



Given the recent advancements in the technology of cellular telephones (i.e. smart phones), they are now used in a capacity beyond that of a basic telephone. For many, cellular telephones are used as a bedside alarm clock and personal organizer. Cellular telephone usage can reach 24 hours/day, leaving users increasingly exposed to the potentially harmful effects of radiofrequency radiation exposure. Our findings indicated significant electrophysiological and behavioral changes in mice exposed *in-utero* to radiation. The significant trend between the groups treated for 0, 9, 15, and 24 hours/day demonstrates that the effects are directly proportional to usage time, and suggests that safety limits, particularly for pregnant women, can be established. Though it is difficult to translate these findings to human risks and vulnerability, we identify a novel potential contribution to the increased prevalence in hyperactive children, one that is easily prevented. However, it is important to note that hyperactivity and anxiety are closely related and my confound one another.

In this study we used cellular telephones as a source of EMR to mimic human exposure. However there are several limitations to this study that include lack of a defined exposure from a traditional EMF generator. Further we did not measure the level of exposure and the distance to the source was not fixed; mice were free to move within the confines of the cage. Power density measurements with respect to orientation, polarization, reflection, and interference were not considered. In order to determine the maximal effects and potential risks associated with exposure, the mice were exposed from conception to birth, however mouse brain development is incomplete at birth and distinct from that of humans. While neurological effects were found here, future studies should focus on a more narrow gestational age of exposure, use EMF generators to more precisely define exposure, and limit variation in the distance from the source. Definitive studies in humans are required prior to extrapolating these behavioral findings to humans.

In summary, we demonstrate that fetal radiofrequency radiation exposure led to neurobehavioral disorders in mice. We anticipate these findings will improve our understanding of the etiology of neurobehavioral disorders. The rise in behavioral disorders in developed countries may be, at least in part, due to a contribution from fetal cellular telephone radiation exposure. Further testing is warranted in humans and non-human primates to determine if the risks are similar and to establish safe exposure limits during pregnancy.

Methods

Exposure and Behavioral Tests. Over five separate experiments, a total of 27 breeding cages were set-up each containing 3 CD-1 female mice and 1 CD-1 male mouse (13 experimental cages and 14 control cages). Each experimental cage was equipped with a muted and silenced 800–1900 Mhz cellular phone with a SAR of 1.6 W/kg placed over the feeding bottle area at a distance of 4.5–22.3 cm from the mice. The cellular phones were then placed on an active call for 24 hours per day and the 33 experimental female mice were exposed throughout gestation (days 1–17). An additional six females were exposed to an active phone for either 9 or 15 hours per day. Each control cage was equipped with a deactivated phone and was kept under the same conditions. To assure equal exposure time independent of the variable length of gestation (18–20 days), at the end of day 17 all phones were removed. On day 18 all female mice were separated and placed in their own cage yielding a total of 39 exposed pregnant females and 42 unexposed pregnant females. Throughout the experiment, both the control and experimental mice were fed and given water *ad libitum*. The mice were maintained on a 12 hour light/dark cycle (07:00 on) and all procedures were approved by the Yale University Animal Care and Use Committee.

Memory was evaluated using a standard object recognition memory test. A total of 161 pups were tested (82 experimental mice and 79 control mice) at 8, 12, and 16 weeks. The test consisted of two learning days (Day 1 and 2) and one test day (Day 3). On Day 1 four opaque exploration chambers were set-up in the exam room at a luminosity of 420–440 Lux. Prior to conducting each test, the mice were placed in the testing room and allowed 1 hour to acclimate to the light. Two identical objects were then placed in each of the four chambers and a single mouse was placed in each chamber to explore the two identical objects for 15 minutes. Before repeating the experiment, the objects and the chambers were cleaned thoroughly with a detergent solution to remove any scents or odors. On Day 3 a video camera was placed over all 4 chambers and the objects were rearranged so that each chamber had one familiar object and one novel object. The mice were then allowed to explore both objects and were filmed for 5 minutes. Upon completing the experiment, 3 observers, blinded to

the treatment regimen, viewed the first 2 minutes of footage to determine the time spent exploring the novel object. Exploration of the new object was defined as sniffing at less than 1 cm. A preference index was then calculated by dividing the time spent exploring the new object by the total exploration time multiplied by one hundred. The percent time spent idle - not exploring either of the objects was also calculated in order to ensure that our findings are in fact due to memory deficits and not distractibility or hyperactivity.

The light-dark box test was conducted using a light-dark box, constructed of black and white Plexiglass (45×27×27 cm). The dark compartment (18×27 cm) was made of black Plexiglass with a black Plexiglass cover and the light compartment (27×27 cm) was made of white Plexiglass and remained open. The light compartment was kept at a luminosity of 420–440 Lux. An opening (7.5×7.5 cm) was located in the wall between the two chambers allowing free access between the light and dark compartments. A video camera was then placed over the box for filming. Prior to conducting each test, the mice were placed in the testing room and allowed 1 hour to acclimate to the light. A single mouse was then placed in the light chamber and was allowed to explore the box for 5 minutes while being filmed. Before repeating the experiment, the chambers were cleaned thoroughly with a detergent solution to remove any scents or odors. Three observers, blinded to the treatment regimen, then viewed the footage and recorded the total time spent in the dark as well as the total number of transitions. This data was then interpreted as described in the text to analyze anxiety and hyperactivity.

The Step Down Assay was performed to determine fearful behavior by placing a mouse gently on a platform (96 well plate) and recording the time on the platform. The timer was stopped once the mouse stepped off the platform with all four paws. Before repeating the experiment, the platform was cleaned thoroughly with a detergent solution to remove any scents or odors.

Corticosterone Measurement. Gestational stress was analyzed by collecting serum on Day 12 of gestation from 6 exposed and 6 unexposed pregnant females. Serum samples were tested for corticosterone levels using an enzyme immunoassay kit (Assay Designs, Ann Arbor, MI) as recommended by the manufacturer.

Electrophysiology. Mice from control and cell phone-exposed groups were anesthetized with ether and then decapitated. The brains were rapidly removed and immersed in an oxygenated cutting solution at 4°C containing (in mM): sucrose 220, KCl 2.5, CaCl₂ 1, MgCl₂ 6, NaH₂PO₄ 1.25, NaHCO₃ 26, and glucose 10, and adjusted to pH 7.3 with NaOH. Coronal cortical slices (300 μm thick) were prepared from the prefrontal area of the brain and the ventral medial hypothalamus (VMH) using a vibratome. After preparation, slices were maintained in a holding chamber with artificial cerebrospinal fluid (ACSF) (bubbled with 5% CO₂ and 95% O₂) containing (in mM): NaCl 124, KCl 3, CaCl₂ 2, MgCl₂ 2, NaH₂PO₄ 1.23, NaHCO₃ 26, glucose 10, pH 7.4 with NaOH, and were transferred to a recording chamber constantly perfused with bath solution (33°C) at 2 ml/min after at least a 1 hr recovery.

Whole-cell voltage clamp (at −60 mV) was performed to observe miniature excitatory postsynaptic currents (mEPSCs) in layer V cortical neurons with a Multiclamp 700 A amplifier (Molecular devices, CA). The patch pipettes (tip resistance = 4–6 MΩ) were made of borosilicate glass (World Precision Instruments) with a pipette puller (Sutter P-97) and back filled with a pipette solution containing (in mM): K-gluconate 135, MgCl₂ 2, HEPES 10, EGTA 1.1, Mg-ATP 2, Na₂-phosphocreatine 10, and Na₂-GTP 0.3, pH 7.3 with KOH. mEPSCs were recorded in pyramidal neurons under voltage clamp (at −60 mV) in the presence of tetrodotoxin (TTX, 0.5 μM), and a GABA-A receptor antagonist picrotoxin (50 μM). Both input resistance and series resistance were monitored constantly during experiments. The series resistance (between 20 and 40 MΩ) was partially compensated by the amplifier and only recordings with stable series and input resistance throughout experiments were accepted. All data were sampled at 3–10 kHz and filtered at 1–3 kHz with an Apple Macintosh computer using Axograph X (AxoGraph Scientific). mEPSC events were detected and analyzed with AxoGraph X and plotted with Igor Pro software (WaveMetrics, Lake Oswego, OR) as described previously by Rao, et al (2007). Linear correlation was performed with the software GB-STAT (Dynamic Microsystems, Inc, Silver Spring, MD).

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Author contributions

TSA treated the mice, performed the behavioral studies, analyzed the data and wrote the manuscript. GG and XBG performed and analyzed the electrophysiology studies. HST designed the experiment, analyzed the data and edited the manuscript.

Additional information

Competing financial interests: The authors declare no competing financial interests.

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Fetal Exposures and Cell Phones

Hugh S. Taylor MD

RESEARCH

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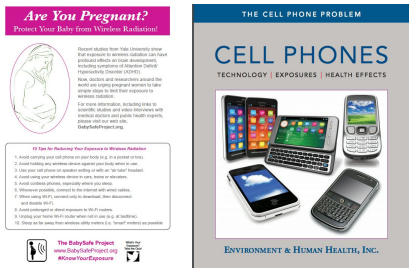
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Cell Phones: Technology, Exposures, Health Effects by Environment and Human Health, Inc.

Prenatal and Children; Fetal Cell Phone Exposure: How Experimental Studies
Guide Clinical Practice, Hugh S. Taylor MD. PhD, Chair of Obstetrics,
Gynecology and Reproductive Sciences, Yale School of Medicine

Fetal Cell Phone Exposure: How Experimental Studies Guide Clinical Practice

Hugh S. Taylor, M.D.

Chair of Obstetrics, Gynecology and
Reproductive Sciences

Yale School of Medicine

Cell Phones

- Use of cell phones has grown dramatically over the last twenty years.
- Operate at frequencies slightly higher than TV and FM Radio signals (Nonionizing).
- Analog and digital phones operate in the frequency range of 900 - 1800 MHz.
- The maximum powers of these phones are 2W and 1W (900 and 1800 MHz respectively). Average power are $1/8$ of maximum.

S.A.R.

Specific Energy Absorption Rate
watts per kilogram

- Electromagnetic waves interacting with matter can be
 - Reflected
 - Absorbed
 - Transmitted
- Exactly what happens depends on
 - the **frequency of the electric field**
 - the **natural frequencies** of the atoms and molecules
- Microwaves emitted by mobile phone systems
 - Are absorbed by human tissue

Specific energy Absorption Rate (SAR)

watts per kilogram

- Measures energy absorbed per kilogram per second.
- SAR is a property of
 - an emitting device
 - in a particular position with respect to
 - an absorbing substance

Mobile phones communicate with base stations

- Macrocells - up to about 22 miles. Power output in tens of watts.
- Microcells - infill, airports, railway stations. Range of few hundred yards.
- Picocells - Sited inside buildings. Low power.

Thermal Effects

- Force produced by an electric field on charged objects (ions in the body) causes them to move, results in electric currents. Currents flowing through resistance of the material results in heating. Heat input causes increased blood flow for heat dissipation (equilibrium).
- Increase in brain temp by cell phones is estimated to be 0.1 C (to equilibrium).

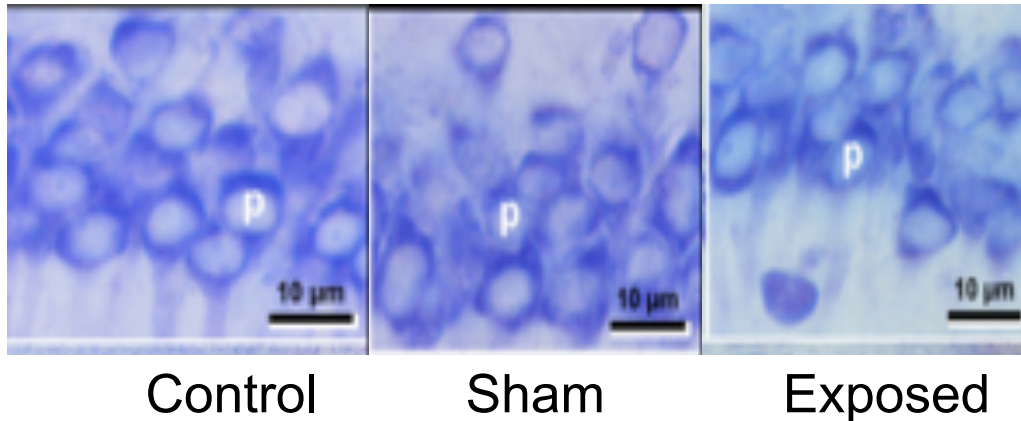
Plausible Biological Effects of Cell Phone EM Radiation

- Could fields induce cell polarization?
- Alter membrane potential?
- Could fields affect movement of ions through cell membrane channels?
- Does it increase free radical production?
- Do fields effect gene expression?
- Others?
- If any of these effects are real, do they result in an adverse health outcome?

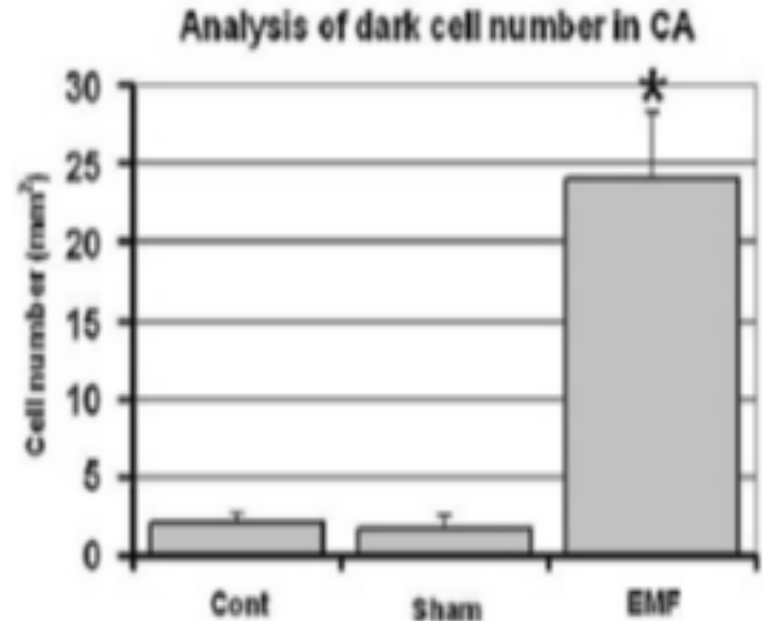
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900 MHz electromagnetic field exposure affects hippocampal pyramidal cells in adult female rats

1h/day x 28 days; 16 wk females



Postnatal EMF exposure caused a significant decrease of pyramidal cells in the Cornu ammonis of the EMF group.

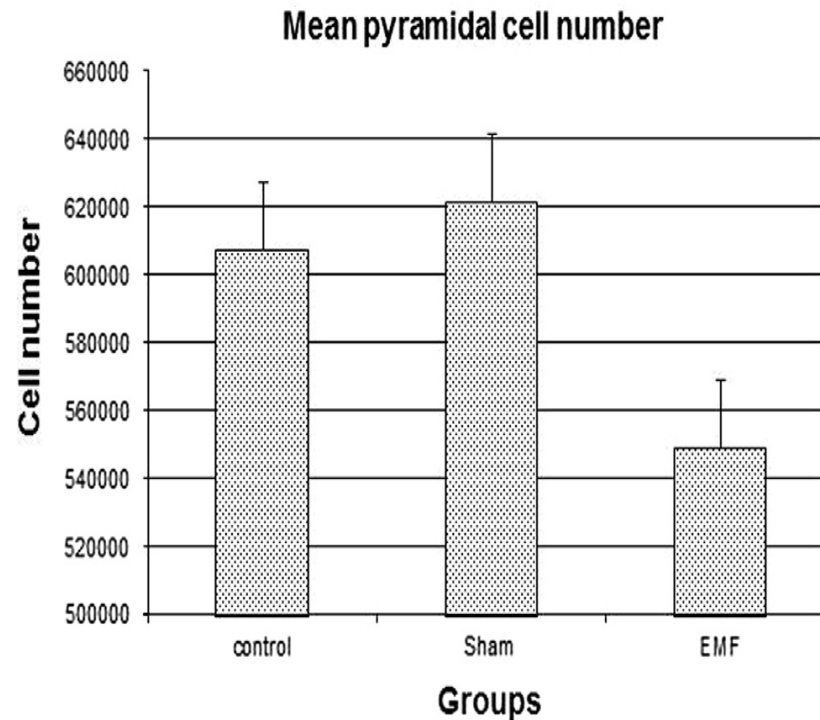
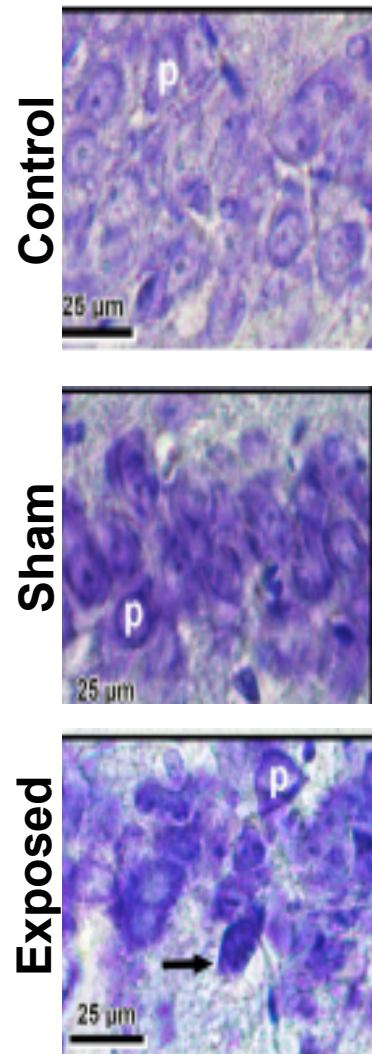


Significantly more dark cells compared with both the control and sham Mean±SEM *p < 0.01.

900 MHz electromagnetic field exposure affects hippocampal pyramidal cells in prepubescent male rats

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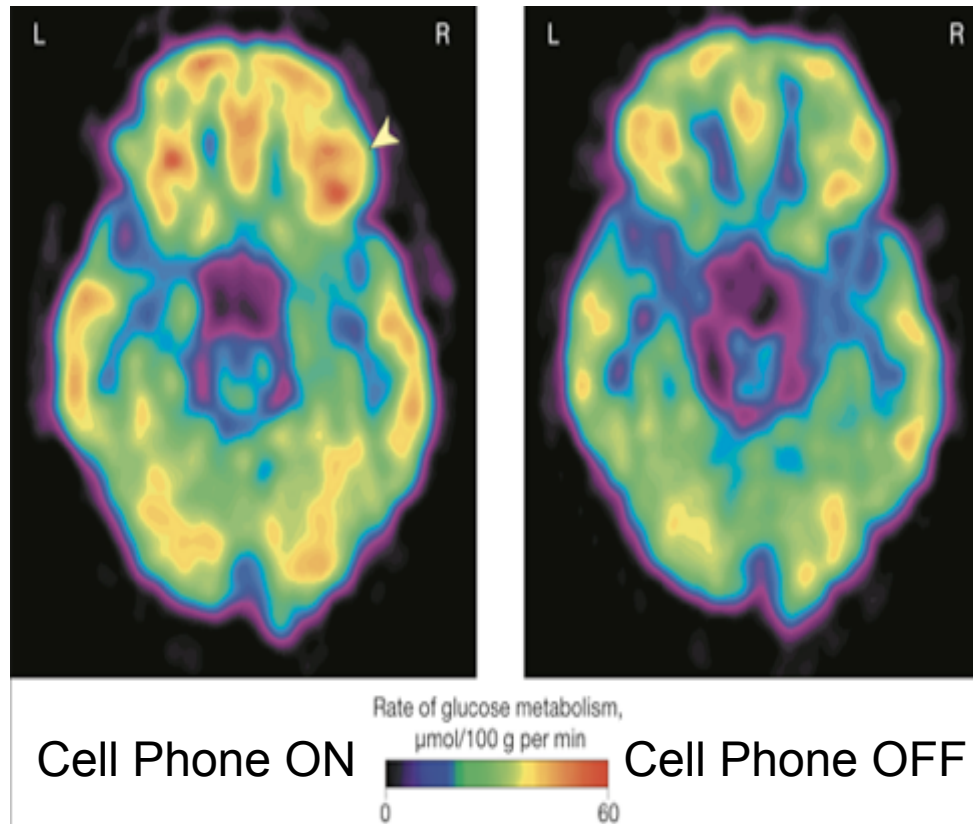
Exposure: 1h/day x 30 days; 8 wk males



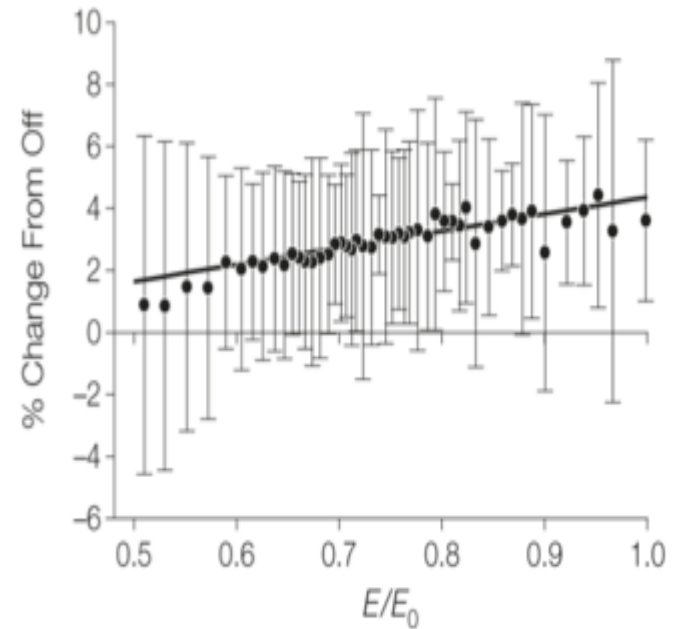
Lower mean number of pyramidal neurons in exposed group than in the control and sham.

50 minutes with a cell phone turned on against the ear significantly alters cerebral glucose metabolism

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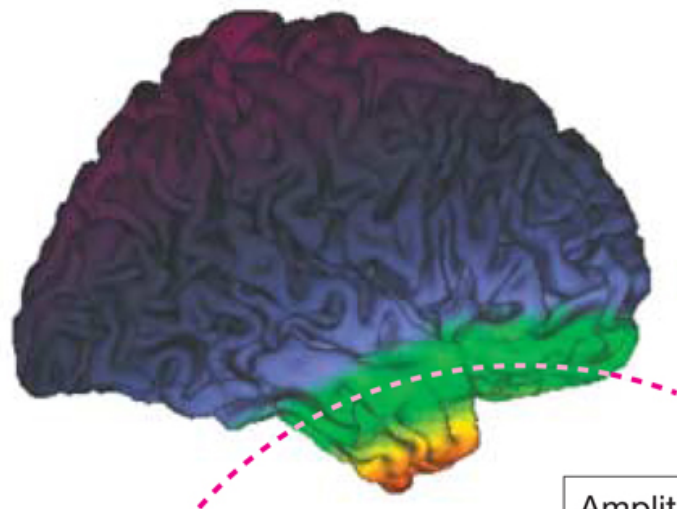
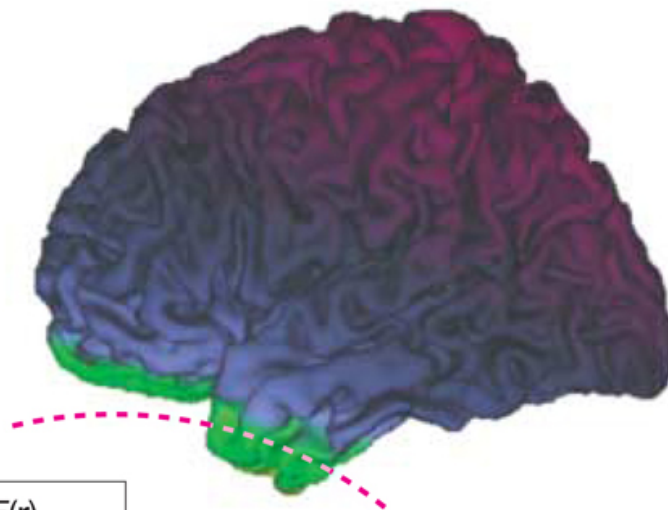


Normalized glucose metabolism higher, at higher brain tissue doses

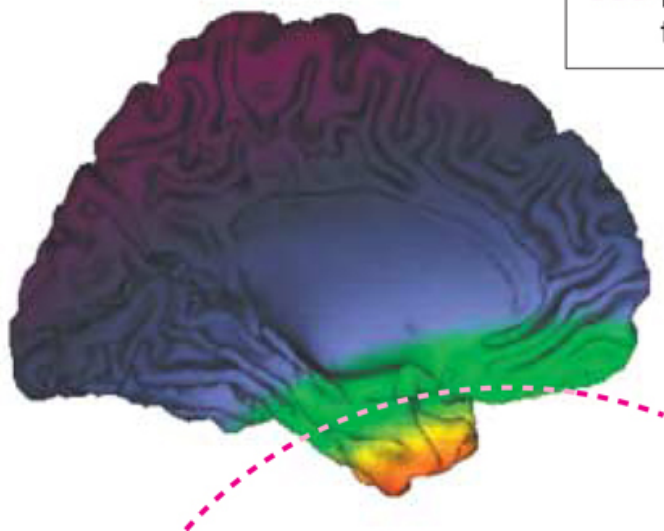


Volkow et al, JAMA, 2011, 305 (8): 808-813.

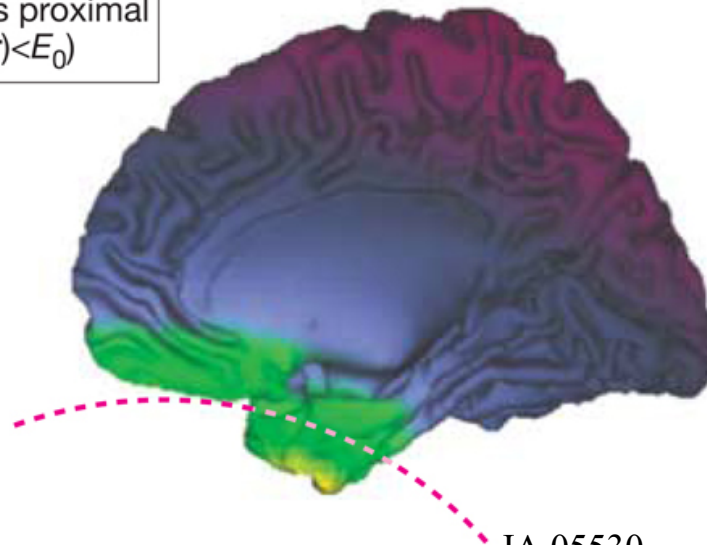
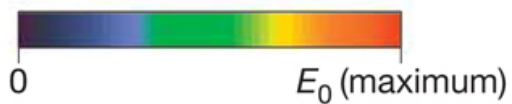
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RIGHT HEMISPHERE
Lateral viewLEFT HEMISPHERE
Lateral view

Medial view



Medial view

Amplitude of electric field, $E(r)$ --- Boundary of clusters proximal
to antenna ($E_0/2 < E(r) < E_0$)

Cell Phone Use During Pregnancy May be Harmful to the Fetus



Fewer, abnormal hippocampal granular cells in the dentate gyrus (DG) of newborn rats following prenatal 900 MHz EMF exposure

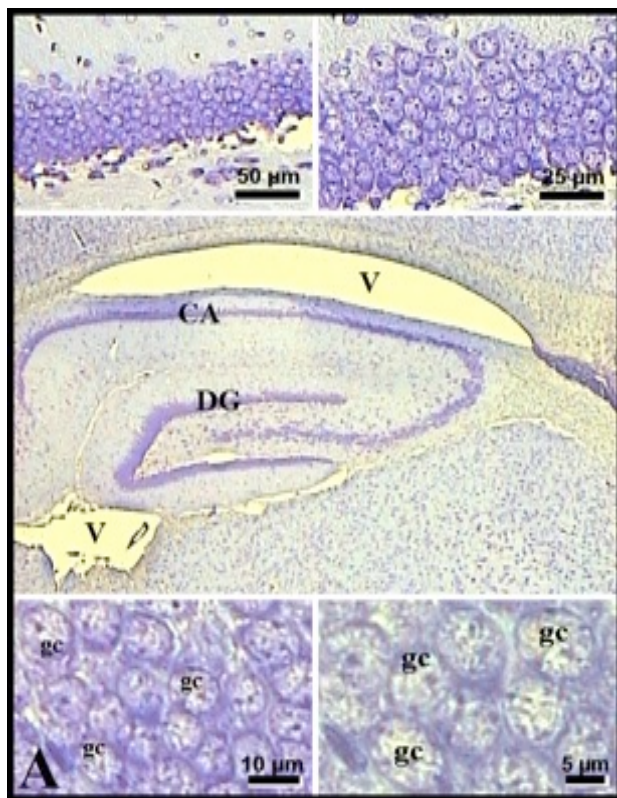
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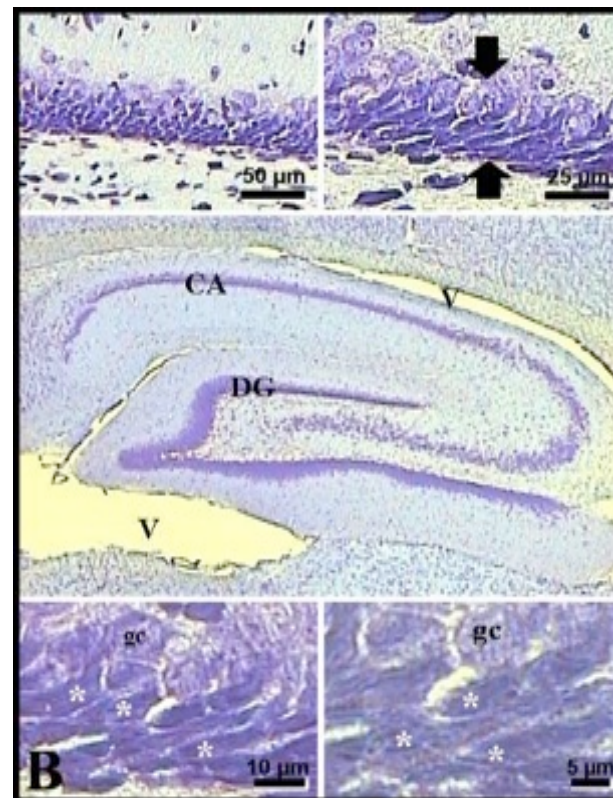
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Control



Exposed



Representative photomicrographs and magnifications of the medial region of DG. Control group granular cells normal; most in the EMF group abnormal, condensed. (arrows - dark-blue cells interspersed among normal nerve cells).

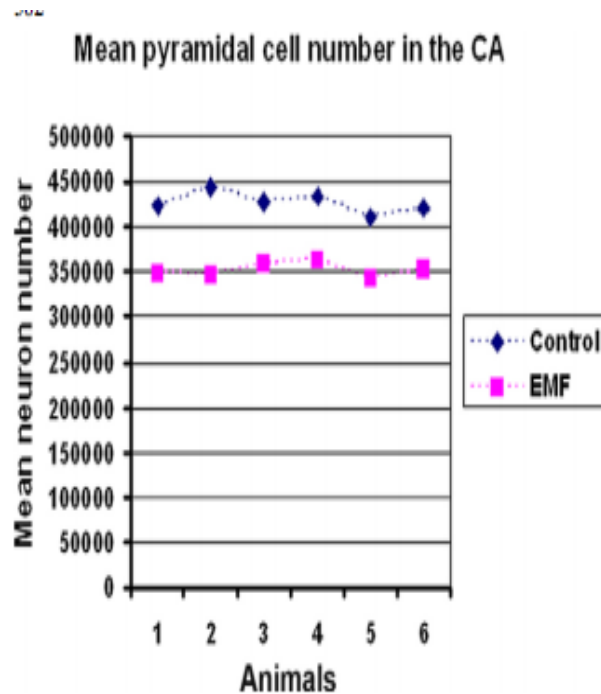
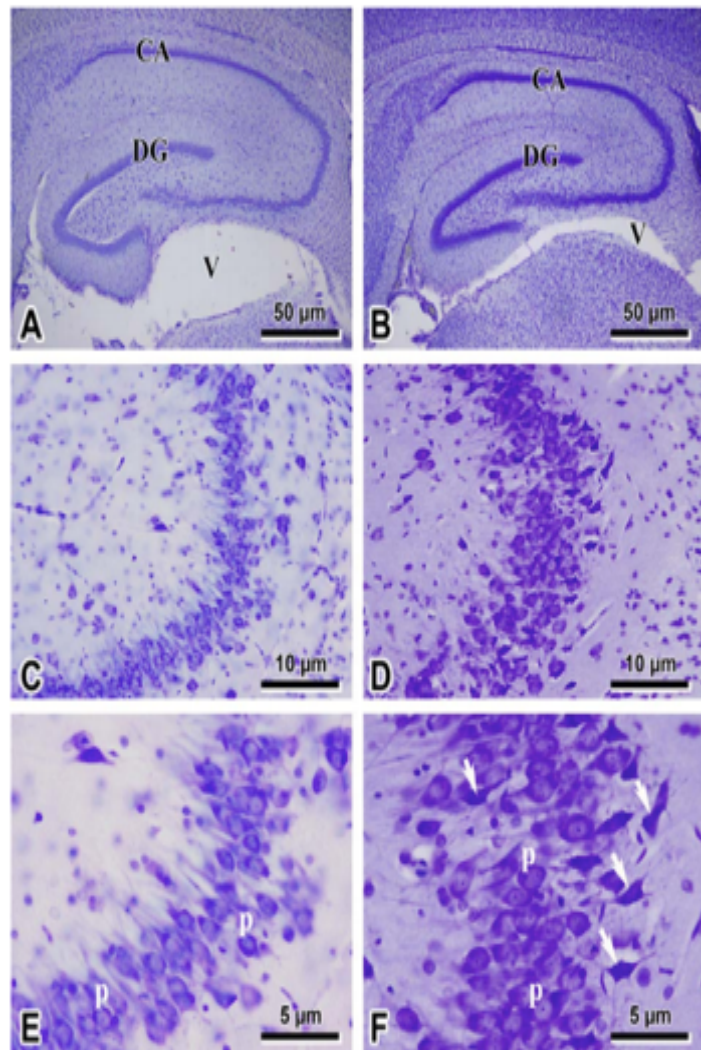
Fewer pyramidal cells in rat pups' hippocampus with 900 MHz RF prenatal exposure (1h daily x 19 days)

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Control

Exposed

Hippocampus sections: More cells are abnormal, with shrunken morphology following prenatal EMF exposure.



Significantly fewer pyramidal cells in the cornu ammonis with EMF exposure.

Prenatal and Postnatal Exposure to Cell Phone Use and Behavioral Problems in Children

- Mothers were recruited to the Danish National Birth Cohort early in pregnancy.
- When the children of those pregnancies reached 7 years of age in 2005 and 2006, mothers were asked to complete a questionnaire regarding the current health and behavioral status of children, as well as past exposure to cell phone use.
- Mothers evaluated the child's behavior problems using the Strength and Difficulties Questionnaire.
- N=13,159

TABLE 2. Association of Prenatal and Postnatal Exposure to Cell Phone Use With Overall Behavioral Problems Score

	Postnatal Exposure				Prenatal Exposure ^a	
	No		Yes		Unadjusted OR	Adjusted OR (95% CI) ^b
	Unadjusted OR	Adjusted OR (95% CI) ^b	Unadjusted OR	Adjusted OR (95% CI) ^b		
Prenatal exposure						
No	1.0 ^c	1.0 ^c	1.25	1.18 (0.96–1.45)	1.0 ^c	1.0 ^c
Yes	1.77	1.58 (1.29–1.93)	2.16	1.80 (1.45–2.23)	1.74	1.54 (1.32–1.81)
Postnatal exposure ^d	1.0 ^c	1.0 ^c	1.26	1.18 (1.01–1.38)		

n = 12,068 with information about prenatal and postnatal exposure; n = 12,112 with information about prenatal exposure; n = 13,054 with information about postnatal exposure.

^aOR for prenatal exposure adjusted for postnatal exposure.

^bAdjusted for sex of child, age of mother, smoking during pregnancy, mother's psychiatric problems, and socio-occupational levels.

^cReference category.

^dOR for postnatal exposure adjusted for prenatal exposure.

EPIDEMIOLOGY

TABLE 3. Associations of Specific Behavioral Problems in Children With Prenatal and Postnatal Exposure to Cell Phone Use

	Prenatal Exposure Only		Postnatal Exposure Only		Both Prenatal and Postnatal Exposure	
	Unadjusted OR	Adjusted OR (95% CI) ^a	Unadjusted OR	Adjusted OR (95% CI) ^a	Unadjusted OR	Adjusted OR (95% CI) ^a
Behavioral problems						
Emotional	1.23	1.12 (0.97–1.30)	1.13	1.06 (0.92–1.23)	1.50	1.25 (1.07–1.47)
Hyperactivity	1.39	1.29 (1.08–1.53)	1.00	0.98 (0.82–1.17)	1.52	1.35 (1.12–1.63)
Conduct problems	1.29	1.21 (1.05–1.40)	1.06	1.02 (0.89–1.18)	1.69	1.49 (1.28–1.74)
Peer problems	1.36	1.27 (1.06–1.52)	1.11	1.08 (0.90–1.29)	1.51	1.34 (1.11–1.63)
Reference category is no prenatal or postnatal exposure to cell phone use.						
^a Adjusted for sex of child, age of mother, smoking during pregnancy, mother's psychiatric problems, and socio-occupational levels.						

TABLE 5. Association of Characteristics of Mother's Cell Phone Use During Pregnancy With Overall Behavioral Problems Score in Children With Prenatal Exposure (n = 3322)

	No. (%)	Unadjusted OR	Adjusted OR (95% CI) ^a	Adjusted OR (95% CI) ^{a,b}
Times spoken per day				
0–1	1873 (56.4)	1.00 ^c	1.00 ^c	1.00 ^c
2–3	777 (23.4)	1.49	1.33 (0.99–1.79)	1.31 (0.97–1.77)
4+	347 (10.4)	1.60	1.51 (1.02–2.22)	1.47 (1.00–2.18)
Missing	325 (9.8)	—	—	—
<i>P</i> for trend	—	0.28	0.61	0.62
Percentage of time turned on				
0	397 (12.0)	1.00 ^c	1.00 ^c	1.00 ^c
<50	500 (15.1)	0.70	0.62 (0.35–1.11)	0.62 (0.35–1.10)
50–99	954 (28.7)	1.20	0.93 (0.58–1.48)	0.91 (0.57–1.45)
100	1427 (43.0)	1.43	1.09 (0.70–1.70)	1.06 (0.68–1.65)
Missing	44 (1.2)	—	—	—
<i>P</i> for trend	—	0.15	0.13	0.13

^aEstimates adjusted for sex of child, age of mother, smoking during pregnancy, mother's psychiatric problems, and socio-occupational levels.^bAlso adjusted for postnatal exposure to cell phones.^cReference category.

EPIDEMIOLOGY

Conclusions

- Exposure to cell phones 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.

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Cell phone use and behavioural problems in young children.

- To see if a larger, separate group of DNBC children would produce similar results after considering additional confounders, children of mothers who might better represent current users of cell phones were analyzed. This 'new' dataset consisted of **28,745** children with completed Age-7 Questionnaires to December 2008.
- The highest OR for behavioral problems were for children who had both prenatal and postnatal exposure to cell phones compared with children not exposed during either time period.
- The adjusted effect estimate was **1.5 (95% CI 1.4 to 1.7)**.

Controlled study of Fetal Radiofrequency Radiation Exposure From Cellular Telephones and Behavior in Adult Mice

Fetal Radiofrequency Radiation Exposure From 800-1900 Mhz- Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice

Aldad et al, Scientific Reports. 2012; 2: 312.

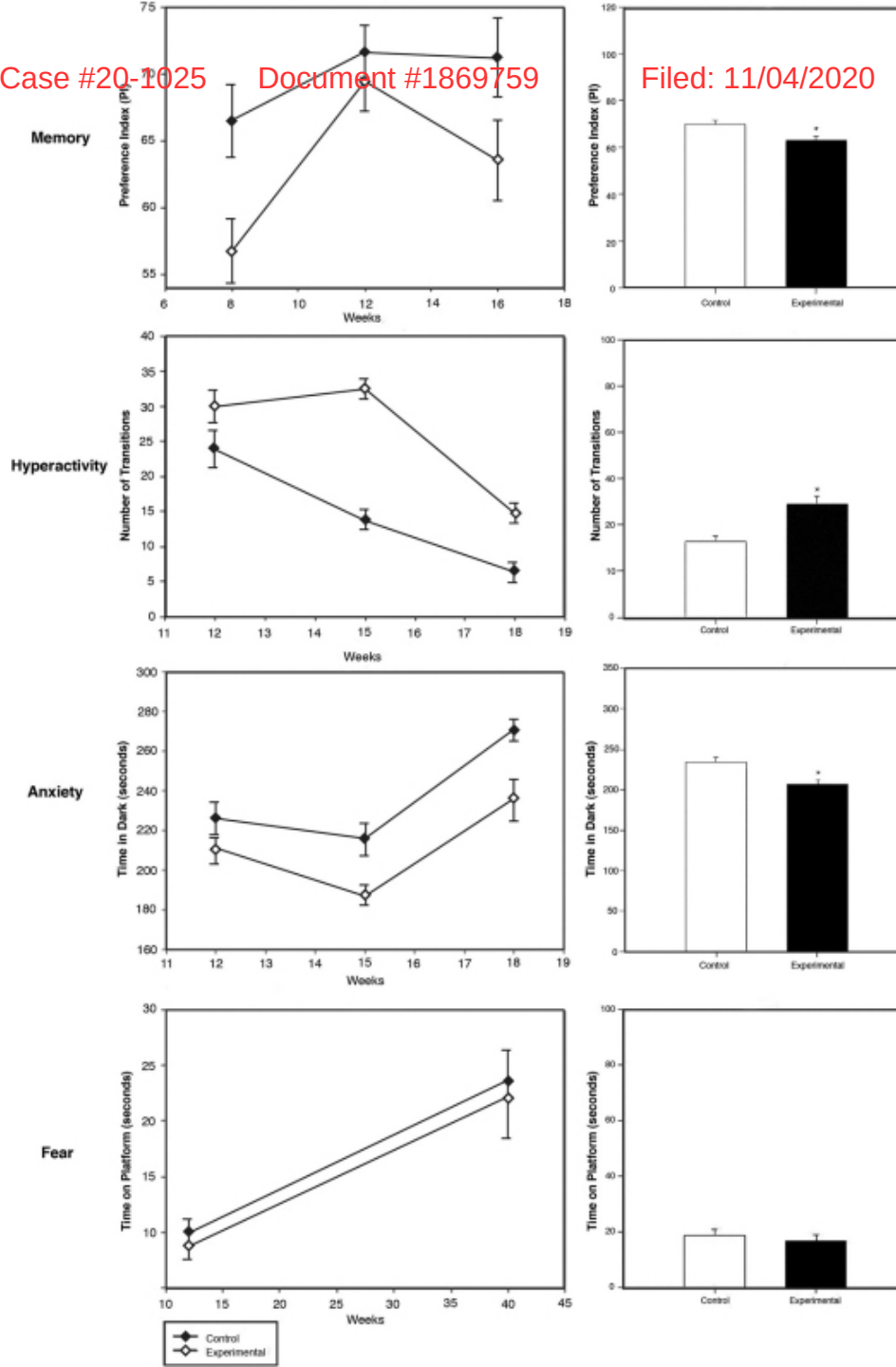
JA 05541

Fetal Brain Programming

42 pregnant controls



- A muted and silenced 800–1900Mhz cellular phones with a SAR of 1.6W/kg was used.
- The phones were positioned above each cage over the feeding bottle area at a distance of 4.5–22.3cm from each pregnant mouse.
- Mice exposed as a fetus were tested as adults.

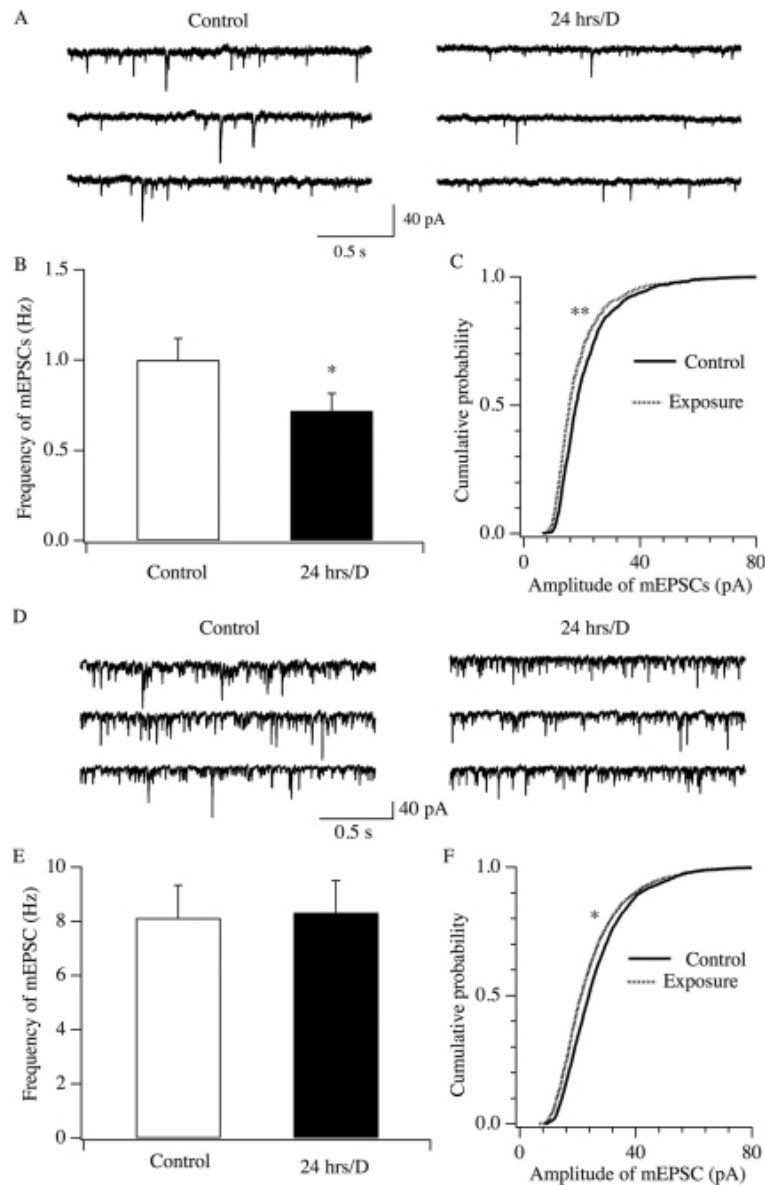


Definition

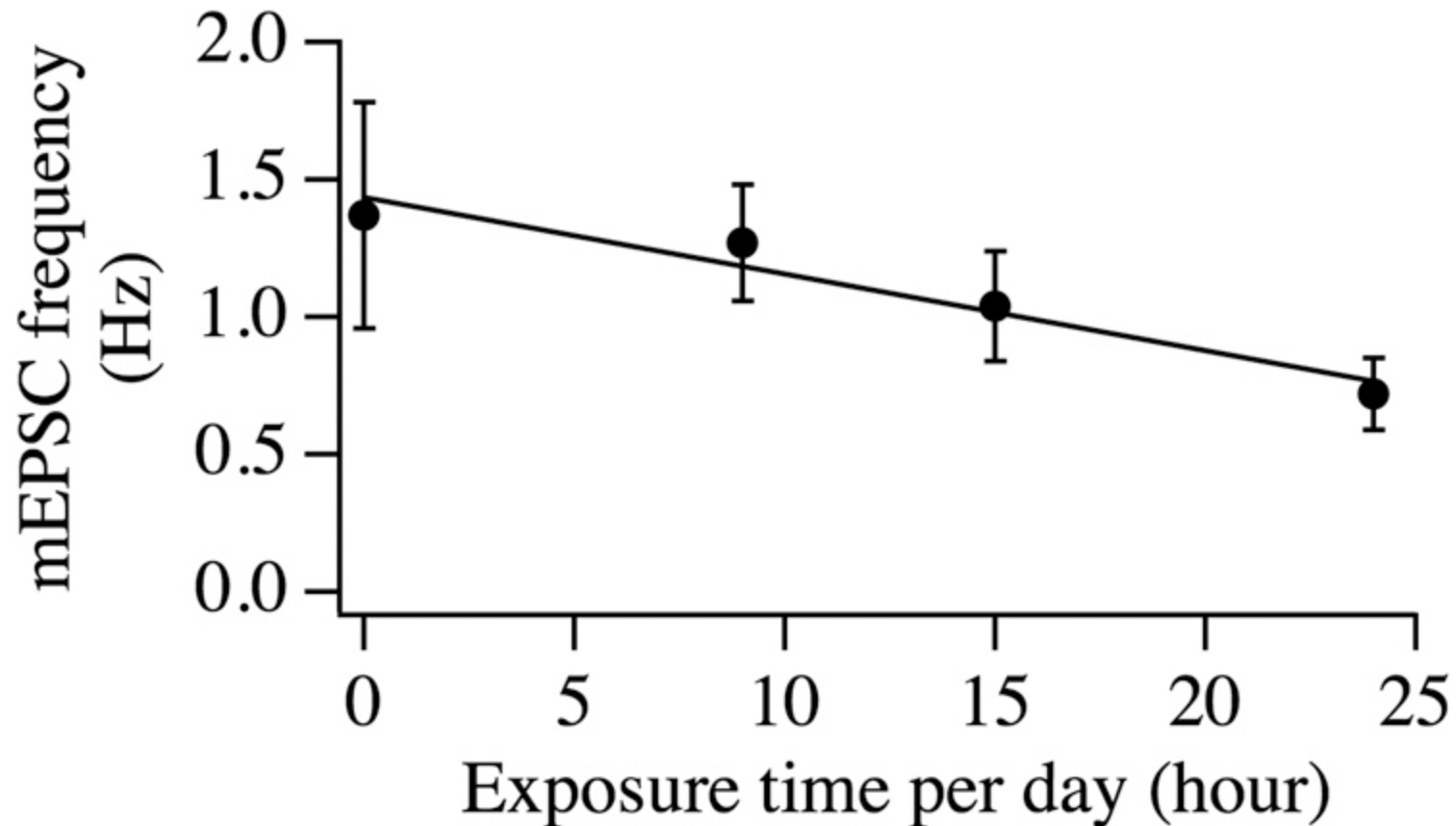
- Attention Deficit Hyperactivity Disorder (ADHD), sometimes called Attention Deficit Disorder (ADD), involves hyperactivity, difficulty paying attention and a tendency to act impulsively.



Altered Synaptic Efficiency



Diminished Effect with Decreased Exposure



No brain tumors

No effect of post-natal exposure

And its not just mobile phones!

- 'WiFi' Wireless Networking
- Bluetooth devices
- Wireless keyboards and mice
- DECT cordless phones
- Baby Monitors
- 'Walkie Talkie'



- All involve electromagnetic waves in the radio and microwave part of the spectrum

Mobile Phones :

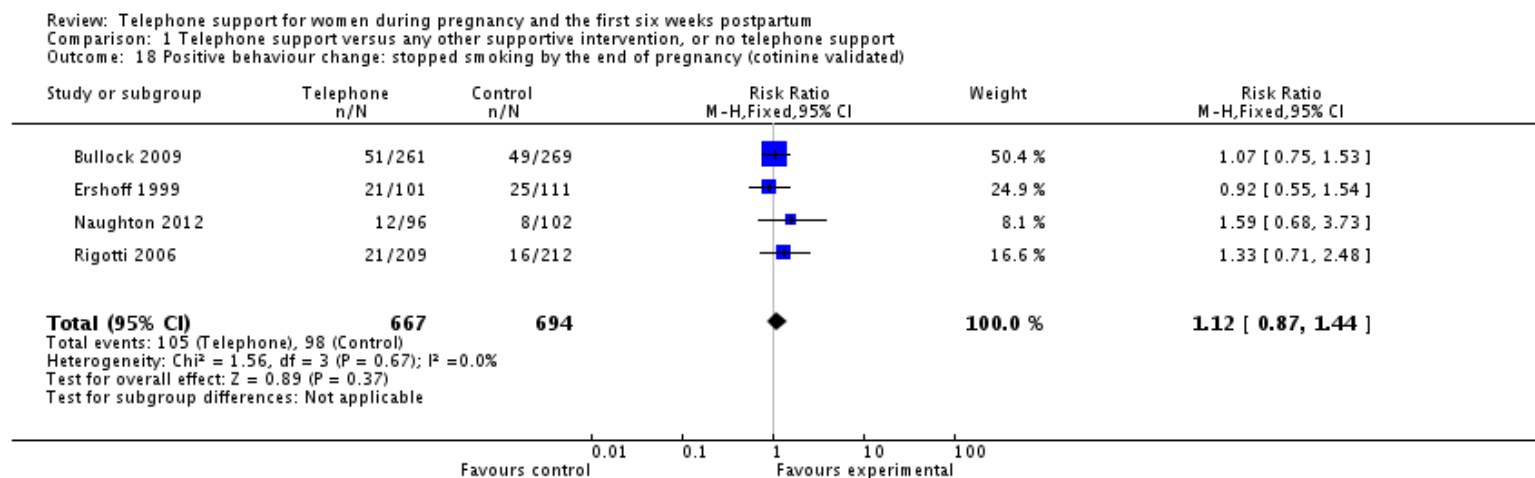
Comparison of handsets and base stations

	Power Watts	Intensity Watts per square metre	Maximum SAR Watts per kilogram
Handset	1	200	About 1
Base Station	60	0.01	About 0.001
Wi Fi	0.1	< 0.01	About 0.0001

Effectiveness of mHealth [cell phone] interventions for maternal, newborn and child health in low- and middle-income countries.

Lee et al, J Glob Health. 2016;6(1):010401.

Telephone support for women during pregnancy and the first six weeks postpartum



Broader Issue:

- What role do the fetal environmental exposures play in the health of the next generation?

Prenatal & Children; Dr. Suleyman Kaplan Comments, Sep. 2, 2013

August 15, 2013

Comment Filed by:

Professor Dr. Suleyman Kaplan,
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Kurupelit, Ondokuz Mayıs Universitesi,
55139 Samsun, Turkey

ET Docket Nos. 03–137 and 13–84; FCC 13–39

Background:

I am currently Editor of the Journal of Experimental and Clinical Medicine, President of the Turkish Society for Stereology, Director of Health Sciences Institute and Head of the Department of Histology and Embryology at Ondokuz Mayıs University, Samsun, Turkey.

I have conducted research in Neurology for over twenty years. I received my M.Sc. in 1987 and my PhD in 1991 from the Dept. of Histology and Embryology, Medical School, Ondokuz Mayıs University, Samsun, Turkey. The title of my PhD thesis was “Neuronal asymmetry in the hippocampus of 4 and 20 weeks old male and female rats.” I have been a Professor since 2000 at the Dept. of Histology and Embryology, Medical School, Ondokuz Mayıs University, Samsun, Turkey. My research and professional experience focuses on Stereology, Obesity, Neurotoxicity, Peripheral nerve regeneration, and Electromagnetic fields (EMF).

I have helped produce four research reports showing that exposure to 900MHz EMF significantly damaged neuronal development in the rat brain. These published studies include:

- Chronic prenatal exposure to the 900 megahertz electrical field induces pyramidal cell loss in the hippocampus of newborn rats (Bas et al., 2009)
- Effects of prenatal exposure to a 900 MHz electromagnetic field on the dentate gyrus of rats: a stereological and histopathological study (Odaci, et al., 2008)
- Purkinje cell number decreases in the adult female rat cerebellum following exposure to 900 MHz electromagnetic field (Sonmez et al., 2010)
- 900 MHz electromagnetic field exposure affects qualitative and quantitative features of hippocampal pyramidal cells in the adult female rat (Bas, et al., 2009).

Summary of Related Research

Effects of prenatal exposure to a 900 MHz electromagnetic field on the dentate gyrus of rats: a stereological and histopathological study. Prenatal exposure to 900MHz EMF fields affect nerve cell development in the rat brain. The research report

details how prenatal 900 MHz exposure caused a statistically significant decrease in the number of granule cells in the dentate gyrus of rat offspring. These neurons are an important source of inputs to the hippocampus. The hippocampus is a part of the brain that controls behavior and cognitive functions such as spatial learning and working memory. For this study we used state of the art high precision design based stereological techniques to investigate the impact of 900 MHz exposure on pregnant rat offspring.

We found that exposure caused a progressive postnatal decline in the number of granule cells of dentate gyrus. This suggests that exposure during critical periods of embryonic development damages the normal rat hippocampus development and exposure may also induce neurodevelopment retardation. While animal studies cannot be directly translated to humans, this research would correspond to the third trimester in a human pregnancy. This research showed neural cell loss in the dentate gyrus due to prenatal electromagnetic exposures.

Chronic prenatal exposure to the 900-megahertz electrical field induces pyramidal cell loss in the hippocampus of newborn rats.

Prenatal exposure to 900 MHz decreases pyramidal cells in the hippocampus. This research report details how pregnant rats were exposed to 60 minutes of 900 MHz EMF fields a day for the duration of their pregnancies and later the brains of their offspring were analyzed at four weeks old using the optical fractionator technique. The exposed offspring showed a significant reduction in the total number of pyramidal cells.

The pyramidal cells are located in the cornu ammonis of the hippocampus, which involves short-term memory and learning. This research suggests that electromagnetic fields could disturb the development of the cornu ammonis, which could result in impaired short-term memory and learning.

900 MHz electromagnetic field exposure affects qualitative and quantitative features of hippocampal pyramidal cells in the adult female rat.

900 MHz EMF exposure induces neuronal damage and cell loss in the rat hippocampus. The report documents our research exposing female rats to 900 MHz from 12 weeks to 16 weeks of age.

Stereological analyses using the optical fractionator technique were done blind to obtain unbiased results. The results showed a statistically significant decrease in the pyramidal cells of the hippocampus and also showed an increase in dark cells. This research again shows impacts on the part of the brain involved in memory and learning. Sixteen-week-old rats are comparable to the age of human teenagers.

Purkinje cell number decreases in the adult female rat cerebellum following

exposure to 900 MHz electromagnetic field. 900 MHz EMF effects neuron number in the cerebellum. The cerebellum is a region of the brain that is thought to be involved in cognitive functions such as attention and language (and in regulating fear and pleasure responses) in addition to its role in motor control (coordination, precision and equilibrium). This research report documents our research on the effect of 900 MHz EMF on the number of Purkinje cells in the adult female rat cerebellum. Purkinje cells are important neurons in the cerebellum. In this study we exposed rats to 900MHz for one hour a day from 12 to 16 weeks of age and blind analyzed their Purkinje cells with the

optical fractionator technique. Results showed the exposed rats had significantly lower total numbers of Purkinje cells in their cerebellum. This suggests that long-term exposures to 900 MHz EMF leads to decreases of Purkinje cell numbers in the female rat cerebellum. Sixteen-week-old rats correspond to human teenagers for developmental stage comparison.

900 MHz EMF exposures at a SAR of 2W/Kg seem to have significant non-thermal biological effects. In the two research studies of 900 MHz exposures to the adult rat brain the specific energy absorption rate (SAR) varied between 0.016 (whole body) and 2W/kg (locally in the head). In the two research studies on prenatal exposure a 900 MHz continuous wave electromagnetic energy generator SAR of 2W/kg was used on the pregnant mice.

This research provides useful data on the possible toxic effects of EMF exposure on the Central Nervous System during critical periods of brain development. We conducted our research with 900 MHz EMF based on the fact that so many mobile phones operate at this frequency. In our research, the body weight of the rats did not show any effects from exposure, so there was no outward visual abnormality. However, the significant negative impact on neuron production in the hippocampus and cerebellum raises serious questions about the possible non thermal effects of electromagnetic fields on the parts of the mammal brain that involve attention, learning and memory.

The non-thermal biological effects of EMF exposure are of increasing concern to scientists. The research our lab has done fits into a larger context of research showing electromagnetic fields have adverse effects on animal tissue. (Dutta et al., 1989; Odaci et al., 2008; Bas et al., 2009a,b; Ragbetli et al., 2010, 2009; Ammani et al., 2010; Maskey et al., 2010). Several studies indicate that EMFs emitted by mobile phones could affect body tissue, systems and their physiologic activities (Mausset et al., 2001; Mausset-Bonnefont et al., 2004; Salford et al., 2003; Koyu et al., 2005; Yildiz et al., 2006; Manikonda et al., 2007).

* * *

Specific Comments on the FCC's Notice of Inquiry

In its Notice of Inquiry the FCC asks: "...whether its current limits are appropriate as they relate to device use by children." (p.2, Item 53).

The answer is a No. Current limits may not be appropriate as they relate to device use by children due to their vulnerability and developing bodies. Over the past few decades, several experimental studies have emerged which indicate electromagnetic fields could affect brain activity and neurons at the cellular level. The research from our laboratory shows that chronic exposure to electromagnetic fields can have long-term effects in brain morphology. The use of mobile phones by children and teenagers deserves special concern because this group will experience much higher cumulative exposure to EMF than previous generations.

Research on the mammal brain such as I have documented in this submission raises the question as to whether children and the developing fetus are more sensitive to EMF exposure than adults. The brain is particularly vulnerable during the growth process, which begins at conception and continues through the teen years. The research I have documented in rats corresponds to EMF exposure during the human developmental stages of the embryo and the teen years. Neuron production begins during gestation, through the early postnatal period and then continues at a slower rate into adulthood. Environmental insults during the early growth stages can have profound impacts later in life. While animal studies cannot be directly translated to humans, similar effects in humans would have far reaching consequences for future generations.

B. On p.4, Item 63 of the Inquiry the Commission requests comment on "*whether the Commission should consistently require either disclosure of the maximum SAR value or other more reliable exposure data in a standard format, perhaps in manuals, at point-of-sale, or on a Web site.*"

Again, the answer is YES. Consumers should know the details of exposures that are possible from the phone or device they buy. Consumers should be provided with this information in order to make informed decisions.

In the introduction to FCC 13-39 Section 5 Inquiry, the FCC asks, "*whether our exposure limits remain appropriate given the differences in the various recommendations that have developed and recognizing additional progress in research subsequent to the adoption of our existing exposure limits.*"

The answer is NO. Recent research is raising questions as to the appropriateness of the current exposure limits. The research I have presented shows significant non-thermal biological health impacts from lower intensity electromagnetic fields. While further research is critical to fully understand the possible effects on brain development, this research adds to accumulating evidence that the current exposure levels may not protect from non-thermal biological health effects. Exposure limits should protect humans from adverse biological effects.

Respectfully submitted,

Dr. Suleyman Kaplan

Citations: Ammari, M., Gamez, C., Lecomte, A., Sakly, M., Abdelmelek, H., De Seze, R., 2010. GFAP expression in the rat brain following sub-chronic exposure to a 900 MHz electromagnetic field signal. *Int. J. Radiation Biol.* 86, 367–375.

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Prenatal & Children; Amended Declaration of Dr. David O. Carpenter M.D.
(Dec. 20, 2011); Morrison et al v. Portland Schools, No. 3:11-cv-00739-MO
(U.S.D.C. Oregon, Portland Div.)

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United States District Court

District of Oregon

Portland Division

AHM, by and through
her Guardian *ad litem* and father,
David Mark Morrison, and
David Mark Morrison, individually,

v.

Portland Public Schools,

Defendant.

Civil Action No. 3:11-cv-00739-MO

**Amended Declaration of
Dr. David O. Carpenter, M.D.**

I, Dr. David O. Carpenter, M.D., under penalty of perjury pursuant to 28 U.S.C. § 1746,
hereby make the following declaration in support of an injunction against Portland Public Schools'
use of WI-FI:

1. I am a public health physician, educated at Harvard Medical School. My current title is Director of the Institute for Health and the Environment at the University at Albany and Professor of Environmental Health Sciences within the School of Public Health. Formerly, I was the Dean of the School of Public Health at the University of Albany and the Director of the Wadsworth Center for Laboratories and Research of the New York State Department of Health.

2. I served as the Executive Secretary to the New York State Powerlines Project in the 1980s, a program of research that showed children living in homes with elevated magnetic fields coming from powerlines suffered from an elevated risk of developing leukemia. After this I became the spokesperson on electromagnetic field (EMF) issues for the state during the time of my employment in the Department of Health. I have published several reviews on the subject and have edited two books.

3. I am a Co-Editor and a Contributing Author of the *BioInitiative: A Rationale for a Biologically-based Public Exposure Standard for Electromagnetic Fields (ELF and RF)*, www.bioinitiative.org. It documents bioeffects, adverse health effects and public health conclusions about impacts of electromagnetic radiation (electromagnetic fields including extremely-low frequency ELF-EMF and radiofrequency /microwave or RF-EMF fields). The public health chapter from this report was subsequently published in a peer-reviewed journal.

4. Additionally, I am a Co-Author of *Setting Prudent Public Health Policy for Electromagnetic Field Exposures*, *Reviews on Environmental Health*, Volume 23, No 2, 2008, attached as Addendum A-2.

5. In addition, in 2009, I was invited to present to the President's Cancer Panel on the subject of powerline and radiofrequency fields and cancer, and have testified on this issue before the United States House of Representatives.

6. In sum, I am a public health physician, professor and former public health school Dean with expertise in electrophysiology, low-frequency electromagnetic fields bioeffects, and

radiofrequency (RF) and microwave (MW) radiation bioeffects.

7. WI-FI deploys pulse-modulated (“PM”) microwave (“MW”) radiation (within the larger RF radiation spectrum) with a carrier frequency that is similar to that used by a microwave oven: about 2.45 GHz. This is the “Agent”. The 2.45 GHz frequency was chosen for the oven because of its wavelength and harmonic resonance with the water molecule, to ensure the most efficient absorption by living tissues and effective heating by way of the agitation of water at the molecular level. The pulse-modulation of a wave with lower frequencies in addition to the high-frequency carrier signal, increases the exposure complexity and in turn the bioeffects in an exposed population.

8. In the context of school development, WI-FI exposes building occupants including children and adults constantly from both computers and infrastructure antennas. Duration may be an even more potent contributing factor to RF/MW radiation bioeffects than exposure levels. Chronic, such as all-day, school exposure, is more likely than short and intermittent exposure, such as cell phone use, to produce harmful health effects, and is likely to do so at lower exposure levels.

9. Persons stationed close to school computers with WI-FI and especially those very near to any WI-FI infrastructure will receive considerably higher exposure than do others.

10. It is generally accepted within the relevant scientific community and has been established beyond any reasonable doubt that adverse human health effects occur at far lower levels of RF/MW radiation exposure than those that cause noticeable heating, particularly where the wavelength approaches body-part size and thus maximizes absorption, where the wavelength has resonance with the water molecule, where there is more complex, modulated wave, where there is chronic exposure duration, and where exposed persons lack the capacity voluntarily to remove themselves from radiation sources.

11. Some effects are shown to occur at several hundred thousand times below the FCC public exposure guidelines, which are set based on the fallacious assumption that there are no adverse health effects at exposures that do not cause easily measureable heating. FCC guidelines

also only apply to 30-minute public exposures; therefore do not even infer safety at durations >30 minutes, such as in a school setting.

12. Exposure to high-frequency RF and MW radiation and also the extreme low frequency (ELF) EM fields that accompany WI-FI exposure have been linked to a variety of adverse health outcomes. Some of the many adverse effects reported to be associated with and/or caused by ELF fields and/or RF/MW radiation include neurologic, endocrine, immune, cardiac, reproductive and other effects, including cancers.

13. Studies of isolated cells have shown that RF/MW exposures may cause changes in cell membrane function, cell communication, metabolism, activation of proto-oncogenes, and can trigger the production of stress proteins at exposure levels below FCC guidelines and also at and less than school WI-FI exposure levels and parameters. Resulting effects in cellular studies include without limitation DNA breaks and chromosome aberrations, cell death including death of brain neurons, increased free radical production, activation of the endogenous opioid system, cell stress and premature aging.

14. Human studies of comparable RF/MW radiation parameters show changes in brain function including memory loss, retarded learning, performance impairment in children, headaches and neurodegenerative conditions, melatonin suppression and sleep disorders, fatigue, hormonal imbalances, immune dysregulation such as allergic and inflammatory responses, cardiac and blood pressure problems, genotoxic effects like miscarriage, cancers such as childhood leukemia, childhood and adult brain tumors, and more.

15. There is consistent evidence for increased incidence of effects in individuals who live near to high-power short-wave, AM, FM and TV transmission towers. This is particularly relevant because, like WI-FI, radio-TV transmission towers give continuous, whole-body radiation, not just radiation to the head, constantly.

16. Since WI-FI transmitters, both infrastructural and on computers, are indoors, where children and teachers may be very close by, and since WI-FI, at 2.45 GHz, deploys a

wavelength, at ~12.2 cm or ~ 4.8 inches, more absorbable by children's and adults' bodies and brains than radio-TV wavelengths, the harmfulness of WI-FI radiation likely exceeds that of radio-TV towers.

17. Like second-hand smoke, EMF and RF/MW radiation involve complex mixtures, where different frequencies, intensities, durations of exposure(s), modulation, waveform and other factors are known to produce variable effects, often more harmful with greater complexity. Decades of scientific study have produced substantial evidence that EMF and RF/MW radiation may be considered neurotoxic, carcinogenic and genotoxic. Sources of fields and radiation, but are not limited to: power lines, navigational radar, cell phones, cordless phones [or Digitally Encoded Cordless Transmission Devices (D.E.C.T.) phones], cell towers, 'smart' meters and their grids or infrastructure, "smart" boards, meters and grids, WiMax and wireless internet (WI-FI).

18. The RF/MW radiation and low-frequency EMF science that currently exists includes tens of thousands of studies dating back to the 1920s. On the basis of this vast body of literature, many public health experts believe, myself included, that it is likely society will face epidemics of neurotoxic effects and degeneration, cancers and genotoxicity in the future, resulting from the extreme and mostly involuntary exposure to RF/MW radiation and EMFs. WI-FI radiation in schools exceeds natural background levels of microwave radiation by trillions of times. Thus, it is important that all of us restrict our use of cell phones, and be as free as possible from exposure to unnatural, background sources of MW radiation, particularly WI-FI.

19. In public health science, it is generally accepted fact that vulnerable subgroups exist within any human population. This is also recognized specifically for RF/MW radiation and fields. These groups include children, pregnant women, the elderly and those with preexisting illnesses and/or impairments. Children are more vulnerable to RF/MW radiation because of the susceptibility of their developing nervous systems. RF/MW penetration is greater relative to head size in children, who have a greater absorption of RF/MW energy in the tissues of the head at WI-FI frequencies.

Such greater absorption results because children's skulls are thinner, their brains smaller, and their brain tissue is more conductive than those of adults, and since it has a higher water content and ion concentrations. The Presidential Cancer Panel found that children 'are at special risk due to their smaller body mass and rapid physical development, both of which magnify their vulnerability to known carcinogens, including radiation.'

http://deainfo.nci.nih.gov/advisory/pcp/annualReports/pcp08-09rpt/PCP_Report_08-09_508.pdf

20. FCC public RF/MW radiation exposure guidelines are based on the height, weight and stature of a 6-foot tall man, not children or adults of smaller stature. The guidelines do not take into account the unique susceptibility of growing children to exposures. Since children are growing, their rate of cellular activity and division is more rapid, and they are at more risk for DNA damage and subsequent cancers. Growth and development of the central nervous system is still occurring well into the teenage years, such that the neurological impairments predictable by the extant science may have great impact upon development, cognition, learning, and behavior. Prenatal exposure has been identified as a risk factor for childhood leukemia, and is associated with miscarriage. Children are largely unable to remove themselves from exposures to harmful substances in their environments. Their exposure is involuntary.

21. When WI-FI is in operation in a school, children and their parents have no choice but to allow the school to expose them to trillions of times higher microwave radiation than exists naturally on Earth at the same frequencies. Children and other building users are exposed to as much as 30-40 hours per week of constant, digitally encoded WI-FI signals from each wireless device and infrastructural antenna in a school building. Based upon a review of the Mount Tabor WI-FI Floor Plan, a given child is subject to direct signals from multiple WI-FI transmitters, including rooms full of students and teachers transmitting numerous laptop and other wireless signals. There is a major legal difference between an exposure that an individual chooses to accept and one that is forced upon a person, especially a dependent, who can do nothing about it.

22. WI-FI in the Portland Schools deploys similar PM MW radiation, at 2.45 and 5 GHz, to that of cell and cordless phones and their infrastructure. There is clear and strong evidence that intensive use of cell phones increases incidence of brain cancer, tumors of the auditory nerve, and cancer of the parotid gland, the salivary gland in the cheek by the ear. Cell and cordless phone radiation closely resembles that of WI-FI radiation exposure, except that WI-FI is more hazardous by way of frequency, duration, and the involuntary nature of exposure. While a cell or cordless phone is used only intermittently and primarily voluntarily, a WI-FI radiation microenvironment is constant in duration, with unavoidable radiation exposure even when nearby students are not actively using it. Because WI-FI radiation is essentially the same as, but more hazardous than, that for cell and cordless phones, there is every reason to understand that the health effects will be the same or worse, varying in relation to the total dose of radiation, and intensified by the constancy of duration. There is evidence from Scandinavian studies of cell phone usage that children who use cell phones are about five times more likely to develop brain cancer than if their usage starts as an adult. Thus, it is especially necessary to protect children from pulse-modulated MW radiation such as both cell phones and WI-FI deploy.

23. Based on a high degree of scientific certainty, Portland Public Schools' use of WI-FI is causing and will continue to cause AHM, other students, and school staff and faculty adverse health effects, and should be discontinued immediately. Educating by way of the Internet via cabled systems only decreases MW radiation exposure and is of minimal expense.

24. Having reviewed hundreds, possibly thousands, of studies in RF/MW radiation and ELF fields, published from decades ago to the present, I would provide you the following primary evidence, without limitation. Due to the active suppression of the RF/MW literature, some researchers in public health science are less aware of these studies. However, the forefront experts specializing in these areas, RF/MW radiation and ELF fields, recognize the certainties in this large body of scientific literature, which establishes without limitation that PM MW radiation with chronic duration is quite harmful to humans, particularly children, as well as to animals and plants.

25. It is not surprising that even as of 1990, the US Environmental Protection Agency ("EPA") had determined RF/MW radiation a "probable carcinogen". Now that we have much more confirming study in the interim, the conclusion is yet more certain. And when we focus on MW radiation, particularly pulse-modulated radiation, on long, non-intermittent duration and on more vulnerable subgroups such as children, we see that the cancer outcome is very certain, indeed. Amongst the epidemiologic studies showing cancer outcomes, the following are particularly strong:

- a. Dode AC, Leao M, Tejo FdeAF, gomes ACR, Dode DC, Dode MC, Moreira CW, Condessa VA, Albinatti C and Calaffa WT. Mortality by neoplasia and cellular telephone base stations in the Belo Horizonte municipality, Minas Gerais State, Brazil. *Sci Total Environ* 409: 3649-3665:2011. This study shows higher rates of cancer in people living close to cell phone towers than for people living further away. Cell phone radiation is similar to but likely not as harmful as 2.45 GHz radiation from WI-FI. The exposure levels in this study are lower than those that Portland school building occupants receive from WI-FI.
- b. Oberfeld G. Environmental Epidemiology Study of Cancer Incidence in the Municipalities of Hausmannstatten & Vasoldsberg (Austria), 2008. This government-commissioned study found significantly increased cancer risk relative to a lower-exposure reference category, 23x higher for breast cancer and 121x higher for brain tumors, with strong exposure-effect relations.
- c. Michelozzi P, Capon A, Kirchmayer U, Forastiere F, Biggeri A, Barca A and Perucci CA. Adult and childhood leukemia near a high-power radiostation in Rome, Italy. *Am J Epidemiol.* 155: 1098-1103: 2002. The authors show that there is a significant elevation of childhood leukemia among residents living near to Vatican Radio, and that the risk declines with distance away from the transmitter. This is RF radiation in frequencies similar to that of WI-FI.

- d. Ha M, Im H, Lee M, Kim HJ, Kim BC, Gimm YM and Pack JK. Radio-frequency radiation exposure from AM radio transmitters and childhood leukemia and brain cancer. *Am J Epidemiol* 166: 270-279: 2007. Leukemia and brain cancer in children in Korea were investigated in relation to residence within 2 km of AM radio transmitters. There was a significant elevation in rates of leukemia but not of brain cancer. WI-FI radiation is more harmful than AM.
- e. Park SK, Ha M, Im HJ. Ecological study on residences in the vicinity of AM radio broadcasting towers and cancer death: preliminary observations in Korea. *Int Arch Occup Environ Health*. 2004 Aug;77(6):387-94. This study found higher mortality areas for all cancers and leukemia in some age groups in the area near the AM towers.
- f. Hallberg O. Johansson O. *Med Sci Monit* 2004 Jul;10(7):CR336-40. Malignant melanoma of the skin – not a sunshine story! Increased incidence and mortality from skin melanoma are concluded to result from continuous disturbances of cell repair mechanisms by body-resonant EMFs from FM/TV networks.
- g. Hallberg O. Johansson O. 2005. FM Broadcasting exposure time and malignant melanoma incidence, *Electromagnetic Biology and Medicine* 24;1-8. Age-specific incidence of malignant melanoma of the skin is related to FM broadcasting radiation at whole-body resonant frequencies. This is very relevant to children, since the smaller wavelengths of WI-FI are at resonant frequencies with dimensions of the human head, particularly the child's head.
- h. Dolk H, Shaddick G, Walls P, Grundy C, Thakrar B, Kleinschmidt I, Elliot P. Cancer Incidence near radio and television transmitters in Great Britain. I – Sutton-Colfield transmitter, and II. Al high-power transmitters. *Am J Epidemiol* 1997; 145(1):1-9 and 10-17. In the first study, there was a statistically significant

increase in cancer; in the second, a small but significant increase in adult leukemia.

i. Hocking B, Gordon IR, Grain HL, Harfield GE. Cancer incidence and mortality and proximity to TV towers. *Medical J of Australia*. 1985;165:601-605. At extremely low exposure levels, there was an association between increased childhood leukemia incidence and mortality and proximity to TV towers. TV radiation, in the VHF and UHF bands, is similar to but not as harmful as WI-FI radiation at 2.45 GHz.

j. Grayson JK. Radiation exposure, socioeconomic status, and brain tumor risk in the US Air Force: A nested case-control study. *Am J Epidemiol* 1996; 143:480-6. This study found an association between exposure to ELF and RF/MW radiation and brain tumors.

k. Szmigielski S. Cancer morbidity in subjects occupationally exposed to high frequency (radiofrequency and microwave) electromagnetic radiation. *Sci Total Environ* 1996;180:9-17. This study showed huge increases in leukemia and Non-Hodgkin's lymphomas. Though exposure levels are higher in this study than they would be with school WI-FI, it is possible that certain students or teachers stationed immediately next to the WI-FI infrastructure could receive comparable levels in radiation peaks.

26. Additional studies show neurologic, immune, endocrine, reproductive and cardiac, adverse health effects from low-dose, chronic exposure to RF/MW radiation in humans:

a. Papageorgiou CC, Hountala CD, Maganioti AE, Kyprianou MA, Rabavilas AD, Papadimitriou GN, Capsalis CN. Effects of WI-FI signals on the p300 component of event-related potentials during an auditory hayling task. *J Integr Neurosci* 2011 Jun;10(2):189-202. This study concludes that WI-FI exposure may exert gender-related alterations on neural activity.

- b. Altpeter ES, Roosli M et al. Effect of Short-wave magnetic fields on sleep quality and melatonin cycle in humans: The Schwarzenburg shut-down study. *Bioelectromagnetics* 27:142-150, 2006. Sleep quality improved and melatonin excretion increased when the transmitter was shut down.
- c. Abelin T et al. Sleep disturbances in the vicinity of the short-wave braodcast transmitter Schwarzenburg. *Somnologie* 9:203-209, 2005. There is strong evidence of a causal relationship between operation of a short-wave radio transmitter and sleep disturbances in the surrounding population.
- d. Hutter HP et al. Subjective symptoms, sleeping problems, and cognitive performance in subjects living near mobile phone base stations. *Occup Environ Med* 2006;63:307-313, 2006. There was a significant relation of some symptoms, especially headaches, to measured power density, as well as effects on wellbeing and performance.
- e. Preece AW, Georgious AG, Duunn EJ, Farrow SC. *Occup Environ Med* 2007 Jun;64(6):402-8. Compared to control village, there were highly significant differences in the reporting of migraine, headache and dizziness military and cell phone antenna systems.
- f. Buchner K, Eger, H. Changes of clinically important neurotransmitters under the influence of modulated RF fields – a long-term study under real-life conditions. *Umwelt-Medizin-Gesellschaft* 24(1):44-57, 2011. There is clear evidence of health-relevant effects, including increase in adrenaline/noradrenaline, subsequent decrease in dopamine from a new MW-emitting base station. During counterregulation, trace amine PEA decreased and remained decreased. Clinically documented increases in sleep problems, cephalgia, vertigo, concentration problems and allergies followed the onset of new microwave transmissions.

- g. Eliyahu I, Luria R, Hareuveny R, Margaliot M, Neiran N and Shani G . Effects of radiofrequency radiation emitted by cellular telephones on the cognitive functions of humans. *Bioelectromagnetics* 27: 119-126: 2006. A total of 36 human subjects were exposed to PM MW and were tested on four distinct cognitive tasks. Exposure to the left side of the brain slows left-hand response time in three of the four tasks.
- h. Barth A, Winker R, Ponocny-Seliger E, Mayrhofer W, Ponocny I, Sauter C and Vana N. *Occup Environ Med* 65: 342-345: 2008. A meta-analysis for neurobehavioural effects due to electromagnetic field exposure emitted by GSM mobile phones. The authors looked at 19 studies of cognitive function in cell phone users, and found in the meta-analysis that there is evidence for a decreased reaction time, altered working memory and increased number of errors in exposed persons.
- i. Augner C, Hacker GW, Oberfeld G, Florian M, Hitzl W, Hutter J and Pauser G. Effects of exposure to base station signals on salivary cortisol, alpha-amylase and immunoglobulin A. *Biomed Environ Scie* 23: 199-207: 2010. This was a human experimental study with exposure to PM MW radiation wherein immune indicators were monitored after five 50-minute sessions. The researchers found dose-dependent changes in cortisol and alpha-amylase.
- j. Avendano C, Mata A, Sanchez Sarimiento CA and Doncel GF. Use of laptop computers connected to internet through WI-FI decreases human sperm motility and increases sperm DNA fragmentation. *Fert Steril*, 2012, In press. In this study human sperm were exposed to WI-FI from a laptop, and were found to show reduced motility after a 4-hour exposure. The results are consistent with other publications (see Agarwal et al., *Fert Steril* 89: 124-128: 2008) that reported that those who use cell phone regularly have reduced sperm count.

k. Baste V, Riise T and Moen BE (2008) *Int J Epidemiol* 23: 369-377; 2008. Radiofrequency electromagnetic fields: male infertility and sex ratio of offspring. This is a study of Norwegian Navy personnel chronically exposed to RF fields on the job. The rates of infertility were related to level of exposure in a dose-dependent fashion.

27. Many toxicologic and other animal studies, of which the following are but a few, support conclusions of cancer, genotoxicity, neurotoxicity and other health outcomes from RF/MW radiation.

a. Sinha R. Chronic non-thermal exposure of modulated 2450 MHz microwave radiation alters thyroid hormones and behavior of male rats. *Int. J. Radiation Biol.* 84:6:505-513, 2008. This study of 2.45 GHz at levels and durations comparable to and less than those of school WI-FI concluded that the radiation was sufficient to alter the levels of thyroid hormone as well as emotional reactivity compared to controls.

b. Nitthy H, Grafstrom G, Tian DP, Malmgren L, Brun A, Persson BRR, Salfor LG and Eberhardt J. *Bioelectromagnetics* 29: 219-232: 2008. This study showed cognitive impairment in rats after long-term exposure to PM MW radiation. This study of rats shows that after 2 hours per week for 55 weeks there was impaired memory for objects in exposed as compared to sham animals.

c. Kimmel S et al. Electromagnetic radiation: Influences on honeybees (*Apis mellifera*). A significant difference between non-exposed and fully irradiated bees was the result of the influence of high-frequency PM RF/MW radiation.

d. Panagopoulos DJ et al. Bioeffects of mobile telephony radiation in relation to its intensity or distance from the antenna. *Int. J Radiat Biol*, 86;(5):345-357, 2010. The PM MW radiations at 900 and 1800 MHz decreased the reproductive capacity by cell death induction, with an increased bioactivity "window" at 10

uW/cm², and still evident down to 1 uW/cm².

e. Everaert J, Bauwens D. A possible effect of electromagnetic radiation from mobile phone base stations on the number of breeding house sparrow (*passer domesticus*). *Electromagnetic Biology and Medicine*, 26:63-72, 2007.

Long-term exposure to higher-level low-intensity PM MW radiation negatively affects the abundance or behavior of House Sparrows in the wild.

f. Magras I, Xenos T. RF Radiation-Induced Changes in the Prenatal Development of Mice. *Bioelectromagnetics* 18:455-461, 1997. Near almost 100 TV and FM broadcast transmitters, with exposure levels between 0.168 uW/cm² and 1.053 uW/cm², found in the more exposed groups testicular damage and decreasing size of litters to irreversible infertility.

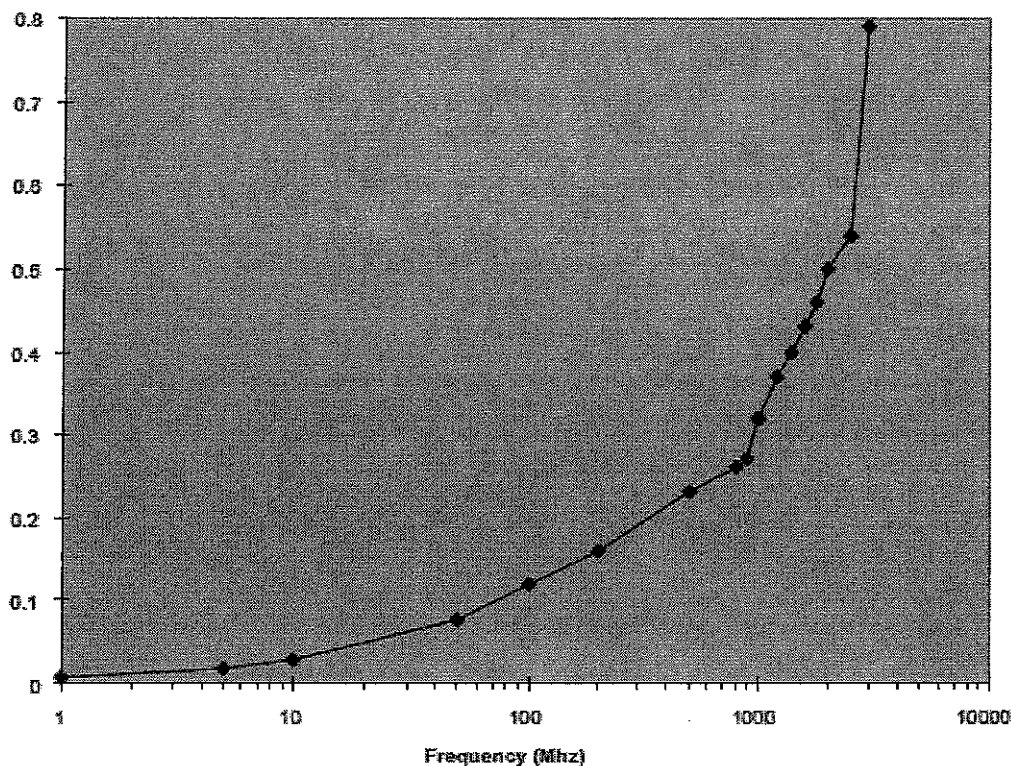
g. Balmori A. Electromagnetic pollution from phone masts. Effects on wildlife, *Pathophysiology* 2009. This large review of wildlife effects concludes, “pulsed telephony microwave radiation can produce effects on nervous, cardiovascular, immune and reproductive systems,” including damage to the nervous system by altering EEG and changes to the blood-brain barrier, disruption of the circadian rhythms (sleep-wake) by interfering with the pineal gland and hormonal imbalances, changes in heart rate and blood pressure, impairment of health and immunity towards pathogens, weakness, exhaustion, growth problems, problems in building the nest or impaired fertility, embryonic development, hatching percentage, genetic and developmental problems, problems of locomotion, promotion of tumors and more.

28. Exposure thresholds for harmful effects are lowered in human populations and individuals when duration is increased. Due to the variability of thresholds for harmful effects both in the population and within the individual, there is no exposure power density that is safe. The School's WI-FI deploys arguably the worst possible frequency of 2.45 GHz, that of the

microwave oven, worst because it is most absorbable by the brain and most resonant with the water molecule, such that:

- a. absorption-per-exposure is maximized, dramatically lowering effects thresholds for population and individual effects; and
- b. water molecules in tissues and cells are highly agitated.

Microwave Absorption in Brain Tissue (Grey Matter)



Curry, Ph.D., *Wireless LANs in the schoolroom*

29. This above graph, from physicist William Curry PhD's presentation *Wireless LANs in the Schoolroom*, shows how absorption in brain tissue (grey matter) increases exponentially toward the ultra-high frequency (UHF) area of the microwave oven and WI-FI.

30. In the case of the Portland Schools, the additional, unused but still deployed carrier frequency of 5 GHz would likely increase absorption in other, smaller organs, such as the thyroid.

31. The graph also illustrates the problem with the drive of the wireless industry toward ever higher frequencies within the cm microwave band. While nearly all the lower frequency bands have already been allocated by the FCC for specific types of radio transmissions, and transmission of ever more information content on any given channel requires greater bandwidth, each new deployment undermines further the integrity of the population's health. Engineers who design these systems have no training that would qualify them to consider the effects on biologic systems, which is why public health scientists need to be called in to policymaking *prior to* contracting and deployment, not after the fact.

32. The following studies explain the mechanisms of interaction between RF/MW radiation and biologic systems at the cellular level.

- a. The cell membrane recognition process -- which includes signal transduction and 'heat-shock protein' release -- was first discerned by Litovitz and his co-workers at Catholic University of America in the mid-1990s.

Below are a few citations that make the point.

- i. Litovitz, T., C. Montrose, et al. (1994). "Superimposing spatially coherent electromagnetic noise inhibits field induced abnormalities in developing chick embryos." *Bioelectromagnetics* 15(2): 105-113.
- ii. DiCarlo, A., J. Farrell, et al. (1998). "A simple experiment to study electromagnetic field effects: Protection induced by short term exposures to 60 Hz magnetic fields." *Bioelectromagnetics* 19(8): 498-500.
- iii. Penafiel, L., T. Litovitz, et al. (1997). "Role of modulation on the effect of microwaves on ornithine decarboxylase activity in L929

- cells." *Bioelectromagnetics* **18**(2): 132-141.
- iv. Dicarlo, A. L., Michael T. Hargis, L. Miguel Penafiel, Theodore A. Litovitz, A. (1999). "Short-term magnetic field exposures (60Hz) induce protection against ultraviolet radiation damage." *International journal of radiation biology* **75**(12): 1541-1549.
 - v. Litovitz, T., C. Montrose, et al. (1990). "Amplitude windows and transiently augmented transcription from exposure to electromagnetic fields." *Bioelectromagnetics* **11**(4): 297-312.
 - vi. Litovitz, T., M. Penafiel, et al. (1997). "The role of temporal sensing in bioelectromagnetic effects." *Bioelectromagnetics* **18**(5): 388-395.
 - vii. Litovitz, T., L. Penafiel, et al. (1997). "Role of modulation in the effect of microwaves on ornithine decarboxylase activity in L929 cells." *Bioelectromagnetics* **18**: 132-141.]
 - viii. Litovitz, T., D. Krause, et al. (1993). "The role of coherence time in the effect of microwaves on ornithine decarboxylase activity." *Bioelectromagnetics* **14**(5): 395-403.
- b. Cell membrane reaction is lipid peroxidation.
 - i. Serban, M. and V. Ni (1994). "Lipid peroxidation and change of plasma lipids in acute ischemic stroke." *Romanian journal of internal medicine= Revue roumaine de médecine interne* **32**(1): 51.