**Comments on the National Toxicology Program Bioassay on RF GSM- and CDMA-Modulated Cell Phone RFR, NTP TR 595, March 12, 2018, submitted on behalf of Environmental Health Trust**

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## Introduction

We write as experts with nearly a century of experience in public health who have served as advisors or members of numerous committees of the U.S. National Academy of Sciences (DLD and ABM), the World Bank, the United Nations Development Program, and the International Agency for Research on Cancer. One of us (DLD) previously served as a Scientific Advisory Board member of the National Toxicology Program. We have published more than 400 scientific articles or monographs, as well as several peer-reviewed publications that are directly relevant to the draft NTP Bioassay Report on RF radiation, and have received numerous academic and other

awards, including commendations from the Director of the U.S. National Cancer Institute (DLD).

The Environmental Health Trust (EHT) is a virtual scientific think tank nonprofit public health research organization headquartered in Jackson Hole, Wyoming. EHT has been addressing human health effects of cellphone radio-frequency (RF) radiation for more than a decade and has provided testimony to the U.S. Senate and other groups around the world on environmental health matters and published and conducted a number of relevant and important peer-reviewed studies.

EHT also organizes scientific conferences and briefs policymakers in the United States and internationally, including last year co-sponsoring with the Israel Institute for Advanced Study an Expert Forum on Wireless Radiation and Health which forms the foundation for a Special Issue of Elsevier publication, Environmental Research on the same topic, in press. We closely monitor regulatory actions and the changing recommendations on RF radiation by government agencies around the world. EHT's briefing on international regulations regarding RF radiation, cellphone regulations and Wi-Fi in schools is the most comprehensive in the world.

The National Toxicology Program began this study of RF in 1999 when fewer than 33% of Americans were regular cellphone users, while currently there are more phones than people in the country. As the report notes, analog 1 G technology has been superseded by digital technology relying on GSM and CDMA. Most importantly, current smart phones can and do simultaneously rely on different frequencies operating at different powers at the same time. In addition, a number studies have reported synergies between some forms of ionizing and non-ionizing radiation and toxic chemical exposure that are not evaluated in the current system.

As a general note, the Draft Bioassay uses the terms "mobile phone" and "cell phone" interchangeably, and one term should be used consistently.

Before explaining our comments on the current draft, as a general matter we wish to point out that the NTP bioassay on RF evaluates GSM and CDMA technology but does not and cannot be used to estimate impacts of 4G or 5G or some of the newer operating systems. Thus, while the exposure system used in this bioassay represents a state of the art approach, it is not designed to mimic the newest models of smart phones such as the iPhone X, or other closely held digital transmitting devices, that can have more than 4 antennas operating simultaneously on different RF frequencies at different powers, i.e., data, voice, streaming video and photos, LCP-LTE (liquid crystal polymer-long term evolution) and other high speed data transceivers, etc. (See Appendix 2 for further information on newly published studies on biological impacts of 5G.)

**These comments address 6 aspects of the NTP study:**

1. Exposures used in the NTP study are relevant to current wireless technologies Americans use, and French government tests of cellphone radiation emissions confirm that cellphones can have emissions that result in the public being exposed to radiation SAR levels that exceed the exposure levels used in the NTP study.

2. The NTP findings significantly increase the weight of evidence linking radio-frequency to cancer and confirm that RF can cause adverse biological effects.
3. The NTP findings should trigger the World Health Organization International Agency for Research on Cancer to re-evaluate the carcinogenicity of RFR.
4. The NTP findings of differing observations in CDMA groups compared to GSM highlights the importance of focusing on modulation and signal characteristics, rather than solely focusing on power density in understanding biological effects and human health risk.
5. The NTP findings need to be followed by a quantitative health risk assessment by U.S. health agencies and, in the meantime, U.S. policy must be changed to reduce exposure to the public.
6. Important research studies and clarifications need to be added to this report in the science review sections, and we have detailed comments for various sections of the report.

**1. Exposures used in the NTP study are relevant to current wireless technologies Americans use.** This is confirmed by French government tests of cellphone radiation emissions which document that cellphones can have emissions which result in the public being exposed to radiation SAR levels that exceed the exposure levels used in the NTP study (and exceed FCC limits).

First, and most importantly, the NTP exposures are relevant because the exposures were at non-thermal levels, and thus the NTP findings of carcinogenicity indicate that government regulatory limits are non-protective because regulatory limits are based *only* on protecting from thermal health risks.

Second, the NTP exposures are relevant to regulatory limits for localized exposures, that is when people use the phone near their body. For cellphone users, body tissues located nearest to the phone's antenna receive higher exposures than tissues located distant from the antenna. Thus, when an individual holds a cellphone next to his or her head or body, exposure to the brain will be much higher than exposures averaged over the whole body.

As stated in the NTP report, the localized cellphone SAR exposure limit in the U.S. for the public is 1.6 W/kg averaged over any 1 gram of tissue for the head and body. The U.S. SAR exposure limit for "extremities," such as wrists, hands, feet, ankles and ears, is 4.0 W/kg averaged over 10 grams of tissue. The U.S. also has an "occupational" SAR limit, which is 8.0 W/kg averaged over any 1 gram of tissue for the head and body and 20.0 W/kg averaged over 10 grams of tissue for "extremities." When considering organ-specific risk (e.g., risk to the brain) from cellphones, the important measure of exposure is these localized SAR value limits. Many cellphones emit radiation that can produce local doses near 1.6 W/kg. The NTP exposure groups were at 1.5, 3.0, and 6.0 W/kg SAR, well within FCC SAR threshold ranges.

Cellphone manufacturers provide SAR values for their cellphones' emissions deep in manuals (rarely read by users) or in operating systems language, however, most of the public is unaware of this verbiage. The public is also unaware that alongside the SAR test values for their phones are FCC statements that instruct users to keep a minimum separation distance away from their cellphones in order to maintain FCC compliance. For example, the distance for a Blackberry Bold is 5 mm, for the Apple iPhone 4 10 mm, and for most laptop PCs the distance is 20 cm (about 8 inches).[1] When these FCC instructions are violated, the user can exceed FCC RF limits.

Recent tests by the French government confirm that cellphones used in body contact conditions can in fact far exceed this 1.6 W/kg limit, by up to 9 times.[2] In March 2018, the full cellphone SAR test reports (including pictures and data) for over 400 phones were placed online by ANSES documenting that when cellphones are placed in body contact positions, regulatory limits can be exceeded in the area near the antenna. As an example, the ANSES data[3] states that the iPhone 6 Model PLUS A1524 had a SAR of 1.11 W/kg when tested at 5 mm distance from the body. However, this same phone had a SAR of 3.17 when tested at body contact, exceeding regulatory limits. The full test report for this iPhone is online at https://www.anfr.fr/das/COM078140003/RE051-14-106289-1_Ed._1.pdf, as are all the other reports for cellphones tested by the French government.

In addition, when we extrapolate the U.S. FCC SAR from the French tests data, we find even more significant differences. EU tests average SAR over 10 grams whereas the U.S. FCC averages SAR over 1 gram of tissue, so they cannot be directly compared. Research documents that a localized SAR at 1 gram averaging is roughly 2 to 3 times that of the SAR at a 10 gram average.[4,5,6] Therefore, a range of 200% to 300% is a reasonable equation to determine an equivalent value for FCC SAR values. The iPhone 6 Model PLUS A1524 ANSES SAR of 3.17 W/kg is in fact 6.34 W/kg to 9.51 W/kg if we compute for the FCC SAR equivalent. Thus, we can conclude that this phone at body contact could exceed FCC limits by potentially up to 5.94 times.

SAR testing of phones is done under conditions of maximum power usage. Since people do not always use their phones at maximum power, this has long been considered as providing an

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[1] https://ehtrust.org/fine-print-manufacturer-radio-frequency-radiation-warnings/

[2] https://ehtrust.org/france-cell-phone-radiation-tests-make-model-sar-radiation-measurements-379-phones/

[3] https://data.anfr.fr/explore/dataset/das-telephonie-mobile/table/?disjunctive.marque&disjunctive.modele&dataChart=eyJxdWVyaWVzIjpbeyJjb25maWciOnsiZGF0YXNldCI6ImRhcy10ZWxlcGhvbmllLW1vYmlsZSIsIm9wdGlvbnMiOnsiZGlzanVuY3RpdmUubWFycXVlIjp0cnVlLCJkaXNqdW5jdGl2ZS5tb2RlbGUiOnRydWV9fSwiY2hhcnRzIjpbeyJ0eXBlIjoibGluZSIsImZ1bmMiOiJBVkciLCJ5QXhpcyI6ImRhc190ZXRlX25vcm1lX25mX2VuXzUwMzYwIiwic2NpZW50aWZpY0Rpc3BsYXkiOnRydWUsImNvbG9yIjoiIzY2YzJhNSJ9XSwieEF4aXMiOiJkYXRlX2R1X2NvbnRyb2xlX3Bhcl9sX2FuZnIiLCJtYXhwb2ludHMiOiIiLCJ0aW1lc2NhbGUiOiJ5ZWFyIiwic29ydCI6IiJ9XX0%3D&q=apple

[4] Inaccuracies of a Plastic "Pinna" SAM for SAR Testing of Cellular Telephones Against IEEE and ICNIRP Safety Guidelines

[5] SARs for pocket-mounted mobile telephones at 835 and 1900 MHz.

[6] Some present problems and a proposed experimental phantom for SAR compliance testing of cellular telephones at 835 and 1900 MHz

additional margin of safety. However, cellphones are now used by consumers day and night, in positions directly on the body *and* in conditions of high power. For example, in rural areas where base stations are sparse, the output power levels used by mobile phones are on average considerably higher,[7,8] Similarly, when people use a phone in basements, elevators, the interior of large buildings or in other areas of low reception due to building materials, the phone output is higher. Consumers are in fact using cellphones while the device is transmitting continuously and at maximum power—such as might happen during a call when the user uses a headset and the phone is in the user's chest pocket at the fringe of a reception area. A large metal schoolbus, traveling through low reception areas with all passengers using cellphones and a myriad of other wireless RF-emitting devices (laptops and tablets) positioned in various positions resting on their bodies is also a realistic scenario. Phones will go to higher power in a vehicle as they connect to each cell tower the vehicle passes. Additionally, SARs can combine from multiple independent sources[9] in use in the vehicle or space, pushing the SAR induced in human tissue even higher.

Perhaps even more importantly, it needs to be noted that the current SAR test protocols are outdated and do adequately reflect human exposure to RFR (especially children's exposure), nor do SAR tests adequately characterize the variables of the signal important in understanding biological effects. SAR test calculations mask actual exposures by averaging which does not indicate peak radiation exposures to human tissue.

The reality is that people are using more and more wireless RF-emitting devices close to the body—from cellphones to tablets to wearables—and are additionally exposed to more and more base stations that add RF radiation into their inside *and* outside environments. A short list of the RF radiation-emitting equipment that is increasing exposures to the public includes cell towers, cellular antennas placed on utility poles in front of homes now referred to as "small cells," Wi-Fi routers, Wi-Fi and other wireless network access points *inside* buildings, cordless phone base stations, wirelessly connected home security and other sensor systems and wireless speaker networks.

In the NTP study in which animals were exposed to 1.5, 3.0, and 6.0 W/kg RF radiation, exposures in the brain were within 10% of the whole-body exposure levels. Therefore, with respect to exposures to the brain, exposures of rats to RF radiation were similar to or slightly higher than human exposures from cellphones held next to the head.

**2. The NTP findings significantly increase the weight of evidence linking radio-frequency to cancer and confirm that RF can cause adverse biological effects.**

[7] http://oem.bmj.com/content/61/9/769
[8] http://oem.bmj.com/content/66/10/664
[9] http://article.sapub.org/10.5923.j.ijea.20150502.01.html

The NTP is not just “one additional animal study” but a major large-scale, well designed study. NTP animal studies are considered the gold standard worldwide.

If RF were safe, the exposed animals simply should not have shown any evidence of carcinogenicity. However, evidence of carcinogenicity was found. A statistically significant increase in the incidence of heart Schwannoma was observed in GSM and CDMA treated male rats. Significantly increased incidences of right ventricular cardiomyopathy were found in 3 and 6 W/kg GSM male and female rats and 6 W/kg CDMA male rats. In addition, incidences were found across exposed groups that include malignant glioma in the brain and adenoma of the pars distalis in the pituitary gland.

**3. The NTP findings should trigger the World Health Organization International Agency for Research on Cancer to re-evaluate the carcinogenicity of RFR.**

When the International Agency for Research on Cancer (IARC) classified RF as a Class 2 B possible carcinogen *in 2011,* the IARC Working Group concluded that there was “limited evidence” in experimental animals for the carcinogenicity of RF-EMF.[10] With the NTP RFR study completion, scientific evidence in experimental animals is no longer “limited.” As the NTP stated in their 2016 Report of Partial findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats,[11] “These findings appear to support the International Agency for Research on Cancer (IARC) conclusions regarding the possible carcinogenic potential of RFR.”

Furthermore, since 2011, the evidence in humans has significantly increased.[12,13,14,15,16] Because of these recent published studies, there are EHT scientists and a number of other distinguished scientists who currently conclude that the epidemiological evidence merits re-classification of cell phone and wireless radiation as a Class 1 Human

[10] IARC (International Agency for Research on Cancer). 2013. Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields. IARC Monogr Eval Carcinog Risk Hum 102. Available: http://monographs.iarc.fr/ENG/Monographs/vol102/mono102.pdf

[11] Report of Partial findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats https://www.biorxiv.org/content/early/2018/02/01/055699

[12] Coureau, Gaëlle, et al. "Mobile phone use and brain tumours in the CERENAT case-control study." *Occupational Environmental Medicine,* vol. 71, no. 7, 2014, pp. 514-22.

[13] Momoli, F., et al. "Probabilistic multiple-bias modelling applied to the Canadian data from the INTERPHONE study of mobile phone use and risk of glioma, meningioma, acoustic neuroma, and parotid gland tumors." *American Journal of Epidemiology*, 2017.

[14] Turner, Michelle C., et al. "Investigation of bias related to differences between case and control interview dates in five INTERPHONE countries." *Annals of Epidemiology*, vol. 26, 12, 2016, pp. 827-32.

[15] Grell, Kathrine, et al. "The intracranial distribution of gliomas in relation to exposure from mobile phones: analyses from the INTERPHONE study." *American Journal of Epidemiology*, vol. 184, no. 11, 2016, pp. 818-28.

[16] Carlberg, Michael, and Lennart Hardell. "Evaluation of Mobile Phone and Cordless Phone Use and Glioma Risk Using the Bradford Hill Viewpoints from 1965 on Association or Causation." *BioMed Research International* 2017.9218486 (2017).

Carcinogen.[17,18,19] In addition, there are *also* scientists who state that the weight of scientific evidence has now shifted so that the evidence—at a minimum—meets classification to be a Group 2 A "probable" carcinogen, *which would trigger a regulatory response.*[20] Over 236 scientists have signed an Appeal to the United Nations and World Health Organization calling for urgent action to reduce exposure to the public.[21]

In short, the Class 2 B classification is outdated and the weight of evidence has significantly increased. The NTP findings add long awaited animal evidence to the IARC re-evaluation and the classification needs to reflect the latest research.

The IARC re-evaluation is also critically important now that 5G is being planned for deployment in cities worldwide. 5G will use radio-frequency modulations *already in use* in addition to higher frequencies—submillimeter and millimeter waves. Recent research carried out by physicists in Israel has shown that the higher millimeter wave frequencies to be used in 5G applications uniquely interact with sweat ducts of the human skin which can then function as antennas to amplify signals.[22] This work extends studies first produced in 1986.[23] The potential long-term impact of such stimulation on precancerous skin growths should be evaluated carefully, including potential super-growth of bacteria.[24] A lecture by Paul Ben-Ishai, PhD, and additional research on this issue, can be found on the 2017 Conference website.[25,26, 27] Betzalel, Ben Ishai, and Feldman recently published a paper entitled, The human skin as a sub-THz receiver - Does

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[17] Carlberg, Micheal and Lennart Hardell. "Evaluation of Mobile Phone and Cordless Phone Use and Glioma Risk Using the Bradford Hill Viewpoints from 1965 on Association or Causation." *BioMed Research International* 2017 (2017).

[18] http://www.sbwire.com/press-releases/cancer-researcher-states-that-25m-nih-study-confirms-that-cell-phone-radiation-can-cause-cancer-927339.htm

[19] Peleg M et al., Radio frequency radiation-related cancer: assessing causation in the occupational/military setting. *Environ Res.* 2018 Feb 22;163:123-133. doi: 10.1016/j.envres.2018.01.003.

[20] https://betweenrockandhardplace.files.wordpress.com/2017/11/wireless-radiation-and-health-the-past-the-present-and-the-future.pdf

[21] Blank, M., et al. "International Appeal: Scientists call for protection from non-ionizing electromagnetic field exposure." *European Journal of Oncology*, vol. 20, no. 3/4, 2015, pp. 180-2.

[22] Betzalel, Noa, Yuri Feldman, and Paul Ben Ishai. "The Modeling of the Absorbance of Sub-THz Radiation by Human Skin." *IEEE Transactions on Terahertz Science and Technology* 7.5 (2017): 521-8.

[23] Gandhi OP, Riazi A. "Absorption of millimeter waves by human beings and its biological implications." *IEEE Transactions on Microwave Theory and Techniques*, vol. 34, no. 2, 1986, pp. 228-235.

[24] Soghomonyan D, K. Trchounian and A. Trchounian. "Millimeter waves or extremely high frequency electromagnetic fields in the environment: what are their effects on bacteria?" *Applied Microbiology and Biotechnology*, vol. 100, no. 11, 2016, pp. 4761-71.

[25] Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." *Conference on Wireless and Health*, 2017.

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

[27] Feldman, Yuri, et al. "Human Skin as Arrays of Helical Antennas in the Millimeter and Submillimeter Wave Range." *Physical Review Letters*, vol. 100, no. 128102, 2008.

5G pose a danger to it or not?"[28] in which they state, "We are raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored."

Cancer is not the only health concern presented by wireless devices and infrastructure. Impacts on reproduction and brain development have also been repeatedly reported in the peer-reviewed literature, in addition to a myriad of other adverse effects.[29,30,31,32] This will be elaborated on further in these comments, under section 6 which comments on various pages of the technical report.

**4. Signal modulation is important:** While there were parallel findings of schwannoma of the heart in both GSM and CDMA, the NTP findings that differ in CDMA groups compared to GSM in various endpoints highlights the importance of focusing on modulation and signal characteristics, rather than solely focusing on power density in understanding biological effects and human health risk.

Research suggests that recent technologies could have more dramatic biological effects and that power density is not the most relevant characteristic of the exposure.[33] An analysis by cancer researchers found a three-fold higher risk from 3G UMTS modulated cellphone use compared to 2G technology *even though* 3G UMTS modulated cellphones can radiate 1,000-fold less power.[34] These epidemiology findings tally with research that has indicated UMTS microwaves have higher biological efficiency and possibly larger health risk effects compared to GSM radiation emissions.[35] Modulations are evolving to transmit more data faster at a given frequency, and this results in higher peak to average power ratios. In the lab, it is notable that experiments using real-life devices are much more likely to find significant effects.[36]

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[28] Betzael et al.,"The human skin as a sub-THz receiver - Does 5G pose a danger to it or not", *Environ Res.* 2018 Feb 16;163:208-216. doi: 10.1016/j.envres.2018.01.032.

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

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

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

[32] Sonmez, O.F., et al. "Purkinje cell number decreases in the adult female rat cerebellum following exposure to 900 MHz electromagnetic field." *Brain Research*, vol. 1356, 2010, pp. 95-101.

[33] Panagopoulos, Dimitris J., Olle Johansson, and George L. Carlo. "Polarization: A Key Difference between Man-made and Natural Electromagnetic Fields, in regard to Biological Activity." *Scientific Reports*, vol. 5, no. 12914, 2015.

[34]https://ehtrust.org/wp-content/uploads/Epidemiological-Evidence-on-the-Relative-Toxicity-from-Modulated-Radio-Frequency-Radiation-for-Glioma-Risk-v3-4-21-16.pdf

[35] Belyaev et al., Microwaves from UMTS/GSM mobile phones induce long-lasting inhibition of 53BP1/gamma-H2AX DNA repair foci in human lymphocytes. Bioelectromagnetics. 2009 Feb;30(2):129-41. doi: 10.1002/bem.20445.

[36] Panagopoulos, Dimitris J., Olle Johansson, and George L. Carlo. "Real versus simulated mobile phone exposures in experimental studies." *BioMed Research International*, 2015.

In fact, research going back decades has pointed to the importance of modulation, not only SAR values or power density, in impacting human health. For example, in 1994 a (U.S.) Air Force "Material Command, Rome Laboratory Radiofrequency / Microwave Radiation Biological Effects and Safety Standards: A Review" stated, "It was recognized that the SAR does not encompass all of the important factors necessary to determine safe exposure levels. The modulation frequency and peak power of the incident EM field should also be considered. Some of the investigators warned that extra care should be taken by persons that are subjected to pulsed EM fields or by fields that are modulated near the whole-body resonance frequency."

As stated by the U.S. Radiofrequency Interagency Workgroup in 1999 in one of several letters[37] raising concerns about federal regulation, "The parameter used to describe dose/dose rate and used as the basis for exposure limits is time-averaged SAR; time-averaging erases the unique characteristics of an intensity-modulated RF radiation that may be responsible for producing an effect."

**5. The NTP findings need to be followed by a quantitative health risk assessment by U.S. health agencies and, in the meantime, U.S. policy must be changed to reduce exposure to the public.**

A quantitative health risk assessment would allow the determination of levels of risk associated with this widespread exposure.

Contrary to the public's perception of safety, no U.S. agency has done a recent systematic review of the scientific evidence. A long history of what Harvard Press' book "Captured Agency" refers to as "undue industry influence" is part of the history that has led to the current situation in which no federal health agency is accountable to ensure that the public is adequately protected.[38] The EPA was tasked to develop safety standards *decades ago*, was on the verge of issuing proper standards and had an active research program until 1996 when a U.S. Appropriations Bill *not only* removed the funding but also stated that "the Committee believes EPA should not engage in EMF activities."

The FCC opened a proceeding[39] on radio-frequency radiation limits in 2013 in response to a 2012 Government Accountability Office report[40] on cellphone and radio-frequency radiation exposure limits that stated, "The Federal Communications Commission's (FCC) RF energy exposure limit may not reflect the latest research…." The GAO Report followed Congressional hearings on the health effects of cell phone radiation in 2008 and 2009 (viewable on C-Span and include Dr. Bucher presenting the NTP study design[41]).

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[37] 1999: Federal Radio -Frequency Interagency Workgroup (RFIW) Letter to Richard Tell Chair, IEEE SCC28 (SC4) Risk Assessment Work Group from the Radiofrequency Radiation Interagency Work Group on Critical Concerns About RF guidelines. https://ehtrust.org/wp-content/uploads/2016/04/1999-radiofrequency-interagency-workgroup-letter.pdf

[38] Alster, Norm. "Captured agency: How the Federal Communications Commission is dominated by the industries it presumably regulates." *Edmund J. Safra Center for Ethics, Harvard University*, 2015.

[39] https://www.federalregister.gov/documents/2013/06/04/2013-12713/reassessment-of-exposure-to-radiofrequency-electromagnetic-fields-limits-and-policies

[40] https://www.gao.gov/assets/600/592901.pdf

[41] https://ehtrust.org/policy/congressional-hearings/

However, no action by the FCC has been taken for 5 years, despite over 1,000 submissions from doctors, scientists and local governments. The FCC has no medical experts nor public health experts on staff with expertise to review submissions, and so they asked for U.S. health and safety agencies to comment. However, none of the agencies the U.S. public relies on for health information—such as the Centers for Disease Control, the National Cancer Institute, the Environmental Protection Agency and the Food and Drug Administration (FDA)—has submitted comments with opinions or risk assessments or recommendations to the FCC as of the date of these comments to the NTP.

It is notable that over 20 countries explicitly recommend that citizens, especially children, reduce RFR to their brain.[42] Several countries such as India, Italy, Belgium, China and Russia have far lower RFR public exposure limits than the U.S., Australia and ICNIRP. Some countries limit the RFR public exposures with further measures in "sensitive" areas such as hospitals, schools and nursery schools. As an example, Chile's "Antenna Law" prohibits cell antenna/towers in "sensitive areas."

In the U.S., the Connecticut[43] and California Department of Health[44] and the American Academy of Pediatrics[45] have recommended that the public, especially children, reduce cellphone RFR. The Maryland State Council on Children's Environmental Health[46] recommends reducing RFR in schools and recommends wired rather than wireless computer networks. (All of this information and more policies can be found on the Environmental Health Trust website which maintains the largest database on international local/state/national policy.[47])

A quantitative health risk assessment by our health agencies with the NTP data is critical to more comprehensively characterize risks and to trigger updated more protective RFR regulation in the U.S. Current RFR regulations do not protect public health.

**6. Important research studies and clarifications *need to be added* to this report in the science review sections, and we have detailed comments for various sections of the report.**

The following comments apply to GSM- and CDMA-Modulated Cell Phone RFR, NTP TR **595**

## The need to combine pre-neoplastic and tumor responses p. 9, paragraphs 1 and 2

This section of the draft reports what are deemed "weaker" responses in both CDMA and GSM exposed SD rats of multiple sites, including brain, adrenals, pituitary, prostate, pancreas and liver.

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[42] https://ehtrust.org/policy/international-policy-actions-on-wireless/

[43] http://www.ct.gov/dph/lib/dph/environmental_health/eoha/pdf/080415_cell_phones__health_may_2015_final.pdf

[44]https://www.cdph.ca.gov/Programs/CCDPHP/DEODC/EHIB/CDPH%20Document%20Library/Cell-Phone-Guidance.pdf

[45]https://www.healthychildren.org/English/safety-prevention/all-around/Pages/Cell-Phone-Radiation-Childrens-Health.aspx

[46]http://www.sbwire.com/press-releases/first-state-in-the-nation-maryland-state-advisory-council-recommends-reducing-school-wireless-to-protect-children-777904.htm

[47] https://ehtrust.org/policy/international-policy-actions-on-wireless/

In light of other toxicological studies finding similar effects, and in light of the fact that so many different organ systems were involved, we believe that this indicates that RF functions as a broader pluripotent carcinogen or co-carcinogen and that this fact merits explicit discussion in the report and further experimental exploration. In addition, statistical analyses that combine pre-neoplastic and neoplastic responses with tumor responses indicate statistically significant increases (see Ronald D. Melnick and Robert D. Morris, comments being provided).

**Improvement in characterization of signal properties p. 21**
"RF waves are characterized by their wavelength…and their frequency."
This statement is true but should be expanded to include this point.

The properties of RF depend on many different parameters including power density, often measured in V/m, information content, polarity and other characteristics, as indicated by Markova et al, 2012 who also showed that stem cells are much more sensitive than more mature cells to various frequencies.

Unique responses for specific cell types can account for study differences:

- There are sensitive cells and non-sensitve cells. The non-sensitivity in one cell does not "cancel the sensititivity" in others. Most cell experiments were done with mature adult lymphocytes (white blood cells), which are clearly among the non-sensitive cells. Results on lymphocytes do not preclude and contradict positive results in fibroblasts, neural stem and other cells. This principle was confirmed in the ATHEM-2 project: https://www.auva.at/cdscontent/load?contentid=10008.642538&version=1499168711
- There is a signal intensity dose (W/kg) and there is a time dose (hours exposed); a negative outcome with short time exposure does not preclude and contradict a positive outcome with higher time dose (longer exposure) as occurs in the case of glucose metabolism in the brain (see below).

**Abstract and conclusions for NTP TR 595**
**Comment: Information is missing about the relevance of these findings to the International Agency for Cancer (IARC).**

The NTP stated in their *2016* Report of Partial findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats,[48] "These findings appear to support the International Agency for Research on Cancer (IARC) conclusions regarding the possible carcinogenic potential of RFR." However this sentence is not found in the final report.

[48] Report of Partial findings from the National Toxicology Program Carcinogenesis Studies of Cell Phone Radiofrequency Radiation in Hsd: Sprague Dawley® SD rats
https://www.biorxiv.org/content/early/2018/02/01/055699

When the International Agency for Research on Cancer (IARC) classified RF as a Class 2 B possible carcinogen *in 2011,* the IARC Working Group concluded that there was "limited evidence" in experimental animals for the carcinogenicity of RF-EMF.[49] With the NTP RFR study completion, scientific evidence in experimental animals is no longer "limited." It is important that a statement be made in the report to summarize the importance of these findings in terms of the 2011 IARC conclusions.

Note, in a presentation to BioEM in 2016, Michael Wyde's NTP PowerPoint stated in conclusion that the study findings "Supports IARC conclusions of potential carcinogenic potential of RFR." The data has not changed.

The statement in the NTP abstract and in the conclusion should read, "The findings of statistically significant schwannoma increases in the heart of male rats support the International Agency for Research on Cancer (IARC) conclusions regarding the possible carcinogenic potential of RFR." just as NTP stated in the 2016 paper and numerous times in presentations by the NTP such as in the BioEM Conference June 8, 2016[50] on the study findings.[51]

**Comments on Genetic toxicology data pg 14 and page 163.**

*Comments:* Genetic toxicology remarks are substantially changed from previous NIEHS presentations on the data. The investigators should include previous conclusions from the data and if not then please clarify why such analysis is not includes and why changes have been made in data presentation and messaging.

At the annual meeting of the Environmental Mutagenesis and Genomics Society in September 2017 scientists from the National Toxicology Program presented their data on the genotoxicity of cell phone radiation in rats and mice. The abstract of the NIEHS presentation says:
"DNA damage was significantly increased in the frontal cortex of male mice (both modulations), peripheral leukocytes of female mice (CDMA only), and hippocampus of male rats (CDMA only)...These results suggest that exposure to RFR has the potential to induce measurable DNA damage under certain exposure conditions."

However the 2018 draft technical report conclusions regarding genetic toxicity *now omit such a characterization.*
For example on page 163 the technical report (rats) states:

*"Results of the MN assays were negative, but higher levels of DNA damage were observed in some tissues of male rats (hippocampus and frontal cortex in the CDMA modulation). In general, results of the*

[49] IARC (International Agency for Research on Cancer). 2013. Non-Ionizing Radiation, Part 2: Radiofrequency Electromagnetic Fields. IARC Monogr Eval Carcinog Risk Hum 102. Available: http://monographs.iarc.fr/ENG/Monographs/vol102/mono102.pdf
[50] https://ehtrust.org/wp-content/uploads/Wyde-Slides-Bioem-Conference-NTP-study-June-8-2016.pdf
[51] Video of NTP Presentation at NIEHS June 2016 on the NTP Study Findings
Powerpoint Slides on NTP by Dr. Birnbaum, Director of the National Toxicology Program

*comet assay suggested that CDMA induced more effects than GSM, and male rats showed greater sensitivity than female rats."*

and
*"Although the markedly higher levels of DNA damage observed in some rats were suggestive of an exposure- related effect, the high degree of interanimal variation within a treatment group resulted in nonsignificant statistical tests in most instances (for example, male rat cerebellum exposed to CDMA and female rat peripheral blood exposed to CDMA)."*

Such 2018 statements are in contrast to the scientists September 2017 NIEHS abstract which states, "These results suggest that exposure to RFR has the potential to induce measurable DNA damage under certain exposure conditions."

**The comet assay data on mice should be noted in the Rat report for context.**
Although these comments are mainly on the Draft technical report for rats, the mice technical report on page 13 states, *"Significant increases in DNA damage were observed in cells of the frontal cortex of male mice exposed to both modulations, GSM and CDMA. No other tissues showed evidence of a treatment-related effect in male mice. In female mice exposed to the CDMA modulation, significant increases in DNA damage were seen in blood leukocytes at all three exposure levels using both scoring approaches…"*

**Comment:** Where are concluding statements as to this data such as, "These results suggest that exposure to RFR has the potential to induce measurable DNA damage under certain exposure conditions."

Under the "conclusions section" of the mice technical report there is no reference to the DNA findings. Statement should be included in the "conclusions" section on these findings.

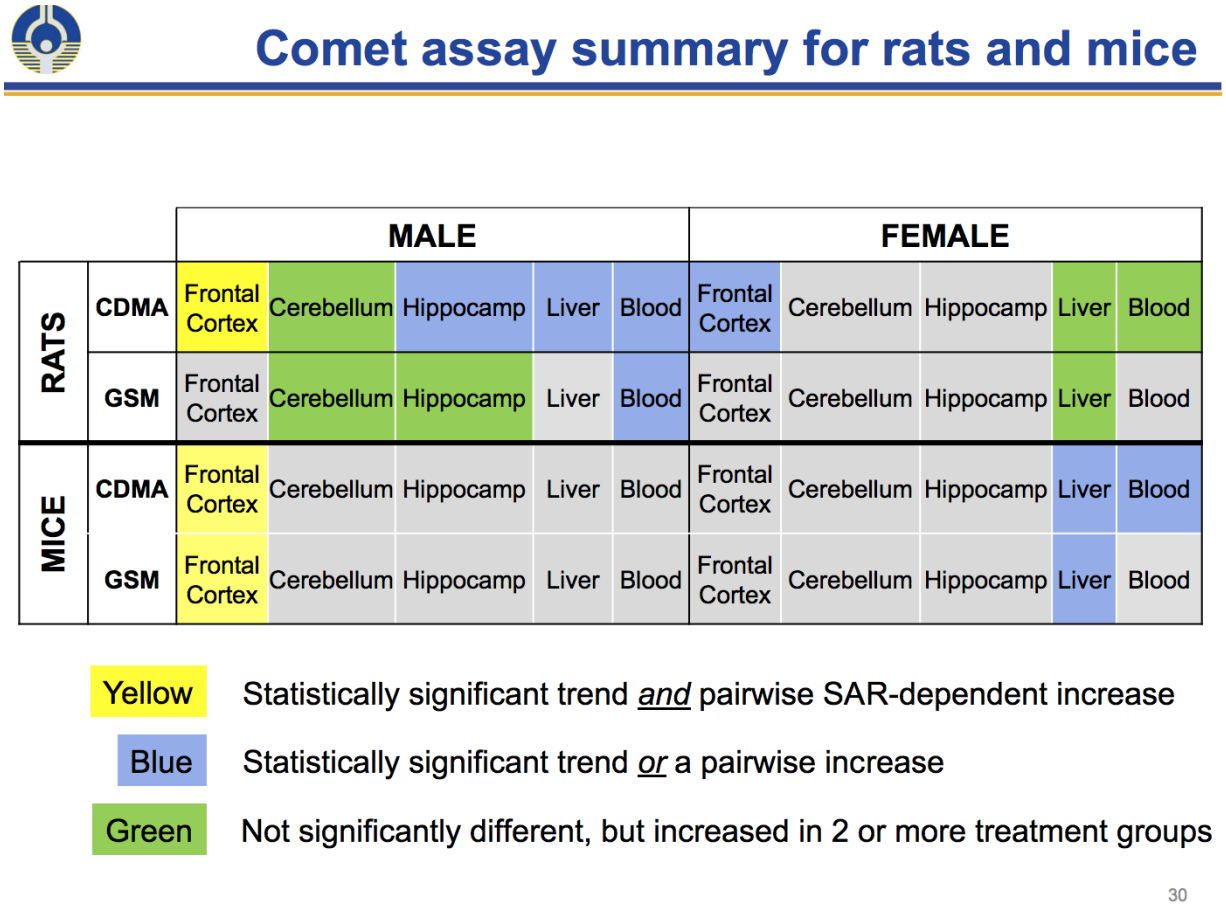
**Comments on both rats and mice reports regarding the discussion of previous research on DNA damage,**

These sections need to be updated. Please see Appendix 2: Studies on DNA damage and Genotoxicity, Prepared by Wilhelm Mosgeller, MD, Professor, University of Vienna Medical School

**Comment on Rat and Mice Technical reports re comet assay.**
In 2016 and 2017[52] presentations of findings from the comet assay were provided on slides by NIEHS/NTP Scientists. A video of the BIOEM 2016 presentation can be found online[53]. Why

[52] 2017 IIAS Conference https://ehtrust.org/wp-content/uploads/Linda-Birnbaum-.pdf
[53] https://youtu.be/m6Qs6mCvmZc

has there been a change in presentation related to these findings? See below slides presented by Michael Wyde at the June 2016 BIOEM Conference[54]. “




The above slides were presented as and reference was made to a manuscript that was in preparation according to the presentation. The 2016 NTP paper on heart and brain data[55] cites the paper as “Smith-Roe SL, Wyde ME, Stout MD, Winters J, Hobbs CA, Shepard KG, Green A, Kissling GE, Tice RR, Bucher JR, Witt KL. Evaluation of the genotoxicity of cell phone radiofrequency radiation in male and female rats and mice following subchronic exposure .”

The NTP technical reports do not include the conclusions from these manuscripts and this should be included. Why is it omitted?

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***pg 161 states,***

[54] June 8, 2016 BioEM2016 Meeting, Ghent, Belgium https://ehtrust.org/wp-content/uploads/Wyde-Slides-Bioem-Conference-NTP-study-June-8-2016.pdf

[55] https://www.biorxiv.org/content/early/2016/05/26/055699

*"Although the markedly higher levels of DNA damage observed in some rats were suggestive of an exposure- related effect, the high degree of interanimal variation within a treatment group resulted in nonsignificant statistical tests in most instances (for example, male rat cerebellum exposed to CDMA and female rat peripheral blood exposed to CDMA)."*

**Comment:** Why is there a change in the characterization of the data. The data did not change but the conclusions and messaging has changed. The 2017 NIEHS presentation states, "DNA damage was significantly increased in the frontal cortex of male mice (both modulations), peripheral leukocytes of female mice (CDMA only), and hippocampus of male rats (CDMA only)...These results suggest that exposure to RFR has the potential to induce measurable DNA damage under certain exposure conditions." Why is this analysis missing from the technical report?

**Genetic toxicology page 10**

This section only states that

*"As part of the 14-week interim evaluation, samples of frontal cortex, hippocampus, cerebellum, liver, and blood leukocytes were evaluated for DNA damage using the comet assay (two sexes, two cell phone RFR modulations, and five tissues per animal). Samples of peripheral blood were also evaluated for chromosome damage in the micronucleus assay. Results are based on the 100-cell scoring approach that was standard at the time of the studies; data obtained using a second, 150-cell scoring approach recommended in a recently adopted international guideline for the in vivo comet assay, are noted for the few instances where results differed between the two methods. A significant increase in DNA damage (% tail DNA) was observed in hippocampus cells of male rats exposed to the CDMA modulation. Although the levels of DNA damage in hippocampus cells were also increased in an exposure- related fashion using the 150-cell scoring approach, the increases were not statistically significant. An exposure-related increase in DNA damage seen in the cells of the frontal cortex of male rats exposed to the CDMA modulation was judged to be equivocal based on a significant trend test. Although results from scoring 100 cells were negative for male rat blood leukocytes exposed to either CDMA or GSM modulations, the results (both CDMA and GSM) were judged to be equivocal when evaluated using the 150-cell scoring method. No statistically significant increases in DNA damage were observed in any of the female rat samples scored with the 100-cell approach; with the 150-cell approach, results in peripheral blood leukocytes of female rats (CDMA) were judged to be equivocal.*

*No significant increases in micronucleated red blood cells or changes in the percentage of immature erythrocytes among total erythrocytes were observed in peripheral blood of rats of either sex exposed to either modulation of cell phone RFR."*

As stated earlier, at the annual meeting of the Environmental Mutagenesis and Genomics Society in September 2017 scientists from the National Toxicology Program presented their data on the genotoxicity of cell phone radiation in rats and mice. The abstract of the NIEHS presentation says:

"DNA damage was significantly increased in the frontal cortex of male mice (both modulations), peripheral leukocytes of female mice (CDMA only), and hippocampus of male rats (CDMA only)...These results suggest that exposure to RFR has the potential to induce measurable DNA damage under certain exposure conditions."

What changed? Why were statements made in September 2017 that are not made in 2018?

**Conclusions page 11.**

**Comment:** Conclusions regarding the genotoxicity findings are missing. This section needs to include a discussion on the genotoxicity findings.

It is notable that when asked about this in the 2/2018 NIEHS press conference Dr. Bucher stated[56] that, "*The genetic toxicology findings in the report, I must say we, as I indicated in my remarks, are puzzling over them. We would like to see and in fact plan to repeat these results when we complete the exposure chamber facility that we are constructing currently to do some follow up studies on the cellphone study findings that we've made to date. The patterns of damage in the brain, to the tissues in the brain of these animals were not particularly consistent with what we saw with the tumor outcomes and were not consistent even within a particular animal across the brain. So we have some questions. We looked quite a bit into the technical aspects as other studies were carried out and we can't really identify any particular reasons for these findings that would've been explained from the standpoint of a technical artifacts. So at this point we really just don't feel like we understand enough about the results to be able to place a huge degree of confidence in the findings."*

Please clarify why there has been a change in the conclusions? How does "not understanding" result in lack of confidence? Why is this sentence that was stated in 2017 omitted in 2018? *"These results suggest that exposure to RFR has the potential to induce measurable DNA damage under certain exposure conditions."*

Please clarify more about how the scientist are "puzzling" to better characterize the scientific discourse on these findings in the reports. The conclusion of the Rat Report needs to include conclusions on the genotoxic evaluation.

### Mechanistic explanations should be expanded p. 31

*"mechanisms of interaction between cell phone RFR and biological systems have not been well characterized."*

**and page 162 which states** "and little is known about the mechanism by which RFR could induce DNA damage in the absence of a thermal effect."

This section should be greatly expanded and further elaborated to reference the work of Igor Belyaev and colleagues and that of Martin Pall and Frank Barnes and Ben Greenebaum, Magda Havas that have described impacts on voltage gated calcium channels,[57] oxidative stress[58,59,60,61] and the importance of cell type as well as signal properties for determining biological impacts.[62]

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[56] Transcript NIEHS NTP Press Conference 2/1/2018 https://www.niehs.nih.gov/news/newsroom/releases/2018/february2/radiofrequency_508.pdf

[57] Pall, Martin L. "EMFs act via activation of voltage-gated calcium channels to produce beneficial or adverse effects." *Journal of Cellular and Molecular Medicine*, vol. 17, no. 8, 2013, pp. 958-65

[58] Barnes, Frank, and Ben Greenebaum. "Some Effects of Weak Magnetic Fields on Biological Systems: RF fields can change radical concentrations and cancer cell growth rates." *IEEE Power Electronics Magazine*, vol. 3, no. 1, 2016, pp. 60-8

It is not accurate to state that "little is known" because there is a significant body of literature that has considered this issue and oxidative stress (found to be altered after EMF exposure) is known to contribute to the development of cancer and other disease.

A 2016 review[63] found "among 100 currently available peer-reviewed studies dealing with oxidative effects of low-intensity RFR, in general, 93 confirmed that RFR induces oxidative effects in biological systems." and concludes that, "our analysis demonstrates that low-intensity RFR is an expressive oxidative agent for living cells with a high pathogenic potential and that the oxidative stress induced by RFR exposure should be recognized as one of the primary mechanisms of the biological activity of this kind of radiation."

Oxidative DNA damage can lead to cellular events such as mutations and and genomic instability which can result in the development of cancer[64]. According to Berquist and Wilson 2012, "Unrepaired oxidative DNA damage can result in bypass mutagenesis during genome copying or gene expression, or blockage of the essential cellular processes of DNA replication or transcription."

Furthermore, induction of oxidative stress is considered a key characteristic of many human carcinogens as detailed in a 2016 paper published in Environmental Health Perspectives[65] which documents how IARC convened two workshops in which an international Working Group of experts identified 10 key characteristics, one or more of which are commonly exhibited by established human carcinogens. The 10 characteristics they identified "are the abilities of an agent to 1) act as an electrophile either directly or after metabolic activation; 2) be genotoxic; 3) alter DNA repair or cause genomic instability; 4) induce epigenetic alterations; 5) induce oxidative stress; 6) induce chronic inflammation; 7) be immunosuppressive; 8) modulate receptor-mediated effects; 9) cause immortalization; and 10) alter cell proliferation, cell death, or nutrient supply".

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[59] Yakymenko, Igor, et al. "Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation." *Electromagnetic Biology and Medicine*, vol. 35, no. 2, 2016.

[60] Dasdag S. and M.Z. Akdag. "The link between RFs emitted from wireless technologies & oxidative stress." *Journal of Chemical Neuroanatomy*, vol. 75, pt. B, 2016, pp. 85-93.

[61] Havas, M. 2016. When theory and observation collide: Can non-ionizing radiation cause cancer? Environmental Pollution, 219:

[62] Markovà, Eva, Lars OG Malmgren, and Igor Y. Belyaev. "Microwaves from mobile phones inhibit 53BP1 focus formation in human stem cells more strongly than in differentiated cells: possible mechanistic link to cancer risk." *Environ Health Perspect*, vol. 118, no. 3, 2010, pp. 394-9

[63] Yakymenko, Igor, et al. "Oxidative mechanisms of biological activity of low-intensity radiofrequency radiation." *Electromagnetic Biology and Medicine*, vol. 35, no. 2, 2016.

[64] Berquist, B.R., Wilson, D.M., III. Pathways for repairing and tolerating the spectrum of oxidative DNA lesions. Cancer Lett. 327, 61-72. 2012.

[65] Smith, M.T., et al., Key characteristics of carcinogens as a basis for organizing data on mechanisms of carcinogenesis. Environ. Health Perspect. 124, 713-721. , 2016.

**Limitations of epidemiological and clinical observations as reported**
**p. 33**
*"There is a very limited set of research investigating the general toxicity of cell phone RFR in humans because most of the focus for research has been on the potential for carcinogenic effects. Studies in humans have failed to demonstrate any consistent adverse health effects in cell phone RFR-exposed populations. There are reports of some exposed individuals that complain of acute, subjective effects following exposure to cell phone RFR, including headaches, fatigue, skin itching, and sensations of heat (Frey, 1998; Chia et al., 2000; Hocking and Westerman, 2000; Sandström et al., 2001; Santini et al., 2002a,b). However, these have primarily been reported in people that consider themselves electrosensitive, and not in the general population. It has been suggested that there are likely other causes, not cell phone RFR, for these subjective symptoms (Kwon and Hämäläinen, 2011). In fact, the validity of electrosensitivity as an actual phenomenon has been questioned and debated. Variable results have been observed in the electroencephalogram (EEG) of volunteers exposed to RFR during sleep. Some studies indicate that exposure to cell phone RFR induces changes in sleep latency and sleep EEG (Mann and Röschke, 1996; Wagner et al., 1998, 2000; Borbély et al.,1999; Huber et al., 2000, 2002, 2003; Loughran et al., 2005; Hung et al., 2007; Regel et al., 2007; Lowden et al., 2011). Glucose metabolism in the brain, a marker for brain activity, is increased in the region of the brain closest to the antenna (Volkow et al., 2011). While these results demonstrate exposure related effects, the toxicologic significance of these findings is unclear."*

**Comment:** This statement should be revised to take into account the extensive literature confirming impacts under controlled conditions. Several investigators have demonstrated that some individuals develop a range of adverse effects under controlled conditions that are documented in a recent chapter of Oxford University Press, written by several treating clinicians and edited by Aly Cohen and Frederick D. vom Saal, *Integrative Environmental Medicine*, 2017, Davis, DL, et al., "Microwave/Radiofrequency Radiation and Human Health: Clinical Management in the Digital Age," pp. 223-254.

**p. 33 NTP Report has inadequate summary of human toxicity findings**

**p. 34**
*"No effects of cell phone RFR on the neuroendocrine system, auditory and vestibular systems, or consistent effects on cognitive performance have been reported in humans. There is also no clear evidence of effects on heart rate or blood pressure*."

This statement as written is confusing and incorrect. The first sentence asserts that there are "no effects…on the neuroendocrine, auditory and vestibular systems." The end of the first sentence asserts that the effects are not consistent.

In fact, this statement is wrong, as acoustic neuroma certainly involves the auditory system as does tinnitus, which is reported in several nations to be increased. Finnish investigators reported that ear canal temperature is increased proportional to RF

exposures. Moreover, in the U.S. up to 1 in 5 persons are reported to experience tinnitus, with higher rates in those who are electrosensitive.

Regarding cardiovascular responses to RF, since the Soviets released their own studies of RF-exposed workers, a number of researchers have confirmed the sensitivity of these outcomes. See also Cleary 1969 Biological Effects and Health Implications of Microwave Radiation; here is a direct quote from this symposium proceedings[66] (page 94):
*"In the interest of occupational hygiene, many ... investigators … have recommended that cardiovascular abnormalities be used as screening criteria to exclude people from occupations involving radio-frequency exposures."*

Increased glucose metabolism may be a short-term health benefit and a long-term risk factor for Alzheimer's and neurodegenerative processes. Regarding increased glucose metabolism in the brain, as Volkow noted in the above quote, it is interesting to note that a recent experimental study found that mice exposed to RF experience both increased glucose and reduced hyperactivity, suggesting some acute beneficial effects of this exposure in ameliorating hyperactivity and anxiety in mice bred to exaggerate such traits.

"5xFAD mice exposed for 8 months to 1950 MHz RF-EMF at a specific absorption rate of 5.0 W/kg for 2 h/day and 5 days/week developed reduced symptoms.

"Behavioral changes were assessed by an open field test and an object recognition memory task after RF exposure was terminated. In addition, cerebral glucose metabolism was analyzed in the brains of the 5xFAD mice using 18F-deoxyglucose positron emission tomography. The hyperactivity-like and anxiolytic behaviors of the 5xFAD mice in open field tests were rescued by RF exposure. Furthermore, long-term RF-EMF exposure improved the cognitive deficits of 5xFAD mice that were observed in the object recognition memory test. Consistent with the behavioral changes, glucose metabolism in the hippocampus and amygdala regions of the brains of 5xFAD mice following RF exposure was significantly increased compared to glucose metabolism in the brains of sham-exposed mice. These data suggest that long-term exposure to RF-EMF might exert beneficial effects on AD in 5xFAD mice."

However, while acute symptoms may be ameliorated, chronic systems such as profound neurodegenerative disease can be worsened by increased brain glucose metabolism; thus a hallmark of Alzheimer's is higher levels of glucose in the brain.

"Led by Madhav Thambisetty, M.D., Ph.D., investigator and chief of the Unit of Clinical and Translational Neuroscience in the NIA's Laboratory of Behavioral Neuroscience, researchers looked at brain tissue samples at autopsy from participants in the Baltimore Longitudinal Study of Aging (BLSA), one of the world's longest-running scientific studies

[66] http://www.magdahavas.com/pick-of-the-week-22-a-very-important-symposium/

of human aging. The BLSA tracks neurological, physical and psychological data on participants over several decades.
Researchers measured glucose levels in different brain regions, some vulnerable to Alzheimer's disease pathology, such as the frontal and temporal cortex, and some that are resistant, like the cerebellum. They analyzed three groups of BLSA participants: those with Alzheimer's symptoms during life and with confirmed Alzheimer's disease pathology (beta-amyloid protein plaques and neurofibrillary tangles) in the brain at death; healthy controls; and individuals without symptoms during life but with significant levels of Alzheimer's pathology found in the brain post-mortem.

They found distinct abnormalities in glycolysis, the main process by which the brain breaks down glucose, with evidence linking the severity of the abnormalities to the severity of Alzheimer's pathology. Lower rates of glycolysis and higher brain glucose levels correlated to more severe plaques and tangles found in the brains of people with the disease. More severe reductions in brain glycolysis were also related to the expression of symptoms of Alzheimer's disease during life, such as problems with memory."

Thus, it is possible that while glucose in the brain is anxiolytic, over the long term higher brain glucose contributes to what has been called diabetes of the brain which has been used to depict advanced stages of Alzheimers, as this longer-term study of human volunteers carried out by the National Institute of Aging indicates (see in this image from the National Institute of Aging, 2017). Thus, it is noteworthy that Volkow's double-blind study with healthy volunteers showed increased glucose in those parts of the brain that Interphone investigators have shown receive the highest amounts of RF exposure from cellphones.

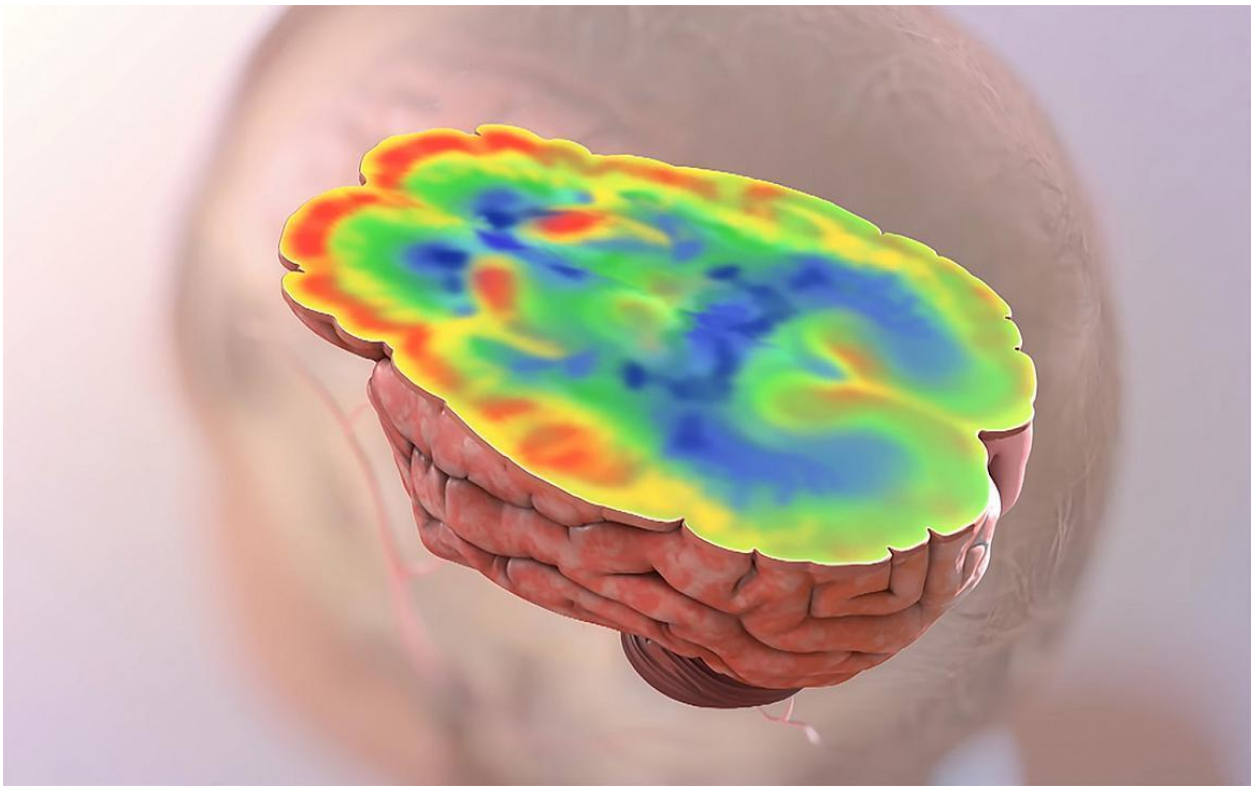

Image from National Institute of Aging 2017

**Animal Carcinogenicity review incomplete**
**p. 34**
"The carcinogenic potential of cell phone RFR in animals and humans is controversial. A comprehensive review of the carcinogenicity of cell phone RFR in laboratory animals and humans was recently conducted and published in the IARC Monograph series (IARC, 2013)."

The section on carcinogenicity in experimental animals has omitted several important published animal research studies, most importantly the Lerchl 2015 study[67] that replicated the Tillmann 2010 study[68] finding a tumor-promotion effect from very low levels, in addition to other animal studies.[69]

[67] Lerchl, Alexander, et al. "Tumor promotion by exposure to radiofrequency electromagnetic fields below exposure limits for humans." Biochemical and Biophysical Research Communications 459.4 (2015): 585-90.
[68] Tillmann, Thomas, et al. "Indication of co-carcinogenic potential of chronic UMTS- modulated radiofrequency exposure in an ethylnitrosourea mouse model." *International Journal of Radiation Biology* 86.7 (2010): 529-41.
[69] Szudziński, A., et al. "Acceleration of the development of benzopyrene- induced skin cancer in mice by microwave radiation." *Arch Dermatol Res* 274.3-4 (1982): 303-12.

The importance of synergies needs to be added to the technical report research review.

Lerchl et al, 2015 reported important synergies of RF at levels 1,000 times lower than the NTP when combined with prenatal exposures to ENU (a known experimental carcinogen):
"Our study confirms and extends the previously published observations of tumor-promoting effects of life-long RF-EMF exposure… since many of the tumor-promoting effects in our study were seen at low to moderate exposure levels (0.04 and 0.4 W/kg SAR), thus well below exposure limits for the users of mobile phones."

Studies on synergies are critical to understanding the biological effect of RFR to humans because we are exposed to cumulative exposures from multiple agents and chemicals *in combination with* radio-frequency which has been shown in these research studies to act as a tumor promoter. These studies need to be included in the science review.

This statement also fails to cite Chou et al. 1992,[70] that published positive results of a large-scale lifetime study in which 100 rats were sham-exposed and 100 rats were exposed for 21 h/day for 25 months to a pulsed RF signal, and should also reference the REFLEX project regarding evidence of DNA damage (see Appendix 3 DNA Damage and Genotoxicity Study overview, also Bioinitiative Reports, 2007, 2012, and on line).

**Review of Evidence on Testes is incomplete and should be revised**

**p. 34**
*"Similarly, no effects of cell phone RFR on protein expression have been reported in the testis (Lee et al., 2010) or in the skin (Masuda et al., 2006; Sanchez et al., 2006, 2008)."*

Cellphone exposure can affect protein expression in the testes. For instance, in the study by Sepehrimanesh et al., different proteomic pattern in rat testes in response to 900 MHz exposure electromagnetic field (EMF) by using 2-dimensional/silver nitrate staining/mass spectroscopy were confirmed. They found that most identified proteins were related to the oxidative stress, HSPs, cytoskeleton, and metabolism (1). Recently, Sepehrimanesh and his colleagues also reported that ATP synthase beta subunit and hypoxia up-regulated protein 1 precursor were significantly up-regulated after 4 h of daily exposure for 30 consecutive days to 900 MHz EMF exposure (2).

In addition, down-expression of lipocalin 2, a protein which mediates delivery of ferric ions to mouse spermatozoa and enhances sperm motility, by real-time PCR and western blotting in mouse testis after exposure to EMF was reported (3).

**References**
1. Sepehrimanesh M, Kazemipour N, Saeb M, Nazifi S. Analysis of rat testicular proteome following 30- day exposure to 900 MHz electromagnetic field radiation. *Electrophoresis*. 2014;35(23):3331-8.

[70] http://www.magdahavas.com/wordpress/wp-content/uploads/2010/09/Chou-CK-et-al.-Long-term-MW-rad-of-Rats-1992.pdf

2. Sepehrimanesh M, Kazemipour N, Saeb M, Nazifi S, Davis DL. Proteomic analysis of continuous 900-MHz radiofrequency electromagnetic field exposure in testicular tissue: a rat model of human cell phone exposure. *Environmental Science and Pollution Research*. 2017;24(15):13666-73.
3. Mohammadi Roushandeh A, Halabian R, Mozafari P, Soleimani Rad J, Sadeghzadeh Oskouei B, Samadi Kuchaksaraei A, Habibi Roudkenar M (2009) Down-regulation of lipocalin 2 expression in mouse testis after exposure to electromagnetic field. *Iran J Med Sci* 34:265–270

**General Comment Regarding Sponsorship Bias as it affects publication of results**
In addition, this section should add that those studies overall have found sponsorship bias, in that research sponsored by industry, which is the majority of studies carried out, tend to produce negative results. In contrast, works published by independent investigators are more likely to find a positive effect (see Henry Lai and Martin Roosli).

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Prasad, M., et al. "Mobile phone use and risk of brain tumours: a systematic review of association between study quality, source of funding, and research outcomes." *Neurological Sciences*, 2017.
Marino, Andrew A. and Simona Carrubba. "The Effects of Mobile-Phone Electromagnetic Fields on Brain Electrical Activity: A Critical Analysis of the Literature." *Electromagnetic Biology and Medicine*, vol. 28, no. 3, 2009, pp. 250-74.
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Ledford, Brandon. "Cell Phones, Electromagnetic Radiation, and Cancer: A Study of Author Affiliation, Funding, Bias, and Results." *Proceedings of the Policy Studies Organization*, no. 11,
Bekelman, Justin E., Li, Yan and Cary P. Gross. "Scope and impact of financial conflicts of interest in biomedical research: a systematic review." *Journal of the American Medical Association*, vol. 289, no. 4, 2003, pp. 454-65.
Friedman, Michael and Lee Friedman. "Financial Conflicts of Interest and Study Results in Environmental and Occupational Health Research."*Journal of Occupational and Environmental Medicine*, vol. 58, no. 3, 2016, pp. 238-47.

**The epidemiology discussion as drafted fails to include a number of recent studies and also does include some discredited work.**

**In the opening paragraph of the Discussion of the report on the NTP study in rats the following appears at p. 151:**

*"While epidemiology studies have not definitively established an association between cell phone radio frequency radiation (RFR) exposure and any specific health problems in humans, the results from some studies are suggestive of potential effects (Lönn et al.,*

*2004b; Hardell et al., 2006, 2007b; Hardell and Carlberg, 2009; INTERPHONE2010, 2011; Benson et al., 2013). Based on available studies, a working group of the International Agency for Research on Cancer (IARC, 2011) classified radiofrequency electromagnetic fields as possibly carcinogenic to humans. Of particular concern were possible associations (limited evidence) with brain glioma and acoustic neuroma (vestibular schwannoma) in the region of the head that is most exposed to RFR when a wireless phone is used at the ear. However, interpretation of these results is complicated by potential misclassification of exposures and by selection and recall biases. It is also possible that exposures to RFR in the general population, such as those from cellular communication, have not occurred for a long enough period of time to ascertain an effect due to the apparent long latency period for some types of adult-onset cancers in humans."*

**In fact, this statement is incomplete and should be revised to take into account the following information:**

Since the IARC conducted its review, there are now several important epidemiology studies, especially in France (Coureau et al. 2014), Sweden (Hardell et al. 2013b, Hardell and Carlberg 2015) and from further reports of the Interphone study (Grell et al. 2016) that confirm the earlier evidence that prolonged exposure to radio-frequency radiation from cellphones more than doubles the risk of glioblastoma and increases the risks of acoustic neuroma (vestibular schwannoma) (Hardell et al. 2013a). Hardell and Carlberg (2015) found that those who began using cellphones and/or cordless phones regularly as children had between 4- to 8-fold increased risk of glioma as adults. In addition, a re-analysis of the Canadian component of the international Interphone study has shown that "potential misclassification of exposures and by selection and recall biases" does not explain the associations previously found in the Interphone study (Momoli et al., 2017). Because of these recent studies, EHT scientists and a number of others currently conclude that the epidemiological evidence merits re-classification of cellphone and wireless radiation as a Class 1 Human Carcinogen.

Brain cancers have now become the number one cancer in children and young adults (Gittleman et al. 2015). In our professional judgment, we may well be on the verge of a major increase in glioblastomas and vestibular schwannomas in humans the world over in part due to cellphone use. In addition, other contributors to this could well be the increased patterns of diagnostic radiation to younger persons.

**Epidemiology References published since IARC review of 2011. Please update the technical report with all of these references.**

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Hardell, L. and M. Carlberg. Mobile phone and cordless phone use and the risk for glioma - Analysis of pooled case-control studies in Sweden, 1997-2003 and 2007-2009. *Pathophysiology* 2015; 22: 1-13.
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Meningioma, Acoustic Neuroma, and Parotid Gland Tumors. *Am. J. Epidemiol.* 2017; 186: 885–893.

**Page 38 NTP TR 595**
*"Additional studies have demonstrated that there was no association between cell phone usage and pituitary gland tumors (Takebayashi et al., 2008; Schoemaker and Swerdlow, 2009), testicular tumors (Schüz et al., 2006; Hardell et al., 2007a), parotid gland tumors (Hardell et al., 2004; Lönn et al., 2006), uveal melanoma in the eye (Schüz et al., 2006; Stang et al., 2009), and cutaneous melanoma (Hardell et al., 2011)."*

This summary missed the following research studies related to the paratoid gland and salivary gland. More will be added in comments submitted by the authors.

Siqueira, Elisa Carvalho, et al. "Cell phone use is associated with an inflammatory cytokine profile of parotid gland saliva." *Journal of Oral Pathology & Medicine*, vol. 45, 2016, pp. 682-6.

- "The exposure of parotid glands to cell phones can alter salivary IL-10 and IL-1β levels, consistent with a pro-inflammatory microenvironment that may be related to heat production."

Sadetzki, Siegal, et al. "Cellular Phone Use and Risk of Benign and Malignant Parotid Gland Tumors—A Nationwide Case-Control Study." *American Journal of Epidemiology*, vol. 167, no. 4, 2007, pp. 457-67.

- " A positive dose-response trend was found...Based on the largest number of benign PGT patients reported to date, our results suggest an association between cellular phone use and PGTs."

The summary needs to add the studies that have found associations between cellphone use and vestibular schwannoma instead of simply citing the Interphone study and the IARC 2013 Monograph which include:
Hardell L, Carlberg M and Hansson Mild K: Use of mobile phones and cordless phones is associated with increased risk fo glioma and acoustic neuroma. *Pathophysiology* 20: 85-110, 2013.

Moon et al. "Association between vestibular schwannomas and mobile phone use." *Tumour Biology*, vol. 35, no. 1, 2014, pp. 581-7.

- "We found that tumors may coincide with the more frequently used ear of mobile phones and tumor volume that showed strong correlation with amount of mobile phone use, thus there is a possibility that mobile phone use may affect tumor growth."

**Draft should delete Danish Cohort Study References and/or include references to numerous critiques of this work.**
The draft report cites the the Danish Cohort Study—despite the fact that this study has major design flaws that invalidate its conclusions and has been so widely criticized that

it was, in fact, not taken heavily into account in the IARC evaluation of 2011. Appendix 4 of this report details the criticism and has a reference list of scientific critiques.

In light of the shortcomings, in 2011 the World Health Organization International Agency for Research on Cancer (IARC) minimized the Danish Cohort findings in their evaluation of cellphone radiation cancer risk. The Danish Cohort design flaws were cited as a reason to give less weight to the Danish study in comparison to the Interphone study and Hardell's efforts. IARC's Robert Bann wrote that the Danish cohort exclusion of the corporate subscribers "seems remarkable" and "could have resulted in considerable misclassification in exposure assessment."

The Danish Cohort Cell Phone and Cancer Study cannot be used as proof of no evidence.

**Comments on NTP Technical Report on Rats**

**Abstract**

The NTP Rat and Mice *abstracts* only state about the study design and history that "The Food and Drug Administration nominated cell phone RFR emission for toxicology and carcinogenicity testing in 1999."

Both abstracts *should include* the fact that the two-year studies used non-thermal doses of RF radiation as a design to test the null hypothesis *that RF radiation at non-thermal levels could not cause any adverse biological effects.* The abstracts should also include that current regulations are based on the assumption that non-thermal levels have no health effects. Thus, this study tests the basis for U.S. regulation on allowable RF radiation exposures to the public. The conclusion on the abstracts should state this information in a few sentences to ensure the summary clarifies in understandable terms the reasoning behind the study design and what the study set out to test.

The NTP technical reports need to clarify in understandable terms *why* the study was designed as it was and *why* this research design can result in information relevant to human health risk.

In the 1/2/2018 press conference, it was stated of the NTP exposures, by Dr. Bucher, that "So I think that the message is that typical cell phone use is not going to be involved, is not going to be directly related to the kind of exposures that we use in these studies …," and the ensuing press coverage of the study stated that the exposures were so high this study is not applicable to human health. Such messaging is misleading. The NTP Report needs to include wording to clarify to the public that the RF exposures were designed to mimic long-term use of the cellphone by humans.

In 2009, when Dr. Bucher of the NTP presented the study to Congress, he stated, of this study, that it was a "state of the art study" and "The NTP is working to provide information that will help clarify any potential health hazards, including cancer risk, from exposure to cell phone radiation and pave the way to better protection for public health...The NTP is in the initial stages of conducting toxicology and carcinogenicity studies in laboratory animals, using specially

designed chambers to provide exposures that simulate those of cell phone users in the United States."

A phrase could be added to the NTP report abstract , for clarity, that "the chambers were designed to provide exposures that simulate those of cell phone users in the United States." Then a clarifying sentence can be added related to explain the regulatory limits for cellphones—e.g., that SAR limits are 1.6 and 4.0 W/kg (public) and 8.0 and 20.0 W/kg (occupational).

**Page 40 NTP TR 595**
Just as the abstract needs to be updated, the study rationale also needs to be clearer in regard to the intention of the design of the studies.

The statement "*Current exposure guidelines are based on protection from acute injury from thermal effects and little is known about the potential for health effects from long-term exposure to RFR below the thermal hazard threshold.*" should be followed by conclusionary sentences such as
"This study was specifically designed to assess the potential for health effects from long-term exposure to RFR below the thermal hazard threshold. Such research would lend important information for health and regulatory agencies because current exposure guidelines are based on the premise that adverse health effects are not possible at RFR levels below the thermal hazard threshold."

**Page 40 GSM- and CDMA-Modulated Cell Phone RFR, NTP TR 595 states,**
*"As the public has become more aware of the uncertainty regarding the potential effects of cell phone RFR on the brain, more emphasis has been placed on the use of wired or wireless headsets (like Bluetooth), which minimize cell phone RFR exposure to the head."*

This needs to include that with wireless earpieces/headsets (like Bluetooth), an additional frequency is emitted. In addition, people also use such accessories with the phone moved into the pocket or resting on the body (e.g., in the bra next to breast), increasing local exposure to different parts of the body. As another example, many people lay on a bed, rest the phone *on their chest or against their abdomen* and talk using earpieces/headsets or speaker mode. Although the exposure to the head is decreased, exposure to other areas of the body can be significantly increased with earpiece/headset use.

**Page 38 GSM- and CDMA-Modulated Cell Phone RFR, NTP TR 595 states,**
"Additional cell phone RFR technologies, like Smart Meters used by power companies, transmit data in real time using cell phone-type RFR. These existing and emerging technologies may potentially increase the level of exposures in human populations"

This paragraph needs to be updated to include the public's ever increasing use of new devices such as wearables, virtual assistants, smart security and other sensor systems, baby monitors and other RF radiation technologies—all of which add to our cumulative daily exposure.

The statement needs to read, “These existing and emerging technologies will increase the level of exposures in human populations”, because it is factual that the exposure is increased. The increase may be small in comparison to ICNIRP limits, but it is an increase nonetheless. The cumulative increase from all our new wireless technologies and Wi-Fi devices has never been adequately quantified in research.

**Page 32 and 33 GSM- and CDMA-Modulated Cell Phone RFR, NTP TR 595 states,** *“Changes have also been noted in the permeability of the blood-brain barrier in some studies (Eberhardt et al., 2008; Nittby et al., 2009, 2011). However, other studies conducted under similar experimental conditions failed to demonstrate any effect of cell phone RF radiation exposure on the permeability of the blood-brain barrier (Grafström et al., 2008; de Gannes et al., 2009; McQuade et al., 2009; Masuda et al., 2009).”*

This summary is incomplete and leaves out several important studies regarding the blood-brain barrier:

Tang, J., et al. “Exposure to 900 MHz electromagnetic fields activates the mkp-1/ERK pathway and causes blood-brain barrier damage and cognitive impairment in rats.” *Brain Research*, vol. 1601, 2015, pp. 92-101.
This study demonstrated, for the first time, the blood-brain barrier and cognitive changes in rats exposed to 900 MHz electromagnetic field (EMF) and aims to elucidate the potential molecular pathway underlying these changes. Researchers found that EMF exposure for 28 days induced the expression of mkp-1, resulting in ERK dephosphorylation. Taken together, these results demonstrated that exposure to 900 MHz EMF radiation for 28 days can significantly impair spatial memory and damage BBB permeability in rat by activating the mkp-1/ERK pathway.

Leszczynski, D., et al. “Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: molecular mechanism for cancer- and blood-brain barrier-related effects.” *Differentiation*, vol. 70, no. 2-3, 2002, pp. 120-9.
Researchers examined whether non-thermal exposures of cultures of the human endothelial cell line EA.hy926 to 900 MHz GSM mobile phone microwave radiation could activate stress response. Results obtained demonstrate that 1-hour non-thermal exposure of EA.hy926 cells changes the phosphorylation status of numerous, yet largely unidentified, proteins. We postulate that these events, when occurring repeatedly over a long period of time, might become a health hazard because of the possible accumulation of brain tissue damage. Furthermore, our hypothesis suggests that other brain damaging factors may co-participate in cellphone radiation-induced effects.

Sirav, Bahriye, and Nesrin Seyhan. "Effects of radiofrequency radiation exposure on blood-brain barrier permeability in male and female rats." *Electromagnetic Biology and Medicine*, 30.4 (2011): 253-260.

"A significant increase in albumin was found in the brains of the RF-exposed male rats when compared to sham-exposed male brains. These results suggest that exposure to 0.9 and 1.8 GHz CW RFR at levels below the international limits can affect the vascular permeability in the brain of male rats. The possible risk of RFR exposure in humans is a major concern for the society. Thus, this topic should be investigated more thoroughly in the future."

Sirav B, Seyhan N. "Effects of GSM modulated radio-frequency electromagnetic radiation on permeability of blood-brain barrier in male & female rats," *J Chem Neuroanat.* 2016 Sep;75(Pt B):123-7

**Page 35 GSM- and CDMA-Modulated Cell Phone RFR, NTP TR 595 states,**
*"There are reports of some exposed individuals that complain of acute, subjective effects following exposure to cell phone RFR, including headaches, fatigue, skin itching, and sensations of heat (Frey, 1998; Chia et al., 2000; Hocking and Westerman, 2000; Sandström et al., 2001; Santini et al., 2002a,b). However, these have primarily been reported in people that consider themselves electrosensitive, and not in the general population. It has been suggested that there are likely other causes, not cell phone RFR, for these subjective symptoms (Kwon and Hämäläinen, 2011)."*

These statements neglect to document the research linking headaches to cellphone use. Numerous research studies have found a link between cellphone radiation and headaches. A 2017 review by Wang and colleagues found a significant association between mobile phone use and headache in children and adults, including a dose-response relationship between risk of headache and call duration and frequency. Similarly, Cho et al. (2016) and Szyjkowska et al. (2014) found an association between headache severity and average call frequency.

Please see this research on headaches and mobile phone use:

Durusoy, Raika, et al. "Mobile phone use, school electromagnetic field levels and related symptoms: a cross-sectional survey among 2150 high school students in Izmir." *Environmental Health* 16.1 (2017): 51.

- "We found an association between mobile phone use and especially headache, concentration difficulties, fatigue, sleep disturbances and warming of the ear showing also dose-response. We have found limited associations between vicinity to base stations and some general symptoms; however, we did not find any association with school EMF levels."
- "Decreasing the numbers of calls and messages, decreasing the duration of calls, using earphones, keeping the phone away from the head and body and similar precautions might decrease the frequencies or prevalence of the symptoms."

Wang, J., et al. "Mobile Phone Use and The Risk of Headache: A Systematic Review and Meta-analysis of Cross-sectional Studies." *Scientific Reports* 7.1 (2017): 12595.

- "Headache is increasingly being reported as a detrimental effect of mobile phone (MP) use. However, studies aimed to investigate the association between MP use and headache yielded conflicting results. To assess the consistency of the data on the topic, we performed a systematic review and meta-analysis of the available cross-sectional studies."
- "We found that the risk of headache was increased by 38% in MP user compared with non-MP user. Among MP users, the risk of headache was also increased in those who had longer daily call duration and higher daily call frequency."
- "Our data indicate that MP use is significantly associated with headache, further epidemiologic and experimental studies are required to affirm and understand this association."

Excerpts:

- "The underlying mechanism of the association between MP use and headache remains unclear but some suggest that breakdown of the blood-brain barrier due to exposure to low intensity MP frequency microwave energy may be involved 33,34,35,36. Also, the dopamine-opiate system may be involved in headaches and low intensity electromagnetic energy exposure affects those systems 37,38,39. However, since Frey's group first reported headaches occurring after microwave energy exposure at approximately the same frequencies and incident energies that present day MP emit 40, the exact mechanism under this association is still not fully understood now."
- "The results of our meta-analysis and lots of previous studies herein supported current clinical opinion that MP use may cause increased risk for headache. Therefore, it is advisable to admit that the use of MP is a risk factor for headache. In Stalin's study 18 and Chiu's study 19, the prevalence of MP usage among adult and children was 69.8% and 63.2% respectively in their study population, and that was only the data from two years ago. We could foresee the prevalence of MP usage will be higher in the future. So it is also advisable to suggest that excessive use of MP should be avoided by increasing social awareness through health promotion activities. It is imperative that health care professionals, clinicians and common people are educated about the deleterious influence of MP on headache. And it is reasonable to instruct children and adolescent about a prudent use of MPs. In addition, we encourage screening of headache patients during routine clinical visits to identify those patients to explore excessive MP use as a potential cause. Intervention and policies must be developed, evaluated and carry out at the population level to raise the awareness of the potential adverse health effect to decrease the headache caused by MP using."

Cho, Y.M., et. al. "A cross-sectional study of the association between mobile phone use and symptoms of ill health. *Environmental Health and Toxicology* (2016).

- The average daily phone call frequency showed a significant correlation with the perceived stress scale score in female subjects. Mobile phone call duration was not significantly associated with stress, sleep, cognitive function, or depression, but was associated with the severity of headaches.

Stalin, P., et al. "Mobile phone usage and its health effects among adults in a semi-urban area of southern India." *Journal of Clinical and Diagnostic Research: JCDR* 10.1 (2016): LC14.

- "The prevalence of mobile phone usage was 70%. Calling facility (94.2%) was used more than the SMS (67.6%). Health problems like headache, earache, tinnitus, painful fingers and restlessness etc., were found to be positively associated with mobile phone usage. There was negative association between hypertension and mobile phone usage."

Chiu, Chang-Ta, et al. "Mobile phone use and health symptoms in children." *Journal of the Formosan Medical Association* 114.7 (2015): 598-604.

- "Mobile phone use was associated with a significantly increased adjusted odds ratio for headaches and migraine (1.42, 95% CI = 1.12–1.81) and skin itches (1.84, 95% CI = 1.47–2.29). Children who regularly used MPs were also considered to have a health status worse than it was 1 year ago (β = 0.27, 95% CI = 0.17–0.37)."
- "Although the cross-sectional design precludes the causal inference for the observed association, our study tended to suggest a need for more cautious use of MPs in children, because children are expected to experience a longer lifetime exposure to radiofrequency electromagnetic fields (RF-EMF) from MPs."

Schoeni, Anna, Katharina Roser, and Martin Röösli. "Symptoms and cognitive functions in Adolescents in relation to mobile phone use during night." *PloS one* 10.7 (2015): e0133528.

- "Overall, being awakened during night by mobile phone was associated with an increase in health symptom reports such as tiredness, rapid exhaustibility, headache and physical ill-being, but not with memory and concentration capacity. Prevention strategies should focus on helping adolescents set limits for their accessibility by mobile phone, especially during night."

Zheng, Feizhou, et al. "Association between mobile phone use and self-reported well-being in children: a questionnaire-based cross-sectional study in Chongqing, China." *BMJ open* 5.5 (2015): e007302.

- "The present study indicated that there was a consistent significant association between MP use and fatigue in children. Further in-depth research is needed to explore the potential health effects of MP use in children."

Küçer N and T. Pamukçu. "Self-reported symptoms associated with exposure to electromagnetic fields: a questionnaire study." *Electromagnetic Biology and Medicine* 33.1 (2014): 15-7.

- Self-reported symptoms were headache, vertigo/dizziness, fatigue, forgetfulness, sleep disturbance-insomnia, tension-anxiety, joint and bone pain, lacrimation of the eyes, hearing loss and tinnitus.
- As a result of the survey, the study has shown that users of mobile phone and computer more often complained of headache, joint and bone pain, hearing loss,

vertigo/dizziness, tension-anxiety symptoms according to time of daily usage ($p < 0.05$)."

Szyjkowska, A., et al. "The risk of subjective symptoms in mobile phone users in Poland – An epidemiological study. *International Journal of Occupational Medicine and Environmental Health* 27.2 (2014): 293-303.

- Headaches were reported significantly more often by the people who talked frequently and long, in comparison with other users.

Redmayne, Mary, Euan Smith, and Michael J. Abramson. "The relationship between adolescents' well-being and their wireless phone use: a cross-sectional study." *Environmental Health* 12.1 (2013): 90.

- The number and duration of cellphone and cordless phone calls were associated with increased risk of headaches.
- Using a wired cellphone headset was associated with tinnitus, while wireless headsets were associated with headache, feeling down/depressed and waking in the night.

Madhuri Sudan, et al. "Prenatal and Postnatal Cell Phone Exposures and Headaches in Children." *Open Pediatrics Medical Journal* 6 (2012): 46-52.

- Children with cellphone exposure had higher odds of migraines and headache-related symptoms than children with no exposure.

Divan, H.A., et al. "Prenatal and postnatal exposure to cell phone use and behavioral problems in children." *Epidemiology*, vol. 19, no. 4, 2008, pp. 523-9.

- Exposure to cellphones prenatally—and, to a lesser degree, postnatally—was associated with behavioral difficulties such as emotional and hyperactivity problems around the age of school entry. These associations may be noncausal and may be due to unmeasured confounding. If real, they would be of public health concern given the widespread use of this technology.

Khan, Muhammad. "Adverse effects of excessive mobile phone use." *International Journal of Occupational Medicine and Environmental Health* 21.4 (2008): 289-293.

- "16.08% of the subjects complained of headache and 24.48% of fatigue. Impaired concentration was reported by 34.27% of respondents, memory disturbances by 40.56%, sleeplessness by 38.8%, hearing problems by 23.07%, and facial dermatitis by 16.78%. The sensation of warmth within the auricle and behind/around the ear was reported by 28.32%. Out of 286 subjects who participated in this study, 44.4% related their symptoms to mobile phone use."

Söderqvist, Fredrik, Michael Carlberg, and Lennart Hardell. "Use of wireless telephones and self-reported health symptoms: a population-based study among Swedish adolescents aged 15–19 years." *Environmental Health* 7.18 (2008).

- "Regular users of wireless phones had health symptoms more often and reported poorer perceived health than less frequent users."

Chia, Sin-Eng, Hwee-Pin Chia, and Jit-Seng Tan. "Prevalence of headache among handheld cellular telephone users in Singapore: a community study." *Environmental Health Perspectives* 108.11 (2000): 1059-1062

- "There is a significant increase in the prevalence of headache with increasing duration of usage (in minutes per day). Prevalence of headache was reduced by more than 20% among those who used hand-free equipment for their cellular telephones as compared to those who never use the equipment. The use of HPs is not associated with a significant increase of CNS symptoms other than headache."

Hocking, B. "Preliminary report: symptoms associated with mobile phone use." *Occupational Medicine* 48.6 (1998): 357-360.

- "Forty respondents from diverse occupations described unpleasant sensations such as a burning feeling or a dull ache mainly occurring in the temporal, occipital or auricular areas."
- "Cranial and other diverse symptoms may arise associated with mobile phone usage. Physicians and users alike should be alert to this. Further work is needed to determine the range of effects, their mechanism and the possible implications for safety limits of RFR."

**Final Comment on text of technical drafts:**
The NTP study was designed years ago and now new technologies are being developed and these technologies require adequate testing for health effects *before* deployment.

*The NTP technical report should dedicate a section to how the technologies they tested is the same and different than these new technologies- notably 5G.* Currently a broad infrastructure is being planned to support the Internet of Things, with a half billion dollars of federal subsidies, to allow implementation of a new standard called 5G. Please see Appendix I for research studies and scientific references on the health issues posed by 5G which uses submillimeter and millimeter wave technology.

**Conclusions and Policy Relevance**
The NTP findings of adverse biological effects at well-controlled "non-thermal" levels add important scientific evidence to the current body of science on the human health impacts of RF radiation. As with many modern matters, wireless technology has become pervasive in our societies long before any systematic studies were ever carried out regarding long-term impacts on public health and the environment. The tools of toxicology are used, as the IARC preamble notes, to predict damage and provide tools for prevention of harm. In contrast, those of epidemiology can only confirm the nature of past harms. The NTP scientists are to be commended for carrying out a well-designed study under the limitations of time and funding and under a level of scrutiny that is without precedence. Never in the history of the NTP has a period of several days been devoted to evaluating a bioassay. This testifies to the profound importance of the technology including but not limited to its obvious role for the global economy.

Conducted under state of the art protocols, the NTP findings strengthen epidemiology studies that link cellphone use to cancer development and promotion, and strengthen experimental studies that link exposure to biochemical effects that can lead to cancer and a myriad of other diseases and illnesses. As the American Academy of Pediatrics and the State of California have reminded us, the case for precautions, especially for our children, has become undeniable. We believe, as do a growing number of governments around the world, that these findings should result in immediate protective cautionary action from government agencies, researchers and the medical community.

While the job of the NTP is to do solid scientific work, there is also an obligation to explain this work to policymakers so that they can develop appropriate responses. At this point, EHT believes that the public needs to be fully informed about the NTP findings and the relevance to human health. The public assumes that RF radiation exposure from cellphones, cell towers and wireless devices is safe. They assume that wireless technologies were pre-market tested for safety. The public assumes that our federal health and safety agencies are dedicating hours and hours of staff time to compiling and evaluating research on the issue and that federal agencies are issuing opinions on human health risk based on their documented systematic review of the best available science. Such assumptions are false, as no U.S. health agency has done a systematic review of the scientific evidence.

As the FDA website makes clear, cellphones and wireless devices were not pre-market tested for safety. There is no post-market surveillance in cellphone users—as there would be with drugs where side effects are tallied. New technologies are coming online without basic prudent long term safety testing. Thus, those digital assistants popping up throughout schools and homes are tested at a distance of 20 cm from an adult male body and were never intended to be cuddled by toddlers. Two decades ago when the average phone cost a few thousand dollars and gasoline cost less than two, our RF radiation regulations were set without any documentation providing adequate data on the effects on children, the elderly or the medically compromised.

Further federal funding and training in the field of bioelectromagnetics was largely suspended in 1996 when the EPA was defunded from developing safety limits for radio-frequency radiation.

This study confirms that RFR can cause adverse biological effects and that federal regulatory limits do not protect the public. A risk assessment needs to be done, a systematic review of the research should be prepared and proper safety limits need to be developed that protect the public from these adverse biological effects.

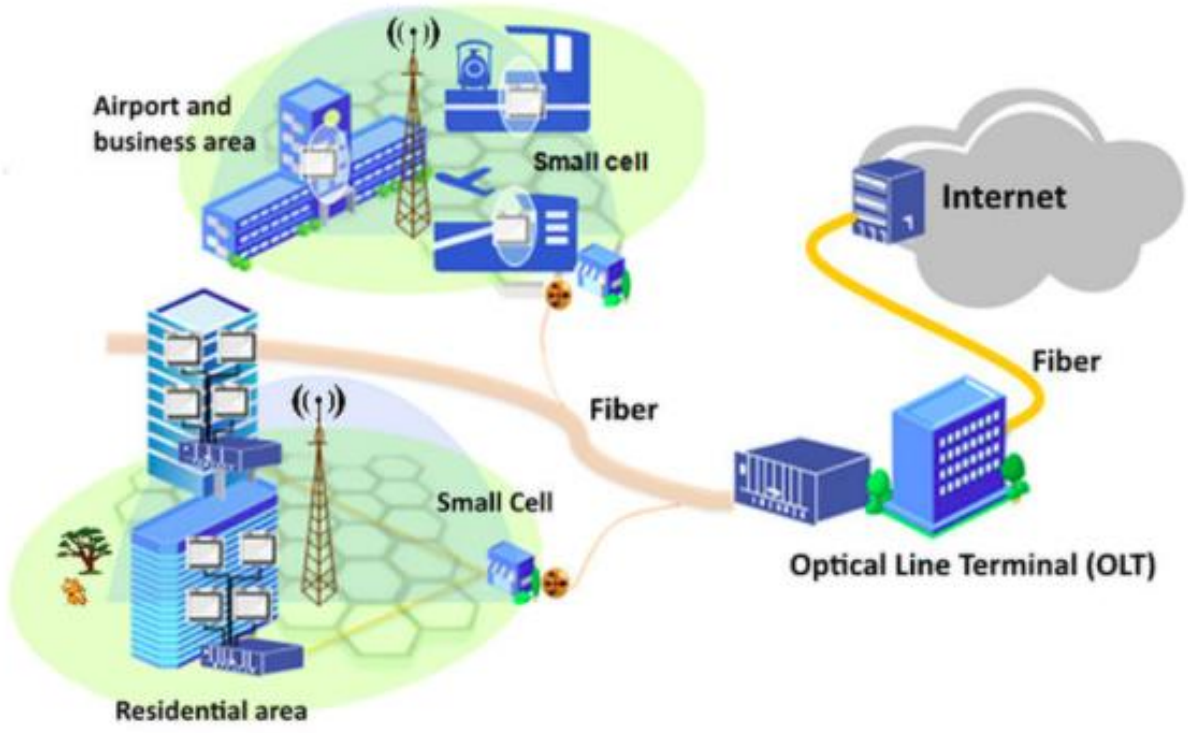
We and other scientists accordingly advise that policymaking institutions should set exposure limits for wireless transmitting devices to as low as reasonably achievable (ALARA), as we learnt to do many years ago for ionizing radiation.

**Appendix I: The importance of future testing of 5G**

The NTP study was designed years ago and now new technologies are being developed and require adequate testing for health effects *before* deployment.

Currently a broad infrastructure is being planned to support the Internet of Things, with a half billion dollars of federal subsidies, to allow implementation of 5G as a national priority. 5G will entail a system of Multiple Input Multiple Output (MIMO), beam-forming technologies that have shown important toxicological impacts. Documented biological impacts of 5G include acceleration of bacterial and cancer cell growth, suppression of immune system and resonating with sweat ducts as antennas.

**Figure 1: Next-generation converged optical-wireless access networks in 5G (drawn by authors, SE Alavi and IS Amiri).**




As the Figure above indicates, fiber-optic cabling is fundamental to 5G. This cable will be at the base or atop each proposed tower that will include MIMO wireless antennas. It should be noted that the projected U.S. system will use 5G to deliver wireless systems that many believe are unlikely to achieve safety or security of communications in contrast to the fiber-optic system that is used extensively in Korea to provide direct high-speed broadband service estimated to be 100 times faster than in the U.S. that includes no microwave radiation.

As to 5G health impacts, a recent publication from Israeli physicists appears in the Special Issue of *Environmental Research*, an Elsevier peer-reviewed publication online, edited by me with Dr. Miller and Ronald Melnick, PhD, DABT, former Senior Scientist

with the NTP. More than 15 articles are planned for this Special Issue and will be shared with the NTP staff as they become available. These include an important report of a lifetime bioassay from the Ramazzini Institute evaluating levels of RF that are from 60 to 6 ,000 times below those of the NTP Bioassay expected to be released before the NTP review March 26, 2018 that will be discussed further in our oral comments.

Among the key findings of the recent study of 5G by Betzalel et al., 2018[71] are these highlights:
"The sweat duct is regarded as a helical antenna in the sub-THz band, reflectance depends on perspiration, which is how this frequency is used as a weapon at higher powers. Non-thermal effects occur due to resonance with the structure of sweat ducts. A realistic skin EM model can be used to estimate the expected SAR for the 5G standard."

The authors conclude that, "One must consider the implications of human immersion in the electromagnetic noise, caused by devices working at the very same frequencies as those, to which the sweat duct (as a helical antenna) is most attuned. We are raising a warning flag against the unrestricted use of sub-THz technologies for communication, before the possible consequences for public health are explored."

Is is critical that this research on future technologies in development be considered and commented on with a short summary in the technical reports as the NTP studies were developed to consider advances in wireless communications.

**Please also note these recent studies on health risks of 5G should be included in the review.**

**Feldman, Yuri and Paul Ben-Ishai. "Potential Risks to Human Health Originating from Future Sub-MM Communication Systems." Abstract, 2017.**

> "We are approaching a situation whereby the wavelength of new communication systems will be on par with the typical layer dimensions of human skin and other tissues. This could lead to preferential layer absorption in these same tissues of wireless signals under the 5G designation. Has industry properly considered possible health consequences as a result of the introduction of the 5G standard?"

**N. Betzalel, Y. Feldman, and P. Ben Ishai, "The Modeling of the Absorbance of Sub-THz Radiation by Human Skin," IEEE Trans. THz Sci. Tech. (Paris) 7(5), 521–528 (2017).**
**Abstract:**

> In the near future, applications will come online that require data transmission in ultrahigh rates of 100 Gbit per second and beyond. In fact, the planning for new industry regulations for the exploitation of the sub-THz band are well advanced under the auspices of IEEE 802.15 Terahertz Interest Group. One aspect of this endeavor is to gauge the possible impact on human health by the expected explosion in commercial use of this band. It is, therefore, imperative to estimate the respective specific absorption rates of human tissues. In the interaction of microwave radiation and human beings, the skin is

[71] https://www.sciencedirect.com/science/article/pii/S0013935118300331

traditionally considered as just an absorbing sponge stratum filled with water. This approach is justified when the impinging wavelength is greater than the dimensions of the skin layer. However, in the sub-THz band this condition is violated. In 2008, we demonstrated that the coiled portion of the sweat duct in upper skin layer could be regarded as a helical antenna in the sub-THz band. The full ramifications of what these findings represent in the human condition are still very unclear, but it is obvious that the absorption of electromagnetic energy is governed by the topology for the skin and its organelles, especially the sweat duct.

**Di Ciaula, Towards 5G communication systems: Are there health implications?, Int J Hyg Environ Health. 2018 Feb 2.**

"Preliminary observations showed that MMW increase skin temperature, alter gene expression, promote cellular proliferation and synthesis of proteins linked with oxidative stress, inflammatory and metabolic processes, could generate ocular damages, affect neuro-muscular dynamics."

"Further studies are needed to better and independently explore the health effects of RF-EMF in general and of MMW in particular. However, available findings seem sufficient to demonstrate the existence of biomedical effects, to invoke the precautionary principle, to define exposed subjects as potentially vulnerable and to revise existing limits.

**TRIPATHI et al., Frequency of the resonance of the human sweat duct in a normal mode of operation, BIOMEDICAL OPTICS EXPRESS 130, Vol. 9, No. 3 | 1 March 2018**

Abstract: The applications of terahertz (THz) waves have been increasing rapidly in different fields such as information and communication technology, homeland security and biomedical engineering. However, study on the possible health implications due to various biological effects induced by THz waves is relatively scarce. Previously, it has been reported that the human sweat ducts play a significant role in the interaction of the THz wave with human skin due to its coiled structure. This structure imposes on them the electromagnetic character of a helical antenna. To further understand these phenomena, we investigated the morphological features of human sweat ducts and the dielectric properties of their surrounding medium. Based upon these parameters, we estimated the frequency of the resonance of the human sweat duct in a normal mode of operation and our estimation showed that there is a broad resonance around 228 GHz. This result indicates that careful consideration should be given while designing electronic and photonic devices operating in the sub-terahertz frequency region in order to avoid various effects on human health due to these waves.

## Appendix 2: Studies on DNA damage and Genotoxicity, Prepared by Wilhelm Mosgeller, MD, Professor, University of Vienna Medical School

| Name | Year | Object, Cell | exposure to | Intensity | time | endpoint | result | comment |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Szerencsi et al Hungary | 2013 s | Human leucocytes | EMF of MRI, 3 T | | 0 to 89 min | MN | No effects | |
| Mixakoshi et al Japan | 2012 | 6 rat babies | 50 Hz ELF | 10 mT + BLMycin | | | increase | Oxygen mechanism |
| Vijayalamaxmi USA | 2009 | Review on 87 publication | ELFF | ~ | ~ | chromAb | Significant increase | But small |
| Cho et al Korea | 2007 | Human fibroblasts | 60 Hz ELF , +- BLMycin | 0,8 mT + BLMycin | 28, 88, 240 hrs | MN | Singnificant increase in co-Exposures No effect of EMF alone | Some dose response but not strong correlation |
| Fereiera et al Brazil | 2006 | Pregnant rats, pubs | Mobile phone UHF EMF | ? | ? | MN in Pubs, oxidat changes | MN increase No effect on oxidat in Liver+blood | Unclear mechanism, how pubs are affected |
| Winker et al Austria . | 2005 | Human diploid fibroblasts | ELF- EMF, intermittend exposure 5'ON. 10 OFF | 1 mT | 2-24 hrs | MN chromab | Significant increase of MN and CA | Clastogenic potential |
| Vijayalaxmi Obe USA/ Germany | 2005 | Review on 63 studies S/DSB, CA, MN, SCE, | ELF-EMF | various | ~ | S/DSB, CA, MN, SCE, | 46% neg 22% pos 32 inconclusive | |
| Demesia et al Greece | 2004 | Rat bone marrow Polycromativ erytorcytes . PMC | 910 MHz mobile phone signal | ~ | 2h /day, 30 days | MN in poly | 3-fold increase | |
| Koyama et al. Japan | 2004 | CHO-K1 cells | 2,45 Ghz | 5, 10, 20, 50, 100, 200 W/kg | 2 hrs | MN | No effect below 50 W/kg Significant increase at 100 - 200 W/kg | Discusses heat effect |
| Port et al. Germany | 2003 | HL-60 | ICNIRP Ocupat. level x 25 | | 0, 24, 48, 72 hr | MN, apoptosis, cell morphology. 1176 genes | No effects in all four endpoints | |
| Pasquini et al. Italy | 2003 | Jurkat cells | ELF Benzene | 5 mT | 1 h to 24 hrs | MN | 1 h ? 24 hr = 1,9 x increase | |
| Cho Korea | 2003 | Human lmphocytes | ELF + benoapyrene (BP) | 0.8 mT | 24 hr | MN SCE | No effect of EMF alone Significant increase in coexposure | ELF enhances BP |
| Simko Germany | 2001 | SHE cells | ELF 50 Hz. + benzoapyrene (BP) and TPA | 1 mT | | MN | MF or TPA alone no effect BP + EMF x 1,8 increase | ELF enhances BP |
| Abrammsson | 2001 | In utero | ELF 50 Hz | 14 | | | No effects | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| -Zetterberg Sweden | | Adult Mice Pluripotent stem cells | | microT | | | | |
| Simko, Germany | 1998 | Amnion cells | | | | MN | | |
| SimkO Germany | 1998 | SCL-II, AFC | ELF-EMF | 0,1 - 1,0 mT | 24, 48, 72, hr | MN | SCL-II increase AFC no increase | |
| Lagroye France | 1997 | | ELF-EMF | | | | | |
| Livingston et al (Roti Roti) USA | 1991 | Human lymphocytes CHO-fibroblasts | ELF -60 Hz | | | | | |
| Ruediger/Austri | 2009 | | | | | | | |

## Appendix 3: Comments on trends in brain cancer

The evaluation of brain cancer is complicated by two facts. First of all, examining total trends in this disease in all age groups can obscure the ability to discern trends in specific age groups. Thus, analyses presented to the American Public Health Association found significant annual increases in gliomas from 1992-2009 in persons ages 20-29 and 30-39 that are masked when looking at the overall age-adjusted rates of cancer. Second, because brain cancers consist of more than 200 different tumor types that affect different regions of the brain, when all brain cancers are examined this can also mask important patterns within specific regions of the brain.

**The table below from Incidence Trends in the Anatomic Location of Primary Malignant Brain Tumors in the United States: 1992–2006, 2012, *World neurosurgery journal*,** Zada et al. shows significant annual increases in gliomas of the frontal and temporal lobes and cerebellum in several different surveillance systems in the U.S. These are the same areas of the brain shown to receive the highest levels of radiation from studies carried out as part of the Interphone project (Cardis et al, 2011) showed that while the amount and duration of use are important determinants of RF dose in the brain, their impact can be substantially modified by communication system, frequency band and location in the brain. It is important to take these into account in analyses of risk of brain tumours from RF exposure for cellphones.

**Table 3.** Annual Percent Change of GBM by Brain Region in 3 Major Cancer Registries, 1992–2006

| Brain Region | LAC APC | LAC *P* Value | CCR APC | CCR *P* Value | SEER 12 APC | SEER 12 *P* Value |
|---|---|---|---|---|---|---|
| Frontal | +3.0% | 0.001 | +2.4% | <0.001 | +2.5% | <0.001 |
| Temporal | +2.3% | 0.010 | +1.9% | 0.026 | +1.3% | 0.027 |
| Parietal | -0.5% | NS | +0.1% | NS | +0.3% | NS |
| Occipital | -1.2% | NS | +0.6% | NS | +0.5% | NS |
| Overlapping | -2.1% | 0.006 | -2.8% | 0.015 | -2.0% | 0.013 |
| Ventricle | N/A | N/A | N/A | N/A | -3.8% | NS |
| Cerebellum | N/A | N/A | +11.9% | <0.001 | +1.6% | NS |
| Brainstem | N/A | N/A | N/A | N/A | -2.7% | NS |
| Cerebrum | -5.4% | NS | -1.4% | NS | +0.6% | NS |
| Brain, NOS | +0.2% | NS | -0.0% | NS | -1.7% | NS |
| All sites combined | +0.5% | NS | +0.3% | NS | +0.4% | NS |

APC, annual percent changes; CCR, California Cancer Registry; GBM, glioblastoma multiforme; LAC, Los Angeles County; NOS, not otherwise specified; N/A, not significant; NS, not significant; SEER, National Cancer Institute's Surveillance, Epidemiology, and End Results.

## Appendix 4 Danish Cohort Criticism

This cohort of cellphone "exposed" persons was established based entirely on two Danish telecom operating companies' cellphone subscriptions from 1982 to 1995, and the supposedly unexposed control group was "contaminated" with corporate cellphone

users.[72] The study authors even state, “Because we excluded corporate subscriptions, mobile phone users who do not have a subscription in their own name will have been misclassified as unexposed.”

Furthermore, because over two-thirds of the subscriptions began in 1994 and 1995, the majority of the cohort members had 2 years or less of subscription time. In addition, no information was gathered on how often or for how long each day an individual used a cellphone over the years investigated by the study. The information on cellphone exposure for those in the “exposed” group was merely the starting date of their cellphone subscription and the length of the cellphone subscription. Consequently, individuals who rarely used their cellphone and others who were heavy cellphone users were placed into the same “exposed” group. Scientists have criticized the study’s flawed design from the beginning. After the 2006 update was published, scientists (Anders Ahlbom, Maria Feychting, Elisabeth Cardis and Paul Elliott) wrote a letter[73] to the *Journal of the National Cancer Institute* (JNCI) criticizing the research because a “large proportion of the population started to use mobile phones after the cohort was defined and thus are included in the reference population” and that the “same problem applies also to corporate users, who are not included as subscribers in the study.” They conclude, “All these circumstances would dilute any excess risk, were it to exist, and push the estimate toward the null.”

The 2011 Danish Cohort publication was heavily criticized by Devra Davis, Denis Henshaw, Ron Herberman, Margaret Meade Glaser, Vini Khurana, Dariusz Leszczynski, Philippe Charlier, Allan H. Frey, Lloyd Morgan and Alasdair Philips in several letters to the editor,[74] and all pointed out serious flaws in the design of the study that invalidate the conclusion made by the Danish Study authors. Dariusz Leszczynski, Research Professor at Finland’s Radiation and Nuclear Safety Authority, wrote a 2011 letter to the British Medical Journal outlining the “several design flaws that should prevent the authors from any conclusions concerning the impact of mobile phone use on the development of brain cancer.” Dr. Christopher Portier, former Associate Director of the National Toxicology Program (NTP), commented on the Danish Cohort in his plenary lecture at the BioEM 2015 Conference, pointing out the “Serious problem with exposure misclassification of the Danish Cohort” in his slide presentation.[75]

In light of these shortcomings, in 2011 the World Health Organization International Agency for the Research on Cancer (IARC) minimized the Danish Cohort findings in their evaluation of cellphone radiation cancer risk. The Danish Cohort design flaws were cited as a reason to give less weight to the Danish study in comparison to the Interphone study and Hardell’s efforts.

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[72] http://www.bmj.com/rapid-response/2011/12/03/re-use-mobile-phones-and-risk-brain-tumours-update-danish-cohort-study

[73] https://academic.oup.com/jnci/article/99/8/655/2522426

[74] http://www.bmj.com/content/343/bmj.d6387/rapid-responses

[75] https://betweenrockandhardplace.wordpress.com/2015/06/16/bioem2015-plenary-session-on-precautionary-principle/

IARC's Robert Bann wrote that the Danish cohort exclusion of the corporate subscribers "seems remarkable" and "could have resulted in considerable misclassification in exposure assessment."

The Danish Cohort Cell Phone and Cancer Study cannot be used as proof of no evidence.

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**Appendix 5: Expert Statements on the NTP Report released directly after the 2/2018 Draft release.**

**Anthony Miller, MD** "Study supports his opinion that radiofrequency is a human carcinogen"

> "This animal evidence...conclusively confirms that radiofrequency radiation is a category 1 human carcinogen."

**Devra Davis, PhD, MPH** "The NTP findings confirm that urgent federal action is needed."

> *"The FDA should perform a quantitative risk assessment to determine the levels of risk associated with this widespread exposure."*

**Submission by Professor Emeritus Anthony B. Miller, MD, FRCP, FRCP (C), FACE. Dalla Lana School of Public Health, University of Toronto.**

**Re: NTP TECHNICAL REPORT ON THE TOXICOLOGY AND CARCINOGENESIS STUDIES IN Hsd:SPRAGUE DAWLEY SD RATS EXPOSED TO WHOLE-BODY RADIO FREQUENCY RADIATION AT A FREQUENCY (900 MHz) AND MODULATIONS (GSM AND CDMA) USED BY CELL PHONES**

In the opening paragraph of the Discussion of the report on the NTP study in rats the following appears:
"While epidemiology studies have not definitively established an association between cell phone radio frequency radiation (RFR) exposure and any specific health problems in humans, the results from some studies are suggestive of potential effects (Lönn et al., 2004b; Hardell et al., 2006, 2007b; Hardell and Carlberg, 2009; INTERPHONE 2010, 2011; Benson et al., 2013). Based on available studies, a working group of the International Agency for Research on Cancer (IARC, 2011) classified radiofrequency electromagnetic fields as possibly carcinogenic to humans. Of particular concern were possible associations (limited evidence) with brain glioma and acoustic neuroma (vestibular schwannoma) in the region of the head that is most exposed to RFR when a wireless phone is

used at the ear. However, interpretation of these results is complicated by potential misclassification of exposures and by selection and recall biases. It is also possible that exposures to RFR in the general population, such as those
from cellular communication, have not occurred for a long enough period of time to ascertain an effect due to the apparent long latency period for some types of adult-onset cancers in humans."

In fact, there is now more evidence from further epidemiology studies, especially in France (Coureau et al. 2014), Sweden (Hardell et al. 2013b, Hardell and Carlberg 2015), and from the Interphone study (Grell et al. 2016) that confirms the earlier evidence that prolonged exposure to radiofrequency radiation from cell phones more than doubles the risk of glioblastoma and increases the risks of acoustic neuroma (vestibular schwannoma (Hardell et al. 2013a). Hardell and Carlberg (2015) found that those who began using cell phones and/or cordless phones regularly as children had between 4- 8-fold increased risk of glioma as adults. In addition, a re-analysis of the Canadian component of the international Interphone study has shown that "potential misclassification of exposures and by selection and recall biases" does not explain the associations previously found in the Interphone study (Momoli et al., 2017).

Brain cancers have now become the number one cancer in children and young adults (Gittleman et al. 2015). It is more than probable that we are on the verge of a major increase in glioblastomas and vestibular schwannomas in humans the world over. We need to take urgent action to reduce exposure to radiofrequency radiation to as low as reasonably achievable, as we learnt to do many years ago for ionizing radiation.

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