To be sent to ICNIRP by October 9, 2018 as an attachment to this form:
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Response to 2018 ICNIRP draft statement, with appendices

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I. Introduction

Scientific documents such as this ICNIRP draft document and its two associated appendices must:

- Be shown to be science-based on several widely accepted principles
- Provide an objective assessment of the scientific literature
- Use clear logic in making inferences or coming to conclusions
- Contain statements supported by citations or provide information, such that the reader can assess whether or not those statements are likely to be valid
- Contain scientific statements that are testable and falsifiable, such that it should be obvious how such statements can be falsified by the reader.

When we have documents where the health and safety of essentially every single human being on earth may be at risk and the health and safety of many other living beings and whole ecosystems may be at risk, such as in this ICNIRP draft document and its appendices, it is especially important that these principles be followed. Accordingly, the following must be viewed as very serious flaws in the ICNIRP draft document and its two appendices.

II. Serious flaws in 2018 ICNIRP draft guidelines and appendix B

1. The biological portions of these ICNIRP drafts (see appendix 1) have 64 different claims for which no evidence is provided. Each of these 64 claims should be documented in terms of the larger scientific literature, not just by cherry picking one or a few studies that can be claimed to support the ICNIRP position. This is particularly important because there is a very large literature contradicting many of these claims.

2. Among the most egregious claims are the undocumented claims that certain EMF effects have no demonstrated health impacts. It is our belief that most, if not all, EMF effects have demonstrated health impacts, as shown by the biomedical scientific literature. Claims of no demonstrated health impacts must, therefore, be based on an extensive review of the biomedical literature on what health effects, if any, are produced by each EMF effect.

3. The conditions used in a study determine what results are obtained. Therefore, a study done under one set of conditions cannot conflict with or show inconsistencies with another done under another set of conditions. The only way to show conflicts or inconsistencies is to do identical studies and produce different results. ICNIRP and other similar organizations often suggest that there are conflicts or inconsistencies based on some superficial similarities, while providing no evidence whatsoever that any such inconsistencies actually exist. This is, therefore, a fundamental logical flaw that needs to be corrected in the ICNIRP draft.

4. A number of specific issues derived from appendix 1 of this document are dealt with below. These include both the biological parts of the ICNIRP draft and various critiques of it. The following 14 critiques are considered particularly important and are therefore singled out for comment here.

III. Critiques of biological parts of ICNIRP draft

1. Neurological and/or neuropsychiatric effects that occur at microwave frequencies

ICNIRP claims that frequencies above 10 MHz are not known to stimulate nerves. However, 27 different reviews listed in appendix 2 show that there are neurological and/or neuropsychiatric effects that occur at microwave frequencies. This claim is therefore false and must be deleted.

2. *Non-thermal effects of microwave frequency electromagnetic fields (EMFs)*

2018 ICNIRP draft guidelines, subsect. 4.3.3 (Temperature elevation):

> "For very low exposure levels (such as within the ICNIRP (1998) basic restrictions), there is extensive evidence that the amount of heat generated is not sufficient to cause harm, but for exposure levels above those of the ICNIRP (1998) basic restriction levels, yet below those shown to produce harm, there is still uncertainty."

ICNIRP provides no evidence for this claim, which is falsified by each of the 89 reviews listed in appendix 2. If ICNIRP wishes to argue against those findings, it should first cite each review, discuss in detail the findings reported and then attempt to rebut each of those 89 bodies of evidence.

2018 ICNIRP draft guidelines, subsect. 4.3.3 (Temperature elevation):

> "Where there is good reason to expect health impairment at temperatures lower than those shown to impair health via radiofrequency EMF exposure, ICNIRP uses those lower temperatures to base limits on."

No evidence is provided to support this claim. Again, this statement clearly appears to be false based on those same 89 bodies of evidence.

3. *Electromagnetic hypersensitivity or EHS*

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing):

> "A small portion of the population attributes non-specific symptoms to various types of radiofrequency EMF exposure; this is referred to as Idiopathic Environmental Intolerance attributed to EMF (IEI-EMF). Double-blind experimental studies have consistently failed to identify a relation between radiofrequency EMF exposure and such symptoms in the IEI-EMF population, as well as in healthy population samples. These human experimental studies provided evidence that 'belief about exposure' (e.g. the so-called 'nocebo' effect), and not exposure itself, is the relevant symptom determinant."

No evidence is provided in support of these assertions. The accepted name for what ICNIRP calls "IEI-EMF" is "electromagnetic hypersensitivity" or EHS and there is much information about it in the scientific literature. It has been shown in four studies that it is possible to identify people with apparent EHS and show that they can be tested in blinded fashion using objectively measurable responses, showing that they are genuinely hypersensitive when compared with normal controls. The four studies are:

1. Rea WR, Pan Y, Yenyves EJ, Sujisawa I, Suyama N, Ross GH. 1991. Electromagnetic field sensitivity. J Bioelectr 10:241-256.
2. Havas M. 2006 Electromagnetic hypersensitivity: biological effects of dirty electricity with emphasis on diabetes and multiple sclerosis. Electromagn Biol Med 2006;25(4):259–68.
3. Havas M, et al. 2010 Provocation study using heart rate variability shows microwave radiation from DECT phone affects autonomic nervous system. In: Giuliani L, Soffritti M, editors. "Non-thermal Effects and Mechanisms of Interaction Between Electromagnetic Fields and Living Matter", European J Oncology — Library. National Institute for the Study and Control of Cancer and Environmental Disease Bologna: Mattioli; 2010. pp. 273–300. 2010.
4. McCarty DE, et al. 2011 Electromagnetic hypersensitivity: evidence for a novel neurological syndrome. Int J Neurosci. www.ncbi.nlm.nih.gov/pubmed/21793784. 2011 Sep 5.

There are other studies that show that there are genuine physiological changes occurring in EHS. Two studies have shown that EHS people have high levels of oxidative stress:

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1. De Luca C, Raskovic D, Pacifico V, Thai JC, Korkina L. 2011 The search for reliable biomarkers of disease in multiple chemical sensitivity and other environmental intolerances. Int J Environ Res Public Health. 2011 Jul;8(7):2770-97. doi: 10.3390/ijerph8072770.
2. Irigaray P, Caccamo D, Belpomme D. 2018 Oxidative stress in electrohypersensitivity self-reporting patients: Results of a prospective *in vivo* investigation with comprehensive molecular analysis. Int J Mol Med. 2018 Oct;42(4):1885-1898. doi: 10.3892/ijmm.2018.3774.

The De Luca et al. citation also showed that genetic polymorphisms in genes encoding enzymes for glutathione utilization produce increased susceptibility to EHS. These findings show that oxidative stress and lowered chemical metabolism have roles in causing EHS and that the ICNIRP claim that it is caused by a nocebo effect is again falsified.

Furthermore, it has been shown using fMRI that there are regions of the brain in EHS people who are especially sensitive to EMF stimulation:

> Heuser G, Heuser SA. 2017 Functional brain MRI in patients complaining of electrohypersensitivity after long term exposure to electromagnetic fields. Rev Environ Health. 2017 Sep 26;32(3):291-299. doi: 10.1515/reveh-2017-0014.

It can be seen from this that EHS is a genuine hypersensitivity condition with major sensitivity responses in the brain. Consequently, not only is what ICNIRP says in this area undocumented, but also each of the ICNIRP claims is also false.

4. Associations between exposure and symptoms or well-being

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing):

> "In studies on transmitters, no consistent associations between exposure and symptoms or well-being were observed when objective measurements of exposure were made, or when exposure information was collected prospectively."

No evidence is provided in support of this assertion.

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing):

> "In studies on mobile phone use, associations with symptoms and problematic behavior have been observed. However, these studies can generally not differentiate between potential effects from radiofrequency EMF exposure and other consequences of mobile phone use, such as sleep deprivation in adolescents using the mobile phone at night."

No evidence is provided in support of this claim.

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing):

> "Overall, the epidemiological research does not provide evidence of a causal effect of radiofrequency EMF exposure on symptoms or well-being."

No evidence is provided in support of this claim. The same 26 reviews on neurological/neuropsychiatric effects that were referred to above also falsify these ICNIRP claims regarding cell phone effects. Similar effects were found, including sleep disruption, fatigue, headache, memory dysfunction, depression, lack of concentration, anxiety, sensory dysfunction and several others. These were found to be produced by many different types of EMF exposures. These included radar, other occupational exposures, three types of broadcast radiation, heavy cell phone use, living near cell phone towers and microwave radiation of the US

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embassy in Moscow. Clearly these are not caused by behavioral changes specific for cell phone use, as ICNIRP argues here. When these problems are becoming almost universal in every single technologically advanced country on earth, surely it is time for ICNIRP to start protecting us from them.

5. *High frequency EMF exposure affects symptoms*

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing):

> "There is thus no evidence that high frequency EMF exposure affects symptoms, except for pain (and potentially tissue damage) at high exposure levels."

No evidence is provided in support of this claim. It is shown to be completely untrue by the 27 reviews on neurological/neuropsychiatric effects previously discussed.

6. *Physiological functions and adverse health effects*

2018 ICNIRP draft guidelines, appendix B, sect. 2.3 (Other brain physiology and related functions):

> "A number of studies of physiological functions that could in principle lead to adverse health effects have been conducted, primarily using *in vitro* techniques. These have included multiple cell lines and assessed such functions as intra- and intercellular signaling, membrane ion channel currents and input resistance, Ca^{2+} dynamics, signal transduction pathways, cytokine expression, biomarkers of neurodegeneration, heat shock proteins, and oxidative stress-related processes. Some of these studies also tested for effects of co-exposure of radiofrequency EMF with known toxins. Although some effects have been reported for some of these endpoints, there is currently no evidence of effects relevant to human health."

No evidence is provided in support of these claims. Is ICNIRP really trying to argue that important signaling pathways, excessive intracellular calcium, inflammation including inflammatory cytokines, neurodegeneration, heat shock responses and oxidative stress have "no relevance to human health"? If so, ICNIRP needs to debunk hundreds of thousands of studies in the PubMed database.

7. *Evidence of eye damage*

2018 ICNIRP draft guidelines, appendix B, sect. 2.3 (Other brain physiology and related functions):

> "Some evidence of superficial eye damage has been shown in rabbits at exposures of at least 1.4 kW m^{-2}, although the relevance of this to humans has not been demonstrated."

Why does ICNIRP state that there is no evidence of human relevance but never tells us if there is any evidence that the findings are not relevant to humans? If there is simply a lack of evidence, then the way ICNIRP describes this speaks to an unconscionable bias on the part of ICNIRP. With human relevance, as with all things, absence of evidence is not evidence of absence.

8. *Endocrine, including neuroendocrine systems, impacted by non-thermal EMF exposures*

In contrast with the many ICNIRP statements with no evidence provided, the endocrine, including neuroendocrine systems, have been widely found to be impacted by non-thermal EMF exposures as shown by the following 12 reviews:

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.

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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.
3. 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.
4. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.
5. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.
6. 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
7. Pall, M. L. 2015. Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action. Rev. Environ. Health 3, 99-116.
8. Sangün Ö, Dündar B, Çömlekçi S, Büyükgebiz A. 2016 The Effects of Electromagnetic Field on the Endocrine System in Children and Adolescents. Pediatr Endocrinol Rev 13:531-545.
9. Hecht, Karl. 2016 Health Implications of Long-Term Exposures to Electrosmog. Brochure 6 of A Brochure Series of the Competence Initiative for the Protection of Humanity, the Environment and Democracy. http://kompetenzinitiative.net/KIT/wp-content/uploads/2016/07/KI_Brochure-6_K_Hecht_web.pdf (accessed Feb. 11, 2018)
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.
12. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

If ICNIRP wishes to disagree with the findings in these reviews, it should cite each of these reviews and describe what findings were documented in each of them. Only then could ICNIRP feel free to disagree with any conclusions reached. Ignoring vast amounts of contrary data and opinion undercuts any claim that ICNIRP may make to providing unbiased science.

9. Neuronal cell death following non-thermal EMF exposures

2018 ICNIRP draft guidelines, appendix B, chap. 5 (Neurodegenerative Diseases):

> "Although one group has reported that exposure to pulsed radiofrequency EMF fields increased neuronal death in rats, which might contribute to an increased risk of neurodegenerative disease, two studies have failed to confirm these results."

No evidence is provided in support of this claim. This is completely inaccurate: approximately a dozen studies found elevated levels of neuronal cell death following non-thermal EMF exposures reviewed in the Tolgaskya and Gordon 1973 review. The two studies by Zhang et al. in rats showed that repeated pulsed microwave/RF radiation in young rats caused them to develop Alzheimer's-like effects as middle-aged rats, including elevated levels of amyloid beta protein and oxidative stress in their brains and including Alzheimer's-like behavioral and memory deficiencies. Other studies have found increased levels of amyloid beta protein following EMF exposures. Why is ICNIRP ignoring such evidence?

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10. Link between radiofrequency EMF exposure and measures of cardiovascular health

2018 ICNIRP draft guidelines, appendix B, chap. 6 (Cardiovascular System, Autonomic Nervous System, and Thermoregulation):

> "Numerous human studies have investigated indices of cardiovascular, autonomic nervous system, and thermoregulatory function, including measures of heart rate and heart rate variability, blood pressure, body, skin and finger temperatures, and skin conductance. Most studies indicate there are no effects on endpoints regulated by the autonomic nervous system."

No evidence is provided in support of this claim.

> "The relatively few reported effects of exposure were small and would not have an impact on health."

No evidence is provided in support of this claim.

> "The changes were also inconsistent and may be due to methodological limitations or chance."

No evidence is provided in support of this claim. Again, the only way to show inconsistency is to perform identical studies that produce widely different findings. If ICNIRP has such studies, it should produce them. If it does not, it should stop falsely claiming inconsistency when one may be looking simply at variation due to changes in the conditions used. When ICNIRP claims there are methodological problems, these need to be clearly stated and clearly documented.

11. Non-thermal radiofrequency EMF exposures produce autoimmune responses

2018 ICNIRP draft guidelines, appendix B, chap. 7 (Immune System and Haematology):

> "There have been inconsistent reports of transient changes in immune function and haematology following radiofrequency EMF exposures."

No evidence is provided in support of this claim.

> "These have primarily been from *in vitro* studies, although some *in vivo* animal studies have also been conducted."

No evidence is provided in support of this claim.

> "There is currently no evidence that such reported effects, if real, are relevant to human health."

A total of 11 animal studies in the EMF Portal database show that non-thermal radiofrequency EMF exposures produce autoimmune responses. These can be easily found by searching that database for *autoimmune* or *autoimmunity for EMFs over 10 MHz*. If ICNIRP wishes to argue that these findings are irrelevant to the large increases in autoimmune incidence and prevalence we have seen in recent years in humans, it should make whatever argument it feels is appropriate. To have ICNIRP ignoring this pattern of evidence is unacceptable.

12. Effects of radiofrequency EMF exposure on reproduction and development

2018 ICNIRP draft guidelines, appendix B, chap. 8 (Fertility, Reproduction, and Childhood Development):

> "There is very little human experimental research addressing possible effects of radiofrequency EMF exposure on reproduction and development. What is available has focused on hormones that are

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relevant to reproduction and development, and as described in the Neuroendocrine System section above, there is no evidence that they are affected by radiofrequency EMF exposure."

This is completely untrue. There are 13 studies showing that such EMFs impact human male reproduction, including sperm motility and aberrations in sperm structure; long-term exposures produce decreases in sperm count. These impacts are shown in the following studies:

1. Avendaño, Mata AM, Sanchez Sarmiento CA. 2012 Use of laptop computers connected to the internet through Wi-Fi deceases human sperm motility and increases sperm DNA fragmentation. Fertil Steril 97: No. 1, January 2012 0015-8282.
2. Agarwal A, Desai NR, Makker K, Varghese A, Mouradi R, Sabanegh E, Sharma R. 2008 Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study. Fertil Steril 92: 1318-1325.
3. Erogul O, Oztas E, Yildirim U, Kir T, Emin A, Komeski G, Irkilata, HC, Irmak MK, Peker AF. 2006 Effects of electromagnetic radiation from cellular phone on human sperm motility. Arch Med Res 37:840-843.
4. Wdowiak A, Wdowiak L, Wiktor H. 2007 Evaluation of the effect of using mobile phones on male fertility. Ann Agric Environ Med 2007, 14: 169-172

The following additional nine studies can all be accessed in the EMF Portal database:

Oni et al., 2011; Iuliis et al., 2009; Zalata et al., 2015; Gorpinchenko et al., 2014; Wang et al., 2015; Baste et al., 2008; Davoudi et al., 2002; Kilgallon and Simmons, 2005; Fejes et al., 2005.

Therefore, the claim by ICNIRP that there are few studies of the effects of EMFs on human reproduction are clearly false. There is also concern about EMF causation of increased spontaneous abortion in humans from an earlier review and from four recent primary literature citations:

1. Goldsmith JR. 1997 Epidemiologic evidence relevant to radar (microwave) effects. Environ Health Perspect. 1997 Dec;105 Suppl 6:1579-87.
2. Mahmoudabadi FS, Ziaei S, Firoozabadi M, Kazemnejad A. 2015 Use of mobile phone during pregnancy and the risk of spontaneous abortion. J Environ Health Sci Eng. 2015 Apr 21;13:34. doi: 10.1186/s40201-015-0193-z.
3. Mortazavi SMJ, Mortazavi SA, Paknahad M. 2012 Association between electromagnetic field exposure and abortion in pregnant women living in Tehran. Int J Reprod Biomed (Yazd) 2017 Feb;15(2):115-116.
4. Liu XY, Bian XM, Han JX, Cao ZJ, Fan GS, Zhang C, Zhang WL, Zhang SZ, Sun XG. 2007 [Risk factors in the living environment of early spontaneous abortion pregnant women]. Zhongguo Yi Xue Ke Xue Yuan Xue Bao. 2007 Oct;29(5):661-4.
5. Zhou LY, Zhang HX, Lan YL, Li Y, Liang Y, Yu L, Ma YM, Jia CW, Wang SY. Epidemiological investigation of risk factors of the pregnant women with early spontaneous abortion in Beijing. Chin J Integr Med. 2017 May;23(5):345-349. doi: 10.1007/s11655-015-2144-z. Epub 2015 Apr 14.

ICNIRP can, if it wishes, argue against these findings, but it cannot simply ignore them and have any sustainable claim that it is protecting our health from EMF effects.

13. Prenatal exposure to EMF non-thermal radiation can produce neurological effects

2018 ICNIRP draft guidelines, appendix B, chap. 8 (Fertility, Reproduction, and Childhood Development):

"Other research has addressed this issue by looking at different stages of development (on endpoints such as cognition and brain electrical activity), in order to determine whether there may be greater sensitivity to radiofrequency fields during these stages."

No evidence is provided in support of this claim.

2018 ICNIRP draft guidelines, appendix B, chap. 8 (Fertility, Reproduction, and Childhood Development):

> "There is currently no evidence that developmental phase is relevant to this issue."

No evidence is provided in support of this claim. Six studies have found that late prenatal EMF non-thermal exposures in rodents produce long-term neurological changes that are maintained as adults, changes similar to those found in ADHD or autism. No similar changes are produced in adults. These changes were found to be produced by cell phone radiation, cordless phone radiation and by Wi-Fi, suggesting that prenatal exposure to a broad range of such radiation can produce these effects. These studies are as follows:

1. Aldad TS, Gan G, Gao X-B, Taylor HS. 2012 Fetal radiofrequency radiation from 800-1900 MH-rated cellular telephone affects neurodevelopment and behavior in mice. Scientific Rep 2, article 312.
2. Othman, H., Ammari, M., Rtibi, K., Bensaid, N., Sakly, M., Abdelmelek, H. 2017. Postnatal development and behavior effects of in-utero exposure of rats to radiofrequency waves emitted from conventional WiFi devices. Environ. Toxicol. Pharmacol. 52:239-247. doi: 10.1016/j.etap.2017.04.016.
3. Bas O, Sönmez OF, Aslan A, Ikinci A, Hanci H, Yildirim M, Kaya H, Akca M, Odaci E. 2013 Pyramidal Cell Loss in the Cornu Ammonis of 32-day-old Female Rats Following Exposure to a 900 Megahertz Electromagnetic Field During Prenatal Days 13-21. Neuroquantology 11: 591-599.
4. Kumari K, Koivisto H, Myles C, Jonne N, Matti V, Heikki T, Jukka J. 2017 Behavioural phenotypes in mice after prenatal and early postnatal exposure to intermediate frequency magnetic fields. Environ Res 162: 27-34.
5. Othman H, Ammari M, Sakly M, Abdelmelek H. 2017 Effects of prenatal exposure to WIFI signal (2.45GHz) on postnatal development and behavior in rat: Influence of maternal restraint. Behav Brain Res 326: 291-302 doi: 10.1016/j.bbr.2017.03.011.
6. Stasinopoulou M, Fragopoulou AF, Stamatakis A, Mantziaras G, Skouroliakou K, Papassideri IS, Stylianopoulou F, Lai H, Kostomitsopoulos N, Margaritis LH. 2016 Effects of pre- and postnatal exposure to 1880-1900 MHz DECT base radiation on development in the rat. Reprod Toxicol 2016; 65: 248-262.

There is a second type of study that also produces clear evidence of fetal effects not seen in adults. These are the two studies in cattle that clearly show high sensitivity of the fetus to EMFs. Conducted by Professor Hässig and his colleagues in Switzerland, they demonstrate effects deep within the body, on cataract formation in newborn calves where the mothers were grazing near a cell phone tower:

1. Hässig M, Jud F, Naegeli H, Kupper J, Spiess BM. 2009 Prevalence of nuclear cataract in Swiss veal calves and its possible association with mobile telephone antenna base stations. Schweiz Arch Tierheilkd 151:471-478.
2. Hässig M, Jud F, Spiess B. 2012 [Increased occurrence of nuclear cataract in the calf after erection of a mobile phone base station]. Schweiz Arch Tierheilkd 154:82-86.

The Swiss safety guidelines are 100 times more stringent than are the ICNIRP safety guidelines, emphasizing the complete inadequacy of the ICNIRP safety guidelines. These two studies clearly show that when pregnant cows are grazing near mobile phone base stations (also 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. Furthermore, because the mothers do not develop cataracts despite their eyes being much more exposed to cell phone tower radiation, this clearly argues

that the fetal eye tissue is vastly more sensitive to EMF effects than is adult eye tissue. When ICNIRP claims there is no evidence but there clearly is evidence, this destroys whatever credibility ICNIRP may have had.

14. EMF exposure has important role in cancer causation

2018 ICNIRP draft guidelines, appendix B, chap. 9 (Cancer):

> "There is a large body of literature concerning cellular and molecular processes that are of particular relevance to cancer. This includes studies of cell proliferation, differentiation and apoptosis-related processes, proto-oncogene expression, genotoxicity, increased oxidative stress, and DNA strand breaks. Although there are reports of effects of radiofrequency EMF on a number of these endpoints, there is no substantiated evidence of health-relevant effects."

No evidence is provided in support of this claim. What ICNIRP is apparently claiming is that these effects of EMF exposure, each of which has been shown in an extraordinarily large scientific literature to have an important role in cancer causation, are—inexplicably—not relevant to health! We are relying on the Melnick critique to provide a much broader-ranging assessment of the many flaws in this cancer section of the ICNIRP draft. We urge ICNIRP to pay close attention to the Melnick critique.

5. Appendix 2 contains reviews documenting each of eight different non-thermal EMF effects. These effects are as follows:

1. Effects on cellular DNA including single-strand and double-strand breaks in cellular DNA and on oxidized bases in cellular DNA; also evidence for chromosomal mutations produced by double strand DNA breaks (23 reviews).
2. 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 (19 reviews).
3. Widespread neurological/neuropsychiatric effects (27 reviews).
4. Apoptosis/cell death (an important process in production of neurodegenerative diseases that is also important in producing infertility responses) (13 reviews).
5. Oxidative stress/free radical damage (important mechanisms involved in almost all chronic diseases; direct cause of cellular DNA damage) (21 reviews).
6. Endocrine, that is hormonal effects, including neuroendocrine, peptide and other non-steroid hormones; also steroid hormones (12 reviews).
7. Increased intracellular calcium: intracellular calcium is maintained at very low levels (typically about 2×10^{-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) (16 reviews).
8. Cancer causation by EMF exposures (36 reviews).

ICNIRP appears to be systematically avoiding citing and discussing review articles that discuss contrary findings and express contrary opinions to those expressed by ICNIRP. That is not acceptable. If ICNIRP wishes to take a position contrary to those taken in these reviews, at a minimum, ICNIRP must cite each contrary review, discuss its main findings and only then can ICNIRP argue against the positions taken in these reviews.

6. Appendix 3 contains reviews showing that pulsed EMFs are, in most cases, much more biologically active than are non-pulsed (continuous wave) EMFs of the same average intensity (13 reviews). This is important because all wireless communication devices communicate via pulsations and because the "smarter" the device, the more it pulses because the pulsations convey the information. This raises the issue that such "smarter" devices may, in fact, be much more dangerous than are less "smart" devices, even if the "smart" devices have lower intensity radiation.

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What should be obvious is that *you could not 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, despite ICNIRP's claims to the contrary.

There is an additional complication here. There have been shown to be intensity windows of exposure, where exposures within a window produce maximum biological effects, but either lower or higher exposures produce much lower effects:

1. Belyaev, I., 2005. Non-thermal biological effects of microwaves. Microwave Rev. 11, 13-29.
2. Belyaev, I., 2015. Biophysical mechanisms for nonthermal microwave effects. In: Markov M.S. (Ed), Electromagnetic Fields in Biology and Medicine, CRC Press, New York, pp 49-67.
3. Pall, M. L. 2015 Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action. Rev. Environ. Health 3, 99-116. doi: 10.1515/reveh-2015-0001.

Each of these issues seriously threatens the whole structure advocated by ICNIRP and must, therefore, be seriously considered by ICNIRP in order to produce a scientifically valid document. They threaten the ICNIRP claim that:

1. Effects are only seen if intensities are above some level but are not seen at lower intensities.
2. Average intensities are all that need to be considered, when in fact average intensities are often irrelevant to biological effects seen.
3. Pulsations can be ignored.
4. Dose response curves are linear or, at least, monotone.

IV. Conclusion

It is our opinion that safety can only be assessed biologically and that the whole structure that ICNIRP proposes is deeply flawed.

Signed:

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Appendix 1

Consideration of biological aspects in ICNIRP 2018 draft and ICNIRP Appendix B

2018 ICNIRP draft guidelines, subsect. 4.3.1 (Nerve stimulation)

Exposure to EMF can induce electric fields within the body, which for frequencies up to 10 MHz can stimulate nerves (Saunders and Jeffreys, 2007); this is not known to occur in vivo at frequencies higher than approximately 10 MHz. The Saunders and Jeffreys article does not test this, so no evidence is provided by ICNIRP supporting this statement. Furthermore each of the 27 reviews on neurological/neuropsychiatric effects listed in appendix 2 provides clear evidence that this is not true. Each provides a body of evidence showing that microwave frequency EMFs do cause neurological and/or neuropsychiatric effects. *The effect of this stimulation varies as a function of frequency, and is typically reported as a 'tingling' sensation for frequencies around 100 kHz (where peak field is most relevant)* **[no evidence provided]**. *As frequency increases, heating effects predominate and the likelihood of nerve stimulation decreases; at 10 MHz the electric field is typically described as 'warmth'* **[no evidence provided]**. *Nerve stimulation by induced electric fields is protected by the ICNIRP low frequency guidelines (2010)* **[no evidence provided; massively contradicted by the 27 reviews]**, *and is not discussed further here.* We have here multiple claims by ICNIRP that are both undocumented by them and are contradicted by very large amounts of evidence that have been reviewed earlier. This raises the question of why ICNIRP did not cite and discuss this very large literature that opposes their position.

2018 ICNIRP draft guidelines, subsect. 4.3.2 (Membrane permeabilization)

When (low frequency) EMF is pulsed, the power is distributed across a range of frequencies, which can include radiofrequency EMF (Joshi and Schoenbach, 2010). If the pulse is sufficiently intense and brief, exposure to the resultant EMF may cause cell membranes to become permeable, which in turn can lead to other cellular changes. However, there is no evidence that the radiofrequency spectral component from an EMF pulse (without the low- frequency component) is sufficient to cause this permeability. **Joshi and Schoenbach did not test this, so no evidence is provided.** *The restrictions on nerve stimulation in the ICNIRP (2010) guidelines provide adequate protection against the low frequency components* **[no evidence provided]**, *so additional protection from the resultant radiofrequency EMF is not necessary* **[no evidence provided]**. *Membrane permeability has also been shown to occur with 18 GHz continuous wave exposure (e.g. Nguyen et al., 2015). This has only been demonstrated in vitro, and requires very high exposure levels (circa 5 kW kg^{-1}) that far exceed those required to cause thermally-induced harm (see Section 4.3.3).* (**Nguyen et al. was a study of bacteria and there is no evidence provided here on mammalian cells, let alone human cells**). *Therefore there is also no need to specifically protect against this effect, as restrictions designed to protect against smaller temperature elevations will also protect against this.* **Logic does not follow**. The genuine membrane permeabilization that is produced by low intensity, non-thermal effects of EMFs, is through activation of voltage-gated ion channels, with the voltage-gated calcium channels (VGCCs) being particularly important. It has been shown that there are 28 published studies which showed that low-intensity EMF effects can be blocked or greatly lowered by calcium channel blockers [Pall ML, 2013 and 2018; J Cell Mol Med. 2013 Aug;17(8):958-65; Environ Res. 2018 Jul;164:405-416.], drugs that are specific for blocking the VGCCs. Microwave frequency EMF exposures lead, in turn, to excessive calcium signaling via increased levels of [Ca2+]i, as shown in many of the reviews listed above on increased calcium levels.

2018 ICNIRP draft guidelines, subsect. 4.3.3 (Temperature elevation)

Radiofrequency EMFs can generate heat in the body. As heat can affect health, it is important that heat generated by EMF is kept to a safe level. However, as can be seen from appendix B, there is a dearth of radiofrequency exposure research using sufficient power to cause heat- induced health effects. Of particular note is that although exposures (and resultant temperature rises) have occasionally been shown to cause severe harm, the literature lacks concomitant evidence of the highest exposures that do not cause harm. For very low exposure levels (such as within the ICNIRP (1998) basic restrictions) there is extensive evidence that the amount of heat generated is not sufficient to cause harm, but for exposure levels above those of the ICNIRP (1998) basic restriction levels, yet below those shown to produce harm, there is still uncertainty **[no evidence provided]** Each of the 89 reviews listed in appendix 2 falsifies this claim. If ICNIRP wishes to argue against those findings, ICNIRP should cite each of those reviews, discuss in detail what findings they report and only then can ICNIRP attempt to rebut each of those 89 bodies of evidence. *Where there is good reason to expect health impairment at temperatures lower than those shown to impair health via radiofrequency EMF exposure, ICNIRP uses those lower temperatures to base limits on* **[no evidence provided; again this statement clearly appears to be false based on those same 89 bodies of evidence]**.

2018 ICNIRP draft guidelines, appendix B, sect. 2.1 (Brain electrical activity and cognitive performance)

Human research addressing higher cognitive function has primarily been conducted within the ICNIRP (1998) basic restriction values, with very limited research at levels high-enough to provide health-effect threshold information. This has primarily been assessed via performance measures, and derivations of the electroencephalogram (EEG) and cerebral blood flow (CBF) measures (sensitive measures of brain electrical activity and blood flow/metabolism, respectively). Most double-blind human experimental studies on cognitive performance, CBF or event-related potential (a derivative of the EEG) measures of cognitive function did not report an association with radiofrequency EMF **[no evidence provided]**. *A number of sporadic findings have been reported, but these do not show a consistent or meaningful pattern* **[no evidence provided]**. *This may be a result of the large number of (uncontrolled-for) statistical comparisons, a possibility consistent with the lack of replication of such reports* **[no evidence provided].** The only way to show lack of replication is to do identical studies and obtain different results. If ICNIRP has many examples of such identical studies, then it needs to document them. If it does not, then it needs to stop making false claims of lack of replication. *Of particular importance is that the larger, more methodologically rigorous studies have failed to identify effects of radiofrequency EMF exposure on these cognitive domains* **[no evidence provided]**. *There are therefore no substantiated reports of radiofrequency EMF negatively affecting performance, CBF or event-related potential measures of cognitive function* **[no evidence provided]**. *Studies analyzing frequency components of the EEG have reliably shown that the 8–13 Hz alpha band in waking EEG and the 10–14 Hz 'sleep spindle' frequency range in sleep EEG, are affected by radiofrequency EMF exposure with SARs <2 W kg^{-1}, but there is no evidence that these relate to adverse health effects* **[no evidence provided]**. *Both rodents and non-human primates have shown a decrease in food-reinforced memory performance with exposures to radiofrequency EMF at a whole body average SAR >5 W kg^{-1} for rats, and a whole body average SAR >4 W kg^{-1} for non-human primates, exposures which correspond to increases in body core temperatures of approximately 1 °C. However, there is no indication that these changes were due to reduced cognitive ability, rather than the normal temperature-induced*

reduction of motivation (hunger) [no evidence provided]. *Such changes in motivation are considered normal and reversible thermoregulatory responses, and do not in themselves represent an adverse health effect* [**no evidence provided]**. Having an interpretation, however plausible or implausible it may be, does not provide compelling evidence to the issue of whether this is a health effect. *Similarly, although not considered an adverse health effect, behavioral changes to reduce body temperature have also been observed in non-human primates at a whole body average SARs of 1 W kg^{-1}, with the threshold the same for acute, repeated exposures and for long-term exposures* **[no evidence provided]**. *There is limited epidemiological research on higher cognitive function* **[no evidence provided]**. *There have been reports of subtle changes to performance measures with radiofrequency EMF, but findings have been contradictory and alternative explanations for observed effects are plausible* **(no evidence provided]**. Again only identical studies that produce widely different findings can provide evidence of contradictory findings. If ICNIRP has such studies, it should produce them. If it does not, it should stop making false claims of contradictory findings. *Further details concerning the term 'substantiated' can be found in the main guidelines document. In summary, there is no substantiated experimental or epidemiological evidence that exposure to radiofrequency EMF affects higher cognitive functions relevant to health* **[no evidence provided].**

2018 ICNIRP draft guidelines, appendix B, sect. 2.2 (Symptoms and wellbeing)

There is research addressing the potential for radiofrequency EMF to influence mood, behavior characteristics and symptoms. A number of human experimental studies testing for acute changes to wellbeing or symptoms are available, and these have failed to identify any substantiated effects of exposure **[no evidence provided]**. See next section for discussion. *A small portion of the population attributes non-specific symptoms to various types of radiofrequency EMF exposure; this is referred to as Idiopathic Environmental Intolerance attributed to EMF (IEI-EMF). Double-blind experimental studies have consistently failed to identify a relation between radiofrequency EMF exposure and such symptoms in the IEI-EMF population, as well as in healthy population samples* [no evidence provided]. *These human experimental studies provided evidence that 'belief about exposure' (e.g. the so-called 'nocebo' effect), and not exposure itself, is the relevant symptom determinant* [**no evidence provided]**. The accepted name for what ICNIRP calls IEI-EMF is electromagnetic hypersensitivity or EHS and there is much information about it in the scientific literature. It has been shown in four studies, that it is possible to identify people with apparent EHS and show that they can be tested in blinded fashion using objectively measurable responses, showing that they are genuinely hypersensitive when compared with normal controls. The four studies are: Rea WR, Pan Y, Yenyves EJ, Sujisawa I, Suyama N, Ross GH. 1991. Electromagnetic field sensitivity. J Bioelectr 10:241-256; Havas M. 2006 Electromagnetic hypersensitivity: biological effects of dirty electricity with emphasis on diabetes and multiple sclerosis. Electromagn Biol Med 2006;25(4):259–68; Havas M, et al. 2010 Provocation study using heart rate variability shows microwave radiation from DECT phone affects autonomic nervous system. In: Giuliani L, Soffritti M, editors. "Non-thermal Effects and Mechanisms of Interaction Between Electromagnetic Fields and Living Matter", European J Oncology — Library. National Institute for the Study and Control of Cancer and Environmental DiseaseBologna: Mattioli; 2010. p. 273–300. 2010; McCarty DE, et al. 2011 Electromagnetic hypersensitivity: evidence for a novel neurological syndrome. Int J Neurosci. bhttp://www.ncbi.nlm.nih.gov/pubmed/21793784> 2011 Sep 5. There are other studies that show that there are genuine physiological changes occurring in EHS. Two studies have shown that EHS people have high levels of oxidative stress: De Luca C, Raskovic D, Pacifico V, Thai JC, Korkina L. 2011 The search for reliable biomarkers of disease in multiple chemical sensitivity and other environmental intolerances. Int J Environ Res Public Health. 2011 Jul;8(7):2770-97. doi:

10.3390/ijerph8072770. Irigaray P, Caccamo D, Belpomme D. 2018 Oxidative stress in electrohypersensitivity self□reporting patients: Results of a prospective in vivo investigation with comprehensive molecular analysis. Int J Mol Med. 2018 Oct;42(4):1885-1898. doi: 10.3892/ijmm.2018.3774.k; Furthermore it has been shown using fMRI that there are regions of the brain in EJHS people who are especially sensitive to EMF stimulation: Heuser G, Heuser SA. 2017 Functional brain MRI in patients complaining of electrohypersensitivity after long term exposure to electromagnetic fields. Rev Environ Health. 2017 Sep 26;32(3):291-299. doi: 10.1515/reveh-2017-0014. It can be seen from this that EHS is a genuine hypersensitivity condition with major sensitivity responses in the brain. Consequently not only is what ICNIRP says in this area undocumented, but also each of the ICNIRP claims is also false).

Epidemiological research has addressed potential long-term effects of radiofrequency EMF exposure from fixed site transmitters and devices used close to the body on both symptoms and well-being, but with a few exceptions these are cross-sectional studies with self-reported information about symptoms and exposure **[no evidence provided]**. *Selection bias, reporting bias, and nocebo effects are of concern in these* studies **[no evidence provided]**. Most of the scientific literature calls what ICNIRP calls IEI-EMF, electromagnetic hypersensitivity or EHS. The ICNIRP statements here are both undocumented and contradicted by a substantial scientific literature, as shown immediately above. *In studies on transmitters, no consistent associations between exposure and symptoms or well-being were observed when objective measurements of exposure were made, or when exposure information was collected prospectively* **[no evidence provided]**. *In studies on mobile phone use, associations with symptoms and problematic behavior have been observed. However, these studies can generally not differentiate between potential effects from radiofrequency EMF exposure and other consequences of mobile phone use, such as sleep deprivation in adolescents using the mobile phone at night* **[no evidence provided]**. *Overall, the epidemiological research does not provide evidence of a causal effect of radiofrequency EMF exposure on symptoms or well-being* **[no evidence provided]**. The same 27 reviews on neurological/neuropsychiatric effects, which were referred to above, also falsify these ICNIRP claims regarding cell phone effects. Similar effects were found including sleep disruption, fatigue, headache, memory dysfunction, depression, lack of concentration, anxiety, sensory dysfunction and several others were found to be produced by many different types of EMF exposures. These included radar, other occupational exposures, three types of broadcast radiation, heavy cell phone use, living near cell phone towers and microwave radiation of the US embassy in Moscow. Clearly these are not caused by behavioral changes specific for cell phone use, as ICNIRP argues here. When these problems are becoming almost universal in every single technologically advanced country on earth, surely it is time for ICNIRP to start protecting us from them. *However, there is evidence that radiofrequency EMF, at sufficiently high levels, can cause pain. Walters et al. (2000) reported a pain threshold of 12.5 kW m^{-2} for 94 GHz, 3-second exposure to the back, which raised temperature at a rate of 3.3 °C per second (from 34 °C to 43.9 °C). This is similar to that found for heating due to sources other than EMF, where 'weak to moderate' pain was reported for smaller temperature elevations (+4 °C) but with a similar rate of temperature elevation (4 °C per second; Green & Akirav, 2010). However, as Walters et al. used an exposure scenario more relevant to radiofrequency EMF, and as Green and Akirav (2010) has not been replicated (which is particularly important here due to the methodological difficulties associated with self-report measures)* **[no evidence provided]**, *it is difficult to determine the relevance of 'rate of temperature elevation' to human health at present. Another instance of pain induced by radiofrequency EMF is due to 'indirect' exposure via contact currents, where radiofrequency EMF in the environment is redirected via a conducting object to a person, and the resultant current flow, dependent on frequency, can stimulate nerves, cause pain and/or damage tissue* **[no evidence provided]**.

Thresholds are very difficult to determine, with the best estimates of thresholds for health effects being for pain, which is approximately 10 and 20 mA for children and adults respectively (extrapolated from Chatterjee et al., 1986). There is thus no evidence that high frequency EMF exposure affects symptoms, except for pain (and potentially tissue damage) at high exposure levels **[no evidence provided].** Shown to be completely untrue from the 27 reviews on neurological/neuropsychiatric effects, previously discussed. *In summary, no reports of adverse effects on symptoms and wellbeing have been substantiated, except for pain, which is related to elevated temperature at high exposure levels* **[logically flawed statement based on a biased assessment of the literature]**. *Thresholds for these have not been clearly identified, but the best estimate is within the vicinity of 10 and 20 mA for indirect contact currents, for children and adults respectively, and 12.5 kW m^{-2} for direct millimeter-wave exposure* **[no evidence provided].**

Sections 2.1 and 2.3 are wildly contradicted by 27 reviews on neurological and neuropsychiatric effects of non-thermal EMF exposures both in animals and in humans. Those reviews are as follows:

1. Marha K. 1966 Biological Effects of High-Frequency Electromagnetic Fields (Translation). ATD Report 66-92. July 13, 1966 (ATD Work Assignment No. 78, Task 11). http://www.dtic.mil/docs/citations/AD0642029 (accessed March 12, 2018)
2. 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)
3. Tolgskaya MS, Gordon ZV. 1973. Pathological Effects of Radio Waves, Translated from Russian by by Haigh. Consultants Bureau, New York/London, 146 pages.
4. Bawin SM, Kaczmarek LK, Adey WR. 1975 . Effects of modulated VHF fields on the central nervous system. Ann NY Acad Sci 247:74-81.
5. Bise W. 1978 Low power radio-frequency and microwave effects on human electroencephalogram and behavior. Physiol Chem Phys 10:387-398.
6. 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.
7. Frey AH. 1993 Electromagnetic field interactions with biological systems. FASEB J 7:272-281.
8. Lai H. 1994 Neurological effects of radiofrequency electromagnetic radiation. In: Advances in Electromagnetic Fields in Living Systems, Vol. 1, J.C. Lin, Ed., Plenum Press, New York, pp. 27-88.
9. Grigor'ev IuG. 1996 [Role of modulation in biological effects of electromagnetic radiation]. Radiats Biol Radioecol 36:659-670.
10. Lai, H 1998 Neurological effects of radiofrequency electromagnetic radiation. http://www.mapcruzin.com/radiofrequency/henry_lai2.htm.
11. Valentini E, Curcio G, Moroni F, Ferrara M, De Gennaro L, M. Bertini M. 2007 Neurophysiological Effects of Mobile Phone Electromagnetic Fields on Humans: A Comprehensive Review. Bioelectromagnetics 28:415-432.
12. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.
13. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.
14. Kundi M, Hutter H-P. 2009 Mobile phone base stations—Effects on wellbeing and health. Pathophysiology 16:123-135.

15. Khurana VG, 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.
16. 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
17. Carpenter DO. 2013 Human disease resulting from exposure to electromagnetic fields. Rev Environ Health 2013;28:159-172.
18. Politański P, Bortkiewicz A, Zmyślony M. 2016 [Effects of radio- and microwaves emitted by wireless communication devices on the functions of the nervous system selected elements]. Med Pr 67:411-421.
19. Hensinger P, Wilke E. 2016. Mobilfunk-Studienergebnisse bestätigen Risiken Studienrecherche 2016-4 veröffentlicht. Umwelt Medizin Gesellshaft 29:3/2016.
20. Pall ML. 2016 Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. J Chem Neuroanat 75(Pt B):43-51. doi: 10.1016/j.jchemneu.2015.08.001.
21. Hecht, Karl. 2016 Health Implications of Long-Term Exposures to Electrosmog. Brochure 6 of A Brochure Series of the Competence Initiative for the Protection of Humanity, the Environment and Democracy. http://kompetenzinitiative.net/KIT/wp-content/uploads/2016/07/KI_Brochure-6_K_Hecht_web.pdf (accessed Feb. 11, 2018)
22. Sangün Ö, Dündar B, Çömlekçi S, Büyükgebiz A. 2016 The Effects of Electromagnetic Field on the Endocrine System in Children and Adolescents. Pediatr Endocrinol Rev 13:531-545.
23. Belyaev I, Dean A, Eger H, Hubmann G, Jandrisovits R, Kern M, Kundi M, Moshammer H, Lercher P, Müller K, Oberfeld G, Ohnsorge P, Pelzmann P, Scheingraber C, Thill R. 2016 EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. Rev Environ Health DOI 10.1515/reveh-2016-0011.
24. Zhang J, Sumich A, Wang GY. 2017 Acute effects of radiofrequency electromagnetic field emitted by mobile phone on brain function. Bioelectromagnetics 38:329-338. doi: 10.1002/bem.22052.
25. Lai H. 2018. A Summary of Recent Literature (2007–2017) on Neurological Effects of Radio Frequency Radiation. Chapter 8 in Mobile Communications and Public Health, Marko Markov, Ed., CRC press, pp 185-220.
26. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.
27. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

If ICNIRP wishes to argue about these many findings, it should cite each of these reviews, present the important, relevant findings of each of them and only then should ICNIRP make whatever arguments it may have in disagreeing with them. Pretending that vast amounts of contrary evidence and opinion do not exist simply destroys whatever credibility ICNIRP may have.

2018 ICNIRP draft guidelines, appendix B, sect. 2.3 (Other brain physiology and related functions)

A number of studies of physiological functions that could in principle lead to adverse health effects have been conducted, primarily using in vitro *techniques. These have included multiple cell lines and assessed such functions as intra- and intercellular signaling, membrane ion channel currents and input resistance, Ca2+ dynamics, signal transduction pathways, cytokine expression, biomarkers of neurodegeneration, heat shock proteins, and oxidative stress-related processes. Some of these studies also tested for effects of co-exposure of radiofrequency EMF with known*

toxins. Although some effects have been reported for some of these endpoints, there is currently no evidence of effects relevant to human health **[No evidence provided]**. Is ICNIRP really trying to argue that important signaling pathways, excessive intracellular calcium, inflammation including inflammatory cytokines, neurodegeneration, heat shock responses and oxidative stress have "no relevance to human health?" If so, ICNIRP needs to debunk hundreds of thousands of studies in the PubMed database. *There have been some reports of morphological changes to cells, but these have not been replicated, and their relevance to health has not been demonstrated* **[no evidence provided]**. *There have also been reports of radiofrequency fields inducing leakage of albumin across the blood-brain barrier, but due to methodological limitations of the studies and failed attempts to independently replicate the results, there remains no evidence of an effect* **[no evidence provided]**. *Intense pulsed low frequency electric fields (with radiofrequency components) can cause cell membranes to become permeable, allowing exchange of intra- and extra-cellular materials (Joshi and Schoenbach, 2010); this is referred to as electroporation. 18 GHz continuous wave exposure can result in a similar effect (Nguyen et al., 2017). These require very high field strengths (e.g. 10 kV m^{-1} (peak) in tissue in terms of the former, and 5 kW kg^{-1} for the latter). These levels have not been shown to adversely affect health in realistic exposure scenarios in humans, and given their very high thresholds, are protected against by limits based on effects with lower thresholds and are not discussed further. Animal studies have also reported that the heating that results from radiofrequency EMF exposure may lead to formation of cataract in rabbits. In order for this to occur, very high local SAR levels (100 – 140 W kg^{-1}) at low frequencies (< 6 GHz) are needed, with increases of several degrees centigrade maintained for several hours* **[no evidence provided]**. *However, the rabbit model is more susceptible to cataract formation than primates (with primates more relevant to human health), and cataracts have not been found in primates exposed to radiofrequency fields* **[no evidence provided]**. *No substantiated effects on other deep structures of the eye have been found (e.g. retina, lens or iris)* **[no evidence provided]**. *However, rabbits can be a good model for damage to superficial structures of the eye at higher frequencies (30-300 GHz), because the shape of the facial structure is less relevant to exposure in the more superficial tissue that receives the highest exposure at higher frequencies. However, as the baseline temperature of the anterior portion of the eye (including the cornea) is relatively low (compared with the posterior portion of the eye that would be exposed at lower frequencies), very high exposure levels are required to cause harm superficially* **[no evidence provided]**. *For example, Kojima et al. (2018) reported that adverse health effects to the cornea can occur at > 1.4 kW m^{-2} across frequencies from 40 to 95 GHz, and no effects were found below 500 W m^{-2}; the authors concluded that the blink rates in humans would preclude such effects in humans. In summary, there is no evidence of effects of radiofrequency EMF on physiological processes or eye pathology that impair health in humans* **[no evidence provided]**. *Some evidence of superficial eye damage has been shown in rabbits at exposures of at least 1.4 kW m^{-2}, although the relevance of this to humans has not been demonstrated* Why does ICNIRP state that there is no evidence of human relevance but never tells us if there is any evidence that the findings are not relevant to humans. If there is simply a lack of evidence, then the way ICNIRP describes this speaks to an unconscionable bias on the part of ICNIRP. With human relevance as with all things, absence of evidence is not evidence of absence.

2018 ICNIRP draft guidelines, appendix B, chap. 3 (Auditory, vestibular, and ocular function)

A number of animal and some human studies have tested for potential effects of radiofrequency EMF on function and pathology of these systems. Sub-millisecond pulses of radiofrequency EMF can result in audible sound. Specifically, within the 200-3000 MHz range the microwave hearing effect can result from brief (approximately 100 μS) radiofrequency pulses to the head, which cause

thermoelastic expansion that is detected by sensory cells in the cochlea via the same processes involved in normal hearing **[no evidence provided that this is the actual mechanism]**. *This effect is perceived as a brief low-level noise, often described as a 'click' or 'buzzing'. The most recent report has provided a specific absorption (SA) value of 4.5 mJ 190 kg^{-1} per pulse to reach the 20 mPa auditory sound pressure threshold at the cochlea for 10 and 20 µS pulses at 2.45 GHz, which by definition is barely audible (Roschmann, 1991). This equates to a temperature rise of approximately 1 x 10-6 °C per pulse. There is no evidence that the microwave hearing effect can affect health, and so the present Guidelines do not provide a restriction to specifically account for microwave hearing* **[no evidence provided**; there have been reports that exposures which produce microwave hearing also produce tinnitus, which is a human health effect]. *A few studies reported effects of mobile phone emissions on auditory function and cellular structure in animal models* **[no evidence provided]**. *However, results are inconsistent, and no association of radiofrequency EMF exposure with risk of tinnitus, hearing impairment or vestibular dysfunction has been substantiated in epidemiological studies* [**no evidence provided**; any epidemiological assessment should be extensively documented and should be assessed by professional epidemiologists that have no vested interests here]. *Human laboratory studies also failed to identify any adverse health effects of exposure* **[no evidence provided]**. *A number of experimental human studies have tested for changes to normal sensory processing due to radiofrequency EMF exposure. These have largely been conducted at exposure level within the ICNIRP (1998) basic restriction levels, and although there are some reports of effects in both categories of research, the results are highly variable, with the larger and more methodologically rigorous studies failing to find such effects* **[no evidence provided**; where ICNIRP claims there are methodological problems, these need to be extensively documented. Failing that ICNIRP cannot claim to be protecting us from radiation effects.] *There is very little epidemiological research addressing sensory effects of devices that emit radiofrequency EMF* **[no evidence provided]**. *The available research has focused on mobile phone use and does not provide substantiated evidence that this is associated with increased risk of tinnitus, hearing impairment, vestibular or ocular function* **[no evidence provided]**.

In summary, no effects on auditory, vestibular, or ocular function relevant to human health have been substantiated **[no evidence provided]**.

2018 ICNIRP draft guidelines, appendix B, chap. 4 (Neuroendocrine system)

A small number of human studies have tested whether indices of endocrine system function are affected by radiofrequency EMF exposure. Several hormones, including melatonin, growth hormone, luteinising hormone, cortisol, epinephrine and norepinephrine have been assessed, but no consistent evidence of effects of exposure has been observed **[no evidence provided]**. *In animal studies, robust changes have only been reported from acute exposures with whole body SARs in the order of 4 W kg^{-1}, which result in core temperature rises of 1 °C or more* **[no evidence provided]**. *However, there is no evidence that this corresponds to an impact on health* **[Is there evidence against such an impact? If so, it should be presented]**. *Although there have been a few studies reporting field-dependent changes in some neuroendocrine measures, these have also not been substantiated* **[no evidence provided]**. *The literature as a whole reports that repeated, daily exposure to mobile phone signals does not impact on plasma levels of melatonin or on melatonin metabolism, oestrogen or testosterone, or on corticosterone or adrenocorticotropin in rodents under a variety of conditions* **[no evidence provided]**. *The two epidemiological studies on potential effects of exposure to radiofrequency EMF on melatonin levels had conflicting results, and both had methodological limitations, including possible nocebo effects* **[no evidence provided]**. *For*

other hormonal endpoints no epidemiological studies of sufficient scientific quality have been identified **[no evidence provided]**. *In summary, the lowest level at which an effect of radiofrequency EMF on the neuroendocrine system has been observed is 4 W kg^{-1} (in rodents and primates), but there is no evidence that this translates to humans or is relevant to human health* **[no evidence provided]**. *No other effects have been substantiated* **[no evidence provided]**.

In contrast with the many statements with no evidence provided, the endocrine including neuroendocrine systems have been widely found to be impacted by non-thermal EMF exposures as shown by the following reviews:

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.
3. 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.
4. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.
5. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.
6. 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
7. Pall, M. L. 2015. Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action. Rev. Environ. Health 3, 99-116.
8. Sangün Ö, Dündar B, Çömlekçi S, Büyükgebiz A. 2016 The Effects of Electromagnetic Field on the Endocrine System in Children and Adolescents. Pediatr Endocrinol Rev 13:531-545.
9. Hecht, Karl. 2016 Health Implications of Long-Term Exposures to Electrosmog. Brochure 6 of A Brochure Series of the Competence Initiative for the Protection of Humanity, the Environment and Democracy. http://kompetenzinitiative.net/KIT/wp-content/uploads/2016/07/KI_Brochure-6_K_Hecht_web.pdf (accessed Feb. 11, 2018)
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.
12. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

If ICNIRP wishes to disagree with the findings in these reviews, what it needs to do is cite each of these reviews, describe what findings were documented in each of them, and only then should ICNIRP feel free to disagree with any conclusions reached. Ignoring vast amounts of contrary data and opinion just undercuts any claim that ICNIRP may have to providing unbiased science.

2018 ICNIRP draft guidelines, appendix B, chap. 5 (Neurodegenerative diseases)

No human experimental studies exist for neurodegenerative diseases **[Of course not. Such studies are not allowable for ethical reasons. Why is ICNIRP starting with this when this is totally irrelevant?]**. *Although one group has reported that exposure to pulsed radiofrequency EMF fields increased neuronal death in rats, which might contribute to an increased risk of neurodegenerative disease, two studies have failed to confirm these results* **[no evidence provided].** This is completely inaccurate; there were approximately a dozen studies finding elevated levels of neuronal cell death following non-thermal EMF exposures reviewed in the Tolgaskya and Gordon 1973 review; The two studies by Zhang et al. in rats showed that repeated pulsed microwave/RF radiation in young rats caused them to develop Alzheimer's-like effects as middle aged rats, including elevated levels of amyloid beta protein and oxidative stress in their brains and including Alzheimer's-like behavioral and memory deficiencies Other studies have found increased levels of amyloid beta protein following EMF exposures. Why is ICNIRP ignoring such evidence? *Some other effects have been reported (e.g. changes to neurotransmitter release in the cortex of the brain, protein expression in the hippocampus, and autophagy in neurons which was not accompanied by apoptosis), but such changes have not been shown to lead to neurodegenerative disease* **[no evidence provided]**. *Other studies investigating effects on neurodegeneration are not informative due to methodological or other shortcomings* **[no evidence provided]**. It is unacceptable for ICNIRP to make a claim of methodological shortcoming without documenting such a claim. *A Danish epidemiological cohort study has investigated potential effects of mobile phone use on neurodegenerative disorders, and reported reduced risk estimates for Alzheimer disease, vascular and other dementia, and Parkinson disease. These findings are likely to be the result of reverse causation, as prodromal symptoms of the disease may prevent persons with early symptoms to start using a mobile phone* **[no evidence provided]**. *Results for multiple sclerosis are inconsistent, with no effect observed among men, and a borderline increased risk in women, but with no consistent exposure-response pattern* **[no evidence provided].** Again, the only way to show inconsistency is to perform identical studies that produce widely different findings. If ICNIRP has such studies, it should produce them. If it does not, it should stop falsely claiming inconsistency when one may be looking simply at variation due to changes in the conditions used.

In summary, no adverse effects on neurodegenerative diseases have been substantiated **[no evidence provided]**.

2018 ICNIRP draft guidelines, appendix B, chap. 6 (Cardiovascular system, autonomic nervous system, and thermoregulation)

As described above, radiofrequency EMF can induce heating in the body. Although humans have a very efficient thermoregulatory system, too much heat puts the cardiovascular system under stress and may lead to adverse health effects.

Numerous human studies have investigated indices of cardiovascular, autonomic nervous system, and thermoregulatory function, including measures of heart rate and heart rate variability, blood pressure, body, skin and finger temperatures, and skin conductance. Most studies indicate there are no effects on endpoints regulated by the autonomic nervous system **[no evidence provided]**. *The relatively few reported effects of exposure were small and would not have an impact on health* **[no evidence provided]**. *The changes were also inconsistent and may be due to methodological limitations or chance* **[no evidence provided].** Again, the only way to show inconsistency is to perform identical studies that produce widely different findings. If ICNIRP has such studies, it

should produce them. If it does not, it should stop falsely claiming inconsistency when one may be looking simply at variation due to changes in the conditions used. When ICNIRP claims there are methodological problems, these need to be clearly stated and clearly documented.

With exposures at higher intensities, up to a whole body SAR of about 1 W/kg (Adair, Mylacraine and Cobb, 2001b), sweating and cardiovascular responses occurred similar to that observed under increased heat load from other sources. The body core temperature increase was generally less than 0.2 °C. The maximal increase in skin temperature of the exposed area observed with 2450 MHz was less than 4 °C at a whole body SAR of approximately 1 W kg^{-1}, which again does not represent an adverse health effect. With exposures to 100 and 250 MHz leading to a whole body average SAR of 0.68 W kg^{-1}, hot spots occurred in the skin of the ankles with an average temperature increase of up to 4 °C (Adair et al., 2005). However, reports of effects that are sufficient to impact on health have not been substantiated **[no evidence provided]**. *The situation is different for animal research, in that far higher levels of exposure have been used, often to the point where thermoregulation is overwhelmed and temperature increases to the point where death occurs. For example, Frei et al. (1995) exposed rats to 13 W kg^{-1} 35 GHz fields, which raised body core temperature by 8 °C (to 45 °C), resulting in death. Similarly, Jauchem and Frei (1997) exposed rats to 13.2 W kg^{-1} 350 MHz fields, and reported that thermal breakdown (i.e. where the thermoregulatory system cannot cope with the increased body core temperature) occurred at approximately 42 °C. These are serious adverse health effects that need to be avoided, however there is not sufficient research using lower exposures to evaluate the threshold for health effects in rodents* **[no evidence provided]**. *It is also difficult to relate these animal findings to humans, as humans are more-efficient thermoregulators than rodents, and thus their thermoregulatory systems can deal effectively with higher exposure levels than rodents. Taberski et al. (2014) reported that in hamsters, no body core temperature elevation is seen at 4 W kg^{-1}, with the only detectable effect a reduction on food intake (which is consistent with reduced eating in humans when warmer).* This is, of course, circular reasoning. ICNIRP is assuming that the effects must be thermal and is then making false conclusions based on that assumption.

Few epidemiological studies on cardiovascular, autonomic nervous system, or thermoregulation outcomes are available **[no evidence provided]**. *Those that are have not demonstrated a link between radiofrequency EMF exposure and measures of cardiovascular health* **[no evidence provided]**. *In summary, no effects on the cardiovascular system, autonomic nervous system, or thermoregulation that compromise health have been substantiated for exposures with whole body average SARs below approximately 1 W kg^{-1}, and there is some evidence that 4 W kg-1 is not sufficient to alter body core temperature in hamsters* **[no evidence provided]**. *However, there is strong evidence that whole body exposures in rats that are sufficient to increase body core temperature by several degrees centigrade can cause serious adverse health effects in rats.*

2018 ICNIRP draft guidelines, appendix B, chap. 7 (Immune system and haematology)

There have been inconsistent reports of transient changes in immune function and haematology following radiofrequency EMF exposures **[no evidence provided]**. *These have primarily been from* in vitro *studies, although some in vivo animal studies have also been conducted* **[no evidence provided]**. *There is currently no evidence that such reported effects, if real, are relevant to human health.* There are 11 animal studies in the EMF Portal database each showing that non-thermal radiofrequency EMF exposures produce autoimmune responses. If ICNIRP wishes to argue that these findings are irrelevant to the large increases in autoimmune incidence and prevalence we have seen in recent years in humans, it should make whatever argument it feels is appropriate. To

have ICNIRP ignoring this pattern of evidence is unacceptable. *The few human studies have not indicated any evidence that radiofrequency EMF affects health in humans via the immune system or haematology* **[no evidence provided]**.

2018 ICNIRP draft guidelines, appendix B, chap. 8 (Fertility, reproduction, and childhood development)

There is very little human experimental research addressing possible effects of radiofrequency EMF exposure on reproduction and development. What is available has focused on hormones that are relevant to reproduction and development, and as described in the Neuroendocrine System section above, there is no evidence that they are affected by radiofrequency EMF exposure. **This is completely untrue.** There are 13 studies showing that such EMFs impact human male reproduction including sperm motility and aberrations in sperm structure; long-term exposures produce decreases in sperm count. These are shown in the following studies:

Avendaño, Mata AM, Sanchez Sarmiento CA. 2012 Use of laptop computers connected to the internet through Wi-Fi deceases human sperm motility and increases sperm DNA fragmentation. Fertil Steril 97: No. 1, January 2012 0015-8282.
Agarwal A, Desai NR, Makker K, Varghese A, Mouradi R, Sabanegh E, Sharma R. 2008 Effects of radiofrequency electromagnetic waves (RF-EMW) from cellular phones on human ejaculated semen: an in vitro pilot study. Fertil Steril 92: 1318-1325.
Erogul O, Oztas E, Yildirim U, Kir T, Emin A, Komeski G, Irkilata, HC, Irmak MK, Peker AF. 2006 Effects of electromagnetic radiation from cellular phone on human sperm motility. Arch Med Res 37:840-843.
Wdowiak A, Wdowiak L, Wiktor H. 2007 Evaluation of the effect of using mobile phones on male fertility. Ann Agric Environ Med 2007, 14: 169-172
The following additional studies can all be accessed in the EMF Portal database: Oni et al., 2011; Iuliis et al., 2009; Zalata et al., 2015; Gorpinchenko et al., 2014; Wang et al., 2015; Baste et al., 2008; Davoudi et al., 2002; Kilgallon and Simmons, 2005; Fejes et al., 2005.

So these claims by ICNIRP are clearly false. There is also concern about EMF causation of increased spontaneous abortion in humans from an earlier review and from four recent primary literature citations:

Goldsmith JR. 1997 Epidemiologic evidence relevant to radar (microwave) effects. Environ Health Perspect. 1997 Dec;105 Suppl 6:1579-87.
Mahmoudabadi FS, Ziaei S, Firoozabadi M, Kazemnejad A. 2015 Use of mobile phone during pregnancy and the risk of spontaneous abortion. J Environ Health Sci Eng. 2015 Apr 21;13:34. doi: 10.1186/s40201-015-0193-z.
Mortazavi SMJ, Mortazavi SA, Paknahad M. 2012 Association between electromagnetic field exposure and abortion in pregnant women living in Tehran. Int J Reprod Biomed (Yazd) 2017 Feb;15(2):115-116.
Liu XY, Bian XM, Han JX, Cao ZJ, Fan GS, Zhang C, Zhang WL, Zhang SZ, Sun XG. 2007 [Risk factors in the living environment of early spontaneous abortion pregnant women]. Zhongguo Yi Xue Ke Xue Yuan Xue Bao. 2007 Oct;29(5):661-4.
Zhou LY, Zhang HX, Lan YL, Li Y, Liang Y, Yu L, Ma YM, Jia CW, Wang SY.
Epidemiological investigation of risk factors of the pregnant women with early spontaneous abortion in Beijing. Chin J Integr Med. 2017 May;23(5):345-349. doi: 10.1007/s11655-015-2144-z. Epub 2015 Apr 14.

ICNIRP can, if it wishes, argue against these findings, but it cannot simply ignore them and have any sustainable claim that it is protecting our health from EMF effects. Other research has addressed this issue by looking at different stages of development (on endpoints such as cognition *and brain electrical activity), in order to determine whether there may be greater sensitivity to radiofrequency fields during these stages* **[no evidence provided]**. *There is currently no evidence that developmental phase is relevant to this issue.* **[No evidence provided].** There are six studies that have each found that late prenatal EMF exposures in rodents produce long-term neurological changes which are maintained as adults, changes similar to those found in ADHD or autism. No similar changes are produced in adults. These changes were found to be produced by cell phone radiation, cordless phone radiation and by Wi-Fi, suggesting that prenatal exposure to a broad range of such radiation can produce these effects. These studies are as follows:

Aldad TS, Gan G, Gao X-B, Taylor HS. 2012 Fetal radiofrequency radiation from 800-1900 MH-rated cellular telephone affects neurodevelopment and behavior in mice. Scientific Rep 2, article 312.
Othman, H., Ammari, M., Rtibi, K., Bensaid, N., Sakly, M., Abdelmelek, H. 2017. Postnatal development and behavior effects of in-utero exposure of rats to radiofrequency waves emitted from conventional WiFi devices. Environ. Toxicol. Pharmacol. 52:239-247. doi: 10.1016/j.etap.2017.04.016.
Bas O, Sönmez OF, Aslan A, Ikinci A, Hanci H, Yildirim M, Kaya H, Akca M, Odaci E. 2013 Pyramidal Cell Loss in the Cornu Ammonis of 32-day-old Female Rats Following Exposure to a 900 Megahertz Electromagnetic Field During Prenatal Days 13-21. Neuroquantology 11: 591-599.
Kumari K, Koivisto H, Myles C, Jonne N, Matti V, Heikki T, Jukka J. 2017 Behavioural phenotypes in mice after prenatal and early postnatal exposure to intermediate frequency magnetic fields. Environ Res 162: 27-34
Othman H, Ammari M, Sakly M, Abdelmelek H. 2017 Effects of prenatal exposure to WIFI signal (2.45GHz) on postnatal development and behavior in rat: Influence of maternal restraint. Behav Brain Res 326: 291-302.
Stasinopoulou M, Fragopoulou AF, Stamatakis A, Mantziaras G, Skouroliakou K, Papassideri IS, Stylianopoulou F, Lai H, Kostomitsopoulos N, Margaritis LH. 2016 Effects of pre- and postnatal exposure to 1880-1900 MHz DECT base radiation on development in the rat. Reprod Toxicol 2016; 65: 248-262.

There is a second type of study that also produces clear evidence of fetal effects not seen in adults. These are the two studies in cattle that clearly show high sensitivity of the fetus to EMFs. Conducted by Professor Hässig and his colleagues in Switzerland, they demonstrate effects deep within the body, on cataract formation in newborn calves where the mothers were grazing near a cell phone tower. [Hässig M, Jud F, Naegeli H, Kupper J, Spiess BM. 2009 Prevalence of nuclear cataract in Swiss veal calves and its possible association with mobile telephone antenna base stations. Schweiz Arch Tierheilkd 151:471-478. Hässig M, Jud F, Spiess B. 2012 [Increased occurrence of nuclear cataract in the calf after erection of a mobile phone base station]. Schweiz Arch Tierheilkd 154:82-86]. The Swiss safety guidelines are 100 times more stringent than are the ICNIRP safety guidelines, emphasizing the complete inadequacy of the ICNIRP safety guidelines. These two studies clearly show that when pregnant cows are grazing near mobile phone base stations (also 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. Furthermore, because the mothers do not develop cataracts despite their eyes being much more exposed to cell phone tower radiation, this clearly argues that the fetal eye tissue is

vastly more sensitive to EMF effects than is adult eye tissue. When ICNIRP claims there is no evidence but there clearly is evidence, this destroys whatever credibility ICNIRP may have had.

However, extensive, well-performed studies have failed to identify developmental effects at whole body average SAR levels up to 4 W kg^{-1}. In particular, a large four-generation study on fertility and development using SAR levels up to 2.34 W kg^{-1} found no evidence of adverse effects (Sommer et al., 2009) **(This claim is shown to be false in the previous paragraph).** *Some studies have reported effects on male fertility at exposure levels below this value, but these studies have had methodological limitations, and reported effects have not been substantiated* **[no evidence provided]**. Completely false as shown in previous paragraph. *Epidemiological studies have investigated various aspects of male and female infertility and pregnancy outcomes in relation to radiofrequency EMF exposure. Some epidemiological studies found associations between radiofrequency EMF and sperm quality or male infertility, but taken together, the available studies do not provide strong evidence for an association with radiofrequency EMF exposure as they all suffer from limitations in study design or exposure assessment* **(no evidence provided].** Untrue as shown above. *A few epidemiological studies are available on maternal mobile phone use during pregnancy and potential effects on child neurodevelopment. There is no substantiated evidence that radiofrequency EMF exposure from maternal mobile phone use affects child cognitive and psychomotor development, or causes developmental milestone delays* **[no evidence provided]**.

In summary, no adverse effects of radiofrequency EMF exposure on fertility, reproduction or development relevant to human health have been substantiated **[no evidence provided]**.

2018 ICNIRP draft guidelines, appendix B, chap. 9 (Cancer)

There is a large body of literature concerning cellular and molecular processes that are of particular relevance to cancer. This includes studies of cell proliferation, differentiation and apoptosis-related processes, proto-oncogene expression, genotoxicity, increased oxidative stress, and DNA strand breaks. Although there are reports of effects of radiofrequency EMF on a number of these endpoints, there is no substantiated evidence of health-relevant effects. **[No evidence provided]**. What ICNIRP is apparently claiming is that these effects of EMF exposure, each of which has been shown in an extraordinarily large scientific literature to have an important role in cancer causation, are—inexplicably—not relevant to health! We are relying on the Melnick critique to provide a much broader ranging assessment of the many flaws in this cancer section of the ICNIRP draft. We urge ICNIRP to pay close attention to the Melnick critique.

A few animal studies on the effect of radiofrequency EMF exposure on carcinogenesis have reported positive effects, but in general, these studies either have shortcomings in methodology or dosimetry, or the results have not been replicated in independent studies. Indeed, the great majority of studies have reported a lack of carcinogenic effects in a variety of animal models. A replication of a study in which exposure to radiofrequency EMF increased the incidence of liver and lung tumors in an animal model with prenatal exposure to the carcinogen ENU (ethylnitrosourea) indicates a possible promoting effect (Lerchl et al., 2015; Tillmann et al., 2010). The lack of a dose-response relationship, as well as the use of an untested mouse model for liver and lung tumors whose relevance to humans is uncertain (Nesslany et al., 2015), makes interpretation of these results and their applicability to human health difficult, and therefore there is a need for further research to better understand these results.

A recent, large animal study, performed by the US National Toxicology Program (NTP) reported an increased rate of cardiac schwannoma in male rats exposed to radiofrequency EMF, but not in female rats or either male or female mice (NTP 2018). As the exposure was approximately 75 times higher than the ICNIRP (1998) whole body average general public limit, the results are not directly relevant to radiofrequency EMF levels that humans would typically be exposed to. Further, humans are far more efficient at diminishing the resultant body core temperature rise than rats. As noted by the internal NTP review (NTP 2018), there are also a number of methodological issues that limit the usefulness of the results for EMF health assessment. Of particular note is that the statistics were not able to determine whether the higher number of cardiac schwannomas that were reported was more than what would be expected by chance alone (given that no control for multiple comparisons was applied). This is particularly important given that a graded dose-response relation was not found, no consistency across rodent species or genders was found, and the results are not consistent with the radiofrequency EMF cancer literature more generally. A similar study that was conducted concurrently with the NTP study reported that they had replicated these NTP results on cardiac schwannoma (Falcioni et al., 2018). However, similar to the NTP study, the statistics were also not designed to determine whether the increase was higher than would be expected by chance alone (due to uncorrected multiple statistical comparisons). The schwannoma findings in these two studies are inconsistent in terms of the exposure-response association as the Italian study observed an 'increased' number of schwannomas at low exposure levels where no increase in schwannoma was observed in the NTP study. These studies therefore do not provide sufficient evidence to conclude that radiofrequency EMF can cause cancer.

A large number of epidemiological studies of mobile phone use and cancer risk have also been performed. Most have focused on brain tumors, acoustic neuroma and parotid gland tumors, as these occur in close proximity to the typical exposure source from mobile phones. However, some studies have also been conducted on other types of tumors, such as leukaemia, lymphoma, uveal melanoma, pituitary gland tumors, testicular cancer, and malignant melanoma. With a few exceptions, the studies have used a case-control design and have relied on retrospectively collected self-reported information about mobile phone use history.

Only two cohort studies with prospective exposure information are available. Several studies have had follow-ups that were too short to allow assessment of a potential effect of long-term exposure, and results from case-control studies with longer follow-up are not consistent. The large, IARC coordinated, Interphone study did not provide evidence of a raised risk of brain tumors, acoustic neuroma or parotid gland tumors among regular mobile phone users, and the risk estimates did not increase with longer time since first mobile phone use (Interphone, 2010; 2011). It should be noted that although somewhat elevated odds ratios were observed at the highest level of cumulative call time for acoustic neuroma and glioma, there were no trends observed for any of the lower cumulative call time groups, with among the lowest risk estimates in the penultimate exposure category. This, combined with the inherent recall bias of such studies, does not provide evidence of an increased risk. Similar results were observed in a Swedish case-control study of acoustic neuroma (Pettersson et al., 2014). Contrary to this, a set of case-control studies from the Hardell group in Sweden report significantly increased risks of both acoustic neuroma and malignant brain tumors already after less than five years since the start of mobile phone use, and at quite low levels of cumulative call time. However, they are not consistent with trends in brain cancer incidence rates from a large number of countries or regions, which have not found any increase in the incidence since mobile phones were introduced. Furthermore, no cohort studies (which, unlike case-control studies, are not affected by recall or selection bias) report a higher risk of glioma, meningioma or acoustic neuroma among mobile phone subscribers, or when estimating

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mobile phone use through prospectively collected questionnaires. Studies of other types of tumors have also not provided evidence of an increased tumor risk in relation to mobile phone use. Only one study is available on mobile phone use in children and brain tumor risk. No increased risk of brain tumors was observed. Studies of exposure to environmental radiofrequency EMF fields, for example from radio and television transmitters, have not provided evidence of an increased cancer risk either in children or in adults. Studies of cancer in relation to occupational radiofrequency EMF exposure have suffered substantial methodological limitations and do not provide sufficient information for the assessment of carcinogenicity of radiofrequency EMF fields. Taken together, the epidemiological studies do not provide evidence of a carcinogenic effect of radiofrequency EMF exposure at levels encountered in the general population. In summary, no effects of radiofrequency EMF on cancer have been substantiated.

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Appendix 2

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

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

Effects on cellular DNA including single-strand and double-strand breaks in cellular DNA and on oxidized bases in cellular DNA; also evidence for chromosomal mutations produced by double-strand DNA breaks

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. Goldsmith JR. 1997 Epidemiologic evidence relevant to radar (microwave) effects. Environ Health Perspect 105(Suppl 6):1579-1587.
3. Yakymenko IL, Sidorik EP, Tsybulin AS. 1999 [Metabolic changes in cells under electromagnetic radiation of mobile communication systems]. Ukr Biokhim Zh (1999), 2011 Mar-Apr:20-28.
4. Aitken RJ, De Iuliis GN. 2007 Origins and consequences of DNA damage in male germ cells. Reprod Biomed Online 14:727-733.
5. Hardell, L., Sage, C. 2008. Biological effects from electromagnetic field exposure and public exposure standards. Biomed. Pharmacother. 62, 104-109.
6. 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.
7. Phillips JL, Singh NP, Lai H. 2009 Electromagnetic fields and DNA damage. Pathophysiology 16:79-88.
8. Ruediger HW. 2009 Genotoxic effects of radiofrequency electromagnetic fields. Pathophysiology. 16:89-102.
9. 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.
10. Makker K, Varghese A, Desai NR, Mouradi R, Agarwal A. 2009 Cell phones: modern man's nemesis? Reprod Biomed Online 18:148-157.
11. Yakymenko I, Sidorik E. 2010 Risks of carcinogenesis from electromagnetic radiation and mobile telephony devices. Exp Oncol 32:729-736.
12. 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.
13. 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
14. 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.
15. Pall, M. L. 2015 Scientific evidence contradicts findings and assumptions of Canadian Safety Panel 6: microwaves act through voltage-gated calcium channel activation to induce biological impacts at non-thermal levels, supporting a paradigm shift for microwave/lower frequency electromagnetic field action. Rev. Environ. Health 3, 99-116. doi: 10.1515/reveh-2015-0001.

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16. Pall ML. 2016 Electromagnetic fields act similarly in plants as in animals: Probable activation of calcium channels via their voltage sensor. Curr Chem Biol 10:74-82.
17. Hensinger P, Wilke E. 2016. Mobilfunk-Studienergebnisse bestätigen Risiken Studienrecherche 2016-4 veröffentlicht. Umwelt Medizin Gesellshaft 29:3/2016.
18. Houston BJ, Nixon B, King BV, De Iuliis GN, Aitken RJ. 2016 The effects of radiofrequency electromagnetic radiation on sperm function. Reproduction 152:R263-R276.
19. Batista Napotnik T, Reberšek M, Vernier PT, Mali B, Miklavčič D. 2016 Effects of high voltage nanosecond electric pulses on eukaryotic cells (in vitro): A systematic review. Bioelectrochemistry. 2016 Aug;110:1-12. doi: 10.1016/j.bioelechem.2016.02.011.
20. 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.
21. Pall ML. 2018 How cancer can be caused by microwave frequency electromagnetic field (EMF) exposures: EMF activation of voltage-gated calcium channels (VGCCs) can cause cancer including tumor promotion, tissue invasion and metastasis via 15 mechanisms. Chapter 7 in Mobile Communications and Public Health, Marko Markov, Ed., CRC press, pp 163-184.
22. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.
23. Wilke I. 2018 Biological and pathological effects of 2.45 GHz on cells, fertility, brain and behavior. Umwelt Medizin Gesselshaft 2018 Feb 31 (1).

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

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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7. 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.
8. Kang N, Shang XJ, Huang YF. 2010 [Impact of cell phone radiation on male reproduction]. Zhonghua Nan Ke Xue 16:1027-1030.
9. 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
10. 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.

11. Carpenter DO. 2013 Human disease resulting from exposure to electromagnetic fields. Rev Environ Health 2013;28:159-172.
12. 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.
13. Adams JA, Galloway TS, Mondal D, Esteves SC, Mathews F. 2014 Effect of mobile telephones on sperm quality: a systematic review and meta-analysis. Environ Int 70:106-112.
14. Liu K, Li Y, Zhang G, Liu J, Cao J, Ao L, Zhang S. 2014 Association between mobile phone use and semen quality: a systematic review and meta-analysis. Andrology 2:491-501.
15. K Sri N. 2015 Mobile phone radiation: physiological & pathophysiological considerations. Indian J Physiol Pharmacol 59:125-135.
16. Hensinger P, Wilke E. 2016. Mobilfunk-Studienergebnisse bestätigen Risiken Studienrecherche 2016-4 veröffentlicht. Umwelt Medizin Gesellshaft 29:3/2016.
17. Houston BJ, Nixon B, King BV, De Iuliis GN, Aitken RJ. 2016 The effects of radiofrequency electromagnetic radiation on sperm function. Reproduction 152:R263-R276
18. Pall ML. 2018 Wi-Fi is an important threat to human health. Environ Res 164:404-416.
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Neurological and neuropsychiatric effects

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Apoptosis/cell death

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

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Endocrine, that is hormonal effects

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Increased intracellular calcium

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Cancer causation by EMF exposures

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Appendix 3

Reviews showing that pulsed EMFs are, in most cases, much more biologically active than are non-pulsed (continuous wave) EMFs of the same average intensity

Pulsed EMFs are, in most cases, much more biologically active than are non-pulsed (continuous wave) EMFs of the same average intensity. This is important because all wireless communication devices communicate via pulsations and because the "smarter" the device, the more it pulses 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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