency's determination that, "the current safety limits for cell phone radiation remain acceptable for protecting the public health." That determination was based on, "hundreds of studies from which to draw a wealth of information about these technologies," and the FDA pledged to continue to review, "many sources of scientific and medical evidence . . . as new scientific data are published," including the NTP's report.[3]

The NTP released the final version of its report on November 1, subsequent to my remarks in Sioux Falls. Dr. Shuren of the FDA again reviewed the report and again affirmed the current RF limits. "We have relied on decades of research and hundreds of studies to have the most complete evaluation of radiofrequency energy exposure. This information has informed the FDA's assessment of this important public health issue, and given us the confidence that the current safety limits for cell phone radiofrequency energy exposure remain acceptable for protecting the public health," wrote Dr. Shuren. He stated again that, "the FDA has reviewed, and will continue to review, many sources of scientific and medical evidence . . . and will continue to do so as new scientific data are published."[4]

Thank you again for contacting me about small cell deployment and 5G. I look forward to continuing to engage with you on these issues.

Sincerely,

Brendan Carr

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[2] *See, e.g.,* 47 C.F.R. § 1.1310(e).

[3] Statement from Jeffrey Shuren, M.D., J.D., Director of the FDA's Center for Devices and Radiological Health, on the recent National Toxicology Program draft report on radiofrequency energy exposure (February 2, 2018), https://www.fda.gov/newsevents/newsroom/pressannouncements/ucm595144.htm.

[4] Shuren, *supra* note 1.

EXHIBIT K.2.

PETER A. DEFAZIO
4TH DISTRICT, OREGON

TRANSPORTATION AND
INFRASTRUCTURE
CHAIRMAN

Congress of the United States
House of Representatives

PLEASE RESPOND TO:

☐ 2134 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-3704
(202) 225-6416

☐ 405 EAST 8TH AVENUE, #2030
EUGENE, OR 97401
(541) 465-6732
1-800-944-9603

☐ 125 CENTRAL AVENUE, #350
COOS BAY, OR 97420
(541) 269-2609

☐ 612 SE JACKSON STREET, #9
ROSEBURG, OR 97470
(541) 440-3523

☐ defazio.house.gov

April 15, 2019

Chairman Ajit Pai
Federal Communications Commission
445 12th Street SW
Washington, DC 20554

Dear Chairman Pai and Acting Commissioner Sharpless:

I write to inquire about the status of the federal government's research into the potential health effects of radiofrequency (RF) radiation and its relation to the Federal Communications Commission's (FCC) current guidelines for what it considers to be safe RF exposure levels for humans.

As you know, the impending rollout of 5G technology will require the installation of hundreds of thousands of "small cell" sites in neighborhoods and communities throughout the country, and these installations will emit higher-frequency radio waves than previous generations of cellular technology. This means that Americans will be exposed to more non-ionizing RF radiation than ever before.

The FCC's current guidelines for RF safety were adopted in 1996, a time when our society's relationship with and understanding of wireless technology was much different than it is today. In fact, in August 2012 – almost seven years ago – the Government Accountability Office (GAO) released a report recommending that the FCC "should formally reassess and, if appropriate, change its current RF energy exposure limit and mobile phone tested requirements..."[1] The report continued:

> The [FCC's] RF energy exposure limit may not reflect the latest research, and testing requirements may not identify maximum exposure in all possible usage conditions...By not formally reassessing its current limit, FCC cannot ensure it is using a limit that reflects the latest research on RF energy exposure. FCC has also not reassessed its testing requirements to ensure that they identify the maximum RF energy exposure a user could experience.

While I was pleased to see the FCC seek comments in 2013 on whether its RF safety guidelines should be reassessed,[2] it is unacceptable that six years later the FCC still has not conducted a reassessment of its 1996 guidelines.

Meanwhile, concern about exposure to RF radiation has been increasing. My constituents in southwest Oregon have expressed their concerns regarding possible health effects from increased RF exposure, particularly in light of upcoming 5G technology. They are not alone – Americans across the country are expressing similar worries about possible adverse health effects from this technology, and they are understandably demanding answers from the federal government.

Moreover, states and municipalities across the country, including in my congressional district, are hearing from citizens who are concerned about this technology being installed in their communities. Yet

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[1] Government Accountability Office, "Exposure and Testing Requirements for Mobile Phones Should Be Reassessed," GAO-12-771, July 2012, https://www.gao.gov/assets/600/592901.pdf.

[2] Federal Communications Commission, "Reassessment of Federal Communications Commission Radiofrequency Exposure Limits and Policies: Proposed Changes in the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields," FCC 13-39, 29 March 2013, https://docs.fcc.gov/public/attachments/FCC-13-39A1.pdf.

because Section 704(a) of the Telecommunications Act of 1996 – legislation which I opposed – expressly prohibits state and local governments from regulating wireless infrastructure based on RF emissions, and because the FCC's onerous new clarifying rules[3] usurp local control over 5G small cell installations, states and municipalities are forced to depend on the federal government for information about the safety of 5G technology.

It is clear that the federal government has not been transparent enough about the current status of 5G RF radiation research and its guidelines on RF exposure limits. As Senator Richard Blumenthal noted in a February 2019 Senate hearing,[4] the FCC's and FDA's responses to congressional inquiries on this issue have been less than satisfactory, merely reiterating general statements that 5G technology is safe without citing specific research or studies.

Even though the FDA states that it "believes the weight of scientific evidence does not show an association between exposure to radiofrequency from cell phones and adverse health outcomes," it also states that "there is consensus that additional research is warranted to address gaps in knowledge…"[5]

I request the FCC and FDA provide answers to the following questions:

1. What scientific literature or research has the FCC and FDA used to determine that 5G technology will not cause any adverse health effects in humans? Please cite specific studies and research conducted.

2. What gaps exist in our current understanding of possible health effects from 5G technology, as well as the possible health effects of RF radiation writ large?

3. What efforts has the federal government taken to educate the public, as well as state and local governments, about its research on RF radiation and safety guidelines as it relates to 5G technology?

I strongly urge the FCC, FDA, and relevant agencies to be open and transparent about the research and methods used for determining RF safety guidelines, as well as any outstanding questions your agencies may have about this new technology. Full transparency is needed, and the American people expect and deserve no less from their government.

I look forward to your reply.

Sincerely,

PETER A. DEFAZIO
Member of Congress

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[3] Federal Communications Commission, "Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment," FCC 18-111, 2 August 2018; https://docs.fcc.gov/public/attachments/FCC-18-111A1.pdf; and FCC 18-133, 26 September 2018, https://docs.fcc.gov/public/attachments/FCC-18-133A1.pdf.
[4] Senate Committee on Commerce, Science, and Transportation; Hearing: "Winning the Race to 5G and the Next Era of Technology Innovation in the United States," 02:03:59 – 2:08:50, 6 February 2019, https://www.commerce.senate.gov/public/index.cfm/hearings?ID=06336057-CC60-45DF-A361-32D7401EE6CB.
[5] U.S. Food and Drug Administration, "Radiation-Emitting Products: Current Research Results," https://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/CellPhones/ucm116335.htm

EXHIBIT K.3

Received & Inspected

Congress of the United States
Washington, DC 20515

APR 22 2019

FCC Mailroom

April 16, 2019

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The Honorable Ajit Pai
Chairman
Federal Communications Commission
445 12th Street. SW
Washington, DC 20554

Dear Chairman Pai,

I write to express the concern of constituents and local officials in my district regarding possible detrimental health effects of radiofrequency radiation (RF) emitted by 5G small cells.

From Huntington to Lake Success and beyond, small cell towers are being installed in residential neighborhoods in close proximity to houses throughout my district. I have heard instances of these antennae being installed on light poles directly outside the window of a young child's bedroom. Rightly so, my constituents are worried that should this technology be proven hazardous in the future, the health of their families and value of their properties would be at serious risk.

As I am sure you are aware, the National Toxicology Program (NTP) released a study in November of last year which linked RF radiation used in 2G and 3G networks to cancerous growths in rats.[1] Though this $30 million, 10 year long study does not apply to 4G or 5G technology, the ubiquity of cellphone use throughout our country requires that this research be taken seriously in safety determinations of cellular technologies moving forward. While I understand that the FDA has reviewed this specific study, I wish to pass along my constituents' strong desire that further studies also be taken seriously and given a proper evaluation.[2] This is just one of the many pieces of research forwarded to my office by passionate activists who want to ensure the safety of their family, friends, and communities.

Another area of concern for many of my constituents is the FCC's outdated guidelines for safe human exposure to RF energy. The Commission's original updated guidelines were created in 1996 when much of the technology in use today was not yet available for widespread consumption, including 5G.[3] In a letter dated December 17, 2018, Commissioner Carr explains

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[1] National Toxicology Program, "Cell Phone Radio Frequency Radiation Studies," https://www.niehs.nih.gov/health/materials/cell_phone_radiofrequency_radiation_studies_508.pdf

[2] U.S. Food and Drug Administration, Office of the Commissioner. "Press Announcements - Statement from Jeffrey Shuren, M.D., J.D., Director of the FDA's Center for Devices and Radiological Health on the National Toxicology Program's Report on Radiofrequency Energy Exposure." U S Food and Drug Administration Home Page. November 1, 2018. https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm624809.htm.

[3] "Human Exposure to Radio Frequency Fields: Guidelines for Cellular Antenna Sites." Federal Communications Commission. March 12, 2019. https://www.fcc.gov/consumers/guides/human-exposure-radio-frequency-fields-guidelines-cellular-and-pcs-sites.

that safe exposure limits have been altered and updated in the FCC's guidelines since that time. How have these safety determinations been made and does the FCC plan on releasing the data it used to set these new limits?

5G will bring about a transformation to how people and networks communicate. While I understand the importance of this technology for the future of the American economy, I believe we must also be as certain as possible that it is safe. I respectfully request that you provide my office and all relevant House Committees with the information used by the FCC, FDA, and other related health agencies to make 5G safety determinations.

Please contact Michael Christesen (michael.christesen@mail.house.gov) in my office with any questions.

Sincerely,

Thomas R. Suozzi

Thomas R. Suozzi
Member of Congress

(TRS/mcc)

EXHIBIT L

SAN FRANCISCO
PLANNING DEPARTMENT

1650 Mission St.
Suite 400
San Francisco,
CA 94103-2479

Reception:
415.558.6378

Fax:
415.558.6409

Planning
Information:
415.558.6377

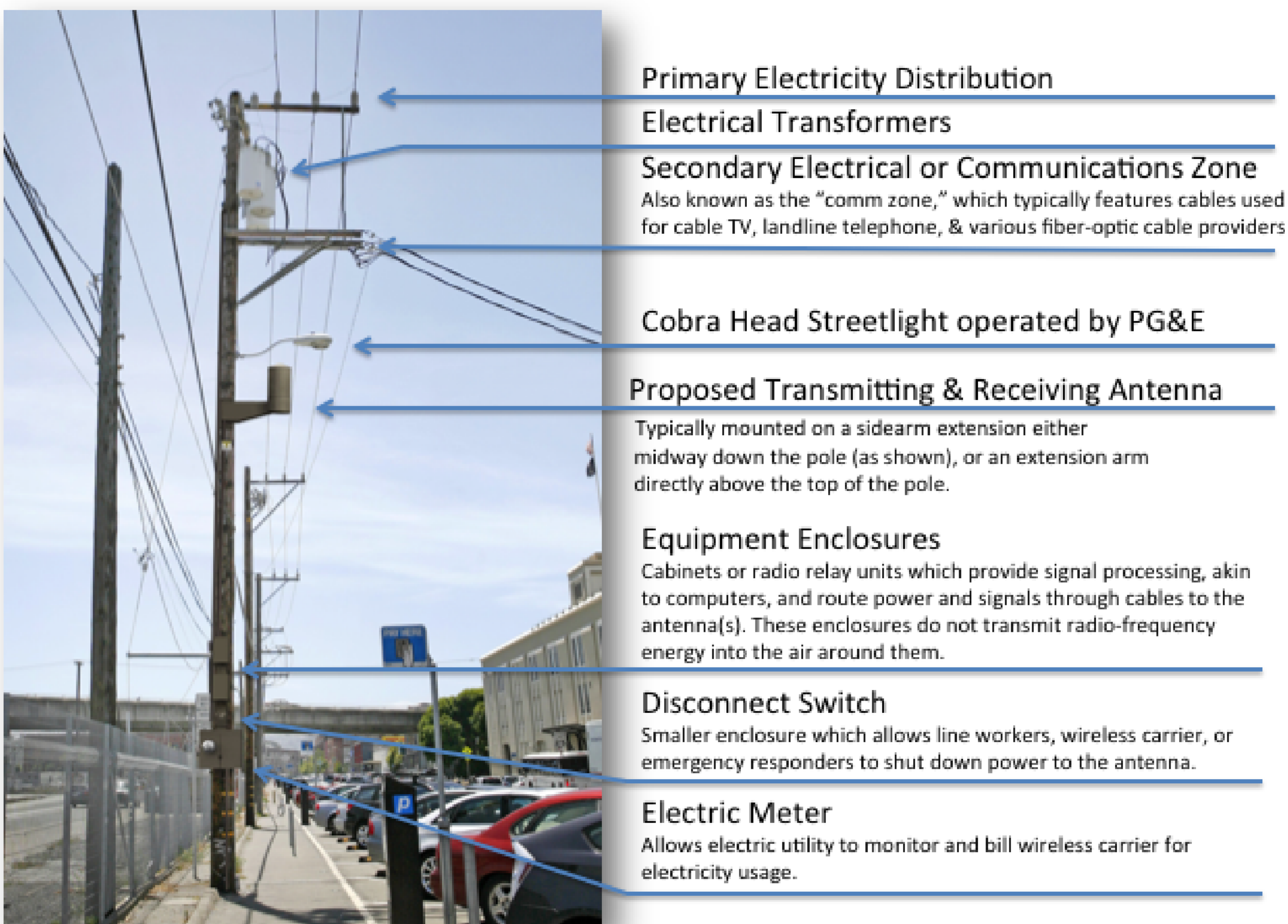
Frequently Asked Questions about Wireless Facilities on Wooden Utility and Wooden Streetlight Poles

1. **Can the City prohibit the installation of wireless facilities on wood poles? No.** Under State law, telecommunications carriers have a right to install wireless facilities on wood poles in the public right-of-way. The City, however, regulates the design, location, and placement of those facilities through Article 25 of the Public Works Code. The City will also conduct an environmental review under the California Environmental Quality Act (CEQA).

    - LINK: SF Government TV video of Board of Supervisors committee hearing on Article 25

2. **Does the City prefer wireless facilities on wood poles? No**. Our preference is for wireless carriers to work with the community, and Planning Department on well-designed and scale-appropriate rooftop-mounted facilities (example photo simulations on pages 37 & 38, and a second example on pages 32 & 33); which are then complemented by wireless facilities on steel poles. Wireless facilities on rooftops and steel poles are generally less intrusive than wood pole-mounted facilities.

Breakdown of one type of Personal Wireless Services Facility on a wood pole owned by the Joint Pole Association



3. **Does the City's permit review address health concerns?** Only in part. Under federal law (1996 Telecommunications Act), the City is prohibited from denying a permit to construct a wireless facility based on health concerns over RF emissions, provided that the emissions from the facility comply with Federal Communications Commission (FCC) standards. In order to assure compliance with FCC standards, the Department of Public Health (DPH) reviews every application for a wireless facility and generally requires an RF emissions study for each facility.

   If the facility is approved and installed, then field testing is required to ensure the facility meets the FCC's standards. Residents can ask for testing of their dwelling units at no charge (free) by contacting the City (Planning, Public Works, or Public Health). Testing is also required every time a permit is renewed, and every time the site is modified (replacing/adding antennas or equipment), when those modifications may affect the antenna(s) output.

   The City has not seen a pattern of wireless facilities on wooden poles exceeding RF emissions standards set by the FCC.

4. **The Radio-Frequency (RF) report indicates the maximum RF exposure level at ground level. Does the RF report take into account the RF exposure level on upper stories of residences closer to the antenna?**

   When an RF report is prepared it takes into account the location, orientation, and output of the antenna, relative to the nearest publicly-accessible areas, such as balconies, roof decks, and nearby dwellings (including upper stories). The RF emissions at any publicly-accessible area must also comply with the standards set by the Federal Communications Commission (FCC). Field testing can be arranged at no charge for residents, including from within their dwelling.

   Antennas are typically placed either midway up the wooden pole (side-arm configuration) or on top of a pole (top-mount). When antennas are placed in a side arm configuration and the placement is also parallel and close to a building, the antennas are typically setup in such a manner where the RF emissions are focused ("sectorized pattern") up and down streets, and not directly toward the building behind the antenna. In other words, this means that while the antenna enclosure may be round in shape, the RF emissions are not necessarily sent in all directions for antennas next to a building. Further information can be obtained from the Department of Public Health.

5. **How can I get more information about my health concerns?** A copy of the DPH report for every proposed and existing wireless facility can be obtained from Patrick Fosdahl at (415) 252-3094 or Patrick.Fosdahl@sfdph.org. In addition, general information about the safety of wireless facilities can be found on the FCC's web site (link).

   Link 1: First Sample DPH Radio-Frequency (RF) emissions, and noise review.

   Link 2: Second Sample RF Emissions Report

Frequently Asked Questions about Wireless Facilities on Wood Streetlight and Wood Utility Poles

6. **Is a permit required from the City?** Yes. The Department of Public Works (DPW) issues permits* for wireless facilities in the public right-of-way under Article 25 of the Public Works Code, and Department of Public Works (DPW) Order No. 183440. As required by Article 25, DPW refers applications for wireless permits to the:

   - Department of Public Health (DPH) for radio frequency (RF) emissions and noise review (see item 11).
   - Planning Department staff for design, environmental (CEQA), and historic preservation review. *These facilities are **not** reviewed by the Planning Commission.*
   - Recreation and Parks Department for review, if the facility is located near a public park or plaza.

   **Permits for wireless facilities on lands under the jurisdiction of the Port of San Francisco are issued by the Port. For a map of Port jurisdiction visit http://bsm.sfdpw.org/mapviewer/, choose the Jurisdiction box on the left, and Port of San Francisco.*

7. **Does the City's permit review address the design of the facility?** Yes. The Planning Department works with each applicant for a wireless facility permit to consider a design that is appropriate for the proposed location. Each design has its own challenges, such as the overall height of a top-mounted antenna, or the potential for a side-mount antenna to impair views. In addition, City staff continually engages with wireless carriers and equipment manufacturers to seek designs that are less intrusive. Residents are encouraged to discuss their concerns with the Planning Department's Wireless Planner, Omar Masry, at (415) 575-9116 or Omar.Masry@sfgov.org.

   - LINK: Design Preferences for Wireless Facilities on Wooden Poles

8. **Who owns the wood poles?** The majority of wood utility poles in San Francisco are managed by the Joint Pole Association (JPA), which is an association of utility companies and government agencies. Other wood poles are solely owned by Pacific Gas & Electric. These are typically streetlight-only wood poles. The City and County of San Francisco is a member of the JPA.

9. **How many wireless facilities are there in San Francisco?** As of April 2015, there are 383 existing wireless facilities on wood poles and approximately 700 wireless facilities outside of the public right-of-way; primarily on building rooftops.

Map of 1,000+ existing wireless facilities in San Francisco (map does not include all of the 383 existing facilities mounted on wooden utility poles):

New! Wireless Telecommunications Facilities N/A April 2015

Interactive map and Google Fusion Table displaying locations of wireless / cell tower telecommunications facilities (including cell phone masts) in San Francisco.

Frequently Asked Questions about Wireless Facilities on Wood Streetlight and Wood Utility Poles

10. **Does the City receive revenue from the use of wooden utility poles the facilities?** No. But the San Francisco Public Utilities Commission has started to allow the installation of wireless facilities on its (steel) street light poles, and the San Francisco Municipal Transportation Agency is allowing the installation of wireless facilities on its (steel) support poles. Both agencies will receive license fees for use of their poles. Link to information about wireless facilities on steel light and transit poles.

11. **Who do these facilities serve and what companies operate them?** The wireless facilities installed on utility poles are primarily intended to serve customers of wireless carriers licensed by the FCC to operate in San Francisco including AT&T Mobility, Sprint, T-Mobile, and Verizon Wireless. You might see signs on the utility poles that identify companies such as Crown Castle (NextG), ExteNet Systems, and Mobilitie as the owner of the facilities. These companies are authorized by the California Public Utilities Commission (CPUC) to install and operate the wireless facilities on wooden poles on behalf of their wireless carrier customers, but they still must obtain permits from DPW. The CPUC is a distinct State agency which regulates various utilities throughout California. *The San Francisco Public Utilities Commission (SFPUC) is not a part of the CPUC.*

12. **Do the antennas generate noise?** No. However, some, but not all wireless facilities feature cooling fans within the equipment cabinets, in order to regulate the temperature for the computers inside. If an existing system seems to be generating excessive noise, please contact the Department of Public Health at (415) 252-3904. In some instances, steps can be taken to reduce noise from cooling fans.

13. **Once DPW has issued a wireless permit can other carriers install additional facilities on the same wooden pole?** Generally, there will only be one wireless facility on each pole. CPUC regulations generally prohibit installing enough equipment on a utility pole that would accommodate two separate wireless facilities. It is possible, however, that a single wireless facility on a utility pole could serve more than on carrier.

14. **Can carriers install new (wood) poles on my street to support their wireless facilities?** No. DPW will generally only allow new wood poles to replace existing poles. Pole replacements are sometimes needed to ensure the pole can handle the load of the equipment or for wider vertical separation between various utility facilities on the pole. Planning staff continues to work with carriers and PG&E to seek less intrusive pole height replacements.

15. **Is the City planning to underground the wood poles?** There are no pending proposals for new neighborhood-wide undergrounding efforts. In the event an undergrounding effort begins, the wireless carriers would be required (as a condition of their utilities permit) to remove their facilities from the wooden poles.

16. **What equipment do wireless carriers typically install on the wood poles?** A typical wireless facility on a utility pole consists of one or more antennas and one or more equipment boxes. To meet CPUC requirements, the antennas will be mounted either at the top of the pole or on side arms midway down the pole. The equipment boxes will be attached to the pole. While every system varies, the equipment boxes typically include an electric meter, a disconnect switch, and computers to control the antennas. Some wireless facilities also feature an equipment box, on the same pole or a nearby pole, that contains batteries used to provide temporary emergency power to the facility in case of a power outage.

Frequently Asked Questions about Wireless Facilities on Wood Streetlight and Wood Utility Poles

17. **Can carriers change the equipment they installed on a permitted wireless facility?** Yes. Consistent with federal law, Article 25 of the Public Works Code generally allows modifications of permitted wireless facilities, provided those modifications are within certain limits.

18. **Can I protest the installation of a wireless facility on my block?** Yes. If you have received notice that a wireless facility has been proposed to be installed on your block it means DPW has tentatively approved the application. It also means that the Planning Department, DPH, and possibly the Recreation and Park Department have recommended that DPW grant the permit. While you may protest the issuance of the permit, you must do so in the time set forth in the notice, which will be 20 days after the notice is postmarked. DPW will not consider an untimely protest. If your protest is timely, DPW will hold a hearing to determine whether to issue the permit. DPW will notify you of the date and time for the hearing. You will be given the opportunity during the hearing to explain the reasons for your protest. Contact information for protests can be found on the DPW web site (link).

19. **Can I appeal DPW's issuance of a wireless permit?** Yes. Whether or not you protested the permit you may appeal DPW's issuance of the permit to the Board of Appeals. As with protests, you must file your appeal in the time required by City law, which is generally 15 days after the permit is issued. More information about filing an appeal can be found on the Board of Appeals web site (link). Only the environmental determination may be appealed to the Board of Supervisors (link).

20. **Why do the conditions of approval include a street tree**? The Planning Department typically requests a street tree to be provided by the wireless carrier for each facility mounted on a pole within the public right-of-way; in order to screen the equipment. In the event a tree cannot be planted due to conflicts such as existing trees, driveways or utility infrastructure (link to location requirements), the wireless carrier would be required to pay an in-lieu fee to be used by the SF Bureau of Urban Forestry.

21. **Are wireless facilities on poles banned in Europe or other California cities, including Berkeley?** No. Wireless systems can be found on poles and buildings in Europe, and on poles in other California cities, including Berkeley. Berkeley recently passed an ordinance to require that when people purchase cell phones that they are made aware that the mobile device itself generates radio-frequency (RF) emissions, and provide relevant information (link). The ordinance is currently subject to legal challenge.

22. **Do Personal Wireless Services Facilities on wooden poles also provide public Wi-Fi?** No. The term "Personal Wireless Services Facility" is the term used in Federal law. The City does provide public Wi-Fi in many locations, typically using smaller antennas, known as Access Points. City public Wi-Fi (network name: #SFWiFi) can be found on Market Street (Castro Street to Embarcadero), in many City buildings, and in over 30 City parks (link).

For more information on wireless facilities visit www.sf-planning.org/wirelessforms

Frequently Asked Questions about Wireless Facilities on Wood Streetlight and Wood Utility Poles

Common Terms:

DAS – Acronym for a Distributed Antenna System (also referred to as oDAS, with the "o" standing for outdoor installations). A network of antennas and equipment enclosures usually attached to poles in in the public right-of-way.

"Macro" Wireless Telecommunication Services (WTS) Facility - Typically three to sixteen panel antennas mounted on the roof of a building, along with multiple equipment cabinets. Permits reviewed by the Planning Department, Fire Department, DPH, and Department of Building Inspection (DBI). Also subject to the City's Wireless Guidelines, and Planning Code. Macro WTS facilities typically require Planning Commission approval in most residential, neighborhood commercial, and mixed-use zoning districts.

"Micro" Wireless Telecommunications Services (WTS) Facility - Typically one or two antennas mounted on the roof of a building. Permits reviewed by the Planning Department, Fire Department, DPH, and Department of Building Inspection (DBI); subject to the City's Wireless Guidelines, Planning Code, and review by the Zoning Administrator. Example link.

Personal Wireless Services Facility Permit – Permit for wireless facilities mounted on (typically wood or steel) poles in the public right-of-way. Permits administered by the Department of Public Works and subject to Article 25 of the Public Works Code.

Public Right of Way (PROW) – Typically streets and sidewalks, where light and utility poles are placed.

Small Cells – Similar to DAS, though a different communications network architecture.

Please note, that some of the square boxes mounted on wood poles in San Francisco, similar to the example photo to the right, are used for various purposes.

Wireless carriers sometimes use these cabinets to hold batteries to power some wireless facilities in the event of a power outage.

However, many of these boxes are used by "**wired**" telephone, internet, and/or cable TV providers such as Comcast, Sonic, or Wave.

The boxes are used to splice cables, or to boost power to communication wires and increase signal quality. These boxes do not create radio-frequency emissions, and generally do not generate noise.

Disconnect Switch

Electric Meter

Frequently Asked Questions about Wireless Facilities on Wood Streetlight and Wood Utility Poles

Sonic Internet Service Provider installed fiber-optic cable splice box

Pole Top Example

Existing Personal Wireless Facility mounted on a wooden streetlight pole in the Richmond neighborhood.

The antenna is found at the top of the pole.

An electric meter and equipment enclosure (computers) are near the bottom of the pole. The computer cabinets sometimes feature cooling fans, but do not emit radio-frequency emissions; which are created by the antenna on top of the pole.

Side Arm Examples

Existing Personal Wireless Services Facilities mounted on wooden streetlight poles in the Inner Richmond and Pacific Heights neighborhoods. The antenna is found on a side arm extension below the streetlight (above), or below the communications zone (lower wires in photo below). An electric meter and equipment enclosure (computers) are near the bottom of the pole.

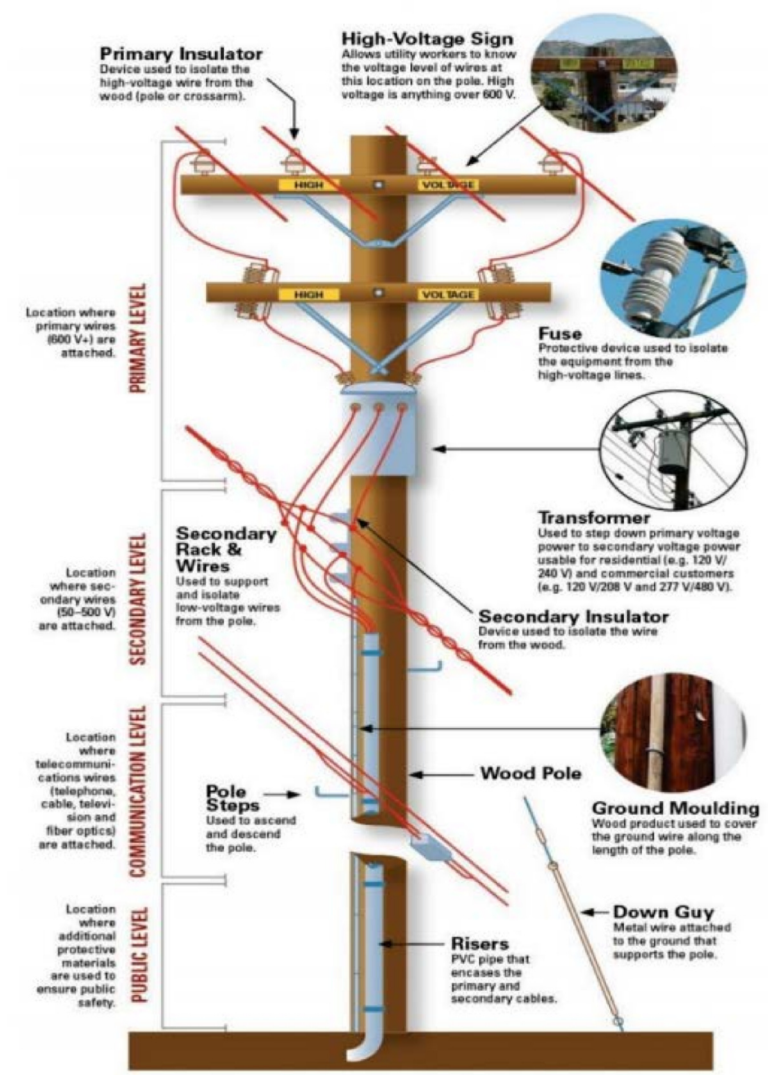
Side Arm Example

Existing Personal Wireless Facility mounted on a wooden streetlight pole in the Sunset neighborhood.

The two (2) panel antennas are on a side arm.

An electric meter and equipment enclosure (computers) are near the bottom of the pole.

This type of design is considered one that significantly detracts from streetscapes; and new proposals such as this would not typically be approved.



Utility Pole Diagram

[Link to a report by the California Public Utilities Commission (CPUC): "A Brief Introduction to Utility Poles"]

EXHIBIT M

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Review

A review of the ecological effects of radiofrequency electromagnetic fields (RF-EMF)

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ABSTRACT

Objective: This article presents a systematic review of published scientific studies on the potential ecological effects of radiofrequency electromagnetic fields (RF-EMF) in the range of 10 MHz to 3.6 GHz (from amplitude modulation, AM, to lower band microwave, MW, EMF).
Methods: Publications in English were searched in ISI Web of Knowledge and Scholar Google with no restriction on publication date. Five species groups were identified: birds, insects, other vertebrates, other organisms, and plants. Not only clear ecological articles, such as field studies, were taken into consideration, but also biological articles on laboratory studies investigating the effects of RF-EMF with biological endpoints such as fertility, reproduction, behaviour and development, which have a clear ecological significance, were also included.
Results: Information was collected from 113 studies from original peer-reviewed publications or from relevant existing reviews. A limited amount of ecological field studies was identified. The majority of the studies were conducted in a laboratory setting on birds (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. No clear dose–effect relationship could be discerned. Studies finding an effect applied higher durations of exposure and focused more on the GSM frequency ranges.
Conclusions: In about two third of the reviewed studies ecological effects of RF-EMF was reported at high as well as at low dosages. The very low dosages are compatible with real field situations, and could be found under environmental conditions. However, a lack of standardisation and a limited number of observations limit the possibility of generalising results from an organism to an ecosystem level. We propose in future studies to conduct more repetitions of observations and explicitly use the available standards for reporting RF-EMF relevant physical parameters in both laboratory and field studies.

Contents

Abbreviations: ELF-EMF, extremely low field electromagnetic field; CW, continuous wave; MW, microwave; PW, pulsed wave; GSM, global system for mobile communications; UHF, ultra-high frequency; VHF, very-high frequency; DECT, digital enhanced cordless telecommunications; UWB, ultra wide band; AM, amplitude modulation; FM, frequency modulation; GTEM, gigahertz transverse electromagnetic cell; UMTS, universal mobile telecommunications system; CDMA, code division multiple access; TDMA, time division multiple access; WCDMA, wideband code division multiple access; Wi-Fi, Wireless Fidelity; WLAN, wireless local area network; WiMAX, worldwide interoperability for microwave access.

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1. Introduction

1.1. Scope

Anthropocene is a term which has been proposed for the current epoch, due to the global environmental effects of increased human population, and the economic and industrial development and to the deep overall domination and contamination of humans over the environment (Crutzen and Stoermer, 2000; Zalasiewicz et al., 2010). Amongst the many changes, a radical modification has also taken place in the exposure of beings to man-made electromagnetic fields. A continuous, chronic, exposure to a wide range of modulated radiofrequency electromagnetic fields (RF-EMF) burdens all species and groups across the globe.

In terms of mechanisms, the WHO confirms that to date the accepted health effects ascribable to RF-EMF are caused by temperature elevation (van Deventer et al., 2011). Though, several studies have identified possible effects of RF-EMF on organisms, no alternative effect mechanisms have been confirmed to date. Most of the literature has focused on human and occupational health, largely based on animal model studies under laboratory conditions and test subjects exposed to lower frequencies of the spectrum (i.e. extremely low field, ELF-EMF). From the available studies, it became clear that, especially under higher dosages, effects of RF-EMF may be observed. As a response, occupational and human health threshold values and guidelines, proposed by international organisations (ICNIRP, 2010), have been increasingly incorporated into national regulations of states (EU, 2011). However, results are still not conclusive and there is still some uncertainty about the low dosages and non-thermal effects applied in some studies which did find an effect, and the overall quality of the setup of research in the field. The ever increasing use of RF-EMF in the cellular phone ranges (e.g. GSM and UMTS) and the newer forms of wireless communication (e.g. WiFi, WLAN and WiMAX), which are rarely present in the available studies, require new investigations which will look at possible short and long-term effects.

Over time several monographs and reviews have been compiled as to the biological effects of RF-EMF on humans, and on animals (see among others: Michaelson and Dodge, 1971; NCRP, 1986; Bryan and Gildersleeve, 1988; Adair, 1990; Verschaeve and Maes, 1998; Juutilainen, 2005; Balmori, 2009; Pourlis, 2009; ICNIRP, 2010). While of great relevance for the understanding of the phenomenon, these studies lack in the consideration of potential effects which may directly affect other organisms or ecosystems, because of the very limited attention which is usually received by the adverse ecological effects of RF-EMF.

1.2. Problem definition

Limited research and reviews have focused on investigating the possible ecological effects of RF-EMF. It can be argued that many human-related biological studies using animal models (e.g. rats and rabbits) may provide also relevant information about potential ecological effects. Many ecological endpoints (e.g. fertility, reproduction and growth) studied at the level of the individual animal, are also crucial from an ecological point of view. Ecology is, one of the sub-disciplines of biology, which studies all living organisms (including human beings), at all organisational levels (i.e. from the smallest molecular system to the largest ecosystem levels). Ecology is the scientific study of the distribution and abundance of organisms and the interactions that determine distribution and abundance (Begon et al., 2005). Those interactions refer to the abiotic and the biotic environment. By definition ecology focuses on the higher organisational levels of populations, communities and ecosystems. Despite the lack of information of the ecological effects of RF-EMF, following this definition, it is then plausible to link biological studies with ecological endpoints at the individual animal level to ecological interpretations at a higher organisation level.

This field of research is of crucial importance for the understanding of mechanisms of interaction between complex ecosystems and the environment. Animal studies have still been identified as a major research agenda point by the WHO (Van Deventer et al., 2011). The WHO stated that high priority in the field should be given to research on the effects of RF-EMF on development and behaviour, on ageing and reproduction of animal subjects. The result of these studies might be ecologically interpreted, because they include ecologically relevant endpoints.

As far as strictly ecological research has been conducted, it was mostly presented in the form of non-peer-reviewed *grey literature*. A review of Balmori (2009) is the only oriented one at the effects of RF-EMF on wildlife. However, the contribution by Balmori (2009) has some methodological issues. The criteria for the screening of the literature or the rationale for the inclusion or exclusion of relevant articles have, in fact, not been presented. The review is also missing a detailed analysis of the selected papers (e.g. of the duration of exposure and of the physical parameters) and it includes only studies finding a significant effect of RF-EMF.

1.3. Research focus

Evidence suggests that there is a large lacuna in research regarding the ecological effects of RF-EMF. The aim of this contribution is to conduct a scientifically sound review of potential ecological effects of RF-EMF. Using the definition and guidelines provided in the clinical sector by Higgins and Green (2006), a systematic review on potential ecological effects of RF-EMF was performed.

The study focuses on the range from 10 MHz to 3.6 GHz (i.e. from AM to the lower band MW EMF), using a transparent, comprehensive and objective substantive review approach and analysis of the available scientific literature on the ecological effects of RF-EMF. The literature search was based on a clear and objective research strategy (see Section 2) performed which used two databases: ISI Web of Knowledge and Google Scholar. The experimental, physical and biological parameters, which were provided by the selected papers were classified and analysed to look for trends and possible links between dosages and effects.

Papers evaluating ecological endpoints as part of biological investigations were selected with a focus on higher organisational biological levels: ecosystem, community, and species. As much as possible also biological studies, present in biological reviews or in relevant papers, if relevant from an ecological point of view, were included in this review and analysed.

A complete review of the biological literature was beyond the scope of this paper. However, laboratory studies on animals and plants which investigated biological endpoints can still provide information relevant for the ecological level.

First in Section 2 the methods are described, in Section 3 the general results are presented, and in Section 4 the specific results are given for each of the analysed groups (i.e. birds, insects, other vertebrates, other organisms, and plants). The final sections (Sections 5 and 6) provide a synthesis, with possible links between dose–response relationship, the setup and dosage of the studies, together with general conclusions and recommendations.

2. Review method

2.1. Criteria of literature search

The literature research was conducted, in the second half of 2011, using ISI Web of Knowledge and Google Scholar databases. Publications on ecological effects of RF-EMF on all relevant endpoints on non-human organisms and parts of organisms (e.g. tissues and cells) were taken into consideration Additional scientific articles published after December 2011 were added upon indication and suggestion of experts.

In order to maintain a high scientific standard for this review paper, only publications which were peer reviewed were considered. As criterion for peer review, the presence of the publication in the ISI Web of Knowledge was used. As for papers present only on Google Scholar an expert selection was made based on the ecological relevance and quality of the studies. The criteria used were based on quality criteria defined by relevant methodological reviews (Repacholi and Cardis, 1997; Stam, 2010). Repacholi and Cardis (1997) suggest that reviews should take into consideration only literature published in scientific peer-reviewed journals to guarantee a selection of articles free from methodological deficiencies and with rigorous analysis and conclusions. They also suggest care when dealing with peer-reviewed reports not published in scientific journals as well as conference abstracts, which are usually not peer-reviewed. In this review, only peer-reviewed papers have been selected. In a limited number of cases peer revision could not be guaranteed: the case of a study conducted by Harst et al. (2006) on honey bee (*Apis mellifera*), where no sufficient information could be found on the review procedure of the relative journal, and the studies by Van Ummersen (1961, 1963), Carpenter et al. (1960), and Clarke (1978) which were reported by the (peer-reviewed) review by Bryan and Gildersleeve (1988).

The literature search was limited to the range of frequencies from 10 MHz to 3.6 GHz. Papers on the biological and ecological effects of ELF-EMF in the range of 1 Hz–100 kHz (e.g. power line fields) were not considered. Date of publication was not used as a restriction and all publications falling within the selection criteria above were analysed, including those which did not find significant effects.

The keywords used in the literature research process are reported in the appendix to this review. Two main categories were defined: *RF-EMF specific* keywords (e.g. GSM, DECT and 1800 MHz) and *ecological* keywords (e.g. growth, population and eco*).

2.2. Description of the literature search

2.2.1. Main search strategy

A step-wise search strategy was conducted to find the most relevant articles in the RF-EMF range selected.

As a first step, the literature research was conducted on the ISI Web of Knowledge website, which provided 451,031 hits. Since this number of articles was too large to handle, a selection process was started. The collection was further refined by selecting only articles, reviews and proceeding papers as document types (440,528 hits). Then specific categories were selected: applied physics, cell biology, plant sciences, environmental sciences, biophysics, zoology, ecology, biology and microbiology. The number of hits was so reduced to 98,620.

In order to reduce the number of hits, all the results clearly outside the RF-EMF field of research, or beyond the scope of this review were excluded. This process reduced the number of hits further to 90,408 hits. A further screening was conducted selecting keywords from the RF-EMF specific and from the ecological defined groups, using one or two of RF-EMF keywords singularly or in combination with a single keyword from the ecological group. The obtained results ranged from 10 hits to 600. Titles were then screened one by one to select papers that could be of interest.

An analogous pattern of searches was performed on Google Scholar and only articles that had not yet been found on ISI Web of Knowledge were added. The number of hits for the initial combination of keywords was 3,600,000, and then reduced with an analogous procedure as described in ISI, but with a more attentive look at the content and the source of the selected papers.

After this first step of the searching process, 709 presumably relevant articles were identified. A one-by-one screening of titles and abstract was performed to investigate which papers would meet the defined criteria (e.g. frequency range and biodiversity exposure to RF-EMF). This second screening led to a new selection of 307 papers.

A closer analysis of the content of these 307 selected papers revealed that most of them regarded highly specific and strictly technical *biological* studies (e.g. rat tissues, cell-line studies, neuronal studies and calcium signalling), which were difficult to link directly to ecological effects, and, therefore, discarded. The final selection was reduced to 55 clearly relevant papers.

2.2.2. Related-references search

As a second step, it was decided to proceed by using a selected number of the 57 available articles to create a search based on “related references” to the ones used by their authors. The first articles used were those that clearly met the scope of the review in terms of focus and content: e.g. Balmori (2005), Panagopoulos et al. (2010) and five others. The screening of a total of 4000 hits provided 32 additional relevant hits.

Also a selection of the relevant references was conducted from the four relevant reviews (Bryan and Gildersleeve, 1988; Juutilainen, 2005; Pourlis, 2009; Verschaeve and Maes, 1998) and this resulted in 15 additional articles.

Regular updates were conducted until October 2012 to also include the most recently published relevant literature. After a careful analysis of all gathered information a total of 113 articles was selected and described in detail in the following sections. The total number of experiments carried out in these articles was 152.

3. General overview of results

The biggest share of the articles (c. 90%) involves laboratory studies with biological endpoints with a clear ecological relevance. The remaining part were ecological field studies (Table 1).

Most of the laboratory studies included had growth, development, behaviour and reproduction/fertility as biological endpoints. The endpoints analysed in field studies were behaviour, shift in populations and fertility. In circa 65% of the studies a statistical significant effect of RF-EMF on ecological relevant endpoints has been found (Table 1). There were no clear differences in percentage effects between articles included in reviews or not included in reviews. Development seemed to be less significantly affected in percentage than growth and fertility.

The most represented groups include vertebrates, other than birds (i.e. predominantly rats, mice and rabbits), then birds and plants. Articles which found significant effects of RF-EMF were found more frequently in the case of birds, insects (i.e. mostly honey bees and fruit flies) and plants. The group of other vertebrates (Table 1) was equally distributed among significant and non-significant effects. Effects were significant in all the articles on other organisms.

The type of endpoints studied differed across groups. Fertility was the mostly analysed endpoint for the birds. Growth was affected in all the experiments conducted on plants and other organisms, while it was affected in 25% of the studies on other vertebrates and ca. 40% on the birds. The effects of RF-EMF on behaviour were found in thirteen of the twenty of the studies on other vertebrates and in 85% ca. of the studies on insects.

Table 1
General overview of effects and no-effects studies across articles types, endpoints and species groups.

General findings of articles		Count
Included in review (including 80 articles, 4 reviews and 18 articles from these reviews)		113
Finding an effect		74
Not finding an effect		39
Laboratory studies		106
Field studies		8
Endpoints investigated		152
	Effect	No effect
Subdivision of articles among species		
Birds	18	8
Insects (including bees, fruit flies and ants)	15	2
Other vertebrates (mostly animal models)	25	25
Other organisms (nematodes, bacteria, etc.)	4	0
Plants	12	4
End points studied in screened articles		
Birds	20	18
Growth	3	4
Development	4	3
Fertility/reproduction	4	8
Behaviour/stress	3	0
Mutation	4	0
Mortality	0	1
Population decline	2	2
Insects	22	3
Growth	–	–
Development	4	0
Fertility/reproduction	9	1
Behaviour/stress	6	1
Mutation	–	–
Mortality	0	1
Population decline	1	0
Other vertebrates	35	27
Growth	4	1
Development	9	5
Fertility/reproduction	7	11
Behaviour/stress	13	7
Mutation	1	1
Mortality	1	2
Population decline	–	–
Other organisms	4	0
Growth	2	0
Development	–	–
Fertility/reproduction	–	–
Behaviour/stress	2	0
Mutation	–	–
Mortality	–	–
Population decline	–	–
Plants	22	2
Growth	12	0
Development	3	0
Fertility/reproduction	1	0
Behaviour/stress	3	1
Mutation	3	1
Mortality	–	–
Population decline	–	–

4. Ecological effects of RF-EMF

4.1. Birds

Birds have been widely used to analyse the environmental significance of exposure to nonionizing radiation. The ability of birds to detect magnetic stimuli has been documented by several studies (see Keeton, 1971; Thalau et al., 2005; Wiltschko and Wiltschko, 1996; Wiltschko et al., 2001). A total of 26 articles was selected from the screened literature with 38 relevant endpoints. With the exception of five field studies, all studies were conducted in a laboratory setting.

Of the 26 studies, 70% have been significantly related to the effect of RF-EMF (Table 1). In most cases the effects studied were growth and fertility and were conducted, until the early nineties, under a continuous microwave system of exposure (i.e. 2450 MHz). The physical parameters usually reported regarded the measured level of power flux density and specific absorption rate (SAR). These parameters were either measured using probes or specific detectors or were based on the information of the manufacturers of the exposure devices.

Chicken (*Gallus domesticus*) and Japanese quail (*Coturnix coturnix* subsp. *japonica*) represented the most studied experimental system in laboratory studies on birds. Approximately 60% of the laboratory studies considered a system at the embryo or egg stages of development.

4.1.1. Laboratory studies

4.1.1.1. Embryo and egg. In the eighties and early nineties researchers focused on the effects of MW EMF. There was a high level of interest especially in the ranges that would be relevant, at that time, for the possible implementation of new source of renewable power based on the collection of solar energy in space by means of solar power satellites (SPS add to abbreviation list) and its transmission to earth via MW EMF (Glaser, 1968; Wasserman et al., 1984). The three more recent studies (Table 2) investigated the typical cellular phones range of frequencies.

All the measured physical parameters varied greatly across studies. The estimated SARs ranged between 0.001 W/kg and 140 W/kg (Kleinhaus et al., 1995; Van Ummersen, 1961), while the duration of the exposure was as little as 9 s (McRee and Hamrick, 1977) with peak values of 45 days (Grigoryev, 2003). The variation which was found for the power density ranged from 4.4×10^{-6} mW/cm^2 as in Reijt et al. (2007) to 400 mW/cm^2 measured in Van Ummersen (1961).

Table 2
Summary of articles reporting ecological effects of RF-EMF on birds.

Reference	Country	Species	Scientific name	Life stage[a]	Type of study[b]	Number of subjects[c]	Duration of exposure	Frequency [MHz]	Wave/ modulation[d]	Power density [mW/cm^2][e]	SAR [W/kg][f]	Effect[g]	Effect size[h]
Carpenter et al. (1960)	USA	Chicken	*Gallus gallus* subsp. *domesticus*	Emb	Lab	n/a[i]	1–15 min	2450	MWCW	200	70	Teratogenic effects on the embryo	+
										280	98	Idem	
										400	140	Idem	
Van Ummersen (1961, 1963)	USA	Chicken	*As above*	Emb	Lab	n/a	1–15 min	2450	MW CW	200	70	Inhibition of growth	+
										280	98	Idem	
										400	140	Idem	
Hills et al. (1974)	Canada	Chicken	*As above*	Emb	Lab	n/a	20–300 s; first 2 days of incubation	2450	MW CW	0.2 246 1020	n/a	Reduced chicken hatchability	+ (33%)
Giarola and Krueger (1974)	USA	Chicken	*As above*	Juv	Lab	n/a	28 days	880	UHF CW	0.5	n/a	Reduced growth rate	+
							Idem	260	VHF CW	0.5	n/a	Reduced growth rate	+
Hamrick and McRee (1975)	USA	Japanese quail	*Coturnix coturnix* subsp. *japonica*	Emb	Lab	n/a	24 h	2450	MW CW	30	14	Reduced hatchability, altered/ organ development	—
McRee et al. (1975)	USA	Japanese quail	*As above*	Emb	Lab	57 (4)	4 h for first 5 days of incubation	2450	MW CW	30	14	Altered development	—
Krueger et al. (1975)	USA	Chicken	*As above*	Ad	Lab	5 (5)	12 weeks	260	VHF	0–1	n/a	Unaltered fertility, reproduction and hatchability	—
							Idem	915	UHF	1.25	n/a	Unaltered fertility, reproduction and hatchability	–
							Idem	2450	MW CW	1	n/a	Unaltered fertility, reproduction and hatchability	–
Davidson et al. (1976)	Canada	Chicken	*As above*	Juv	Lab	n/a	4.5–6 s	2450	MW	1.043	n/a	Unaffected egg production	–
											n/a	Unaltered growth, reproduction, mortality	–
McRee and Hamrick (1977)	USA	Japanese quail	*As above*	Emb	Lab	n/a	First 12 days of incubation	2450	MW CW	5	4.03	Unaltered development	–
Clarke (1978)	USA	Chicken	*As above*	Emb	Lab	n/a	34th–60th hr of incubation	2450	MW PW (mod. 60 Hz and 12 Hz)	100	n/a	Behavioural changes in hierarchy positioning as adults	+
Fisher et al. (1979)	Canada	Chicken	*As above*	Emb	Lab	n/a	4–5 days	2450	MW CW	3.5	n/a	Early embryonic development	+
Cabe and McRee (1980)	USA	Japanese quail	*As above*	Emb	Lab	n/a	First 12 days of incubation	2450	MW CW	5	4.03	Altered response to behavioural tests as adults	+
Inouye et al. (1982)	USA	Japanese quail	*As above*	Emb	Lab	n/a	First 12 days of incubation	2450	MW	5	4.03	Developmental retardation of Embryos	+ (7%)
												No differences after week 8	—

McRee et al. (1983)	USA	Japanese quail	*As above*	Emb	Lab	270 (120)	First 12 days of incubation	2450	MW CW	5	4.03	Reduction in reproductive capacity	+ (8%)
Wasserman et al. (1984)	USA	Sparrow; junco	*Zonotrichia albicollis*; *Junco hyemalis*	Var	Field	12 flocks (2 flocks)	20 min; 200 min	2450	MW	25	0.85–0.92	Variation in level of aggression of birds after exposure	+ (11%)
							20 min	2450		100	Idem		
							7–10 min	2450		155	Idem		
Byman et al. (1985)	USA	Japanese quail	*As above*	Egg	Lab	30 (90)	60 min during 17 days incubation	2450	MW CW	20–50	0.5	Unaltered growth or abnormal development	−
Gildersleeve et al. (1987)	USA	Japanese quail	*As above*	Emb	Lab	468 (468)	12 days during incubation	2450	MW CW	5	4.03	Unaltered fertility, reproduction and hatchability	−
Kleinhaus et al. (1995)	Israel	Migratory birds	n/a	n/a	Sim	n/a	n/a	4–26	Broadcast station	n/a	0.001–0.004	Unaltered development and population levels	−
Bastide et al.(2001)	France	Chicken	*As above*	Emb	Lab	300 (300)	Incubation period	900	GSM	n/a	n/a	Increased mortality. Inhibition of normal development	+ (53%)
Grigoryev (2003)	Russia	Chicken	*As above*	Emb	Lab	n/a	21 days	900	GSM	n/a	n/a	Increased mortality	+
Balmori (2005)	Spain	White stork	*Ciconia ciconia*	Pop	Field	60 nests	2 months	900–1800	GSM base station	0.001477 (mean within 200 m); 7.45093×10^{-5} (mean farther than 300 m)	n/a	Severe decline in productivity	+ (46%)
Balmori and Hallberg (2007)	Spain	Sparrow	*Passer domesticus*	Var	Field	40 visits (1200 data points)	3 years and 8 months	1 MHz–3000	GSM to MW	0.00325 (max); 4.24403×10^{-5} (mean)	n/a	Decline in bird population and dose–effect relationship found between electric field strength and population decline at specific locations	+ (75%)
Everaert and Bauwens (2007)	Belgium	Sparrow	*As above*	Var	Field	150 locations	4 months during the breeding period	925–960	GSM base station	4.34589×10^{-6}	n/a	Significant relationship between number of house sparrows and levels of power density	+ (70%)
							Idem	1805–1880	GSM base station	9.07759×10^{-6}	n/a	Idem	
Reijt et al. (2007)	Poland	Great tit; blue tit	*Parus major*; *Cyanistes caeruleus*	Ad	Field	72 (42)	45 days	1200–3000	Radar	20–50	n/a	Unaltered fertility and growth	−
												Possible shift in species distribution	+ (50%)
Batellier et al. (2008)	France	Chicken	*As above*	Egg	Lab	(240)	Incubation period	900	GSM	0.00306–0.04197	n/a	Reduced hatchability. Increased Embryo mortality	+(42%)+

[a] Life stage refers to the age of the tested subject at the moment of the experiment. Emb = embryo, Ad = adult and Egg = egg.
[b] Studies divided in laboratory and field studies. Lab = laboratory study and Field = field study.
[c] Number of subjects involved in the experiment or field study where reported in the study. In brackets information about number of control subjects.
[d] Wave/modulation indicates the type of RF-EMF applied/measured in the study. CW = continuous wave, MW = microwave, PW = pulsed wave GSM = Global System for Mobile Communications, UHF = Ultra-High Frequency, and VHF = Very high frequency.
[e] Values of power density are reported as provided by authors or recalculated by conversion of electric field values ($PD = EF^2/3770$) and expressed in mW/cm^2.
[f] Values of SAR are reported as provided by authors and expressed in W/kg.
[g] Biological or ecologically relevant endpoints studied.
[h] Size of the effect where significant. It indicates the ration between maximum effect and percentual difference compared to control. A + sign indicates a significant effect and a − sign indicates that no significant effect was found.
[i] n/a indicates that data was not provided by authors.

The endpoints included growth, hatchability, development based on evidence of abnormal weight of hatchlings, incidences of abnormalities and mortality. Nine of the 15 experiments showed significant differences between RF-EMF and controlled/sham-exposed eggs.

It is a common opinion among experts (Baranski and Czerski, 1976; Bryan and Gildersleeve, 1988) that the results obtained in most of the studies until the 1980s (i.e. until Inouye et al., 1982 in this selection) relate to increases in the temperature of the egg due to the consequences of hyperthermia a few degrees above normal incubation temperature. An abnormal increase in temperature gradient of 3.5 °C had already been observed in the early study by Van Ummersen (1961, 1963), reported in the review conducted by Bryan and Gildersleeve (1988). In a later study, Byman et al. (1985) found no effect on the growth and normal development of born chicks of birds nesting in proximity to antennas. Temperature rise was controlled and the measured power density was 25 mW/cm^2. Analogous results were obtained by Gildersleeve et al. (1987) who kept the internal temperature of irradiated and sham-exposed eggs to a mean of 37.5 °C without detecting any deficiency in the reproductive performance of males and females allowed to hatch.

Among the three more recent studies, Bastide et al. (2001) and Grigoryev (2003) found a significant increase in mortality due to RF-EMF on chicken (*G. gallus* subsp. *domesticus*) embryos exposed to RF-EMF emitted by a GSM device during the duration of the incubation period.

Also Batellier et al. (2008) studied the effect of exposure to GSM and UMTS frequencies on chicken eggs over the entire period of incubation. Four replicates with a total 240 eggs each were used in the experiment to assess mortality rates. Results showed an increased mortality of 42.2% for embryos under a regime of controlled temperature, humidity and external EMF. However, it was not possible to establish a proportional relationship between the intensity of the electric field and embryo mortality.

4.1.1.2. Juvenile and adult. Five studies focused on the impact of RF-EMF at a later phase of development of chickens: four studies on juvenile and only one on adult subjects (Table 2). The endpoints studied were growth, fertility, rate of egg production, hatchability and mortality.

The only study which found a significant difference between exposed and control/sham groups is the study by Giarola and Krueger (1974) on juvenile chickens. The authors examined, exposure to very-high frequency (VHF) and ultra-high frequency (UHF), together with investigation of MW EMF. Exposure determined reduced growth of chicks and consumption. In a follow-up study Krueger et al. (1975), did not find effects either on fertility or hatchability with a continuous exposure period of 12 weeks at a power density (calculated) of 1 mW/cm^2. Experts from the U.S. Department of Energy (1978) attributed the difference in results to the cage used in the first study which may have determined a higher dose of energy absorbed by the target subjects.

4.1.2. Field studies

There were five field studies on the impact of RF-EMF exposure at various frequencies and physical conditions on populations of birds living in areas in the vicinity of cellular phone masts or base-stations. Anomalies and deviations from normality in the behaviour of exposed subjects and in the level of productivity were found in all these studies.

The values of power density provided by studies ranged from 4.4×10^{-6} mW/cm^2 in the study on sparrows by Everaert and Bauwens (2007) to the highest measured value of 155 mW/cm^2 in Wasserman et al. (1984). In this last case, exposure caused a steady temperature raise which determined a continuous gaping for the total duration of exposure of the exposed population of sparrows (*Zonotrichia albicollis*) and juncos (*Junco hyemalis*). Values for the SARs were provided only by the study of Wasserman et al. (1984) and ranged from 0.85 to 0.92 W/kg. The endpoints studied were density, reproduction, behaviour and community composition. In all the studies and experiments conducted, effects of the RF-EMF were found from a variation of 10% to a maximum of 70% compared to control.

Balmori (2005) monitored the variation of a population of white storks (*Ciconia ciconia*) in the vicinity of a GSM base station (i.e. 900–1800 MHz with 217 Hz modulation) in search of possible effects from the exposure. Total productivity within 200 m was on average 46% less than that found at a distance greater than 300 m from the emitting station. An analogous significant difference was found in the breeding success: in 40% more of the cases no new-born chicks were found in the nest.

In another study, Reijt et al. (2007) studied the influence of long term exposure to RF-EMF from radar (200–1300 MHz) on a population of great tits (*Parus major*) and blue tits (*Cyanistes caeruleus*) living around a military radar station. Possible other sources of co-variance (e.g. from human interactions with the location of birds and other pollutants) were not considered in the study. Unlike in the case of Balmori (2005), the exposure seemed not to have affected the number of nesting tits, but the distribution of the different species. The authors state that the results contradict with the study of Balmori (2005), probably because of the exposure of targets to radar MW (i.e. 1200–3000 MHz), instead of mobile phone exposure (i.e. 900–1800 MHz with 217 Hz modulation).

Additionally, Reijt et al. (2007) found that exposed nests were occupied, compared to control, by the less dominant species of tits (blue tit), which would suggest that birds can perceive high frequency RF-EMF as a stressful factor and, thus, would try to avoid nesting in those areas. An average of 50% of the great tits moved from a more exposed section of the study area to a less exposed one: in the interaction with the great tit, the blue tit is usually less dominant according to behavioural studies by Tanner (1966) and Tanner and Romero-Sierra (1974). Therefore, the great tit would move to areas where the power density is lower, and therefore the blue tit would have to nest elsewhere.

Fig. 1 presents a plot of the effect with the relative measured power density, from studies with a significant effect (see Table 2 for details on the studies). It is not possible to define a clear dose–effect relationship, but also at low values of power density strong effects of RF-EMF are found.

4.1.3. Summary

Most studies on birds were laboratory investigations. The target subjects were in the majority of laboratory studies chicken and Japanese quail. Older laboratory studies exposed targets to high level of MW EMF which probably determined an uncontrolled raise in temperature which affected the exposed systems. Amongst the more recent laboratory studies, evidence of an effect of RF-EMF on mortality and development of embryos was in all cases found at both high and low dosages. In all the five field studies found a significant effect of RF-EMF on breeding density, reproduction or species composition. Field observations give a closer representation of real-life exposure, thus RF-EMF, especially in the 900 MHz GSM band could be a certain factor influencing the ecology of birds.

4.2. Insects

Insects are a useful target system for the investigation of RF-EMF because of the limited size, the short life cycle and the possibility of easily detecting developmental defects (Schwartz et al., 1985). It has been demonstrated that insects can sense magnetic fields as a means for navigation and orientation (Abraçado et al., 2005; Kirschvink et al., 2001; Liedvogel and Mouritsen, 2010; Wajnberg et al., 2010; Winklhofer, 2010). Magneto-reception has been associated with the use of ferromagnetic iron oxide particles embedded in tissue or through pairs of molecules with unpaired electrons (known as radical pairs) that are associated with a light sensitive photoreceptor (Ritz et al., 2002; Knight, 2009; Vácha et al. 2009). The exposure to RF-EMF might disrupt

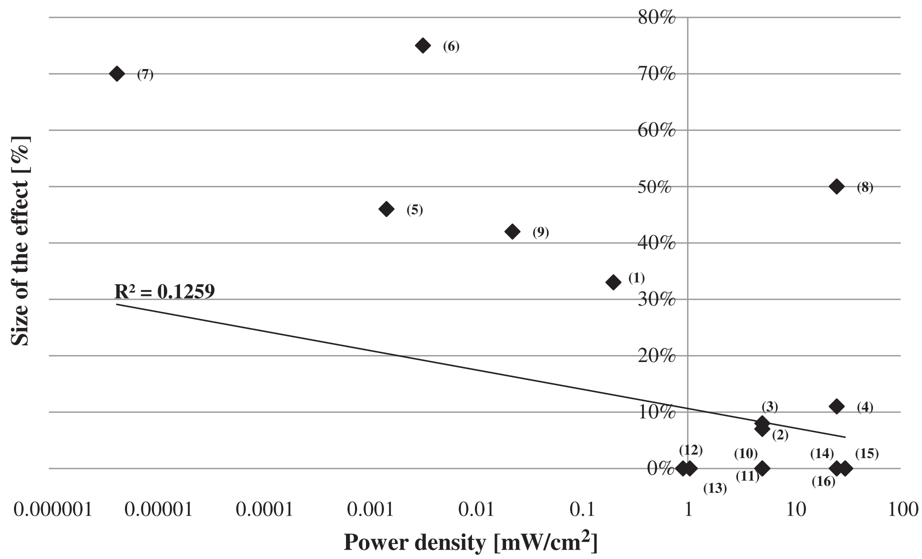

Fig. 1. Size of the ecological effects of RF-EMF on birds related to the power density of exposure. Articles reported in graph: (1) — Hills et al. (1974); (2) — Inouye et al. (1982); (3) — McRee et al. (1975); (4) — Wasserman et al. (1984); (5) — Balmori (2005); (6) — Balmori and Hallberg (2007); (7) — Everaert and Bauwens (2007); (8) — Reijt et al. (2007); (9) — Batellier et al. (2008); (11) — McRee et al. (1975); (12) — Krueger et al. (1975); (13) — Davidson et al. (1976); (14) — McRee and Hamrick (1977); (15) — Byman et al. (1985); and (16) — Gildersleeve et al. (1987). See Table 2 for a complete description of studies. Data is reported for studies from which information could be extracted. The equation of the regression line is $y = -0.0078x + 0.2908$.

this magneto-reception mechanism, which could in turn affect the survival of insects. The most commonly studied species are the honey bee (*A. mellifera*) and the fruit fly (*Drosophila melanogaster*).

4.2.1. Honey bees (A. mellifera)

Over the past few years, a phenomenon known as Colony Collapse Disorder (CCD) has increased the attention of experts on the survival of colonies of honey bees (Balmori, 2009; Schacker, 2008). The reduction in population of bees worldwide could have serious ecological, economic and, thus, political implications given their role as pollinators. It has been estimated that 15% of wild plant species in Europe (Kwak et al., 1998) and 35% of the global crops produced (Klein et al., 2007) are visited by honey bees. Bees are interesting for this reason from an economic perspective: their economic role has been estimated to be around 153 billion euros in the year 2005 (Gallai et al., 2009). RF-EMF has been classified as one of the possible causes of honey bee colonies collapse (Ratnieks and Carreck, 2010). Even though the interest of media and the public in the effects of exposure of honey bees to mobile communication RF-EMF has drastically increased, there seem to be no thorough body of research into their effects in the scientific literature. As a result, the screening conducted in this contribution identified only eight studies which matched the defined criteria (Table 3), for a total of 12 experiments. Six of the studies focused on the frequency ranges specific to mobile communication and in all cases found a significant relationship between the exposure to the field and the effects studied. Only two of the studies found were not produced in the last decade (Westerdahl and Gary, 1981a,b). These studies were the only ones which did not find any significant effect on flight, orientation of behaviour of bees exposed to CW microwaves (i.e. 2450 MHz) at power densities from 3 to 50 mW/cm^2.

Among the studies that did find an effect, Sharma and Kumar (2010), Kumar et al. (2011) and Sahib (2011) found a critical reduction of all studied parameters of the exposed colonies of bees as a response to RF-EMF. In all cases, an acute decrease in the breeding performance or even a collapse of the entire colony resulted as a consequence of exposure to RF-EMF. However, the studies provide limited statistical information on the scale of the effect found and did not take into account other confounding parameters (e.g. the placement of the emitting device inside the hive).

The work by Harst et al. (2006) and Kimmel et al. (2007) from a German research group seems to support the previously described findings, but do not provide any statistical measure of the effects found and did not report any system of control or sham-exposure.

Clearer conclusions can be drawn from the study by Favre (2011), which seems to be the most complete and qualitatively interesting contribution. Using sound-analysis techniques, the author investigated the changes that were triggered in the behaviour of a population of honey bees of the carnica group (*Apis mellifera* subsp. *carnica*). The sounds produced by the bees from five healthy and unexposed hives were used as a negative control and compared with recordings made when the same hives were exposed to a mobile phone handset in a calling position. Another inactive mobile phone was placed, at an earlier stage, to investigate the possible disturbing influence of the sheer presence of the tool in the hives. The analysis of the recorded sounds revealed that the bees produced sounds at higher frequency and amplitude after about 25 to 40 min after the communication had started and became quiet when the handset was switched off.

No particular difference in behaviour and sounds was found for exposure to the inactive handsets. The analysis of the sound data revealed that the bees were, in fact, producing the so-called "worker piping", which usually serves as a signal for swarm exodus as a response to danger or stress, thus RF-EMF directly affected the community of bees under exposure.

4.2.2. Fruit flies (D. melanogaster)

The screening of the literature identified five studies on the fruit fly (*D. melanogaster*) for a total of nine experiments (see Table 3). All the available studies found a significant effect. The RF-EMF applied focused on the GSM 900 MHz and GSM 1800 MHz (named also DCS—Digital Cellular System) systems.

RF-EMF power density was measured in the range of 0.0002 to 0.0407 mW/cm^2, several order of magnitudes lower than those measured in the previously analysed laboratory studies on birds and bees. All the values can be considered typical for digital mobile telephony handsets and in most cases fall within the current exposure criteria (ICNIRP, 1998). Unlike the previous cases, in most studies it was possible to collect information about the magnetic flux density, which ranged from to the time-averaged 0.003 μT of Panagopoulos et al. (2004) measured for a DCS frequency to 0.09 μT in the study by Panagopoulos et al.

Table 3
Summary of articles on ecological effects of RF-EMF on insects.

Reference	Country	Life stage[a]	Type of study[b]	Number of subjects (or distances if specified)[c]	Duration	Frequency [MHz]	Wave/modulation[d]	Power density [mW/cm^2][e]	SAR [W/kg][f]	Effect[g]	Effect size[h]
Honeybee (Apis mellifera)											
Westerdahl and Gary (1981a)	USA	Adult foragers	Lab	50(50) bees	30 min for 10 days	2450	MW CW	3–50	0.075–1.25	No impact of radiation on flight, orientation and homing abilities at any power density	−
Westerdahl and Gary (1981b)	USA	Adult	Lab	50(50) bees	30 min for 10 days	2450	MW CW	3–50	0.075–1.25	No differences in longevity between exposed and sham exposed at any power density	−
Harst et al. (2006)	Germany	Various	Field	25 bees selected from 4 colonies	n/a[i]	1900	DECT base station (mod. 100 Hz)	n/a	n/a	Reduced weight of bees. Colony collapse and abnormalities in behaviour	+ (21%)
Kimmel et al. (2007)	Germany	Various	Field	5 at full exposure, 3 at 50% exposure(8)	4 days, 2 months, 45 min per day	1800	DECT (mod. 100 Hz)	n/a	n/a	Change foraging flight	+ (14%)
Sharma and Kumar (2010)	India	Various	Field	2(2) colonies	Continuous for 15 min. 2×day, 2×week, from Feb. to Apr. (11–15 h)	900	GSM	0.0086	n/a	Decline in colony strength and in the egg laying rate. Decline in the number of returning bees and total number of foragers. Decline in the storing ability of honey	+ (62%) (22%) (16%)
Favre (2011)	Switzerland	Various	Field	5 hives	12 experiments of 40 min	900	GSM	n/a	0.271–0.98	Effect on behaviour: worker piping signal was observed 25 to 40 min after the onset of the mobile phone	+
Kumar et al. (2011)	India	Adult worker	Field	10(20) bees	40 min	900	GSM	n/a	n/a	Decreased lipid level in the organism of exposed bees.	+
Sahib (2011)	India	Various	Field	3(3) colonies	10 days, 10 min per day	900	GSM	n/a	n/a	Decreased returning ability bees in exposed hives; reduced strength; reduced egg laying rate of queen	+ (58%)
Fruit fly (Drosophila melanogaster)											
Weisbrot et al., 2003	USA	n/a	Lab	n/a	2 times for 60 min with an interval of 4 h, for 10 days	1900	GSM PW	n/a	1.4 (human head)	Irradiation increased the number of off-springs, enhancing reproductive success	+ (36% mean; 50% max)
Panagopoulos et al. (2004)	Greece	n/a	Lab	n/a	6 min/day for 5 days	900	GSM device (in talk mode)	0.041	n/a	Decreased reproductive capacity	+ (50%)
Panagopoulos et al., 2007	Greece	n/a	Lab	2 distances (1 control)	6 min/day for 6 days	900	GSM PW phone antenna	0.407 (±0.061)	n/a	Decrease of reproductive capacity, seemingly dependent on field intensity more than on frequency	+ (41.4% mean; 255.2% max)
						1800	DCS PW phone antenna	0.283 (±0.043)	n/a	Idem	
	Greece	n/a	Lab			900			0.89		

Panagopoulos et al., 2010				12 distances (1 control)	6 min/day for 6 days		GSM CW phone antenna	0.378 (±0.059; max value at 0 cm from antenna)		Reproductive capacity decreased at all distances studied at increasing pwoximity to the antenna. A window effect was revealed at distances of 20–30 cm.	+ (11% mean; 40.6% max)
								0.0004 (±0.0001; min value at 100 cm from antenna)	Idem	Idem	Idem
						1800	DCS CW phone antenna	0.252 (±0.05; max value at 0 cm from antenna)	Idem	Idem	Idem
								0.0002 (±0.0001; min value at 100 cm from antenna)	Idem	Idem	
Panagopoulos and Margaritis, 2010	Greece	n/a	Lab	n/a	1–21 min for 5 days	900	GSM PW phone antenna	0.01 (time averaged; ±0.002 at a distance of 30 cm)	0.795	Almost linear decrease in reproductive capacity at increasing durations of exposure.	+ (49.3% mean; 67.4% max)
					1–21 min for 5 days	1800	DCS PW phone antenna	0.011 (time averaged; ±0.003 at a distance of 30 cm)	0.795	Idem	Idem
Panagopoulos, 2012	Greece	n/a	Lab	n/a	6 min for 5 times	900	GSM CW phone antenna	0.063	0.795	Decreased ovarian size after two exposures.	+ (21% mean; 29.5% max)
Other insects: tobacco hornworm (Manduca sexta), American cockroach (Periplaneta americana), and ant (Myrmica sabuleti)											
Schwartz et al. (1985)	Canada	Adults exposed at larval stage	Lab	n/a	From larva to pre-pupal stage	2695 (500 pulse per second)	Anechoic chamber, horn antenna PW	4	23	Decreased food consumption and larval body weight after 20 days. Deformed adults. Higher mortality. Lower number of laid eggs.	+ (50%) (2%) (20%) (23%)
Vacha et al. (2009)	Czech Republic	n/a	Lab	11(11 non exposed)	3 h	1.2–7	RF generator	n/a	n/a	Rise in the locomotor activity and disruptive effect at 1.2 MHz.	+ (14%)
Cammaerts et al. (2012)	France	Various life stages	Lab	6 large naive colonies	Three exposure periods: 4.5 days; 6 days; 1.5 days	900	GSM from vector signal generator	7.95×10^{-5}	n/a	Diminished acquired association between food and a olfactory and visual cues.	+ (40%) (42.5%)

[a] Life stage refers to the age of the tested subject at the moment of the performance of the experiment.
[b] Studies divided in laboratory and field studies. Lab = laboratory study and Field = field study.
[c] Number of subjects involved in the experiment or field study where reported in the study. In brackets information about number of control subjects. Further specifications of type of subjects involved in the studies are reported if provided by authors. In the case of studies regarding the fruit fly the distances applied are reported.
[d] Wave/modulation indicates the type of RF-EMF applied/measured in the study. CW = continuous wave, MW = microwave, GSM = Global System for Mobile Communications, and DECT = Digital Enhanced Cordless Telecommunications.
[e] Values of power density are reported as provided by authors or recalculated by conversion of electric field values ($PD = EF^2/3770$) and expressed in mW/cm^2.
[f] Values of SAR are reported as provided by authors and expressed in W/kg.
[g] Biological or ecologically relevant endpoints studied.
[h] Size of the effect where significant. It indicates the ration between maximum effect and percentual difference compared to control. A + sign indicates a significant effect and a − sign indicates that no significant effect was found.
[i] n/a indicates that data was not provided by authors.

Table 4
Summary of articles on ecological effects of RF-EMF on other vertebrates (than birds).

Reference	Country	Species (*scientific name*)	Life stage[a]	Number of subjects[b]	Duration of exposure	Frequency [MHz]	Wave/ modulation[c]	Power density [mW/cm^2][d]	SAR [W/kg][e]	Effect[f]	Effect size[g]
Chernovetz et al. (1975)	USA	Rat (*Rattus norvegicus*)	n/a[h]	n/a	11–14 days, 10 min	2450	MW CW	20	38	No effect on development	−
Berman et al. (1978)	USA	Mouse (*Mus musculus*)	Emb	n/a	1–17 days, 100 min/day	2450	MW CW	3.4–28	2–22	Reduced foetal weight and hampered development	+
Berman et al. (1980)	USA	Rat (*as above*)	n/a	n/a	80 h, 4 weeks	2450	MW CW	n/a	5.6	Transient reduction in fertility	−
Jensh et al. (1982)	USA	Rat (*as above*)	Ad	12 (59; 4)	6 h/day (pregnancy period)	2450	MW CW	20	5.2	No changes in development	−
									3.6	Idem	
Kowalczuk et al. (1983)	Great Britain	Mouse (*as above*)	Ad	50 (50)	30 min	2450	MW PW	n/a	44	Significant effect on reproduction: decreased sperm count, increased abnormal sperm	+ (35%) (330%)
Lary et al. (1983)	USA	Rat (*as above*)	Ad	n/a	6–11 days, 24 h/day	100	FM	25	0.4	Unaltered development	−
Nawrot et al. (1985)	USA	Rat (*as above*)	Emb	n/a	6–15 days, 8 h/day	2450	MW CW	30	40	Altered development	+
Lebovitz et al. (1987a)	USA	Rat (*as above*)	n/a	n/a	6 h/day, 9 days	1300	PW (600 Hz pulse)	n/a	7.7	No effect on reproduction/fertility: sperm production, sperm morphology	−
Lebovitz et al. (1987b)	USA	Rat (*as above*)	n/a	n/a	8 h	1300	CW	n/a	9	No effect on reproduction/fertility: testicular function	−
D'Andrea et al. (1989)	USA	Rhesus monkey (*Macaca mulatta*)	Juv	5 (same test group, sham-exposed)	1 session of 60 min per day per 1 week	1300	MW PW	0.92 mean (peak of 0.1318)	0.09 mean in the head (15 peak in the head)	No change in behaviour as compared to sham-exposed sessions	−
Berman et al. (1992)	USA	Rat (*as above*)	Juv/Ad	119 (0; 129)	22 h/day, 18 days (from 1st through 19th day of gestation)	970	n/a	n/a	0.07	Unaltered development	−
									2.4	Unaltered development	−
									4.8	Foetal development alterations	+ (7%)
Lai et al. (1994)	USA	Rat (*as above*)	Juv	n/a	n/a	2450	PW	n/a	0.6	Decreased performance in behavioural tasks in T-maze. Deficit in memory function	+ (50%)
Sherry et al. (1995)	USA	Rhesus monkey (*as above*)	Ad	6 (no control or sham-exposed group)	2 min (7200 pulses)	100–1500	MW UWB	1.65782×10^7	0.5 (whole body average)	Unaltered behavioural test performance	−
Klug et al. (1997)	Germany	Mouse (*as above*)	Emb	53 (65)	36 h	150	AM	0.95491–95.4907	n/a	Unaltered growth	−
									0.2	Idem	
									1	Idem	
									5	Idem	
						900	GSM	1.33714	0.2	Idem	
									1	Idem	
									5	Idem	
Jensh (1997)	USA	Rat (*as above*)	Juv/Ad	n/a	6 h/day, 5 days	915	GSM CW	10	n/a	Unaltered growth	−
					6 h/day, 5 days	2450	MW CW	20	n/a	Idem	
Magras and Xenos (1997)	Greece	Mouse (*as above*)	Juv	36	5 pregnancies	88.5–950	FM; UHF TV; GSM	1.053×10^{-3}	1.936×10^{-3}	Progressive decrease in the number of newborns per dam leading to irreversible infertility Improved prenatal development parameters	+ (76%) + (27%)
								168×10^{-6}	Idem	Idem	
Khillare and Behari (1998)	India	Rat (*as above*)	Ad	18 (18)	2 h/day, 35 days	200	AM (mod. 16 Hz)	1.47	1.65–2	Decreased fertility observed in exposed tests. Unaltered development	+ (42%) −
Bornhausen and Scheingraber (2000)	Germany	Rat (*as above*)	Ad	12(12)	20 days (pregnancy period)	900	GSM (mod. 217 Hz)	0.1	0.75	Unaltered growth	−
Sienkiewicz et al. (2000)	UK/USA	Mouse (*as above*)	Ad	n/a	45 min 10 days	900	PW (mod. 217 Hz)	0.54	0.05	Unaltered learning in the performance of tasks	−
									5.7		
Yamaguchi et al. (2003)	Japan	Rat (*as above*)	Ad	168	1 h/day for 4 days; 45 min daily for 4 days; 1 h/day for 5 days and 2 days of rest for 4 weeks	1439	PW TDMA	n/a	1.7	Unaltered learning abilities in the performance of tasks	−

Cassel et al. (2004)	France	Rat (*as above*)	Ad	n/a	45 min	2450	PW	n/a	0.6	Unaltered learning in the performance of tasks	−
Cobb et al. (2004)	USA	Rat (*as above*)	n/a	n/a	45 min, 10 days	2450	MW PW	n/a	0.6	Unaltered brain development and performance of spatial tasks	−
Cosquer et al. (2005)	France	Rat (*as above*)	Juv	48	45 min	2450	PW	n/a	0.6	Unaltered performance in spatial tasks	−
Dasdag et al. (2008)	Turkey	Rat (*as above*)	Ad	14 (10 control; 7 sham-exposed)	2 h/day, 7 days/week, 10 months	900	PW	0.02384–0.17561	0.07–0.57	Unaltered fertility	−
Kumlin et al. (2007)	Finland	Rat (*as above*)	Juv	18(6)	2 h/day, 5 days/week, 5 weeks	900	PW	n/a	0.3 (mean value)	Improvement in learning abilities of rats	+ (20%)
Ribeiro et al. (2007)	Brasil	Rat (*as above*)	Juv	16 (8)	1 h/day, 11 days	1850	PW	1.4	n/a	Unaltered fertility	−
Yan et al. (2007)	USA	Rat (*as above*)	Ad	16	2 times/day for 3-h periods for 18 weeks	1900	CDMA	n/a	1.8	Higher incidence of sperm cell death	+ (37%)
Mathur (2008)	India	Rat (*as above*)	Juv	n/a	2 h/day, 45 days	73.5	AM (mod. 16 Hz)	1.33	0.4	Abnormal behavioural response to noxious stimuli	+ (38%)
Nittby et al. (2008)	Sweden	Rat (*as above*)	Ad	28 (16; 8 sham-exposed)	2 h/week, 55 weeks	900	Lower power level GSM	3.3×10^{-4}	0.62×10^{-3}	Behavioural abnormalities: altered performance of rats during episodic-like memory test	+ (75%)
								n/a	0.37×10^{-3}	Idem	
							GSM	33×10^{-4}	62×10^{-3}	Idem	
									37×10^{-3}	Idem	
Daniels et al. (2009)	South Africa	Rat (*as above*)	Juv	12 (12)	3 h/day, 12 days (2 days after birth)	840	RF signal generator	2.1247×10^{-10} (d = 0.93 m)	n/a	Decreased behaviour. Decreased locomotive activity. Unaltered performance of memory tasks	+ (60%)−
Gathiram et al. (2009)	South Africa	Rat (*as above*)	Ad	32 (32)	8 h/day, 10 days	100–3000	Unique field system	n/a	n/a	Unaltered fertility of exposed male and female individuals	−
Lee et al. (2009)	Korea	Mouse (*as above*)	Ad	17 (14)	90 min/day (15 min break) 17 days (gestation period)	848.5	CDMA	1.4174–8.2501	0.69–4.04	Unaltered development	−
								n/a	2 (Power = 30 W)	Unaltered development	−
				20 (20)	90 min/day (15 min break) 17 days (gestation period)	1950	WCDMA	1.0923–7.0043	1.11–7.13		
Mailankot et al. (2009)	India	Rat (*as above*)	Juv	n/a	1 h/day, 28 days	900–1800	GSM	n/a	n/a	Detrimental effects on fertility	+ (53%)
Nicholls and Racey (2009)	UK	Bat (*Pipistrellus Pipistrellus*)	n/a	n/a	20 h (bat activity); 16 h (insect count); 3 fields	n/a	PW radar	3.8101×10^{-3}–1.7275×10^{-1} (peak values at distance of 10–30 m)	n/a	Reduced foraging and activity of bats	+ (16% in bat counts; 13% bat passes)
										No effect on the abundance of insects	−
Sommer et al. (2009)	Germany	Mouse (*as above*)	Multi-gen.	128 male 256 female,3 generations	570 days (chronic exposure), 30 min/day break	2000	UMTS	0.135	0.08–0.144	Unaltered fertility and development	−
								0.68	0.4–0.72	Idem	
								2.2	1.3–2.34	Idem	
Fragopoulou et al. (2010)	Greece	Mouse (*as above*)	Juv	12 (12)	4 days, 2 h/day	900	GSM	0.05–0.2	0.41–0.98	Deficits in consolidation and/or retrieval of learned spatial information	+ (30%)
Balmori (2010)	Spain	Frog (*Rana temporaria*)	Juv	70 (70)	2 months from egg phase until prior to metamorphosis	648–2155	Cell-phone base station	8.5942×10^{-4}–3.2493×10^{-3}	n/a	Increased mortality rate. Asynchronous growth of exposed subject; disrupted behaviour	+ (90%)
Salama et al. (2010a)	Japan	Rabbit (*Oryctolagus cuniculus*)	Ad	8 (8; 8 sham-exposed)	8 h/day, 12 weeks	800	PW	6.2910×10^{-5}–2.2616×10^{-3} (mean value over time at minimum to maximum distance from the phone)	0.43 (whole body)	Significant decrease in sperm concentration at week 8. Decrease in motile sperm population at week 10. Overall effect on testicular function and reproduction ability	+ (62%) (25%)

(continued on next page)

Table 4 (*continued*)

Reference	Country	Species (*scientific name*)	Life stage[a]	Number of subjects[b]	Duration of exposure	Frequency [MHz]	Wave/ modulation[c]	Power density [mW/cm^2][d]	SAR [W/kg][e]	Effect[f]	Effect size[g]
Salama et al. (2010b)	Japan	Rabbit (*as above*)	Ad	8 (8; 8 sham-exposed)	8 h/day, 12 weeks	800	PW	6.2910×10^{-5}–2.2616×10^{-3} (mean value over time at minimum to maximum distance from the phone)	0.43 (whole body)	Detrimental effects on sexual behaviour: increased number of mounts, increased number of mounts without ejaculation	+
Imai et al. (2011)	Japan	Rat (*as above*)	Juv	24 (24;24)	5 h/day, 7 days/week, 5 weeks	1950	WCDMA CW	n/a	0.4	No effects on reproduction and development	−
Kesari et al. (2011)	India	Rat (*as above*)	Juv	6 (6 sham-exposed)	2 h/day, 35 days	900	n/a	9.2558×10^{-2} (peak value at 20 m);8.2819×10^{-2}(peak value at 30 m)	0.9 (Power= 2 mW)	Potential significant effect on reproduction (fertilizing potential of spermatozoa)	+ (41%)
Sarookhani et al. (2011)	Iran	Rabbit (*as above*)	n/a	18	2 h/day, 2 weeks	950	GSM	n/a	n/a	Decreased reproductive capacity	+ (90%)
Aldad et al. (2012)	USA	Mouse (*as above*)	Ad	39 pregnant (42 sham-exposed)	0 to 24 h/day from day 1 to day 17 of gestation	800 1900	GSM	n/a	1.6	Behavioural and neurophysiological alterations	+ (7%)
Bouji et al. (2012)	France	Rat (*as above*)	Middle-aged	9 (9 sham-exposed)	15 min	900	GSM PW	n/a	6	Altered behaviour and increased stress	+ (47%)
Hao et al. (2012)	China	Rat (*as above*)	n/a	16 (16)	2 times/day for 3 h/day, for 5 days/week, for 10 weeks	916	Mobile phone antenna	1	n/a	Altered learning. Altered memory. Adaptation to field after long term exposure	+ (18%) (18%)
Jiang et al. (2012)	China	Mouse (*as above*)	n/a	5 (5; 5 exposed to gamma radiation; 5 exposed to combined RF and gamma radiation)	4 h/day for 1 to 14 days	900	Wireless transmitter	120	0.548	No effect on mutation	−
Lee et al. (2012)	Korea	Rat (*as above*)	n/a	5 (5; 5 exposed to gamma radiation; 5 exposed to combined RF and gamma radiation)	45 min/day, 5 days/ week, 12 weeks	848.5	CDMA	n/a	2 (4 combined with WCDMA)	No effect on reproduction	−
				idem	idem	1950	WCDMA	idem	2 (4 combined with CDMA)	idem	−
Ozlem Nisbet et al. (2012)	Turkey	Rat (*as above*)	Juv	11 (11;11)	2 h/day for 90 days	900	GSM	n/a	0.003	Increased testosterone level and sperm motility. Altered morphology	+ (15%) (3%)
				idem	idem	1800	GSM	idem	5.3×10^{-5}	idem	+ (14%) (2%)
Poullettier de Gannes et al. (2012)	France	Rat (*as above*)	Various	20 (20;20)	2 h/day, 6 days/week, 18 days	2450	W-LAN Wi-Fi	n/a	0.08	No abnormalities in reproduction and development	−
Yang et al. (2012)	China	Rat (*as above*)	Ad	12 (12 sham-exposed)	20 min	2450	MW PW	65	6	Stress response elicited in rat hippocampus	+ (30%)

[a] Life stage refers to the age of the tested subject at the moment of the performance of the experiment.
[b] Number of subjects involved in the experiment or field study where reported in the study. In brackets information about number of control subjects. Further specifications of type of subjects involved in the studies are reported if provided by authors.
[c] Wave/modulation indicates the type of RF-EMF applied/measured in the study. CW = continuous wave, MW = microwave, GSM = Global System for Mobile Communications, DECT = Digital Enhanced Cordless Telecommunications, PW = pulsed wave, UWB = ultra wide band, AM = amplitude modulation, FM = frequency modulation; UMTS = Universal Mobile Telecommunications System; CDMA = Code division multiple access; TDMA = time division multiple access; and WCDMA = Wideband Code Division Multiple Access.
[d] Values of power density are reported as provided by authors or recalculated by conversion of electric field values ($PD = EF^2/3770$) and expressed in mW/cm^2.
[e] Values of SAR are reported as provided by authors and expressed in W/kg.
[f] Biological or ecologically relevant endpoints studied.
[g] Size of the effect where significant. It indicates the ration between maximum effect and percentual difference compared to control. A + sign indicates a significant effect and a − sign indicates that no significant effect was found.
[h] n/a indicates that data was not provided by authors.

(2010). SAR levels were, when provided, obtained by elaboration of data provided by the manufacturer (i.e. for the human head) of the system used for exposure and not directly measured.

The ecologically relevant endpoints analysed in the studies were growth and reproduction. All of the analysed studies found a significant effect compared to the control. With the exception of a study by Weisbrot et al. (2003), all studies were conducted by a research group from the University of Athens, Greece. In the study of Weisbrot et al. (2003) the irradiation determined a beneficial effect on the reproductive success of the exposed system. The number of offsprings even increased by up to 50% compared to control. All the other studies found a significant depression of growth and reproduction as a response to exposure. Several studies performed by Panagopoulos and co-authors (see Table 4) found a maximum decrease in the endpoints of at least 40% compared to control. Exposure duration lasted for 6 min/day or increased over time up to a maximum of 21 min over a period of six or five days. The reproduction of experiments performed at several distances from the emitting system (i.e. a telephone device) suggested in all cases a quasi-linear decrease at increasing durations of exposure (Panagopoulos and Margaritis, 2010) and increase in proximity to the source of the emission (Panagopoulos et al., 2010). In this last study a window-effect was found at distances of 20–30 cm from the device, which resulted in the highest decrease of the measured values.

4.2.3. Effect on other insects

The remaining studies in this section focus on the tobacco hornworm (*Manduca sexta*), on the American cockroach (*Periplaneta americana*) and on a species of ant (*Myrmica sabuleti*; Table 3). The study by Schwartz et al. (1985) analysed differences in development, reproduction and mortality in tobacco hornworms exposed during their larval stage to PW RF-EMF at a frequency of 2695 MHz and a power density of 4 MW/cm^2. All the measured parameters were affected and effect size was as high as 50% lower compared to control.

The studies on the American cockroach (Vacha et al. 2009) and the ant (Cammaerts et al., 2012) focused on the effects of RF-EMF on the magneto-reception of the insects. In the study by Vacha et al. (2009), it was found that, during and after the rotation of the natural geomagnetic field, the insects turned around, as a response of the detection of the field. However, their ability to detect the geomagnetic field was disrupted after exposure to a field at 1.2 MHz with a magnetic flux density between 12 and 18 nT.

Cammaerts et al. (2012) investigated the impact of RF-EMF on the acquisition and loss of olfactory and visual cues of six experimental colonies of the ant *Myrmica sabuleti*. The exposure to a GSM-generated signal determined a loss in the acquired association between food and a visual cue (40% worse than control), a decreased retention of acquired knowledge, and a total loss of visual memory.

The representation of the size of the effect compared to the power density (Fig. 2) shows that significant effects are found both at high and low dosages, revealing no clear dose–response relationship. In one of the analysed studies, no effects were found at high levels of power density.

4.2.4. Summary

A limited set of articles regarding the possible impact of RF-EMF on honey bees is available in literature. Most of the analysed studies found an effect on the target colonies. The most affected endpoints seemed to be behaviour and orientation of exposed bees, which lead to disruptive consequences in the colonies. The majority of the studies did not provide statistical analysis and did not use clear control measures to analyse results. One exception is the study conducted by Favre (2011), in which the behaviour of the bees seems to be comparable to that experienced by colonies exposed to extreme danger and stress.

The studies analysing the effects of RF-EMF on fruit flies found in all cases a significant effect. Results of one study show an increased reproductive success after exposure. The remaining studies, which were conducted by the same research institute in Greece, found in all cases a significant depression of growth and reproduction at both 900 and 1800 MHz. Two studies on the American cockroach and a species of ant analysed the effects of exposure to RF-EMF on the magneto-reception and orientation of the insects. The behaviour of target systems was disrupted by the exposure to RF-EMF.

4.3. Other vertebrates

The impossibility of conducting laboratory experiments into the effects of RF-EMF on humans steadily increased the number of scientific studies on laboratory vertebrate models. As suggested by the WHO (2006), studies conducted on immature animals can, for instance, provide a useful indicator of possible cognitive and behavioural effects on children. The vast majority of studies focused on the analysis of intracellular pathways, for instance through changes in calcium permeability across membranes (e.g. Maskey et al., 2010); or on gene expression,

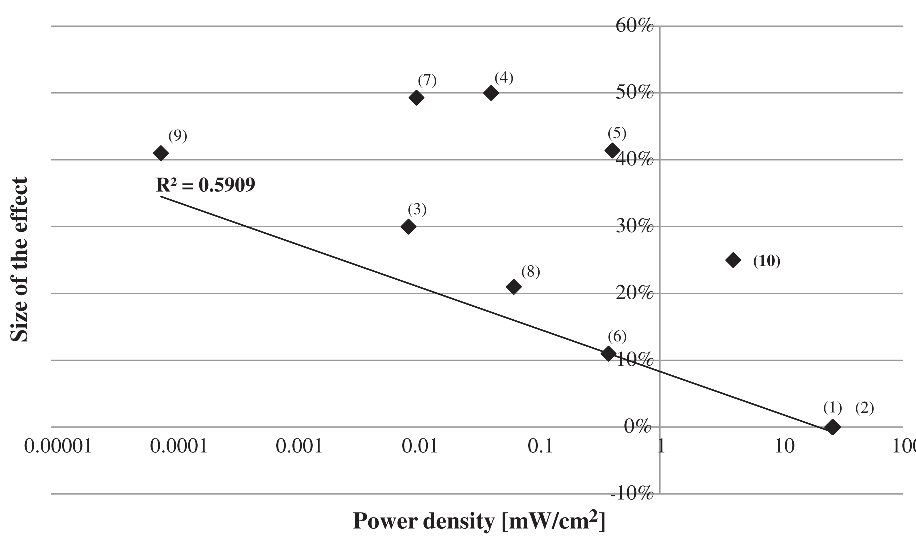

Fig. 2. Size of the effects of RF-EMF on insects compared to the power density of exposure. Articles reported in graph: (1) — Westerdahl and Gary (1981a); (2) Westerdahl and Gary (1981b); (3) — Sharma and Kumar (2010); (4) — Panagopoulos et al. (2004); (5) — Panagopoulos et al. (2007) (6) — Panagopoulos et al., 2010; (7) — Panagopoulos and Margaritis, 2010; (8) — Panagopoulos (2012); (9) — Schwartz et al. (1985); and (10) — Cammaerts et al. (2012). See Table 3 for a complete description of studies.

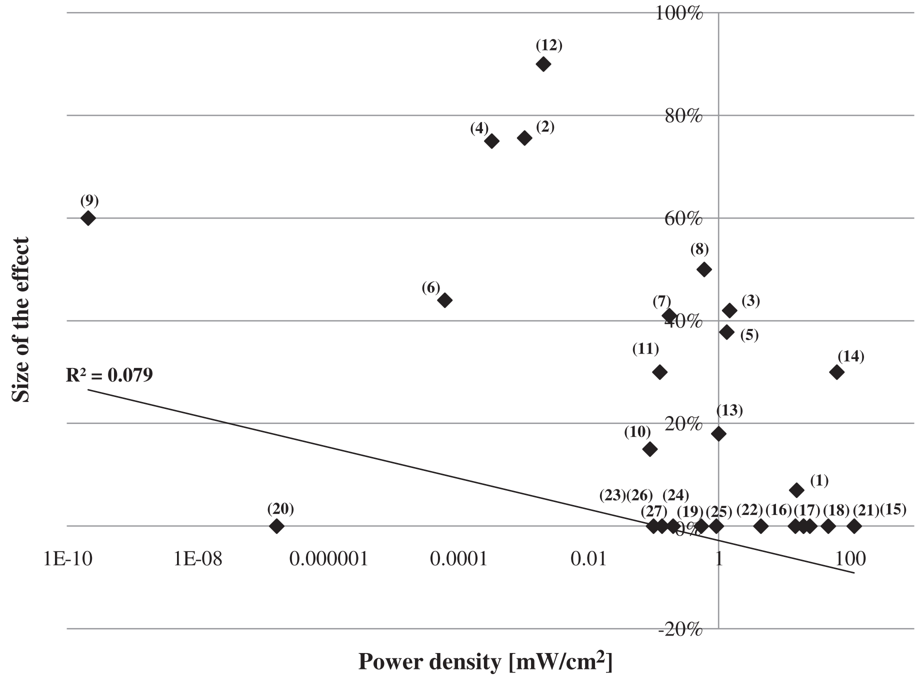

Fig. 3. Size of the effects of RF-EMF compared to the power density of exposed vertebrate animal models. Articles reported in graph: (1) — Berman et al. (1992); (2) — Magras and Xenos (1997); (3) — Khillare and Behari (1998); (4) — Nittby et al. (2008); (5) — Mathur (2008); (6) — Salama et al. (2010a); (7) — Kesari et al. (2011); (8) — Lai et al. (1994); (9) — Daniels et al. (2009); (10) — Nicholls and Racey (2009); (11) — Fragopoulou et al. (2010); (12) — Balmori (2010); (13) — Hao et al. (in press); (14) — Yang et al. (2012); (15) — Jiang et al. (2012); (16) — Chernovetz et al. (1975); (17) — Jensh et al. (1982); (18) — Lary et al. (1983); (19) — D'Andrea et al. (1989); (20) — Sherry et al. (1995); (21) — Klug et al. (1997); (22) — Jensh (1997); (23) — Bornhausen and Scheingraber (2000); (24) — Dasdag et al. (2008); (25) — Lee et al. (2009); (26) — Sommer et al. (2009); and (27) — Sienkiewicz et al. (2000). See Table 4 for a complete description of studies.

namely on the neurons of rats exposed to RF-EMF (e.g. Salford et al., 2003; Zhao et al., 2007); or on possible chromosomal damage in mice cells (e.g. Nikolova et al., 2005).

A total of 50 scientific articles were selected for a total of 62 relevant ecological experiments (Table 4). The endpoints analysed which were of interest were fertility, growth, behaviour and mortality (Table 1).

With the exception of one study on bats (*Pipistrellus pipistrellus*, *Pipistrellus pygmaeus*, *Myotis daubentonii*, and *Myotis nattereri*) breeding nearby a wind turbine and one study on the tadpoles of frogs (*Rana temporaria*), all studies were conducted in a laboratory setting. The animal systems under investigation were rats commonly used in laboratory studies (*Wistar albino rat* and *Sprague Dawley rat*), mice (*Balb/c* and *Balb/c/f*), rabbits (*White New Zealand Rabbit*), rhesus monkeys (*Macaca mulatta*). Of the total of 50 articles, 50% of the studies were conducted on rats. A total of 27 experiments (43%) showed no significant results of an impact of RF-EMF under the physical and experimental settings used. The power density ranged from 0.6×10^{-6} to 20 mW/cm^2, which was the maximum value measured for MW CW exposures (Table 4). The SARs values measured ranged from 0.00194 to 44 W/kg, with a peak value measured at 2450 MHz for MW PW exposure. In the studies in which higher level of exposure to RF-EMF were applied and temperature was not controlled, results may be related to an increase in body temperature as a consequence of exposure.

A large share of the studies on vertebrate animal models focused on changes in behaviour as a result of exposure. This choice may be related to investigating of possible influences of RF-EMF on the behaviour and cognitive performance of humans, who use mobile phone devices in close proximity to their heads. Some commonalities between human and rat response to noxious substances have been explored by other fields of science (Hammond et al., 2004). Lai et al. (1994) suggested that rats suffer from a deficit in spatial working memory function when exposed to RF-EMF (50% decreased performance compared to control). The repetition of the experiment with similar conditions of exposure by Cassel et al. (2004), Cobb et al. (2004), and Cosquer et al. (2005) found no effects on learning abilities of rats in the performance of spatial tasks and no evidence of altered brain development.

Another example in this direction is the work of Daniels et al. (2009), who investigated the effect of RF-EMF in the mobile phone range on the behaviour of the rat with controversial results. Spatial memory was tested using the Morris water maze test (Morris, 1984), and mood disturbances and anxiety-like behaviour were tested in an open field test, for twelve radiated and twelve control subjects. Results showed no significant differences between groups in the Morris test, suggesting no significant difference in the behaviour of exposed and control rats. However, male rats performed significantly worse (60%) in the open field test.

The articles by Lee et al. (2009, 2012) and Imai et al. (2011) are the only studies focusing on the impact of the frequencies network standards found in 3 G mobile communication (Collins and Smith, 2001), working with protocols like wideband code division multiple access (W-CDMA) or CDMA. All experiments, on mice and rats, did not have any observable adverse effect on development, reproduction or mutation of tested subjects. No effects on the development of rats were also observed by the study of Poullettier Poulletier de Gannes et al. (2012), where Wireless Fidelity (Wi-Fi) signal at 2450 MHz was applied on rats, and by the study of Jiang et al. (2012), where mice were exposed to a wireless transmitter at 900 MHz. These studies represent the first attempt to investigate the effects of wireless communication on health.

The field experiment of Balmori (2010) on the behaviour and growth of the tadpoles of frogs (*Rana temporaria*) placed 140 m from a field station provides evidence of the effect of RF-EMF. The exposed group showed low coordination of movements, an asynchronous growth and a high mortality (90%). The control group was exposed to the same environmental conditions, but placed inside a Faraday cage. As a result, the coordination of movements was normal, the development was synchronous, and the mortality rate was 4.2%. The research goal of the field study by Nicholls and Racey (2009) was to test whether PW RF-EMF emitted by a radar could be used as a method of preventing bats from death caused by collisions with wind turbines. The authors analysed 20

Table 5
Summary of articles on ecological effects of RF-EMF on the bacterium *Escherichia coli*, the nematode *Caenorhabditis elegans*, and the land snail *Helix pomatia*.

Reference	Country	Species	Scientific name	Duration of exposure	Frequency [MHz]	Wave/modulation[a]	Power density [mW/cm^2][b]	Magnetic flux density [μT][c]	SAR [W/kg][d]	Effect[e]	Effect size[f]
Grospietsch et al. (1995)	Germany	Bacterium	*Escherichia coli*	6 h	150	PW (mod. 72 Hz)	6.7905	5.4	n/a[g]	Enhanced growth at higher field frequencies, identical at various modulation frequencies	+
				Idem	150	PW (mod. 217 Hz)	6.7905	5.4	n/a		
					150	PW (mod. 1100 Hz)	6.7905	5.4	n/a		
					150	CW	6.7905	5.4	n/a		
Daniells et al. (1998)	UK	Nematode	*Caenorhabditis elegans* strain PC72	2–16 h continuous	750 300	MW TEM cell	n/a	n/a	n/a	Stress reporter gene induction after 2 and 16 h of exposure	+ (150%)
de Pomerai et al. (2002)	UK	Nematode	*Caenorhabditis elegans*	20 h	1000	MW CW	5.37×10^{-5}	n/a	0.001	Enhanced growth as a consequence of exposure	+ (9.8% mean; 11.2% max)
Nittby et al. (2012)	Sweden	Landa snail	*Helix pomatia*		1900	GSM modulated signal	0.068	n/a	0.048	Beneficial induced analgesia	+ (20%)

[a] Wave/modulation indicates the type of RF-EMF applied/measured in the study. Modulation value reported if provided by authors. CW = continuous wave, MW = microwave, GSM = Global System for Mobile Communications, PW = pulsed wave, and DCS = digital cellular system.
[b] Values of power density are reported as provided by authors or recalculated by conversion of electric field values (PD = EF^2/3770) and expressed in mW/cm^2.
[c] Values of magnetic flux density if provided by authors.
[d] Values of SAR are reported as provided by authors and expressed in W/kg.
[e] Biological or ecologically relevant endpoints studied.
[f] Size of the effect where significant. It indicates the ration between maximum effect and percentual difference compared to control. A + sign indicates a significant effect and a − sign indicates that no significant effect was found.
[g] n/a indicates that data was not provided by authors.

foraging sites. The exposure of bats to a pulsed wave radar system determined a significant reduction in foraging activity of bats.

The plotting of the size of the effect with the relative measured power density (where the value was provided by authors) of positive studies does not show any detectable trend (see Fig. 3). No clear pattern is visible from the analysis of the data and effects were found both at high and low levels of power density.

4.3.1. Summary

Rats and rabbits exposed to RF-EMF in a laboratory setting represented the most studied animal model. Changes in behaviour as a result of exposure were analysed in most studies and presented contradictory results. As for the other endpoints, significant effects were found under various conditions of exposure and under different laboratory setups. A field study showed a significant effect of exposure on the growth and mortality rates of tadpoles of frogs under field conditions. In another RF-EMF reduced the foraging activity of bats.

4.4. Other organisms

This section includes studies on the effect of RF-EMF on the bacterium (*Escherichia coli*), the nematode (*Caenorhabditis elegans*), and the land snail (*Helix pomatia*), which constitute the species not yet included in the previous sections.

The screening of the literature identified four studies for a total of eight experiments (Table 5). In all cases effects were significant. The RF-EMF applied were mainly the GSM 900 MHz and GSM 1800 MHz (DCS—Digital Cellular System) systems, with the exception of the study of Grospietsch et al.(1995) and de Pomerai et al. (2002), which studied respectively a pulsed wave modulated frequency at 150 MHz and a microwave continuous wave frequency at 1000 MHz (Table 5).

RF-EMF power density was measured in the range of 0.0005 to 0.679 mW/cm^2. All the values can be considered typical for digital mobile telephony handsets and in most cases fall within the current exposure criteria (ICNIRP, 1998).

The ecologically relevant endpoints analysed in the studies were growth, reproduction and stress. All of the analysed studies found a significant effect compared to the control. The exposure of the bacteria *E. coli* and the nematode *C. elegans* suggests that RF-EMF tend to enhance growth of the organisms. The study on the land snail (Nittby et al., 2012) found a beneficial non-thermal analgesic effect on a group of 29 land snails placed on a hot plate. The response time to heat of GSM-exposed snails was 20% higher than that of the control. The study by Daniells et al. (1998), which exposed a transgenic nematode (*C. elegans* PC72) to RF-EMF at a frequency of 750 MHz, found a significant drastic effect on the stress levels (i.e. 150% higher than control) of the exposed target system.

4.4.1. Summary

Studies on the effects of RF-EMF on the bacterium (*E. coli*), the nematode (*C. elegans*) and the land snail (*H. pomatia*) reported in all cases a significant effect on behaviour and growth of target subjects and under all laboratory setups applied. The study on the *E. coli* and *C. elegans* beneficially affected growth. The exposure of the land snail to RF-EMF retarded the response to heat determining a beneficial analgesic effect.

4.5. Plants and yeasts

The influence of the earth's natural magnetic field or that of superimposed artificial magnetic fields on plants has been known for many years. Static magnetic fields, in fact, have been proven to have a beneficial impact on the stimulation of growth and germination of plants (Dulbinskaya, 1973; Pittman, 1965; Savostin, 1930), or inhibitive impact depending on the species and their physiological state (Krizaj and Valencic, 1989; Ružič et al., 1998). According to Soltani et al.

Table 6
Summary of articles on the ecological effects of RF-EMF on plants.

Reference	Country	Species	Scientific name	Life stage[a]	Type of study[b]	Number of subjects[c]	Duration of exposure	Frequency [MHz]	Wave/ modulation[d]	Power density [mW/cm^2][e]	SAR [W/kg][f]	Effect[g]	Effect size[h]
Haider et al. (1994)	Austria	Spiderwort	*Tradescantia*	Plant cuttings with young flower buds	Field	n/a[i]	30 h	10–21	AM CW	0.43	n/a	Clastogenic effect at all distances and electric field levels	+ (157% mean)
								14		1.3	n/a	Idem	
								10		0.43	n/a	Idem	
								14		2.15	n/a	Idem	
								18–21		0.0003 (200 m from broadcasting area)	n/a		
								18–21		1.1207 (mesh cage at 10 m from the slewable curtain antenna)	n/a		
Balodis et al. (1996)	Latvia	Pine	*Pinus sylvestris*	50–90 years old	Field	20 trees per plot, 8 plots	21 years	154–162	Radio transmitter with horizontal polarisation	n/a	n/a	Diminished radial growth near source	+
Magone (1996)	Latvia	Great duckweed	*Spirodela polyrhiza Schleiden*	Plants of different age	Lab	10–30 plants, 5 flasks	5 days	156–162	PW	0.0018 (max value)	n/a	Accelerated reproduction rate. Developmental abnormalities compared (after 30 to 80 days). Shorter life span	+ (150% mean) (58%) (22%)
Schmutz et al. (1996)	Switzerland	Spruce; beech	*Picea abies ( ) Karst.; Fagus silvatica*	Seedling	Field	135 (3 replicates)	3 years, 7 months	900	MW	10(600 W of power); 30;1;3;0.1;0.3	n/a	Unaltered growth and photosynthetic activity. Decreased calcium and sulphur in beech leaves at increasing power densities	–
Selga and Selga (1996)	Latvia	Pine	*Pinus sylvestris*	Needles and cones	Lab	n/a	n/a	154–162	Radio transmitter (*horizontal polarisation)	4.2440×10^{-7}–16.578	n/a	Cytological andultra-structural changes	+
Urech et al. (1996)	Switzerland	Lichens	*Parmelia tiliaceaHypogymnia physodes*	n/a	Lab	n/a	24 h/day, up to 800 days	2450	MW CW	0.2–50	0.9 (mean wet)	Reduced growth rate at 50 mW/cm^2 (thermal effect). No alterations at 5 mW/cm^2 or below. No alterations at 9.5 MHz	+ (67%) –
								2450	MW CW	50	0.9 (mean wet)		–
								9.5	Short-wave broadcast transmitter	14.65	0.0004 (mean wet)		–
Gos et al. (2000)	Switzerland	Yeast	*Saccharomyces cerevisiae*	Cell	Lab	4 (strains)	1 h	900	GSM PW	n/a	0.13	No effect on mutation or stress	–
							36 h				1.3		
Tkalec et al. (2005)	Croatia	Duckweed	*Lemna Minor*	Cultures of young and old leaves	Lab	n/a	2–14 h	400	CW; GTEM cell	0.0265 (for 14 h); 0.14 (2 h and 4 h); 0.446 (2 h); 40.345 (2 h)	n/a	Reduced growth	+ (15% mean after 8 days)
								400	AM CW	0.140	n/a	Reduced growth	(14% mean after 8 days)
								900	CW; GTEM cell	0.0265(for 14 h); 0.1403(2 h and 4 h); 0.4459 (2 h); 40.3448 (2 h)	n/a	Reduced growth	(37% mean after 8 days)
								900	AM CW	0.140	n/a	Reduced growth	(29% mean after 8 days)
								1900	CW; GTEM cell	0.0265	n/a	Decrease in growth	(22% mean after 8 days)
	France	Tomato		3 weeks old	Lab	n/a	10 min	900	GSM	0.0066	n/a		

Roux et al. (2006)			*Lycopersicon esculentum VFN8.*									Evidence of stress-related responses	+ (173% mean)
Tkalec et al. (2007)	Croatia	Duckweed	*Lemna minor*	Cultures	Lab	10–12	2 h	400–900	GTEM cell	0.0265	n/a	Depending on the field frequencies applied and on strength modulation and exposure time, induced oxidative stress	+ (25% mean)
										1.403	n/a	Idem	
										0.4459	n/a	Idem	
										3.8196	n/a	Idem	
							2–4 h			1.403	n/a	Idem	
Roux et al. (2007)	France	Tomato	*Lycopersicon esculentum VFN8*	Cell cultures	Lab	58 plants, 4 replicates	10 min	900	CW	0.0066	n/a	Strong correlation between stress-related parameters and exposure	+ (6% mean treated; % mean shielded)
Sharma et al. (2009)	India	Mung bean	*Vigna radiata*	Seedling	Lab	50 (50)	0.5 h; 1 h; 2 h; 4 h	900	GSM CW	0.00855	n/a	Inhibition of germination. Inhibition of root growth as a consequence of oxidative stress	+ (16% mean)
Ursache et al. (2009)	Romania	Maize	*Zea mays*	Seedling	Lab	25, 5 replicates	1 h; 2 h; 4 h; 12 h	418	CW; TEM cell	0.6	n/a	Increased photosynthesis efficiency.	+ (60% higher chlorophyll content; 35% higher carotene content)
Jinapang et al. (2010, 2009)	Thailand/USA	Mung bean; water convolvuluses	*Vigna radiata*; *Ipomea aquatica*	Seedling	Lab	240 (15), 3 replicates	1 h; 2 h; 4 h	425	CW; TEM cell	0.015 (power 10 W)	n/a	Improved growth. Optimum respectively at: 100 mW for 1 h and 1 mW of power for 2 h	+ (33% mean mung bean; 28% mean water convol-vuluses)
Vrhovac et al. (2010)	Croatia	Yeast	*Saccharomyces cerevisiae*	Strains (FF18733, FF1481, D7)	Lab	3	15–60 min	905	MW PW; GTEM cell	n/a	0.12	Affected growth of three strains of *Saccharomyces cerevisiae*, due to DNA damage	+ (34% mean)
Chen et al. (2012)	China	Yeast	As above	Cells	Lab		5 min with system on, 10 min with system off for 6 h	1800	GSM PW	n/a	4.7	Altered gene-expression	+

[a] Life stage refers to the age of the tested subject at the moment of the performance of the experiment.
[b] Studies divided in laboratory and field studies. Lab = laboratory study and Field = field study.
[c] Number of subjects involved in the experiment or field study where reported in the study. In brackets information about number of control subjects. Further specifications of type of subjects involved in the studies are reported if provided by authors.
[d] Wave/Modulation indicates the type of RF-EMF applied/measured in the study. CW = continuous wave, MW = microwave, GSM = Global System for Mobile Communications, PW = pulsed wave, UWB = ultra wide band, AM = amplitude modulation, FM = frequency modulation, and GTEM = gigahertz transverse electromagnetic cell.
[e] Values of power density are reported as provided by authors or recalculated by conversion of electric field values ($PD = EF^2/3770$) and expressed in mW/cm^2.
[f] Values of SAR are reported as provided by authors and expressed in W/kg.
[g] Biological or ecologically relevant endpoints studied.
[h] Size of the effect where significant. It indicates the ration between maximum effect and percentual difference compared to control. A + sign indicates a significant effect and a − sign indicates that no significant effect was found.
[i] n/a indicates that data was not provided by authors.

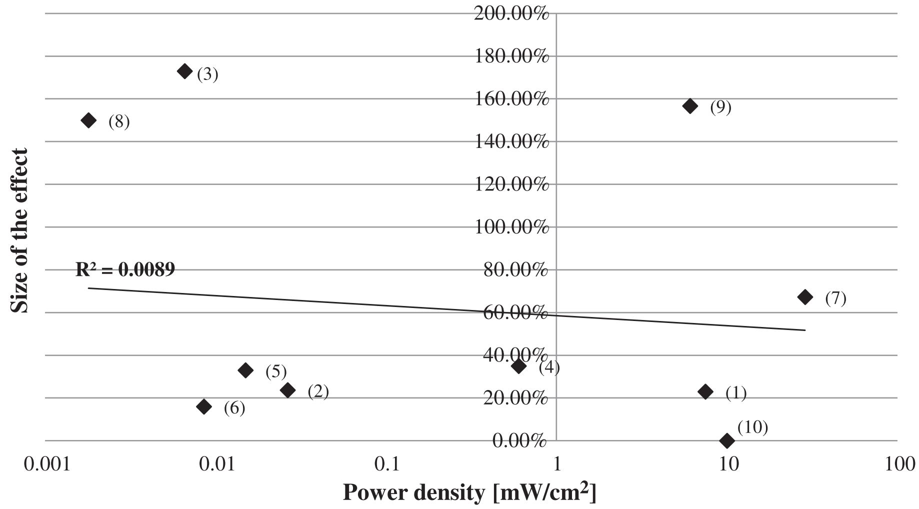

Fig. 4. Size of the effects of RF-EMF compared to the power density of exposed plants. Articles reported in graph: (1) — Tkalec et al. (2005); (2) — Tkalec et al. (2007); (3) — Roux et al. (2007); (4) — Ursache et al. (2009); (5) — Jinapang et al. (2010); (6) — Sharma et al. (2009); (7) — Urech et al. (1996); (8) — Magone (1996); (9) — Haider et al. (1994); and (10) — Schmutz et al. (1996). See Table 6 for a complete description of studies.

(2006), until now no proper physiological explanation has been provided for the described effects, though the biological effects of weak static MF do not only depend on the physical conditions of the exposure (e.g. power density and frequency), but also on the environmental conditions in place.

The analysed literature considered that plants are continuously exposed to RF-EMF as they cannot avoid them, by moving away from the source of emission. As in the case of the studies explored in earlier sections, little is known about a possible mechanism explaining how exposure to RF-EMF may cause biological/ecological effects, and therefore most of the investigations were aimed at the possible mechanisms underlying the effects in plants.

In total, 16 studies and 29 experiments were selected based on the ecological relevance of the endpoints studied (Table 6). Ten experiments investigated the impact of RF-EMF on the inhibition of the regular growth of plants. Four experiments directly investigated the stress levels of plants exposed to RF-EMF as a variation in specific test methods. The remaining studies focused on abnormalities as a consequence of the exposure, and on the effect on the photosynthesis.

The frequency investigated ranged from as low as 10 MHz from an AM CW system (Haider et al., 1994) to 2450 MHz MW CW EMF (Schmutz et al., 1996). Power density ranged from 0.015 mW/cm^2 to 50 mW/cm^2, therefore lower than the values measured in the previous section on the fruit fly (*D. melanogaster*, in Section 4.4) and in line with the applications measured for birds and bees (Sections 4.1 and 4.2). When measured and provided, SAR values were in the range of 0.0–4.7 W/kg (see Table 6).

The experiment by Schmutz et al. (1996) investigated the effects of a long term exposure to 900 MHz MW on the spruce and the beech (*Picea abies* and *Fagus silvatica*). At a measured power density of 10 mW/cm^2, growth parameters and photosynthetic activities of the systems were not affected. No evidence was found on the mutation and the stress levels of yeast (*Saccharomyces cerevisiae*) in the laboratory experiment by Gos et al. (2000) and on mutation in the study by Chen et al. (2012). No information was provided on the levels of power density.

Among the studies with a significant effect on plants, three were published in 1996 by a Latvian group of researchers (Balodis et al., 1996; Magone, 1996; Selga and Selga, 1996). The researchers focused on the area of Skundra, Latvia, where a radio location station had been operating for 20 years. The three studies provide a unique experience of a complete set of experiments and field studies conducted around a radio station in the short as well as in the long term. The area of study also allowed for the investigation of RF-EMF effects at different distances from the station. The effects of other environmental and anthropogenic factors (e.g. pollution levels and population density) were also evaluated without revealing any significant effect on the parameters studied. As a result, the non-thermal RF-EMF under investigation indicated that the effects of short term exposure (i.e. up to five days) are dependent on the stage of growth of great duckweed (*Spirodela polyrhiza*; Magone, 1996) at the time of exposure. The vegetative growth of young plants decreased as a consequence of exposure, while it even accelerated in the case of older plants. The exposed population of adult plants was on average growing 150% more than the control unexposed samples. In the other two studies the pine tree (*Pinus sylvestris*) was under investigation. The effects of RF-EMF emitted by the radio station were analysed using retrospective tree ring data in Balodis et al. (1996): a significant negative correlation between the measured electric field at specific sample locations and the mean relative additional annual increment of pines has been identified. Selga and Selga (1996) found significant cytological and ultra-structural changes in exposed pine needles and cones.

Duckweed (*Lemna minor*) was used as a model plant for the monitoring of effects on growth and other physiological responses also in two studies by Tkalec et al. (2005, 2007), which confirmed that under most of the investigated conditions of field frequencies, modulation, and exposure time growth was significantly reduced (i.e. 29% on average less) compared to control.

A connection between exposure and very rapid molecular stress responses was made in the studies performed by Roux et al. (2006, 2008) focusing on the molecular responses of tomato plants (*Lycopersicon esculentum* Mill VFN8). The study was based on the use of several stress related transcripts (e.g. energy charge and protease inhibitor). Great differences were found in the exposed population compared to the control (up to 300%). The data supports the evidence that plants respond to exposure as they would respond to any other injurious treatment. Even though the RF-EMF used was non-thermal and the total power used was low, results, as the authors commented, are strikingly similar to those found when plants are wounded, cut or burned.

Plotting of the size of the effect and the power density measured in studies (i.e. where provided) did not show any identifiable trend (see Fig. 4): effects were found at high and low dosages and the size of effects varied greatly across studies.

4.5.1. Summary

Significant effects of RF-EMF were found mostly on the inhibition of the growth of exposed plants. Oxidative stress (e.g. for tomato plants or duckweed) and continuous abiotic stress have been presented in some studies as possible determinants of the mechanism. Of interest is the case of studies performed for an extensive period of time in an area in Latvia around a radar station and involving both field and laboratory investigations. These studies showed possible effects of RF-EMF on the radial growth of pine trees (*P. sylvestris*), and on the growth of duckweed (*L. minor*) or great duckweed (*S. polyrhiza*).

5. Synthesis

5.1. General

The reviewed literature focused on birds, insects, plants and other vertebrates studied as model species. Other important ecological groups such as e.g. bumble bees, were underrepresented. Field studies were limited and mostly focused on the analysis of the response of birds and honey bees to RF-EMF. Irrespective of the studied group, development and reproduction were the most studied ecological endpoints.

The number of studies finding effects was highest for plants (90%) and insects (90%), lower for birds (70%), other vertebrates (56%) and other organisms (50%). In all the available field studies significant effects of RF-EMF were found. In laboratory experiments, birds and vertebrate animal subjects were in most cases tested at higher frequencies than smaller organisms (e.g. fruit flies) and plants. Older experiments on birds were often carried out at relatively high frequency MW (i.e. 2450 MHz and higher) and dosages(power density greater than 100 mW/cm^2), which possibly determined a thermal increase of body temperature. In later experiments temperature was kept under control.

The quality of the reported RF-EMF characteristics was heterogeneous. Some studies only provided the frequencies of the RF-EMF emitting device and one dosage parameter (e.g. power density in mW/cm^2). A limited number of studies supplied the full list of physical parameters needed for an adequate description of the exposure (e.g. modulation, spatial connotation of field, polarisation, field pattern and measuring techniques). The reporting of the measured or extrapolated power density values and relative electric field values were discordant and no precise information was given on measurement or calculation procedures. Also relevant biological parameters were often neglected or not described (i.e. size, tissue dielectric properties, size, geometry, and relation to polarisation; see Michaelson, 1991).

The overall quality of the studies varied across and within groups. In the case of the studies regarding bees (with the exception of the study of Favre, 2011) a limited definition of the characterisation parameters of the exposure, and a low number of control/sham measurements limit the possibility of generalising results and for possible ecological effects.

5.2. Dose–effect relationships

The studies that did find an effect did not always refer to the existence of a dose–effect relationship. Two studies from a Greek research group (Panagopoulos and Margaritis, 2010; Panagopoulos et al., 2010) described a non-linear window-effect of RF-EMF at a specific distance from the emitting source. Despite a high number of studies finding a significant effect, there was no clear relationship between applied dosage and size of effect, at the level of ecological groups. However, the analysis was hampered by the use of different and scarcely comparable physical parameters to characterise dosage and the use of different ways of shielding control groups (e.g. not always a Faraday cage was used). Experimental groups were not always shielded from extraneous sources of RF-EMF and other types of RF-EMF not expressly taken into consideration.

One important conclusion is that even at low dosages, high effect percentages were described in the range of between 10 and 90%. There seem to be no specific physical parameters and experimental conditions that seem to determine an effect. In the field experiment the proximity to the emitting device (i.e. usually a base station) contributes to increase the size of the effect.

5.3. From biological to ecological mechanisms and effects

In studies involving RF-EMF exposure temperature increase is often the only recognised and recognisable agent causing an effect. The WHO (2010) considers temperature as the only clear mechanism active, especially in the studies exposing subjects to higher dosages. Most studies only report an effect of RF-EMF, without paying any attention to possible explanations. Stress is often mentioned as a possible influential element. Studies which use a sham-exposed group investigating also the possible influence of the sheer presence of the emitting device in the test area tend to exclude stress as the sole triggering factor for the effect, suggesting that the effect should be ascribed totally to the physical composition of the EMF and to the exposure conditions.

In the case of plants, a used theory is that the effects of RF-EMF could be described and explained, also at non-thermal exposure dosages, as an ordinary stress factor, like drought or heat. The size of effects mentioned in studies with effects is relatively large in comparison with the control situations, and therefore it may be tentatively concluded from these studies that RF-EMF might have a significant ecological effect.

5.4. Differences between effect and no-effect studies: a possible bias?

The differences in articles between effect and no-effect RF-EMF studies were compared regarding the country of the origin, the exposure duration, the applied RF-EMF frequencies, and the impact factor of the journal of publication (see Table 7).

The comparison of the countries of origin of the main authors and research groups showed in both groups a clear prevalence of studies coming from the USA (Table 7). Among the studies that did find a significant effect the most represented countries were India, Greece, France, Croatia, Germany, and Latvia (see Table 7). A lower variation in countries was found in the case of no-effect studies.

The analysis of the duration of the exposure showed that exposure was on average twice as high in the case of positive studies than in studies with no significant effects. Minimum and maximum values were also higher in the first case (see Table 7).

The distribution of studies according to the RF-EMF frequencies applied confirmed a clear prevalence of the range between GSM and MW lower band in the case of studies finding an effect. Most of the studies which did not find an effect applied RF-EMF frequencies higher than 2000 MHz (see Table 7). The analysis of the impact factors (JRC WEB, Journal Citation Reports, 2012) of the journals where the selected articles were published showed on average a higher score for studies not finding an effect (see Table 7).

In conclusion, possible ecological effects of RF-EMF seem to be found more at higher duration in the GSM bands and in the MW frequency bands (>2000 MHz).

5.5. Minimum requirements for studies on ecological effects of RF-EMF

In Michaelson (1991) and Beers (1989) attention is paid to the experimental set up of RF-EMF experiments, and to the criteria to conduct biological (therefore, also ecological) RF-EMF field and laboratory studies. The criteria are in line with the propositions of WHO (van Deventer et al., 2011) and their proposed research agenda. None of the studies analysed in this review reported the use of these standard procedures of exposure and analysis.

According to Michaelson (1991) and Beers (1989), experimental conditions should be meticulously defined, selecting the most appropriate animal species to investigate the effect of RF-EMF: intrinsic physical and physiological dissimilarities between species could be confounding elements. The experiments/studies should include a total precise duration

Table 7
Analysis of differences in articles between RF-EMF effect and no-effect studies.

Parameter	Effect	No effect
Country (number)[a]		
USA	18	17
India	8	3
Greece	8	2
France	5	8
Croatia, China, Germany, Latvia, Spain and UK	3	
Canada, Japan and Switzerland	2	
Others	10	12
Exposure duration (min)[b]		
Mean	146,960.5	63,241.26
Median	1800	1800
Mode	30	300
Standard deviation	836,108.1	232,212.2
Sample variance	6.99E+11	5.39E+10
Minimum	5	0.0875
Maximum	7,257,600	1238,400
Based on number of articles	79	39
Frequency ranges (MHz) (number)[c]		
0–30	3	2
31–200	7	2
201–900	38	9
901–1200	7	1
1201–1800	4	5
1801–2000	3	4
>2000	19	16
Journal Impact Factor[d]		
Mean	2.079973	2.449725
Median	2.291	2.371
Mode	0.73	2.291
Standard deviation	1.094949	0.897919
Sample variance	1.198914	0.806259
Minimum	0.13	0.246
Maximum	4.411	4.411
Based on number of articles	73	40

[a] Country: location of the university where main author or research group are based. Data tested by Fisher Exact Test (p-value = 0.1595).
[b] Exposure duration (min): duration of exposure of target subject in minutes as reported by author. Data tested by Kruskal–Wallis (p-value = 0.9514).
[c] Frequency ranges (MHz): type of RF-EMF frequency ranges applied in studies. Data tested by Fisher Exact Test (p-value = 0.03531).
[d] Journal Impact Factor: impact factor of journal of publication, if available, of RF-EMF study as reported by Journal of Citation Reports on the Web (JRC WEB). Data tested by Kruskal–Wallis (p-value = 0.3233).

of exposure, the length of periods of exposure, intervals (if any) between exposures and heating amplitude. Relatively to the SAR levels, the experts warn that they are often predicted using models which fail to characterise specific features of the species exposed (bone, tissue and energy deposition). All the factors that can influence biological responses at the same SAR level (e.g. sex, age and number of subjects) need to be reported.

As for the setup of laboratory experiments, standard laboratory stressors should be avoided or at least accounted for (e.g. using sham-exposure). The effects of other intervening factors (e.g. temperature, noise and chemicals) should be considered (or avoided).

Relative to the characteristics of the RF-EMF, some effects might be related to (or influenced by) the local geomagnetic field and, oddly enough, by the variation occurring in RF-EMF because of lunar phases (Beers, 1989). Other factors that affect the absorption of the RF-EMF (e.g. frequency, polarisation, modulation and field pattern) have to be considered and reported, together with other possible confounding elements (e.g. RF-EMF alien to the experiment/study under investigation).

In the number of studies analysed in this review, it appears that too little attention is paid to these important recommendations. The majority of the reviewed research has been done using small rodents. Scaling of results to other species is needed to further investigate and extend results to the ecosystem level. Some exposure setups are capable of reflecting or focusing the EMF, inducing the SAR levels to increase more than experimenters may have realised, which may lead to erroneous conclusions. There is a clear need for proper dosimetry in experimental procedures with a detailed description of the methods. A special point of attention is the control: not only a control situation, but also a sham situation should be included. This procedure might introduce some extra difficulties in field situations but might still be possible (e.g. by experimentally shutting down the communication stations for a period of maintenance).

There is a great need for more ecological experiment/studies on the effects of RF-EMF, taking into account the reported guidelines. From this ecological review it became, in fact, clear that the way in which RF-EMF were applied and measured, was very heterogeneous, limiting the possible comparison of the effects found.

6. Conclusions and recommendations

The screening of literature in the field ranges that were analysed provided a limited number of strictly ecological studies. The distinction between biological studies and ecological studies as intended in this review has been detailed in Section 1 of this contribution. Only endpoints that may provide an *ecologically* relevant picture were selected, in order to quantify significant biological effects, which may provide valuable hints on the ecological implications of results. The effects of RF-EMF on different biological groups were investigated. With reference to the groups under investigations in the selected studies (i.e. birds, honeybees, mammals, plants, *Drosophila* and others) there is ecologically relevant evidence that the RF-EMF caused an effect in about 50% of the animal studies and about 90% of the plant studies. No studies, in fact, were found on the impact of RF-EMF at the ecosystem level. The sole study by Reijt et al. (2007) investigated the alteration in the interaction among two species of Tits. Only eight studies were conducted in the field.

Nevertheless, an ecological interpretation of the biological studies under review was necessary. The information and results on effects gathered in laboratory studies may need to be cautiously handled due to the sheer nature of the laboratory solutions adopted. The conditions applied in the laboratory studies, in fact, do not always reflect real conditions of exposure, and at times it is important to carefully evaluate the plausibility that biological systems exposed to RF-EMF could likely translate into ecologically relevant effects.

As suggested by the expert panel to the European Commission SCENIHR (Scientific Committee on Emerging and Newly Identified Health Risks) (2009) and Foster and Repacholi (2004), while it seems appropriate to perform experimental studies using pure experimental RF fields, it may be necessary to emulate the complex modulation patterns and intensity variations typical to real RF-EMF exposure. Few of the studies found were performed in the field and engaged in real exposure conditions and only few laboratory studies dealt with real-exposure modulation.

The ICNIRP guidelines (1998, 2010) provide limiting values as basic restrictions and reference levels for the exposure of humans to RF-EMF. These guidelines have been adopted by most European countries which have imposed limits (EU Commission implantation Reports, 2008). To our knowledge, there are currently no guidelines for the exposure of biodiversity to RF-EMF. The available data has so far been inadequate to judge whether the ICNIRP guidelines and other environmental standards should be the same or significantly different from those appropriate to protect human health (EU, 2011).

However, if we consider that the guidelines might protect biodiversity (i.e. with the consideration of differences in size and exposure conditions), in some studies analysed we encountered applications of dosages hardly experienced by animals and plants in case of real outdoor conditions. As a general trend, no clear relationship was determined between maximum effects found in different studies and the dosage of the RF-EMF applied. Also at very low dosages significant ecologically relevant effects were found. These values are compatible with real field situations, and could be found under environmental conditions. From the limited number of field studies decreasing effects could be determined at increasing distances from the emitting source, but residual relevant effects were still detected as far as 300 m away and with an average measured electric field of 0.53 V/m, thus 7.45×10^{-5} mW/cm^2 (ICNIRIP limit for general human population 0.0004 V/m).

As ICNIRP suggests (2010), when reference levels are exceeded restrictions values are not necessarily exceeded. Further investigations, need to be undertaken. For instance, localised fields in excess of the reference levels can be emitted by certain devices (i.e. wireless or remotely-controlled devices) but there might be a weak coupling of the field with the body of the exposed target subject (e.g. due to the size of the exposed subject). Therefore, while it is not possible to rule out the adverse ecological relevance of effects, ICNIRP (2010) and WHO (2010) suggest to extrapolate only cautious indications on the global impact of RF-EMF on ecosystems.

Considering the relevant remark of Beers (1989) "a long list of reports of positive results yielded by inadequate experiments may appear impressive in a review and yet mean little". No clear relationships, in fact, could be found between dosage and effects because of a wide variety of exposure strengths, durations, conditions, frequencies, time between exposures, assessment methods, measurement systems, replications efforts, and adequate dosimetry. In the older laboratory studies the interpretation of results needs to be filtered by the consideration of a lack of control of temperature. In the other studies the balance of experimental evidence points towards a non-thermal effect of RF-EMF exposure. In field studies additional confusion might be caused by the simultaneous exposure to multiple field strengths and frequencies and other environmental confounding variables. A similar conclusion can be drawn for those laboratory studies that did not adequately control the exposure to other sources of electromagnetic fields, in which the influence of other variables on the result was also usually not handled in the design or in the analysis.

The plotting of the size of the ecologically relevant effects in relationship to the dose conditions applied did not seem to define a trend. Thus, the result of the graphical meta-analysis leads to no definitive conclusions about whether the effects are real, not real, or can be found only under certain conditions. The study of the differences between significant and non-significant studies presented in Section 5 revealed differences in the duration of the exposure of the target subjects, in the selection of the frequency band of exposure and in the impact score of the journals where articles were published.

Potential further sources of bias should be further examined using tools such as *funnel* or *forest* plots (Egger et al., 1997; Peters et al., 2006, 2008). These might reveal asymmetries due to: location biases (e.g. language bias, citation bias and multiple publication bias), heterogeneity (e.g. intensity of intervention and differences in odds ratios), data irregularities (e.g. poor or inadequate analysis), poor choice of effect measure, and chance.

At the current state of our knowledge, it is possible to conclude that there is an urgent need for repetitions of experiments and field studies by other research groups and under other (standard) situations and setup in order to confirm the presence/absence of effects. We, once again, refer to the ICNIRP statement of (2010), suggesting that results can only be accepted 'for health risk assessment if a complete description of the experimental technique and dosimetry are provided, all data are fully analysed and completely objective, results show a high level of statistical significance, are quantifiable and susceptible to independent confirmation, and the same effects can be reproduced by independent laboratories' (Repacholi and Cardis, 1997). If the significant conclusions found by studies are confirmed, they will be important for a mechanistic understanding of the interaction of RF fields with ecosystems.

In the synthesis the requirements to conduct an adequate study of the (ecological) effects of RF-EMF have been described in detail. Advances in dosimetric investigations in terms of precision and resolution were appreciable in some of the more recent studies, while standards seemed to be totally neglected in others. The application of the suggested *best practice* would allow to handle the information on the reported effect or absence of effect with greater precision.

Our review highlights that there is a clear need for the study of the effects of RF-EMF on more species and organisms and, by means of field studies, on populations and interactions between species. Studies at the ecosystem level should start from the consideration of micro-ecosystems and micro-cosmos, which would allow for laboratory results to be more informative and ecologically-relevant, also at a policy level.

The number of experiments assessing new technologies is limited: only 5 matched the ecological criteria set in this review. Experiments evaluating the impact of newer wireless technologies (e.g. WiMAX, WLAN and WiFi), together with studies analysing new generations of mobile phone technologies (e.g. 3G and 4G) would shade some light on the impact of these technologies for ecosystems. To our knowledge solely the study on mice by Lee et al. (2009) investigated the possible impacts of these technologies. In order to minimise the uncertainties as efficiently as possible a number of situations with limited number of studies should be investigated: the long-term monitoring of selected species and/or ecosystems, field studies under a controlled system of exposure, laboratory studies following given recommendations, and studies on important ecological groups, other than those here analysed, would be a solid base on which to focus future studies.

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Appendix A

Keywords for literature screening

Main search strategy

RF-EMF OR SAR OR electromagnetic OR "power density" OR "internal electric field" OR "current density" OR non-ionising OR non-ionising OR RF OR "electric field" OR "magnetic field" OR Wi-Max OR WiMax OR W-LAN OR WiFi OR Wi-Fi OR modulation OR DCS OR GSM OR FM OR UMTS OR AM OR television OR TV or FM or AM or radio OR transmitter OR broadcast OR antenna OR aerial OR "base station" OR phone OR wireless OR DECT OR TETRA OR radar OR phone mast AND reproduction OR fecundity OR mortality OR behaviour OR behaviour OR activity OR density OR growth OR navigation OR orientation OR eco* OR malformation OR insect OR honey bee OR bee OR bat OR fruit fly OR mammal OR plant OR fauna OR biodiversity OR community OR population OR wildlife OR animal OR organism OR tree OR plant OR fish OR invertebrates OR fauna OR flora OR fungi OR birds OR vegetation.

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EXHIBIT N

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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July 14, 2016

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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EXHIBIT O.1.

DEPARTMENT OF HEALTH AND HUMAN SERVICES **Public Health Service**

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June 17, 1999

Mr. Richard Tell
Chair, IEEE SCC28 (SC4)
Risk Assessment Work Group
Richard Tell Associates, Inc.
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Dear Mr. Tell:

The members of the Radiofrequency Interagency Work Group (RFIAWG) have identified certain issues that we believe need to be addressed to provide a strong and credible rationale to support RF exposure guidelines. I am writing on behalf of the RFIAWG members to share these ideas with you and other members of the IEEE SCC28, Subcommittee 4 Risk Assessment Work Group. Our input is in response to previous requests for greater participation on our part in the SCC28 deliberations on RF guidelines. The issues, and related comments and questions relevant to the revision of the IEEE RF guidelines, are given in the enclosure. No particular priority is ascribed to the order in which the issues are listed.

The views expressed in this correspondence are those of the members of the Radiofrequency Interagency Work Group and do not represent the official policy or position of the respective agencies.

The members of the RFIAWG appreciate your consideration of our comments and welcome further dialog on these issues. Feel free to contact me or any member of the RFIAWG directly. A list of the members of the RFIAWG is enclosed, with contact information for your use.

Sincerely yours,

W. Gregory Lotz

W. Gregory Lotz, Ph.D.
Chief, Physical Agents Effects Branch
Division of Biomedical and
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Enclosures (2)
cc: N. Hankin
J. Elder
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RF Guideline Issues

Identified by members of the federal RF Interagency Work Group, June 1999

Issue: Biological basis for local SAR limit

The C95.1 partial body (local) exposure limits are based on an assumed ratio of peak to whole body SAR; that is, they are dosimetrically, rather than biologically based. Instead of applying a dosimetric factor to the whole body SAR to obtain the local limits, an effort should be made to base local SAR limits on the differential sensitivity of tissues to electric fields and temperature increases. For example, it seems intuitive that the local limits for the brain and bone marrow should be lower than those for muscle, fat and fascia; this is not the case with the current limits which implicitly assume that all tissues are equally sensitive (except for eye and testicle). If no other data are available, differential tissue sensitivity to ionizing radiation should be considered.

If it is deemed necessary to incorporate dosimetric factors into the resulting tissue-specific SAR limits these should be based on up-to-date dosimetric methods such as finite-difference time-domain calculations utilizing MRI data and tissue-specific dielectric constants. For certain exposure conditions FDTD techniques and MRI data may allow better simulation of peak SAR values. Consideration should be given to the practical tissue volume for averaging SAR and whether this volume is relevant to potential effects on sensitive tissues and organs.

Issue: Selection of an adverse effect level

Should the thermal basis for exposure limits be reconsidered, or can the basis for an unacceptable/adverse effect still be defined in the same manner used for the 1991 IEEE guidelines? Since the adverse effect level for the 1991 guidelines was based on acute exposures, does the same approach apply for effects caused by chronic exposure to RF radiation, including exposures having a range of carrier frequencies, modulation characteristics, peak intensities, exposure duration, etc., that does not elevate tissue temperature on a macroscopic scale?

Selection criteria that could be considered in determining unacceptable/adverse effects include:

a) adverse effects on bodily functions/systems
b) minimal physiological consequences
c) measurable physiological effects, but no known consequences

If the adverse effect level is based on thermal effects in laboratory animals, the literature on human studies (relating dose rate to temperature elevation and temperature elevation to a physiological effect) should be used to determine if the human data could reduce uncertainties in determination of a safety factor.

Issue: Acute and chronic exposures

There is a need to discuss and differentiate the criteria for guidelines for acute and chronic exposure conditions. The past approach of basing the exposure limits on acute effects data with an extrapolation to unlimited chronic exposure durations is problematic. There is an extensive data base on acute effects with animal data, human data (e.g. MRI information), and modeling to address thermal insult and associated adverse effects for acute exposure (e.g., less than one day). For lower level ("non-thermal"), chronic exposures, the effects of concern may be very different from those for acute exposure (e.g., epigenetic effects, tumor development, neurologic symptoms). It is possible that the IEEE RF radiation guidelines development process may conclude that the data for these chronic effects exist but are inconsistent, and therefore not useable for guideline development. If the chronic exposure data are not helpful in determining a recommended exposure level, then a separate rationale for extrapolating the results of acute exposure data may be needed. In either case (chronic effects data that are useful or not useful), a clear rationale needs to be developed to support the exposure guideline for chronic as well as acute exposure.

Issue: One tier vs two tier guidelines:

A one tier guideline must incorporate all exposure conditions and subject possibilities (e.g., acute or chronic exposure, healthy workers, chronically ill members of the general public, etc.). A two tier guideline, as now exists, has the potential to provide higher limits for a specific, defined population (e.g., healthy workers), and exposure conditions subject to controls, while providing a second limit that addresses greater uncertainties in the data available (about chronic exposure effects, about variations in the health of the subject population, etc.). A greater safety factor would have to be incorporated to deal with greater uncertainty in the scientific data available. Thus, a two-tier guideline offers more flexibility in dealing with scientific uncertainty, while a one-tier guideline would force a more conservative limit to cover all circumstances including the scientific uncertainties that exist.

Issue: Controlled vs. uncontrolled (applicability of two IEEE exposure tiers)

The current "controlled" and "uncontrolled" definitions are problematic, at least in the civilian sector, particularly since there are no procedures defined in the document to implement the "controlled" condition. The new guidelines should offer direction for the range of controls to be implemented and the training required for those who knowingly will be exposed (e.g. workers), along the lines of the existing ANSI laser safety standards. This essential element needs to be included for whatever limits are defined, be they one-tier or two-tier.

For example, the OSHA position is that the "uncontrolled" level is strictly an "action" level which

indicates that there is a sufficiently high exposure (compared to the vast majority of locations) to merit an assessment to determine what controls and training are necessary to ensure persons are not exposed above the "controlled" limit. Many similar "action" levels are part of OSHA and public health standards. Should this interpretation be incorporated into the IEEE standard as a means to determine the need to implement a safety plan? [The laser standard has a multi-tiered (Class I, II, III, IV) standard which similarly requires additional controls for more powerful lasers to limit the likelihood of an excess exposure, even though the health effect threshold is the same.]

On the other hand, if it is determined that certain populations (due to their health status or age) are more susceptible to RF exposures, then a multi-tiered standard, applicable only to those specific populations, may be considered.

The ANSI/IEEE standard establishes two exposure tiers for controlled and uncontrolled environments. The following statement is made in the rationale (Section 6, page 23): "The important distinction is not the population type, but the nature of the exposure environment." If that is the case, consideration should be given to providing a better explanation as to why persons in uncontrolled environments need to be protected to a greater extent than persons in controlled environments. An uncontrolled environment can become a controlled environment by simply restricting access (e.g., erecting fences) and by making individuals aware of their potential for exposure. After such actions are taken, this means that the persons who previously could only be exposed at the more restrictive uncontrolled levels could now be exposed inside the restricted area (e.g., inside the fence) at controlled levels.

What biologically-based factor changed for these people? Since the ostensible public health reason for providing greater protection for one group of persons has historically been based on biological considerations or comparable factors, it is not clear why the sentence quoted above is valid.

<u>Issue:</u> <u>Uncertainty factors</u>

The uncertainties in the data used to develop the guideline should be addressed. An accepted practice in establishing human exposure levels for agents that produce undesirable effects is the application of factors representing each area of uncertainty inherent in the available data that was used to identify the unacceptable effect level. Standard areas of uncertainty used in deriving acceptable human dose for agents that may produce adverse (but non-cancer) effects include

(1) extrapolation of acute effects data to chronic exposure conditions,
(2) uncertainty in extrapolating animal data to humans in prolonged exposure situations,
(3) variation in the susceptibility (response/sensitivity) among individuals,

(4) incomplete data bases,
(5) uncertainty in the selection of the effects basis, inability of any single study to adequately address all possible adverse outcomes.

If guidelines are intended to address nonthermal chronic exposures to intensity modulated RF radiation, then how could uncertainty factors be used; how would this use differ from the historical use of uncertainty factors in establishing RF radiation guidelines to limit exposure to acute or sub-chronic RF radiation to prevent heat-related effects?

There is a need to provide a clear rationale for the use of uncertainty factors.

Issue: Intensity or frequency modulated (pulsed or frequency modulated) RF radiation

Studies continue to be published describing biological responses to nonthermal ELF-modulated and pulse-modulated RF radiation exposures that are not produced by CW (unmodulated) RF radiation. These studies have resulted in concern that exposure guidelines based on thermal effects, and using information and concepts (time-averaged dosimetry, uncertainty factors) that mask any differences between intensity-modulated RF radiation exposure and CW exposure, do not directly address public exposures, and therefore may not adequately protect the public. The parameter used to describe dose/dose rate and used as the basis for exposure limits is time-averaged SAR; time-averaging erases the unique characteristics of an intensity-modulated RF radiation that may be responsible for producing an effect.

Are the results of research reporting biological effects caused by intensity-modulated, but not CW exposure to RF radiation sufficient to influence the development of RF exposure guidelines? If so, then how could this information be used in developing those guidelines? How could intensity modulation be incorporated into the concept of dose to retain unique characteristics that may be responsible for a relationship between exposure and the resulting effects?

Issue: Time averaging

Time averaging of exposures is essential in dealing with variable or intermittent exposure, e.g., that arising from being in a fixed location of a rotating antenna, or from moving through a fixed RF field. The 0.1 h approach historically used should be reassessed, but may serve this purpose adequately. Time averaging for other features of RF exposure is not necessarily desirable, however, and should be reevaluated specifically as it deals with modulation of the signal, contact and induced current limits, and prolonged, or chronic exposure. These specific conditions are discussed in a little more detail elsewhere.

If prolonged and chronic exposures are considered to be important, then there should be a reconsideration of the time-averaging practices that are incorporated into existing exposure guidelines and used primarily to control exposure and energy deposition rates in acute/subchronic exposure situations.

Issue: Lack of peak (or ceiling) limits for induced and contact current

A recent change in the IEEE guidelines allows for 6 minute, rather than 1 second, time-weighted-averaging for induced current limits. This change increases the concern about the lack of a peak limit for induced and contact currents. Will the limits for localized exposure address this issue, i.e., for tissue along the current path?

Issue: Criteria for preventing hazards caused by transient discharges

The existing IEEE recommendation states that there were insufficient data to establish measurable criteria to prevent RF hazards caused by transient discharges. If specific quantitative criteria are still not available, can qualitative requirements be included in the standard to control this hazard (e.g., metal objects will be sufficiently insulated and/or grounded, and/or persons will utilize sufficient insulating protection, such as gloves, to prevent undesirable transient discharge.)?

ISSUE: Limits for exposure at microwave frequencies

Concerns have been expressed over the relaxation of limits for continuous exposures at microwave frequencies above 1500 MHz. The rationale provided in the current guideline (Section 6.8) references the fact that penetration depths at frequencies above 30 GHz are similar to those at visible and near infrared wavelengths and that the literature for skin burn thresholds for optical radiation "is expected to be applicable." The rationale then implies that the MPE limits at these high frequencies are consistent with the MPE limits specified in ANSI Z136.1-1986 for 300 GHz exposures. This is apparently the rationale for "ramping up" to the MPE limits for ***continuous*** exposure of 10 mW/cm^2 at frequencies above 3 GHz (controlled) or 15 GHz (uncontrolled). The rationale should be given as to why this ramp function has been established at relatively low microwave frequencies (i.e., 1500 MHz and above), rather than being implemented at higher frequencies that are truly quasi-optical. For example, one option could be two ramp functions, one beginning at 300 MHz, based on whole- or partial-body dosimetry considerations, and another at higher frequencies (say 30-100 GHz) to enable consistency with the laser standard. Such a revision should help reduce concern that the standard is not restrictive enough for continuous exposures at lower microwave frequencies where new wireless applications for consumers could make this an issue in the future.

Issue: Replication/Validation

Published peer-reviewed studies that have been independently replicated/validated should be used to establish the adverse effects level from which exposure guidelines are derived. The definition of "replicated/validated" should not be so restrictive to disallow the use of a set of reports that

are scientifically valid but are not an exact replication/validation of specific experimental procedures and results.

Peer-reviewed, published studies that may not be considered to be replicated/validated, but are well done and show potentially important health impacts provide important information regarding uncertainties in the data base used to set the adverse effect level (e.g., incomplete data base).

Issue: Important Health Effects Literature Areas:

Documentation should be provided that the literature review process included a comprehensive review of the following three areas:

1) long-term, low-level exposure studies (because of their importance to environmental and chronic occupational RFR exposure);
2) neurological/behavioral effects (because of their importance in defining the adverse effect level in existing RFR guidelines); and
3) micronucleus assay studies (because of their relevance to carcinogenesis).

Issue: Compatibility of RFR guidelines

Compatibility of national and international RFR guidelines remains a concern. It is important for the IEEE Committee to address this issue by identifying and discussing similarities and differences in a revised IEEE guideline and other RFR guidelines. Compatibility/noncompatibility issues could be discussed in the revised IEEE guideline or as a companion document distributed at the time the revised IEEE guideline is released to the public.

EXHIBIT O.2.

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EXHIBIT P

Exhibit P.

Below is an excerpted chart compiled by Levitt and Lai of biological effects at extremely low intensities comparable to 5G infrastructure (contained in Exhibit A. Levitt, B.B., Lai, H.C., *Biological effects from exposure to electromagnetic radiation emitted by cell tower base stations and other antenna arrays,* Environ. Rev. **18**: 369–395 (2010) doi:10.1139/A10-018. Published by NRC Research Press.)

These exposures cannot be considered biologically inactive. Scores of studies have found otherwise, despite industry and FCC assurances.

Table I.

A list of studies reporting biological effects at low intensities of RFR. These papers gave either SAR (W/kg) or power density ($\mu W/cm^2$) of exposure.

		SAR (W/kg)	Power density (uW/cm^2)	Effects reported
Belyaev et al. (2005) (in vitro)	915 MHz, GSM 24 & 48 hr	0.037		Genetic changes in human white blood cells
Belyaev et al. (2009) (in vitro)	915 MHz, 1947 MHz GSM, UMTS 24 & 72 hr	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 or 50-Hz AM, 14 days, 5, 10, 20 min per day,		26	DNA damage in human glial cells

	CW- no effect			
Capri et al. (2004) (in vitro)	900 MHz, GSM 1 hr/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)	People lived close to AM radio and radar installations for more than one year		10	People lived and worked near AM radio antennae and radar installations showed deficits in psychological and short-term memory tests.
De Pomerai et al. (2003) (in vitro)	1 GHz 24 & 48 hr	0.015		Protein damages
D'Inzeo et al. (1988) (in vitro)	10.75 GHz CW 30-120 sec	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	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 hr 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 □s pulse width; 2hr/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
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. (1999) (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- not included)	900 MHz, GSM-217 Hz pulses, 577 □s pulse width; 45 min; narcoleptic patients	0.06		Improved cognitive functions.
Kesari and Behari (2009a) (in vivo) (rat whole body)	50 GHz; 2hr/day, 45 days	0.0008		Double strand DNA breaks observed in brain cells
Kesari and Behari (2009b) (in vivo) (rat whole body)	50 GHz; 2hr/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	902.4 MHz, GSM 20 min		60	Brain wave activation.

body)				
Lerchl et al. (2008) (in vivo) (hamster whole body)	383 MHz (TETRA), 900 and 1800 MHz (GSM) 24 hr/day, 60 days	0.08		Metabolic changes.
Magras and Xenos (1999) (in vivo) (mouse whole body)	'Antenna park'-TV and FM-radio, Exposure over several generations		0.168	Decrease in reproductive function.
Makova et al. (2005) (in vitro)	915 and 905 MHz, GSM 1 hr	0.037		Chromatin conformation in human white blood cells.
Mann et al. (1998) (in vivo) (human whole body)	900 MHz GSM pulse-modulated at 217 Hz, 577 □s width, 8 hr		20	A transient increase in blood cortisol.
Marinelli et al. (2004) (in vitro)	900 MHz CW 2 - 48 hr	0.0035		Cell's self-defense responses triggered by DNA damage.
Navakatikian and Tomashevskaya (1994) (in vivo) (rat whole body)	2450 MHz CW and 3000 MHz pulse-modulated 2 □s pulses at 400 Hz Single (0.5-12hr) or repeated (15-60 days, 7-12 hr/day) exppsure, CW-no effect	0.0027		Behavioral and endocrine changes, and decreases in blood concentrations of testosterone and insulin.
Nittby et al. (2007) (in vivo) (rat whole body)	900 MHz GSM 2hr/wk, 55wk	0.0006		Reduced memory functions.
Novoselova et al. (1999) (in vivo)	From 8.15 -18 GHz, 1 sec sweep time-16 ms		1	Functions of the immune system.

(mouse whole body- wavelength in mm range)	reverse, 5 hr			
Novoselova et al. (2004) (in vivo) (mouse whole body- wavelength in mm range)	From 8.15 -18 GHz, 1 sec sweep time-16 ms reverse, 1. 5 hr/day, 30 days		1	Decreased tumor growth rate and enhanced survival.
Pavicic et al. (2008) (in vitro)	864 and 935 MHz, CW, 1-3 hrs	0.08		Growth affected in Chinese hamster V79 cells.
Panagopoulos et al. (2010) (in vivo) (fly whole body)	GSM 900 and 1800 6 min/day, 5 days		1 - 10	Reproductive capacity and induced cell death.
Panagopoulos and Margaritis (2010a) (in vivo) (fly whole body)	GSM 900 and 1800 6 min/day, 5 days		10	'Window' effect of GSM radiation on reproductive capacity and cell death.
Panagopoulos and Margaritis (2010b) (in vivo) (fly whole body)	GSM 900 and 1800 1- 21 min/day, 5 days		10	Reproductive capacity of the fly decreased linearly with increased duration of exposure.
Pérez-Castejón et al. (2009) (in vitro)	9.6 GHz , 90% AM, 24 hrs	0.0004		Increased proliferation rate in human astrocytoma cancer cells.
Perssson 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 (iDEN); 836.55 MHz (TDMA)	0.0024		DNA damage in human leukemia cells.

	2 hr and 21 hr			
Polonga-Moraru et al. (2002) (in vitro)	2.45 GHz 1hr		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 s pulse length) 1-7 days postcoitum	0.0005		Exposure during early gestation affected kidney development.
Roux et al. (2008a) (in vivo) (tomato whole body)	900 MHz		7	Gene expression and energy metabolism.
Roux et al. (2008b) (in vivo) (plant whole body)	900 MHz		7	Energy metabolism.
Salford et al. (2003) (in vivo) (rat whole body)	915 MHz GSM 2 hr	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, 30 min, effect only observed at 16-Hz modulation	0.00015		Calcium movement in the heart.
Schwarz et al. (2008) (in vitro)	1950 MHz UMTS 24 hr	0.05		Genes in human fibroblasts.
Somosy et al. (1991) (in vitro)	2.45 GHz, CW and 16 Hz square-	0.024		Molecular and structural changes in cells of mouse embryos.

	modulation, modulated field more potent than CW			
Stagg et al. (1997) (in vitro)	836.55 MHz TDMA duty cycle 33% 24 hr	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 15 min	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 □s pulses at 1000 pps, also with or without sinusoidal AM between 14 and 41 MHz, response only with AM modulation, 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, square-wave modulated at 217	0.001		Calcium concentration in heart muscle cells of guinea pig.

	Hz; Also 900 MHz with CW, 16 Hz, 50 Hz and 30 KHz modulations			
Yurekli et al. (2006) (in vivo) (rat whole body)	945 MHz GSM, 217 Hz pulse-modulation 7 hr/day, 8 days	0.0113		Free radical chemistry.

EXHIBIT Q

Bioelectromagnetics

Comment

Comment on SCENIHR: Opinion on Potential Health Effects of Exposure to Electromagnetic Fields, Bioelectromagnetics 36:480–484 (2015)

We write to comment on a Letter to the Editor from The Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) summarizing conclusions of its 2015 science review on electromagnetic fields (EMF) [SCENIHR, 2015a]. SCENIHR's latest review was directed by the European Commission to update its previous 2009 scientific review and offering conclusions on the existence of potential health effects of EMF.

In January of 2015, the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR) published its final opinion on "(P)otential health effects of exposure to electromagnetic fields. The purpose of this document was to update previous SCENIHR opinions in the light of recently available information since then, and to give special consideration to areas that had not been dealt with in the previous opinions or in which important knowledge gaps had been identified" [SCENIHR, 2015b].

We offer comments here summarizing problems with the SCENIHR review process and faulty derivation of many of the Committee's overall conclusions. SCENIHR has not answered the question it was appointed to investigate. The Committee has answered a different question, limiting its conclusions to whether certainty or causal effect is established, instead of possibility of health risks. The title, "Opinion on Potential Health Effects of Electromagnetic Fields," clearly indicates the review should be judging whether potential exists, not certainty of health harm. SCENIHR has used the wrong test by requiring absolute proof and mechanistic evidence of potential EMF effects. The embedded up-shifting language instead requires demonstration of "conclusive or unequivocal evidence" [BioInitiative Working Group, 2014, 2015; SCENIHR, 2015a]. As a result, even where the report documents good quality, peer-reviewed study evidence for potential risk, these data are simply dismissed. Short of a finding of causal evidence, it appears the SCENIHR review process will not label any evidence as having potential health effects. The review as written would be better titled "Opinion on Scientific Certainty of Health Harm from Electromagnetic Fields." SCENIHR Committee's own name establishes that its purpose is to investigate emerging and newly identified health risks, not only those conclusively proven.

Interaction Mechanisms

Genetic damage via oxidative stress leads indirectly to single- and double-strand DNA damage at non-thermal levels. There are dozens of peer-reviewed publications that provide convincing evidence of oxidative stress from extremely low frequency EMF (ELF–EMF) and radiofrequency (RF). Furthermore, there is virtually no mention of epigenetic changes to DNA that can account for at least some adverse health effects of ELF and pulsed RF. The emerging science of epigenetics establishes a plausible mechanism to account for significant disturbances and damage in living tissues caused by ELF–EMF and pulsed RF produced by wireless technologies. Epigenetics refers to transient heritable changes in gene expression that do not involve changes to underlying nuclear acid sequence. DNA methylation, chromatin remodeling, histone modification, and non-coding ribonucleic acid (ncRNA) are currently considered to maintain epigenetic variations in response to environmental changes. It is often heard from traditional scientific thinkers that EMF and RF do not have sufficient energy to break chemical bonds, thus cannot be a cause of cancer, but

Conflicts of interest: None.

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both oxidative stress and epigenetic changes provide mechanisms that can lead to cancer and other diseases. The role of epigenetics is already linked to a variety of human disorders and fatal diseases.

Health Effects From THz Fields

Citing expected increase in use of terahertz (THz) fields, SCENIHR should be citing the few studies reporting biological effects that could reasonably be presumed to lead to adverse health effects with long-term exposure, especially noting the presence of theoretical mechanisms for observed damage. This is a special failure to identify "an emerging and newly identified possible health risk" area.

Health Effects From RF Fields

Brain tumors. The report consistently ignores or dismisses published scientific studies that report positive findings at exposure levels below public safety standards [BioInitiative Working Group, 2014, 2015; SCENIHR, 2015a]. There is a consistent pattern of increased risk for glioma (malignant brain tumor) and acoustic neuroma with use of mobile and cordless phones. A finding of "possible effect" is clearly demonstrated, even though complete understanding of mechanisms responsible is not certain.

Brain activities. The letter fails to note a "possible effect" where there is clear evidence presented by SCENIHR that pulsed RF affects electroencephalogram (EEG), sleep structure and duration, evoked potentials, and brainwave activity. Pulsed RF effects on cognition are documented, however, no finding of "possible effect" is derived. That there is not 100% consistency in studies, where many studies report such effects is expected, and simply points to differing study and subject conditions that do not invalidate inescapable evidence for "possible effects" at levels far below safety limits.

Electrohypersensitivity (EHS). It is wrong to apply an either–or test to provocation studies on EHS. SCENIHR concludes there is no "causal evidence," but this is the wrong test to apply in judging "possible effect" as the Committee was instructed.

Neurological diseases. The sheer volume of studies on neurological effects refutes the statement "human studies show no clear effect, but evidence is limited." Neurological/behavioral effects of ELF–EMF and radiofrequency radiation (RFR) were dismissed as "not firmly identified." We have documented a significant number of studies of ELF radiation reported to cause nervous system effects in 90% of the 105 studies available from 2007 to 2014 [BioInitiative Working Group, 2014; SCENIHR, 2015a]. New neurological RFR studies report effects in 68% of studies on RF radiation (or 144 of 211 studies) in 2014. This has increased from 63% in 2012 (93 of 150 studies). Neurological health effects resulting from non-thermal ELF and RF exposures are clearly documented. Another fundamental flaw is in neglecting many studies showing dependence of non-thermal microwave effects on exposure duration or dose (defined in radiation physics as multiplication of SAR on exposure duration) [BioInitiative Working Group, 2014; SCENIHR, 2015a].

Reproduction and development. SCENIHR concludes that inclusion of new studies of pulsed RF on male fertility at non-thermal levels provide weak evidence only. Their analysis misreads evidence of effects of some studies when drawing conclusions [BioInitiative Working Group, 2014; SCENIHR, 2015a]. In one example, statistically significant damage to sperm DNA and sperm motility and vitality was reported at cell phone radiation exposure of only 1 W/kg, which is a common cell phone exposure [De Iuliis et al., 2009]. De Iuliis et al. say "the range of SAR values over which the consequences of RF-EMR radiation were examined (0.4–27.5 W/kg) include the values covered by conventional mobile phones (0.5–1.5 W/kg)," and "significant reductions in vitality were observed at exposure levels as low as 1.0 W/kg (p. 0.01)." SCENIHR misreports it as "(T)he authors claimed that their results clearly demonstrated that RF exposure can damage sperm function via mechanisms involving the leakage of electrons from the mitochondria and the induction of oxidative stress but the employed SAR values are very high and not relevant to cell phone users." Finally, the entire body of new evidence for risks to fertility and reproduction is dismissed.

SCENIHR conclusions dismissing possible health risks are possible only by omitting key data, ignoring data and conclusions of authors, and dismantling the significance of the De Iuliis et al. results by misreporting it.

Health effects from ELF fields genetic effects (damage to DNA) from ELF–EMF are reported 83% (or 49 of 59 studies) of ELF studies [BioInitiative Working Group, 2014; SCENIHR, 2015a]. These studies span the 2006/2007 to 2014 period and many are overlooked. Childhood leukemia studies continue to support increased risk at 0.3 to 0.4 uT as SCENIHR points out, but then disregards on the basis of "no mechanism," ignoring evidence for oxidative stress and epigenetic changes to DNA as reasonable mechanistic explanations. This clearly violates the cardinal Bradford Hill rule that no mechanism is required for a finding of causal evidence, given plausible mechanism(s) exist and other key indicators are present. SCENIHR simply cannot hold this view in light of existing science and public health knowledge and practice.

Health Effects From Combined Exposure to Environmental Stressors

SCENIHR dismisses meta-analyses showing at least 65 individual studies that report synergistic damage from combined exposures of ELF/RF and toxic chemicals. This is more than sufficient evidence to warrant a finding of "possible effect," in line with the directive to this Committee [BioInitiative Working Group, 2014; SCENIHR, 2015a]. Overall, SCENIHR has not conducted a scientific review process for judging possible health risks. This results in erroneous and deceptive conclusions by failing to conclude such possible health risks do exist. Evidence that SCENIHR has presented clearly and conclusively demonstrates that EMF health risks are possible, and in some cases are established. The Committee is obligated to draw to the attention of the European Commission that EMF is a new and emerging problem that may pose an actual or potential threat.

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EXHIBIT R

No. 04-1515

IN THE
SUPREME COURT OF THE UNITED STATES
OCTOBER TERM, 2004

EMR NETWORK,

Petitioner

v.

FEDERAL COMMUNICATIONS COMMISSION and
UNITED STATES OF AMERICA,

Respondents

Amicus Curiae Brief Of the State Of Connecticut In Support Of Petitioner EMR Network's Petition for Writ Of Certiorari

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Questions Presented for Review by Petitioner

1. Does the Federal Communications Commission have an affirmative duty to develop evidence and to supplement the record in a proceeding before it to avoid "acting ignorantly when intelligent action is possible"----as expressed in the Second Circuit landmark decision in *Scenic Hudson.*

2. Does the Congressional mandate to the Federal Communications Commission to act "in a manner consistent with the public interest" in the deployment of broadband and other advanced wireless services require the FCC to determine the effect of its action on the environment and human health? (47 U.S.C. Sec 157)

3. Does the exclusive regulatory authority assigned to the Federal Communications Commission to set human exposure guidelines for RF Radiation--- pre-empting all State and Local Governments--- obligate the FCC to regularly review and update those guidelines? (47 U.S.C. Sec 332(c)(7)(B)(iv))

4. Does the National Environmental Policy Act (NEPA) impose a "continuing responsibility" on the FCC to use all practicable means to assure safe and healthful surroundings for all Americans when carrying out it statutory functions? (42 U.S.C. Sec. 4331 *et seq*.)

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Amicus Curiae Brief Of the State Of Connecticut In
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INTEREST OF THE AMICUS CURIAE

The State of Connecticut by Richard Blumenthal, its Attorney General, submits this brief pursuant to Supreme Court Rule 37.4 in support of petitioner EMR Network's petition for certiorari from the decision of the United States Court of Appeals for the District of Columbia denying EMR Network's petition for review of an order of the Federal Communications Commission (hereinafter "the Commission"). The State of Connecticut is presented with numerous applications for the siting of telecommunications towers and infrastructure. Among the numerous applications received by the state, the state has received applications for the siting of cell phone towers on a church property, on the front lawn of a house, and on a hospital property. There is a substantial reason to be concerned about the health effects of electromagnetic radiation and the emerging science must be examined in greater detail. Without greater understanding of the emerging science, the state is making siting decisions without the comfort of knowing that its citizens are safe.

The Telecommunications Act of 1996 prohibits the State from making its own informed decisions about the safety of communication towers. The state is prohibited by 47 U.S.C. Sec. 332(c)(7)(B)(iv) from denying an application if the communication facility complies with the Commission's regulations concerning the environmental effects of radio frequency emissions. In other words, the state may not deny an application based on emerging and credible science showing the harm of radiofrequency radiation, as it is otherwise permitted to do under its state laws, if the Commission's outdated standards are met. Only the Commission may change its rules to permit a more protective standard; yet, the Commission has rejected a request to examine the science to ensure that its rules are protective. If a federal agency has the awesome power to preclude states from setting more protective environmental and health standards based on the most credible science available at the time an application is submitted to the state, the federal agency must use every available opportunity to ensure that its standards are based on the best and most current science possible.

SUMMARY OF ARGUMENT

The state of Connecticut is precluded from exercising its police power to protect the health and welfare of its citizens from the effects of radiofrequency radiation by 47 U.S.C. Sec 332(c)(7)(B)(iv), which gives the Commission exclusive power to regulate the environmental effects of radio frequency emissions. The FCC procedures allow it to conduct inquiries into matters over which it has jurisdiction. 47 CFR Sec. 1.430. When the pre-emptive authority to regulate with respect to the environmental effects of radio frequency emissions rests exclusively with the Commission, it is arbitrary and capricious for the Commission to reject petitions for inquiries into such matters because, according to the Commission, there are other agencies better suited to conduct such inquiries.

ARGUMENT

THE PRE-EMPTIVE AUTHORITY OF THE FEDERAL COMMUNICATIONS COMMISSION OVER STATE GOVERNMENTS' ABILITY TO SET HUMAN EXPOSURE GUIDELINES OBLIGATES THE FCC TO REVIEW AND UPDATE THOSE GUIDELINES REGULARLY

The State of Connecticut is precluded from rejecting an application for a telecommunications tower that in its estimation will be harmful to the public health or environment if the applicant is in compliance with FCC standards. Absent the pre-emptive effect of 47 U.S.C. Sec. 332(c)(7)(B)(iv), Conn. Gen. Stat. Section 16-50p permits Connecticut's siting agency to consider the

> nature of the probable environmental impact of the facility alone and cumulatively with other existing facilities, including, but not limited to, electromagnetic fields that, whether acting alone or cumulatively with other effects, on, and conflict with the policies of the state concerning, the natural environment, ecological balance, public health and safety….

The Telecommunications Act eliminates the state's ability to use its state powers to reject an application because it believes the radio frequency emissions to be harmful to its citizens as long as the applicant meets the radio frequency standards set by the Commission. 47 U.S.C. Sec. 332(c)(7)(B)(iv).

In denying EMR's petition for a Notice of Inquiry under FCC rules, 47 CFR Sec. 1.430, based on its determination that it is not the most appropriate forum to initiate such an inquiry, the Commission has abdicated its responsibilities. The FCC Order rejecting EMR's request finds:

> EMR had requested that we initiate a proceeding to gather information and opinion about the need to revise our current guidelines for evaluating human exposure to RF emissions from transmitters under the

> jurisdiction of the Commission. We find that OET was correct in dismissing the petition, having determined that *this Commission is not the most appropriate forum to initiate such an inquiry or proceeding concerning the environmental effects of RF radiation at this time*.

(Emphasis added.) (A-1—A-2).

The Commission's rejection of the request for inquiry based on a determination that it was not equipped to handle questions of environmental effects of radiation is an act in dereliction of its responsibilities, especially in light of its preemptive powers. The Commission is mandated to encourage the deployment of telecommunications technology "in a manner consistent with the public interest." 47 U.S.C. Sec. 157. It has already issued rules based on the thermal effects of radiofrequency radiation. Like it or not, the Commission cannot hold the power to preempt state regulation of environment effects of radiofrequency radiation, and then refuse to inform itself of the need to tighten controls because it is not the "right" agency to do so. The agency's determination on this point was arbitrary and capricious.

CONCLUSION

The Court should grant certiorari to review the arbitrary and capricious action of the Federal Communications Commission in refusing to grant the EMR's request for inquiry under the FCC rules on the biological health and environmental effects of radiofrequency radiation.

Respectfully submitted,

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IN THE
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v.

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APPENDIX

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EXHIBIT S

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