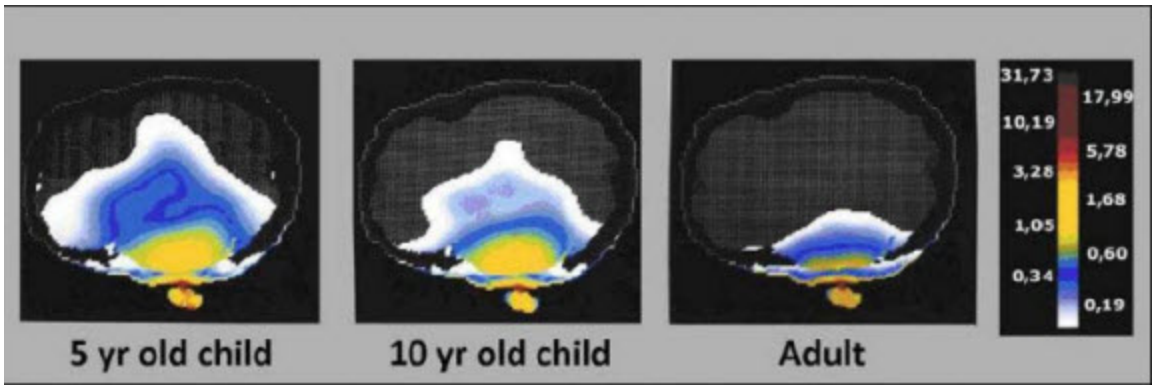
Health Risks to Children from Wireless Radiation
Read the Research Here

This document details the human health risks of wireless radiation *then cites research.*

Children's Unique Vulnerabilities to Wireless Radiation



(Om P. Gandhi et al., 2012)

The image above demonstrates the increased absorption of wireless radiation within the brains of children compared to adults. WIFI radiation has *never* been evaluated for its long term impact on the developing brain. Recent research is linking wireless with serious potential health effects.

"*Children, however, are not little adults and are disproportionately impacted by all environmental exposures, including cell phone radiation. In fact, according to the International Agency for the Research on Cancer, when used by children, the average RF (radiofrequency) energy deposition is two times higher in the brain and 10 times higher in the bone marrow of the skull, compared with mobile phone use by adults*."
– Dr. Robert Block, President of the American Academy of Pediatrics, 2012.

Why are Children and the Developing Fetus More Vulnerable?

- Children have smaller heads with a shorter distance to brain centers.
- Children's skulls and ears are thinner allowing radiation to penetrate further.
- Children's brains contain more fluid and absorb more microwave radiation.

Health Risks

Wi-Fi is low level microwave radiation. Many published studies over the past 20 years have shown an array of serious biological effects from low level microwaves. DNA damage and disruption of the blood brain barrier (BBB) have occurred at levels hundreds of times lower than US exposure limits. In this section we provide an overview of some health issues related to wireless radiation.

Selections of research on each health issue are detailed at the end of this document.

Reproductive Impacts: Consistent evidence from experimental research, epidemiological studies and in vitro (cells) laboratory, and in vivo (animal) studies shows that RF exposure is associated with reduced sperm count, motility and concentration, as well as DNA damage and altered cell structure. Some research also shows damage to the ovaries of rats and mice and changes in the eggs of flies and birds.

> "The epidemiological studies of men assessed for infertility were consistent in demonstrating decreased sperm motility associated with increased use of mobile phones" and "biological effects on sperm motility related to RF exposure". - **The BC Center for Disease Control 2013 Report, *A Radiofrequency Toolkit for Environmental Health Practitioners.***

Cancer: Research showing that long term heavy cell phone users have an increased risk of brain cancer lead to the WHO IARC classification of this radiation as a Class 2 B carcinogen: a "possible human carcinogen". A study showed that adults who started using cell or cordless phones as teenagers had a 8-fold higher risk of brain cancer on the side of their head where they held the phone. To date, the only published study of children's' risk of brain cancer from cell phone use found more than a 2-fold risk after >2.8 years of use (from billing records), combined with a statistically significant trend of increasing risk with increasing year of use.

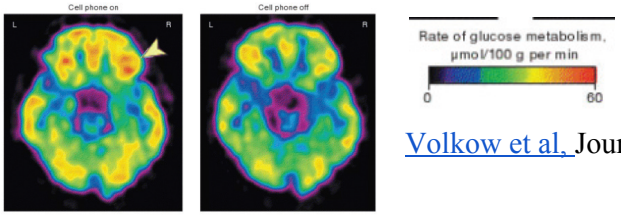
Hearing: Research shows chronic mobile phone usage results in high frequency hearing loss and inner ear damage . Research has also shown significant risk of tumors on the auditory nerve in the brain (acoustic neuromas).

Disruptions to Heart Functioning : Some research shows increases in heart rate, arrhythmias, dizziness, changes in blood pressure and other disturbances in heart functioning from wireless radiation.

> *"A disservice has been done in inaccurately depicting the body of science, which actually indicates that there are biological effects from the radiation emitted by wireless devices, including damage to DNA, and evidence for increased risk of cancer and other substantial health consequences…The public the world over has been misled by this reporting."*
> **Dr. Ronald B. Herberman, Founding Director of the University of Pittsburgh Cancer Institute, Vice Chancellor of Cancer Research at University of Pittsburgh and the first head of an NCI funded cancer center to speak out on the risks from cell phones.**

Headaches: Research shows children who used cell phones or were exposed prenatally to wireless radiation are at higher risk of developing headaches.

Neurotoxic effects: **Experimental research shows chronic exposure kills and reduces brain cells. 2011** NIH research found just 50 minutes of a wireless transmitting device (cell phone) next to the brain increases glucose in the part of the brain most exposed. Preliminary 3G and 4G research has shown that non-thermal levels of this radiation alter the brain's electrical activity.



Volkow et al, Journal of the American Medical Association, 2011

Cognition and Impaired Memory: Recent research at Yale University found prenatally exposed pups had impaired memory, increased hyperactivity and altered brains- consistent with a growing literature.

"We have shown that behavioral problems in mice that resemble ADHD are caused by cell phone exposure in the womb," said **Dr. Hugh Taylor of Yale Medical School**. "The rise in behavioral disorders in human children may be in part due to fetal cellular telephone irradiation exposure."

Behavioral Issues: **Epidemiological studies have shown associations between exposures and behavioral issues in children. For example, a recent** study showed a significant dose-response relationship between the number and duration of voice calls made on cell phones and ADHD risk among children exposed to lead in their environment.

Microwave from wireless tech disrupts thinking – what could be worse for learning? Technology can be used more safely with wired devices that do not produce these biologically-disruptive levels of microwave radiation" said Cindy Sage, Co-Editor of the BioInitiative Report, a comprehensive report written by 29 international experts on the current scientific evidence on electromagnetic fields. The Report recommends wired access without WiFi whenever possible.

Sleep: Research shows this radiation from wireless transmitting devices can impact sleep. For example, this radiation has been shown to delay entrance into deep non-REM sleep and decrease time spent in this stage of sleep. The quantity and quality of sleep has a profound impact on learning and memory. A sleep-deprived person cannot focus or learn efficiently. Sleep also has a critical role in the consolidation of memory essential for learning new information.

"Radiation at extremely low levels (0.0001 the level emitted by the average digital cellular telephone) caused heart attacks and the deaths of some chicken embryos...independent, third-party peer-reviewed studies need to be conducted in the U.S. to begin examining the effects from radiation on migratory birds and other trust species."
-Willie Taylor, US Department of the Interior in his February 2014 letter to Mr. Eli Veenendaal of the National Telecommunications and Information Administration, U.S. Dept. of Commerce.

Oxidative stress: Oxidative stress is the formation of tissue-damaging free radicals. Significant research shows wireless radiation increases oxidative stress which damages cells and their DNA through the production of peroxides and free radicals. Oxidative stress is implicated in the cause of many diseases such as cancer and Alzheimer's disease.

Genotoxic effects: Studies at non-thermal (no measurable temperature change) levels of microwave exposures show chromosomal instability, altered gene expression, gene mutations, DNA fragmentation and DNA structural breaks. Genetic mutations and cellular damage can potentially contribute to cancer growth.

Strong effects have been found in stem cells. Since stem cells are more active in children , researchers are concerned that children are at increased risk.

Scientific data on the biological effects of radiofrequency (RF) indicate the need to pursue a precautionary approach to protect the exposed population. It is clear that RF radiation can cause single and double strand DNA breaks at exposure levels that are currently considered safe under FCC guidelines. - **Dr. Martin Blank of Columbia University in his letter to the LAUSD**.

"Neuronal damage may not have immediately demonstrable consequences, even if repeated. It may, however, in the long run, result in reduced brain reserve capacity that might be unveiled by other later neuronal disease or even the wear and tear of ageing. We can not exclude that after some decades of (often), daily use, a whole generation of users, may suffer negative effects such as autoimmune and neurodegenerative diseases maybe already in their middle age". **Dr. Salford, Dr. Nittby, and Dr. Persson in Effects of Electromagnetic Fields From Wireless Communication upon the Blood-Brain Barrier in the Bioinitiative Report 2012 *a scientific* review of the science by 29 experts in ten countries.**

Endocrine System: Research has shown impacts on pineal gland, adrenal gland and thyroid gland. These glands balance hormones that involve sleep. Research has shown that low levels of microwave exposure can reduce melatonin. Melatonin is not just critical to maintaining our sleep rhythm but it is also an extremely important antioxidant that helps to repair damaged DNA and reduces the growth of cancer cells. Additionally, research shows thyroid hormone levels can be impacted by wireless radiation. It has been established that even a small change in thyroid hormones can alter the brain.

Numerous experimental studies link radiation from wireless transmitting devices to biological effects. Current research is raising serious concerns about long term health impacts.

"Waiting for high levels of scientific and clinical proof before taking action to prevent well-known risks can lead to very high health and economic costs, as was the case with asbestos, leaded petrol and tobacco."
-The 2011 European Commission Resolution 1815

A Selection of Research for each Health Issue is at the end of this online document.
Please also see The Bioinitiative Report 2012 and PowerWatch.

"Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." **The United Nation's Rio Declaration on the Environment and Development, 1992.**

Selected Examples of Credible Published Research

Please click on the underlined links to go to the online abstract.

Reproductive Effects

Adams J, Galloway T , Mondal D, Esteves S, Mathews F. (2014). **Effect of mobile telephones on sperm quality: A systematic review and meta-analysis.** *Environment International*. 80, 106-112.

- Our analyses indicate negative associations between mobile phone exposure on sperm viability and motility. The effects on concentration are more equivocal. Further research is required to quantify these effects more precisely and to evaluate the clinical importance of the risk to both sub-fertile men and the general population.

Agarwal A, Desai NR, Makker K, Varghese A, Mouradi R, Sabanegh E, Sharma R. (2009). **Effects of radiofrequency electromagnetic waves (RFEMW) from cellular phones on human ejaculated semen: an in vitro pilot study,** *Fertil Steril*. (4), 1318-25.

- "Radiofrequency electromagnetic waves emitted from cell phones may lead to oxidative stress in human semen. We speculate that keeping the cell phone in a trouser pocket in talk mode may negatively affect spermatozoa and impair male fertility."

Atasoy HI, Gunal MY, Atasoy P, Elgun S, Bugdayci G. (2013). **Immunohistopathologic demonstration of deleterious effects on growing rat testes of radiofrequency waves emitted from conventional Wi-Fi devices.** *Journal of Pediatric Urology.* 9(2), 223-9.

- Significant increases in serum 8-hydroxy-2'-deoxyguanosine levels and 8-hydroxyguanosine staining in the testes of the experimental group indicating DNA damage due to exposure ($p < 0.05$).

Avendaño C, Mata A, Sanchez Sarmiento CA, Doncel GF.(2012). **Use of laptop computers connected to internet through Wi-Fi decreases human sperm motility and increases sperm DNA fragmentation.** *Fertility Sterility.* 97(1), 39-45.

- Ex vivo exposure of human spermatozoa to a wireless internet-connected laptop decreased motility and induced DNA fragmentation by a nonthermal effect.

Azadi Oskouyi E, Rajaei F, Safari Variani A, Sarokhani MR, Javadi A. (2014). Effects of microwaves (950 MHZ mobile phone) on morphometric and apoptotic changes of rabbit epididymis. Andrologia.

- The epithelial height and diameter of the epididymis in 3 watt and 6 watt groups (2 weeks, 2 h a day with a frequency of 950 MHZ) had a significant decrease, the testosterone level only in 6 watt group was significantly decreased. The rate of apoptosis in the epithelial cells of the epididymis had a significant increase in 6 watt group.

- The **epididymis** is a tube connecting the ducts from each testicle to its vas deferens.

- "This study showed that the microwaves with the frequency of 950 MHz can have negative impacts on morphometric and apoptotic changes of rabbit epididymis.'

Deluliis GN, Newey RJ, King BV, Aitken RJ.(2009). **Mobile phone radiation induces reactive oxygen species production and DNA damage in human spermatozoa in vitro.** *Plos One July 31*, 4(7)

- In step with increasing SAR, motility and vitality were significantly reduced after RF-EMR exposure, while the mitochondrial generation of reactive oxygen species and DNA fragmentation were significantly elevated (P<0.001). Furthermore, we also observed highly significant relationships between SAR, the oxidative DNA damage bio-marker, 8-OH-dG, and DNA fragmentation after RF-EMR exposure.
- “These findings have clear implications for the safety of extensive mobile phone use by males of reproductive age, potentially affecting both their fertility and the health and wellbeing of their offspring”.

Desai NR, Kesari KK, Agarwal A. (2009). **Pathophysiology of cell phone radiation: oxidative stress and carcinogenesis with focus on male reproductive system.** *Reprod Biol Endocrinol.* 7, 114.

- “This review identifies the plasma membrane as a target of RF-EMW. In addition, the effects of RF-EMW on plasma membrane structures (i.e. NADH oxidase, phosphatidylserine, ornithine decarboxylase) and voltage-gated calcium channels are discussed.
- We explore the disturbance in reactive oxygen species (ROS) metabolism caused by RF-EMW and delineate NADH oxidase mediated ROS formation as playing a central role in oxidative stress (OS) due to cell phone radiation (with a focus on the male reproductive system).
- This review also addresses: 1) the controversial effects of RF-EMW on mammalian cells and sperm DNA as well as its effect on apoptosis, 2) epidemiological, in vivo animal and in vitro studies on the effect of RF-EMW on male reproductive system, and 3) finally, exposure assessment and dosimetry by computational biomodeling”.

Ghanbari M, Mortazavi SB, Khavanin A, Khazaei M. (2013). **The Effects of Cell Phone Waves (900 MHz-GSM Band) on Sperm Parameters and Total Antioxidant Capacity in Rats.** *International Journal of Fertility and Sterility* 7(1), 21-8.

- Sperm viability, motility, and total antioxidant capacity in all exposure groups decreased significantly compared to the control group (p<0.05).
- Increasing the duration of exposure from 2 to 3 weeks caused a statistically significant decrease in sperm viability and motility (p<0.05).
- "CONCLUSION: Exposure to cell phone waves can decrease sperm viability and motility in rats. These waves can also decrease sperm total antioxidant capacity in rats and result in oxidative stress."

Gul A, Celebi H, Uğraş S.(2009). **The effects of microwave emitted by cellular phones on ovarian follicles in rats.** *Arch Gynecol Obstet.* 280(5), 729-33.

- Exposure: 30 minutes every 24 hours pregnancy.
- **“** decreased number of follicles in pups exposed to mobile phone microwaves suggest that intrauterine exposure has toxic effects on ovaries.”
- “microwaves of mobile phones might decrease the number of follicles in rats by several known and, no doubt, countless unknown mechanisms.”

La Vignera S, Condorelli R, Vicari E, D'Agata R, Calogero A. (2012) **Effects of the exposure to mobile phones on male reproduction: a review of the literature.** *Journal of Andrology*. 33(3), 350-356.

- Review of Research: "The results showed that human spermatozoa exposed to RF-EMR have decreased motility, morphometric abnormalities, and increased oxidative stress, whereas men using mobile phones have decreased sperm concentration, decreased motility (particularly rapid progressive motility), normal morphology, and decreased viability. These abnormalities seem to be directly related to the duration of mobile phone use."

Markov M, Grigoriev YG.(2013). **Wi-Fi technology – an uncontrolled global experiment on the health of mankind.** *Electromagnetic Biology and Medicine. 32(2), 200-8*

- "For the first time in the history of mankind, because of aggressive use of mobile phones children are exposed to harmful non ionizing radiation and potentially are subject of larger risk than adults. Even if the dose received by the children's brain is the same as for adults, due to the specificity of the body size and physiological development, children are in greater danger."
- We should stop telling the science, politicians and general population that Wi-Fi is harmless... We should better be honest and say that "we do not know what long-term effects might be."
- "the continuous non-controlled exposure of the entire civilization to low-intensity EMFs represents now more serious problem for the mankind than ionizing radiation where the sources of radiation are under strict control and are well localized"

Panagopoulos D, Johansson O, Carlo G. (2013). **Analysing the Health Impacts of Modern Telecommunications Microwaves.** PLoS One. 8(6).

- "In the present study we showed that microwave radiations used in modern mobile telecommunications can damage DNA and induce cell death or heritable mutations which may in turn result in reproduction decreases, degenerative diseases, or cancer. We analyzed the biophysical and biochemical mechanism underlying this biological impact, and discussed dosimetry and protection issues.
- All healthy organisms have defense mechanisms in order to repair biological damages. But defense mechanisms are weaker in children and old individuals, and become also weaker during sickness or during stress conditions. Although even the most serious biological effects may not necessarily lead to health effects in an exposed individual, all health effects are initiated by corresponding biological ones. Thereby, biological effects-especially the most serious ones as is DNA damage or cell death induction-may potentially lead to health effects.

Panagopoulos D. (2012). **Effect of microwave exposure on the ovarian development of Drosophila melanogaster.** *Cell Biochem Biophys*. 63(2), 121-32.

- "the ovarian size of the exposed insects is significantly smaller than that of the corresponding sham-exposed insects, due to destruction of egg chambers by the GSM radiation, after DNA damage and consequent cell death induction in the egg chamber" cells of the virgin females as shown in

previous experiments on inseminated females.
- "The difference in ovarian size between sham-exposed and exposed virgin female flies becomes most evident 39-45 h after eclosion when the first eggs within the ovaries are at the late vitellogenic and post-vitellogenic stages (mid-late oogenesis). More than 45 h after eclosion, the difference in ovarian size decreases, as the first mature eggs of the sham-exposed insects are leaving the ovaries and are laid."
- Marko Markov and Yuri G. Grigoriev of the National Committee of Non-Ionizing

Shahin S, Mishra V, Singh SP, Chaturvedi CM.(2014). **2.45 GHz Microwave Irradiation Adversely Affects Reproductive Function in Male Mouse, Mus musculus by Inducing Oxidative and Nitrosative Stress**. *Free Radic Res.* 48(5), 511-25.

- Significant decrease in sperm count , sperm viability , decrease in seminiferous tubule diameter, degeneration of seminiferous tubules. Reduction in testicular 3β HSD activity and plasma testosterone levels and increased expression of testicular i-NOS was observed.
- These "adverse reproductive effects suggest that chronic exposure to microwave radiation may lead to infertility via free radical species-mediated pathway."

Cancer:

(2011). **Non-ionizing radiation, Part II: Radiofrequency electromagnetic fields / IARC Working Group on the Evaluation of Carcinogenic Risks to Humans.** IARC Monogr Eval Carcinog Risks Hum. 102(2), 1-460.

- Radiofrequency electromagnetic fields are *possibly carcinogenic to humans (Group 2B)." (p. 421)*
- ""Overall, the Working Group reviewed all the available evidence with regard to the use of wireless phones, including both mobile and cordless phones, and the risk of glioma. Time trends were considered, as were several early case–control studies and one cohort study. The evidence from these studies was considered less informative than the results of the INTERPHONE study and the Swedish case–control study. While both of these are susceptible to bias, the Working Group concluded that these findings could not be dismissed as reflecting bias alone, and that a causal interpretation was possible."
- "In considering the evidence on acoustic neuroma, the Working Group considered the same methodological concerns as for glioma, but concluded that bias was not sufficient to explain the positive findings, particularly those of the study from Sweden." (p. 412)

Coureau G, Bouvier G, Lebailly P, Fabbro-Peray P, Gruber A, Leffondre K, Guillamo JS, Loiseau H, Mathoulin-Pélissier S, Salamon R, Baldi I. (2014). **Mobile phone use and brain tumours in the CERENAT case-control study.** *Occup Environ Med.* 71(7), 514-22.

- "CERENAT is a multicenter case-control study carried out in four areas in France in 2004–2006. No association with brain tumours was observed when comparing regular mobile phone users with non-users. However, the positive association was statistically significant in the heaviest users when

considering life-long cumulative duration for meningiomas and number of calls for gliomas Risks were higher for gliomas, temporal tumours, occupational and urban mobile phone use.

- These additional data support previous findings concerning a possible association between heavy mobile phone use and brain tumours."

Davis DL, Kesari S, Soskolne CL, Miller AB, Stein Y.(2013). **Swedish review strengthens grounds for concluding that radiation from cellular and cordless phones is a probable human carcinogen.** *Pathophysiology.* 20(2), 123-9.

- "Given that treatment for a single case of brain cancer can cost between $100,000 for radiation therapy alone and up to $1 million depending on drug costs, resources to address this illness are already in short supply and not universally available in either developing or developed countries. Significant additional shortages in oncology services are expected at the current growth of cancer. No other environmental carcinogen has produced evidence of an increased risk in just one decade...If the increased brain cancer risk found in young users in these recent studies does apply at the global level, the gap between supply and demand for oncology services will continue to widen. Many nations, phone manufacturers, and expert groups, advise prevention in light of these concerns by taking the simple precaution of "distance" to minimize exposures to the brain and body. We note than brain cancer is the proverbial "tip of the iceberg"; the rest of the body is also showing effects other than cancers."

Carlberg M, Hardell L. **Decreased Survival of Glioma Patients with Astrocytoma Grade IV (Glioblastoma Multiforme) Associated with Long-Term Use of Mobile and Cordless Phones.** International Journal of Environmental Research and Public Health. 2014; 11(10):10790-10805.

- We analysed survival of 1678 glioma patients in our 1997–2003 and 2007–2009 case-control studies. Use of wireless phones in the >20 years latency group (time since first use) was correlated to decreased survival for those diagnosed with astrocytoma grade IV .
- "Due to the relationship with survival the classification of IARC is strengthened and RF-EMF should be regarded as human carcinogen requiring urgent revision of current exposure guidelines."

L. Hardell, M. Carlberg, **Cell and cordless phone risk for glioma - Analysis of pooled case-control studies in Sweden, 1997-2003 and 2007-2009,** Pathophysiology (2014), Available online 29 October 2014.

- "Conclusion. We previously analysed the evidence on glioma associated with the use of wireless phones using the Hill criteria [20]. We concluded that glioma and also acoustic neuroma are caused by RF-EMF emissions from wireless phones, and thus regarded as carcinogenic, under Group 1 according to the IARC classification, indicating that current guidelines for exposure should be urgently revised. This pooled analysis gives further support to that conclusion regarding glioma."

Hardell L, Carlberg M, Söderqvist F, Mild K.(2013). **Case-control study of the association between malignant brain tumours diagnosed between 2007 and 2009 and mobile and cordless phone use.** *International Journal of Oncology* 43(6), 1833-45.

- For persons with more than 25 years latency period (time since first use until tumour diagnosis) a 3-fold increased risk was found. The risk increased further for tumours located in the most exposed area of the brain, the temporal lobe, to a 5-fold increased risk.
- "This study confirmed previous results of an association between mobile and cordless phone use and malignant brain tumours. These findings provide support for the hypothesis that RF-EMFs play a role both in the initiation and promotion stages of carcinogenesis".

Hardell L, Carlberg M, Hansson, Mild K. (2006)**. Pooled analysis of two case-control studies on the use of cellular and cordless telephones and the risk of benign brain tumours diagnosed during 1997-2003.** *International Journal of Oncology*. 509-18.

- In the multivariate analysis, a significantly increased risk of acoustic neuroma was found with the use of analogue phones.

Hardell L, Carlberg M, Söderqvist F, Mild KH.(2013). **Pooled analysis of case-control studies on acoustic neuroma diagnosed 1997-2003 and 2007-2009 and use of mobile and cordless phones.** *Int J Oncol.* 43(4), 1036-44.

- "Ipsilateral use resulted in a higher risk than contralateral for both mobile and cordless phones. OR increased per 100 h cumulative use and per year of latency for mobile phones and cordless phones, though the increase was not statistically significant for cordless phones. The percentage tumour volume increased per year of latency and per 100 h of cumulative use, statistically significant for analogue phones. This study confirmed previous results demonstrating an association between mobile and cordless phone use and acoustic neuroma."

Hardell L, Carlberg M, Hansson Mild K. (2011)**. Pooled analysis of case-control studies on malignant brain tumours and the use of mobile and cordless phones including living and deceased subjects.** *Int J Oncol.* 38(5):1465-74.

- An increased risk was found for glioma and use of mobile or cordless phone. The risk increased with latency time and cumulative use in hours and was highest in subjects with first use before the age of 20.

Hardell L, Carlberg M. (2013). **Using the Hill viewpoints from 1965 for evaluating strengths of evidence of the risk for brain tumors associated with use of mobile and cordless phones.** *Rev Environ Health.* 28(2-3), 97-106.

- "All nine issues on causation according to Hill were evaluated. The criteria on strength, consistency, specificity, temporality, and biologic gradient for evidence of increased risk for glioma and acoustic neuroma were fulfilled.
- Based on the Hill criteria, glioma and acoustic neuroma should be considered to be caused by RF-EMF emissions from wireless phones and regarded as carcinogenic to humans, classifying it as group 1 according to the IARC classification. Current guidelines for exposure need to be urgently

revised."

Hardell L, Carlberg M, Hansson Mild K. (2013). **Use of mobile phones and cordless phones is associated with increased risk for glioma and acoustic neuroma.** *Pathophysiology.* 20(2):85-110.

- "We give an overview of current epidemiological evidence for an increased risk for brain tumours including a meta-analysis of the Hardell group and Interphone results for mobile phone use. ..It is concluded that one should be careful using incidence data to dismiss results in analytical epidemiology. The IARC carcinogenic classification does not seem to have had any significant impact on governments' perceptions of their responsibilities to protect public health from this widespread source of radiation".

Carlberg M, Hardell L. **Decreased Survival of Glioma Patients with Astrocytoma Grade IV (Glioblastoma Multiforme) Associated with Long-Term Use of Mobile and Cordless Phones. International Journal of Environmental Research and Public Health.** 2014; 11(10):10790-10805.

- Survival was analyzed for 1678 glioma patients in Hardells1997–2003 and 2007–2009 case-control studies. "Elevated HR (decreased survival) for the most malignant glioma type, astrocytoma grade IV, was found for long-term use of mobile and cordless phones.Highest HR was found for cases with first use before the age of 20 years. These results indicate a survival disadvantage for use of wireless phones in that patient group".
- "The study strengthens the proposed causal association between use of mobile and cordless phones and glioma. Due to the relationship with survival the classification of IARC is strengthened and RF-EMF should be regarded as human carcinogen requiring urgent revision of current exposure guidelines".

Myung S.K., Ju W, McDonnell D, Lee Y, Kazinets G, Cheng C, Moskowitz J.(2009). **Mobile Phone Use and Risk of Tumors: A Meta-Analysis.** *Journal of Clinical Oncology*, 27(33), 556.

- **A Meta-Analysis- "The current study found that there is possible evidence linking mobile phone use to an increased risk of tumors from a meta-analysis of low-biased case-control studies. Prospective cohort studies providing a higher level of evidence are needed".**

Hearing loss

Dhiraj Maskey, Myeung Ju Kim. (2014). Immunohistochemical Localization of Brain-derived Neurotrophic Factor and Glial Cell Line-derived Neurotrophic Factor in the Superior Olivary Complex of Mice after Radiofrequency Exposure. *Neuroscience Letters.* 564, 78-82

- Significant decrements of BDNF immunoreactivity were noted in the lateral superior olive, medial superior olive, superior paraolivary nucleus and medial nucleus of the trapezoid body
- The decrease in the immunoreactivity of neurotrophic factors suggests a detrimental effect of RF exposure in the auditory nuclei.

Oktay M, Dasdag S. (2006). **Effects of intensive and moderate cellular phone use on hearing function.** *Electromagn Biol Med*. 25(1), 13-21.

- Brainstem evoked response audiometric (BERA) and pure tone audiometric (PTA) methods were used to measure the effects of exposure on hearing function of the subjects.
- Detection thresholds in those who talked approximately 2 h per day were found to be higher than those in either moderate users or control subjects.
- This study shows that a higher degree of hearing loss is associated with long-term exposure to electromagnetic (EM) field generated by cellular phones.

Panda N, Munjal S, Bakshi J. (2007). **Audiological Disturbances in Long-Term Mobile Phone Users.** *American Academy of Otolaryngology-Head and Neck Surgery Foundation.*

- 100 people who had used mobile phones for over a year suffered increases in the degree of hearing loss over the span of 12 months.
- The study discovered that people who used their phones for more than 60 minutes a day had a worse hearing threshold than those with less use.
- The authors warn users of cell phones to look out for ear symptoms such as ear warmth, ear fullness, and ringing in the ears (tinnitus) as early warning signs that you may have an auditory abnormality. They also suggest the use of earphones, which they found to be safer than holding a mobile phone up to the ears.

Sudan M, Kheifets L, Arah OA, Olsen J. (2013). **Cell phone exposures and hearing loss in children in the Danish National Birth Cohort.** *Paediatr Perinat Epidemiol.* 27(3), 247- 57**.**

- We observed weak associations between cell phone use and hearing loss at age 7, with odds ratios and 95% confidence intervals from the traditional logistic regression, MSM and DRE models being 1.21 [95% confidence interval [CI] 0.99, 1.46], 1.23 [95% CI 1.01, 1.49] and 1.22 [95% CI 1.00, 1.49], respectively.
- CONCLUSIONS:Our findings could have been affected by various biases and are not sufficient to conclude that cell phone exposures have an effect on hearing. This is the first large-scale epidemiologic study to investigate this potentially important association among children, and replication of these findings is needed.

Velayutham P, Govindasamy GK, Raman R, Prepageran N, Ng KH. (2014). **High-frequency hearing loss among mobile phone users.** *Indian J Otolaryngol Head Neck Surg*. 66(1), 169-72.

- Prospective single blinded study that used high-frequency audiometry.
- This study showed that there is significant loss in the dominant ear compared to the non-dominant ear ($P < 0.05$). Chronic usage mobile phone revealed high frequency hearing loss in the dominant ear (mobile phone used) compared to the non dominant ear.

Heart Function

Esmekaya MA, Ozer C, Seyhan N. (2011). **900 MHz pulse-modulated radiofrequency radiation induces oxidative stress on heart, lung, testis and liver tissues.** *Gen Physiol Biophys***.** 30(1), 84-9.

- MDA and NOx levels were increased significantly in liver, lung, testis and heart tissues of the exposed group compared to sham and control groups .($p < 0.05$).
- Results of our study showed that pulse-modulated RF radiation causes oxidative injury in liver, lung, testis and heart tissues mediated by lipid peroxidation, increased level of NOx and suppression of

antioxidant defense mechanism.

Havas M, Marrongelle J. (2010). **Provocation study using heart rate variability shows microwave radiation from 2.4 GHz cordless phone affects autonomic nervous system.** *European Journal of Oncology.* 5, 273-300.

- 10 of the subjects (40 percent) displayed increased heart rate, arrhythmias (irregular heartbeats, a.k.a. heart palpitations).
- Four subjects experienced overt tachycardia, or intense and prolonged heart racing, after a second or two of exposure, with one subject's heart almost tripling its rate.
- Strong increases in sympathetic nervous activity and decreases in parasympathetic activity from exposures.

Havas M, Marrongelle J. (2013). **Replication of heart rate variability provocation study with 2.4-GHz cordless phone confirms original findings,** *Electromagnetic Biology and Medicine*. 32(2), 253-266.

- Double blind, sham-controlled study documented an increased Heart Rate, altered HRV and changes in the sympathetic and parasympathetic control of the Autonomic Nervous System.
- "Our results demonstrate that the radiation from a 2.4-GHz cordless phone affects the ANS and may put some individuals with preexisting heart conditions at risk when exposed to electromagnetic frequencies to which they are sensitive."

Türedi S, Hancı H, Topal Z, Unal D, Mercantepe T, Bozkurt I, Kaya H, Odacı E. (2014) The effects of prenatal exposure to a 900-MHz electromagnetic field on the 21-day-old male rat heart. Electromagn Biol Med. Aug 28:1-8.

- This study investigated the effects on rat pup heart tissue of prenatal exposure to a 900 megahertz (MHz) EMF. Pregnant rats were divided into experimental (00 MHz EMF (1 h/d) on days 13-21 of pregnancy) and control groups. On postnatal day 21, heart tissues were extracted.

- Malondialdehyde, superoxide dismutase and catalase values were significantly higher in the experimental group rats, while glutathione values were lower. Light microscopy revealed irregularities in heart muscle fibers and apoptotic changes in the experimental group. Electron microscopy revealed crista loss and swelling in the mitochondria, degeneration in myofibrils and structural impairments in Z bands.

- Our study results suggest that exposure to EMF in the prenatal period causes oxidative stress and histopathological changes in male rat pup heart tissue.

Headaches

Divan HA, Kheifets L, Obel C, Olsen J.**Prenatal and postnatal exposure to cell phone use and behavioral problems in children.** Epidemiology. 2008 Jul;19(4):523-9.

- "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."

Küçer N, Pamukçu T. **Self-reported symptoms associated with exposure to electromagnetic fields: a questionnaire study.** Electromagn Biol Med. 2014 Jan;33(1):15-7.

- "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 ($p < 0.05$)."

Madhuri Sudan, Leeka Kheifets, Onyebuchi Arah, Jorn Olsen, Lonnie Zeltzer. (2012). **Prenatal and Postnatal Cell Phone Exposures and Headaches in Children.** *Open Pediatrics Medical Journal.* 46-52.

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

Szyjkowska A, Gadzicka E, Szymczak W, Bortkiewicz A. (2014). **The risk of subjective symptoms in mobile phone users in Poland - An epidemiological study.** I*nt J Occup Med Environ Health*. 27(2), 293-303.

- a questionnaire survey of 53 questions.
- Headaches were reported significantly more often by the people who talked frequently and long in comparison with other users
- Continuous headache, persisting for longer than 6 h since the end of a call, was reported by 26% of the subjects.
- Our results show that the mobile phone users may experience subjective symptoms, the intensity of which depends on the intensity of use of mobile phones.

Neurotoxic Effects/Neurological Impacts:

Bas O, Odaci E, Kaplan S, Acer N. (2009). **900 MHz electromagnetic field exposure affects qualitative and quantitative features of hippocampal pyramidal cells in adult rat.** *Brain Research.* 1265, 178–185.

- A statistically significant decrease in the pyramidal cells of the hippocampus and an increase in dark cells.

Bas O, Odaci E, Mollaoglu H, Ucok K, Kaplan S. (2009)**. Chronic prenatal exposure to the 900 megahertz electromagnetic field induces pyramidal cell loss in the hippocampus of newborn rats.** *Toxicol Ind Health*. 25, 377–384.

- Results: A significant reduction in the total number of pyramidal cells in the cornu ammonis of the hippocampus, which involves short-term memory and learning.
- Sixteen-week old rats are comparable to the age of human teenagers.

Bin Lv, Zhiye Chen, Tongning Wu, Qing Shao, Duo Yan, Lin Ma, Ke Lu, Yi Xie. (2014). **The alteration of spontaneous low frequency oscillations caused by acute electromagnetic fields exposure.** *Clin Neurophysiol.* 125(2), 277-86.

- 30 min LTE 4G exposure modulated the spontaneous low frequency fluctuations in brain regions.

Jing J, Yuhua Z, Xiao-qian Y, Rongping J, Dong-mei G, Xi C. (2012). **The influence of microwave radiation from cellular phone on fetal rat brain,** *Electromagn Biol Med.* 31(1), 57-66.

- Pregnant rats were exposed to different intensities of microwave radiation from cellular phones.
- Significant content differences were found in superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), malondialdehyde (MDA), noradrenaline (NE), dopamine (DA) after fetal brains were assayed.
- "Through this study, we concluded that receiving a certain period of microwave radiation from cellular phones during pregnancy has certain harm on fetal rat brains."

Júnior LC, Guimarães ED, Musso CM, Stabler CT, Garcia RM, Mourão-Júnior CA, Andreazzi AE. (2014). **Behavior and memory evaluation of Wistar rats exposed to 1·8 GHz radiofrequency electromagnetic radiation.** Neurol Res. 36(1).

- Frequency of rearing was increased by 193.3%, revealing an increase in exploratory activity of the animals, which is also related to anxiety, depression, and stressful behavior.
- Our data corroborate that reported by Narayanan et al., 21 who showed in 2012 that animals exposed to mobile phone radiation had an increased frequency of rearing.

Naziroğlu M. and Gumral. (2009). **Modulator effects of L-carnitine and selenium on wireless devices (2.45 GHz)-induced oxidative stress and electroencephalography records in brain of rat.** *Int J Radiat Biol.* 85(8), 680-689.

- Rats exposed to 2.45 GHz 60 min/day for 28 days had lower cortex brain vitamin A ($p < 0.05$), vitamin C ($p < 0.01$) and vitamin E ($p < 0.05$) concentrations.

Nittby H, Brun A, Eberhardt J, Malmgren L, Persson BR, Salford LG. (2010). **Effects of microwave radiation upon the mammalian blood-brain barrier.** *European Journal of Oncology.* 5, 333-355.

- EMF radiation leads to increased permeability of the Blood Brain Barrier (BBB) at non-thermal exposure levels.
- Damaging effects from radiofrequency EMF upon neurons has been shown after 28 days and 50 days.
- "The human BBB is very similar to the rodent BBB... it is our sincere belief, that it is more probable than unlikely, that non-thermal EMF from mobile phones and base stations do have effects upon the human brain.

Odaci E, Bas O, Kaplan S. (2008). **Effects of prenatal exposure to a 900 megahertz electromagnetic field on the dentate gyrus of rats: a stereological and histopathological study.** *Brain Research.* 1238, 224–229.

- Prenatal exposure caused a progressive postnatal decline in the number of granule cells of dentate gyrus of the hippocampus of offspring.

Qiao S, Peng R, Yan H, Gao Y, Wang C, et al. (2014) **Reduction of Phosphorylated Synapsin I (Ser-553) Leads to Spatial Memory Impairment by Attenuating GABA Release after Microwave Exposure in Wistar Rats.** *PLoS ONE.* 9(4)

- In the rat experiments, there was a decrease in spatial memory performance after microwave exposure. Both microwave exposure and p-Syn I silencing reduced GABA release and maximal reduction was found for the combination of the two, indicating a synergetic effect.
- p-Syn I (ser-553) was found to play a key role in the impaired GABA release and cognitive dysfunction that was induced by microwave exposure.

Razavinasab M, Moazzami K, Shabani M. (2014). **Maternal mobile phone exposure alters intrinsic electrophysiological properties of CA1 pyramidal neurons in rat offspring.** Toxicol Ind Health. 30(2), 101-196.

- Mobile phone exposure was mostly associated with a decrease in the number of action potentials fired in spontaneous activity and in response to current injection in both male and female groups. There was an increase in the amplitude of the afterhyperpolarization (AHP) in mobile phone rats compared with the control.
- The results of the passive avoidance and Morris water maze assessment of learning and memory performance showed that phone exposure significantly altered learning acquisition and memory retention in male and female rats compared with the control rats.
- Our results suggest that exposure to mobile phones adversely affects the cognitive performance of both female and male offspring rats using behavioral and electrophysiological techniques.

Redmayne M, Johansson O. (2014) Could myelin damage from radiofrequency electromagnetic field exposure help explain the functional impairment electrohypersensitivity? A review of the evidence. J Toxicol Environ Health B Crit Rev;17(5):247-58.

- “This review of RF-EMF peer-reviewed literature outlines the development of myelin through life, and then considers the evidence for an association between myelin integrity and exposure to low-intensity radiofrequency electromagnetic fields (RF-EMFs) typical in the modern world.
- There are surprisingly little data available in each area, but considered together a picture begins to emerge in RF-EMF-exposed cases: (1) significant morphological lesions in the myelin sheath of rats; (2) a greater risk of multiple sclerosis in a study subgroup; (3) effects in proteins related to myelin production; and (4) physical symptoms in individuals with functional impairment electrohypersensitivity, many of which are the same as if myelin were affected by RF-EMF exposure, giving rise to symptoms of demyelination.In the latter, there are exceptions; headache is common only in electrohypersensitivity, while ataxia is typical of demyelination but infrequently found in the former group.

- Overall, evidence from in vivo and in vitro and epidemiological studies suggests an association between RF-EMF exposure and either myelin deterioration or a direct impact on neuronal conduction, which may account for many electrohypersensitivity symptoms. The most vulnerable are likely to be those in utero through to at least mid-teen years, as well as ill and elderly individuals.

Saikhedkar N, Bhatnagar M, Jain A, Sukhwal P, Sharma C, Jaiswal N. (2014). **Effects of mobile phone radiation (900 MHz radiofrequency) on structure and functions of rat brain.** *Neurol Res.* 2(6),

2499-2504.

- Thus our findings indicate extensive neurodegeneration on exposure to radio waves. Increased production of reactive oxygen species due to exhaustion of enzymatic and non-enzymatic antioxidants and increased lipid peroxidation are indicating extensive neurodegeneration in selective areas of CA1, CA3, DG, and cerebral cortex. This extensive neuronal damage results in alterations in behavior related to memory and learning.

Sirav B, Seyhan N. (2011). **Effects of radiofrequency radiation exposure on blood-brain barrier permeability in male and female rats.** *Electromagnetic Biology and Medicine*. 30(4), 253-60.

- A significant increase in albumin was found in the brains of the RF-exposed male rats when compared to sham-exposed male brains.
- Radio frequency radiation "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."

Volkow ND, Tomasi D, Wang GJ, Vaska P, Fowler JS, Telang F, Alexoff D, Logan J, Wong C. (2011). **Effects of cell phone radiofrequency signal exposure on brain glucose metabolism.** *Journal of the American Medical Association*, 305(8), 808-13.

- A 50-minute cell phone exposure was associated with increased brain glucose metabolism in the region closest to the antenna.

Cognition/Memory

Aldad TS, Gan G, Gao XB, Taylor HS. (2012).**Fetal Radiofrequency Radiation Exposure From 800-1900 MHz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice.** *Scientific Reports;* 2, 312.

- the exposed group had dose responsive impaired neurologic transmission in the prefrontal cortex.
- the mice exposed in utero were hyperactive and had impaired memory.

Deshmukh PS, Banerjee BD, Abegaonkar MP, Megha K, Ahmed RS, Tripathi AK, Mediratta PK. (2013). **Effect of low level microwave radiation exposure on cognitive function and oxidative stress in rats.** *Indian J Biochem Biophys;* 50(2), 114-9.

- "Results showed significant impairment in cognitive function and increase in oxidative stress, as evidenced by the increase in levels of MDA (a marker of lipid peroxidation) and protein carbonyl (a marker of protein oxidation) and unaltered GSH content.
- "Low level MW radiation had significant effect on cognitive function and was also capable of leading to oxidative stress."

Megha, K Deshmukh, PS, Banerjee, BD, Tripathi, AK, Abegaonkar, MP. (2012). **Microwave radiation induced oxidative stress, cognitive impairment and inflammation in brain of Fischer rats.** *Indian J Experimental Biology*. 50(12), 889-896.

- “Significant impairment in cognitive function and induction of oxidative stress in brain tissues of microwave exposed rats were observed.”
- Increased oxidative stress due to microwave exposure may contribute to cognitive impairment and inflammation in brain.”

Nittby H, Grafström G, Tian DP, Malmgren L, Brun A. (2008). **Cognitive impairment in rats after long-term exposure to GSM-900 mobile phone radiation.** *Bioelectromagnetics.* 29, 219–232.

- GSM exposed rats had impaired memory for objects and their temporal order of presentation, compared to sham exposed controls (P = 0.02).
- "Our results suggest significantly reduced memory functions in rats after GSM microwave exposure (P = 0.02)."

Papageorgiou C, Hountala CD, Maganioti AE, Kyprianou MA, Rabavilas AD, Papadimitriou GN, Capsalis CN. (2011). **Effects of wi-fi signals on the p300 component of event-related potentials during an auditory hayling task.** *Journal of Integrative Neuroscience.* 10(2), 189-202.

- A WiFi access point was 1.5 meters away during blind exposures.
- In conclusion, the present findings suggest that Wi-Fi exposure may exert gender-related alterations on neural activity associated with the amount of attentional resources engaged during a linguistic test adjusted to induce Working Memory.

Behavior Issues:

Aldad TS, Gan G, Gao XB, Taylor HS. (2012). **Fetal Radiofrequency Radiation Exposure From 800-1900 Mhz-Rated Cellular Telephones Affects Neurodevelopment and Behavior in Mice.** *Scientific Reports.* 2, 312.

- Mice that were exposed to radiation tended to be more hyperactive and had reduced memory capacity.
- Authors attributed the behavioral changes to an effect during pregnancy on the development of neurons in the prefrontal cortex region of the brain.

Divan HA, Kheifets L, Obel C, Olsen J. (2012). **Cell phone use and behavioural problems in young children.** *J Epidemiol Community Health.* 66(6), 524-9.

- The findings of the previous publication were replicated in this separate group of participants demonstrating that cell phone use was associated with behavioural problems at age 7 years in children, and this association was not limited to early users of the technology.

Divan HA, Kheifets L, Obel C, Olsen J. (2008). **Prenatal and postnatal exposure to cell phone use and behavioral problems in children.** *Epidemiology.* 19(4), 523-9.

- 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.

Feizhou Zheng, Peng Gao, Mindi He, Min Li, Changxi Wang, Qichang Zeng, Zhou Zhou, Zhengping Yu, and Lei Zhang. **Association between mobile phone use and inattention in 7102 Chinese adolescents: a population-based cross-sectional study.** BMC Public Health 2014, 14:1022 doi:10.1186/1471-2458-14-1022

- A cross-sectional study with 7720 middle school students assessed for inattention and information on Mobile phone use.
- Results: Inattention in adolescents was significantly associated with mobile phone (MP) ownership, the time spent on entertainment on MP per day, the position of the MP during the day and the mode of the MP at night.
- The strongest association between inattention and the time spent on the MP was among students who spent more than 60 minutes per day playing on their MP.

Narayanan SN, Kumar RS, Kedage V, Nalini K, Nayak S, Bhat PG, (2014) **Evaluation of oxidant stress and antioxidant defense in discrete brain regions of rats exposed to 900 MHz radiation.** Bratislava Medical Journal; 115(5):260-6.

- Wistar rats (6-8 weeks old) were allotted into control, sham and exposed groups. Exposed group was exposed to 900 MHz of RF-EMR (1 hr/day with peak power density of 146.60 μW/cm2) from an activated GSM mobile phone for four weeks. On 29th day, behavioral analysis was done and later biochemical parameters were studied in amygdala, hippocampus, frontal cortex, and cerebellum.

- Altered behavioral performances were found in RF-EMR-exposed rats. Additionally, elevated TBARS level was found with all brain regions studied. RF-EMR exposure significantly decreased TA in the amygdala and cerebellum but its level was not significantly changed in other brain regions. GST activity was significantly decreased in the hippocampus but, its activity was unaltered in other brain regions studied.

- Conclusion: "RF-EMR exposure for a month induced oxidative stress in rat brain, but its magnitude was different in different regions studied. RF-EMR-induced oxidative stress could be one of the underlying causes for the behavioral deficits seen in rats after RF-EMR exposure."

Sleep

Hillert L, Akerstedt T, Lowden A, Wiholm C, Kuster N, Ebert S, Boutry C, Moffat SD, Berg M, Arnetz BB. (2007). **The Effects of 884 MHz GSM Wireless Communication Signals on Self-reported Symptom and Sleep (EEG)- An Experimental Provocation Study.** *Bioelectromagnetics.* 3(7), 1148-1150.

- A prolonged latency to reach the first cycle of deep sleep (stage 3).
- The amount of stage 4 sleep was also decreased in exposed subjects.
- Subjects reported more headaches during exposures vs. sham exposure.

K. Mann and J. Röschke. (1996). **"Effects of Pulsed High-Frequency Electromagnetic Fields on Human Sleep,"** *Neuropsychobiology*. 33, 41-47.

- Shortening of sleep onset latency and a REM (Rapid Eye Movement) suppressive effect with reduction of duration and percentage of REM sleep.
- “The effects observed possibly could be associated with alterations of memory and learning functions."

Regel SJ1, Tinguely G, Schuderer J, Adam M, Kuster N, Landolt HP, Achermann P. (2007). **Pulsed radio-frequency electromagnetic fields: dose-dependent effects on sleep, the sleep EEG and cognitive performance.** *Journal of Sleep Research***.** 16(3), 253-8.

- Showed a dose-response relationship between EMF field intensity and its effects on brain physiology as demonstrated by changes in the sleep EEG and in cognitive performance.

Schmid MR, Murbach M, Lustenberger C, Maire M, Kuster N, Achermann P, Loughran SP. (2012). **Sleep EEG alterations: effects of different pulse-modulated radio frequency electromagnetic fields.** *Journal of Sleep Research.* 21(1), 50-8.

- "Consistent with previous findings, our results provide further evidence that pulse-modulated RF EMF alter brain physiology".
- Modulation frequency components within a physiological range may be sufficient to induce these effects.

Oxidative Stress

Augner C, Hacker GW, Oberfeld G, Florian M, Hitzl W, Hutter J, Pauser G. (2010). **Effects of exposure to GSM mobile phone base station signals on salivary cortisol, alpha-amylase, and immunoglobulin A.** *Biomed Environ Sci.* 23(3), 199-207.

- Increases of cortisol and a higher concentration of alpha-amylase were detected in subjects under various EMF exposure scenarios.
- RF-EMF in considerably lower field densities than ICNIRP-guidelines may influence certain psychobiological stress markers.

Cetin H, Nazıroğlu M, Celik O, Yüksel M, Pastacı N, Ozkaya MO. (2014)**. Liver antioxidant stores protect the brain from electromagnetic radiation (900 and 1800 MHz)-induced oxidative stress in rats during pregnancy and the development of offspring.** *J Matern Fetal Neonatal Med.* 27(6).

- "EMR-induced oxidative stress in the brain and liver was reduced during the development of offspring.EMR could be considered as a cause of oxidative brain and liver injury in growing rats".

Hamzany Y, Feinmesser R, Shpitzer T, Mizrachi A, Hilly O, Hod R, Bahar G, Otradnov I, Gavish M, Nagler RM.(2013). **Is Human Saliva an Indicator of the Adverse Health Effects of Using Mobile Phones?** *Antioxid Redox Signal.18(6), 622-7.*

- Significant increase in all salivary oxidative stress indices studied in mobile phone users.
- Salivary flow, total protein, albumin, and amylase activity were decreased in mobile phone users.
- "These observations lead to the hypothesis that the use of mobile phones may cause oxidative stress and modify salivary function."

Hou Q1, Wang M, Wu S, Ma X, An G, Liu H, Xie F. (2014)**. Oxidative changes and apoptosis induced by 1800-MHz electromagnetic radiation in NIH/3T3 cells.** *Electromagn Biol Med.*

- Our results showed a significant increase in intracellular ROS levels after EMR exposure
- The percentage of late-apoptotic cells in the EMR-exposed group was significantly higher than that in the sham-exposed groups ($p < 0.05$).
- These results indicate that an 1800-MHz EMR enhances ROS formation and promotes apoptosis in NIH/3T3 cells.

Nazıroğlu M, Yüksel M, Köse SA, Özkaya MO. (2013). **Recent reports of Wi-Fi and mobile phone-induced radiation on oxidative stress and reproductive signaling pathways in females and males.** *J Membr Biol.* 246(12), 869-75.

- Review Paper: "In conclusion, the results of current studies indicate that oxidative stress from exposure to Wi-Fi and mobile phone-induced EMR is a significant mechanism affecting female and male reproductive systems."

Tomruk A1, Guler G, Dincel AS. (2010). **The influence of 1800 MHz GSM-like signals on hepatic oxidative DNA and lipid damage in nonpregnant, pregnant, and newly born rabbits.** *Cell Biochem Biophys*. 56(1), 39-47.

- "the whole-body 1800 MHz GSM-like RF radiation exposure may lead to oxidative destruction as being indicators of subsequent reactions that occur to form oxygen toxicity in tissues"

Yakymenko. (2014). **Low intensity radiofrequency radiation: a new oxidant for living cells.** *Oxid Antioxid Med Sci.* 3(1), 1-3.

- A "strong non-thermal character of biological effects of RFR has been documented" and "it is clear that the substantial overproduction of ROS in living cells under low intensity RFR exposure could cause a broad spectrum of health disorders and diseases, including cancer in humans.
- Undoubtedly, this calls for the further intensive research in the area, as well as to a precautionary approach in routine usage of wireless devices."

DNA Impacts

Burlaka A, Tsybulin O, Sidorik E, Lukin S, Polishuk V, Tsehmistrenko S, Yakymenko.(2013). **Overproduction of free radical species in embryonal cells exposed to low intensity radiofrequency radiation.** *Exp Oncol.* 35(3), 219-225.

- "Exposure of developing quail embryos to extremely low intensity RF-EMR of GSM 900 MHz during at least one hundred and fifty-eight hours leads to a significant overproduction of free radicals/reactive oxygen species and oxidative damage of DNA in embryo cells. These oxidative changes may lead to pathologies up to oncogenic transformation of cells."

Blank M, Goodman R.(2011). **DNA is a fractal antenna in electromagnetic fields.** *Int J Radiat Biol.* 87(4), 409-15.

- "The wide frequency range of interaction with EMF is the functional characteristic of a fractal antenna, and DNA appears to possess the two structural characteristics of fractal antennas, electronic conduction and self symmetry. These properties contribute to greater reactivity of DNA with EMF in the environment, and the DNA damage could account for increases in cancer

epidemiology, as well as variations in the rate of chemical evolution in early geologic history."

Guler G, Tomruk A, Ozgur E, Seyhan N. (2010). **The effect of radiofrequency radiation on DNA and lipid damage in non-pregnant and pregnant rabbits and their newborns.** *Gen Physiol Biophys*. 29(1), 59-66.

- Malondialdehyde and 8-hydroxy-2-deoxyguanosine levels of non-pregnant and pregnant radiofrequency exposed animals significantly increased compared with not-exposed controls.
- The authors conclude, that 1800 MHz GSM-like radiofrequency exposure of non-pregnant and pregnant rabbits for seven days resulted in the release of secondary messengers, such as free radicals, leading to oxidative destruction in lipids and DNA.
- Rabbits prenatally exposed to cell phone radiation developed more indicators of DNA damage such as greater amounts of free radicals.

Güler G , Tomruk A , Ozgur E , Sahin D , Sepici A , Altan N, Seyhan N. (2012). **The effect of radiofrequency radiation on DNA and lipid damage in female and male infant rabbits.** *International Journal of Radiation Biology*. 88(4), 367–373.

- Lipid peroxidation levels in the liver tissues of female and male infant rabbits increased under RF radiation exposure. Liver 8-hydroxy-2 ' -deoxyguanosine (8-OHdG) levels of female rabbits exposed to RF radiation were also found to increase when compared with the levels of non-exposed infants.
- Conclusion: Consequently, it can be concluded that GSM-like RF radiation may induce biochemical changes by increasing free radical attacks to structural biomolecules in the rabbit as an experimental animal model.

Ruediger HW. (2009). **Genotoxic effects of radiofrequency electromagnetic fields.** *Pathophysiology. 16(2-3), 89-102.*

- Review:101 publications reviewed on the genotoxicity of radiofrequency electromagnetic fields (RF-EMF) in vivo and in vitro. Of these 49 report a genotoxic effect and 42 do not. In addition, 8 studies failed to detect an influence on the genetic material, but showed that RF-EMF enhanced the genotoxic action of other chemical or physical agents...Taking altogether there is ample evidence that RF-EMF can alter the genetic material of exposed cells in vivo and in vitro and in more than one way. This genotoxic action may be mediated by microthermal effects in cellular structures, formation of free radicals, or an interaction with DNA-repair mechanisms.

Tomruk A, Guler G, Dincel AS. (2010). **The influence of 1800 MHz GSM-like signals on hepatic oxidative DNA and lipid damage in nonpregnant, pregnant, and newly born rabbits.** *Cell Biochem Biophys*. 56(1), 39-47.

- This study looked at the biological effects of whole-body 1800 MHz GSM-like radiofrequency (RF) radiation exposure on liver oxidative DNA damage and lipid peroxidation levels in nonpregnant, pregnant New Zealand White rabbits, and in their newly borns.
- Key Findings: In nonpregnant RF exposed and pregnant RF exposed malondialdehyde (MDA) and ferrous oxidation in xylenol orange (FOX) levels were increased compared to non pregnant controls.

- In this study, we found that whole-body 1800 MHz GSM-like RF exposure for 15 min/day for a week could affect lipid peroxidation by increasing MDA and FOX levels in nonpregnants and pregnant.
- "the whole-body 1800 MHz GSM-like RF radiation exposure may lead to oxidative destruction as being indicators of subsequent reactions that occur to form oxygen toxicity in tissues"

Xu S, Zhou Z, Zhang L, Yu Z, Zhang W, Wang Y, Wang X, Li M, Chen Y, Chen C, He M, Zhang G, Zhong M. (2010). **Exposure to 1800 MHz radiofrequency radiation induces oxidative damage to mitochondrial DNA in primary cultured neurons.** *Brain Research.* 22(1311), 189-96.

- **"**In this study, we exposed primary cultured cortical neurons to pulsed RF electromagnetic fields at a frequency of 1800 MHz modulated by 217 Hz at an average special absorption rate (SAR) of 2 W/kg. At 24 h after exposure, we found that RF radiation induced a significant increase in the levels of 8-hydroxyguanine (8-OHdG), a common biomarker of DNA oxidative damage, in the mitochondria of neurons. Concomitant with this finding, the copy number of mtDNA and the levels of mitochondrial RNA (mtRNA) transcripts showed an obvious reduction after RF exposure. Each of these mtDNA disturbances could be reversed by pretreatment with melatonin, which is known to be an efficient antioxidant in the brain.
- These results suggested that 1800 MHz RF radiation could cause oxidative damage to mtDNA in primary cultured neurons. Oxidative damage to mtDNA may account for the neurotoxicity of RF radiation in the brain."

Zhijian C, Xiaoxue L, Yezhen L, Shijie C, Lifen J, Jianlin L, Deqiang L, Jiliang H. (2009) **Impact of 1.8-GHz radiofrequency radiation (RFR) on DNA damage and repair induced by doxorubicin in human B-cell lymphoblastoid cells.** *Mutat Res*. 695(1-2), 16-21.

- "In vitro study, a comet assay was used to determine whether 1.8-GHz radiofrequency radiation (RFR, SAR of 2W/kg) can influence DNA repair in human B-cell lymphoblastoid cells exposed to doxorubicin (DOX)
- DNA damage was detected at 0h, 6h, 12h, 18h and 24h after exposure to DOX via the comet assay, and the percent of DNA in the tail (% tail DNA) served as the indicator of DNA damage.
- The results demonstrated that (1) RFR could not directly induce DNA damage of human B-cell lymphoblastoid cells; (2) DOX could significantly induce DNA damage of human B-cell lymphoblastoid cells with the dose-effect relationship, and there were special repair characteristics of DNA damage induced by DOX; (3) E-E-E type (exposure to RFR for 2h, then simultaneous exposure to RFR and DOX, and exposure to RFR for 6h, 12h, 18h and 24h after exposure to DOX) combinative exposure could obviously influence DNA repair at 6h and 12h after exposure to DOX for four DOX doses (0.075microg/ml, 0.10microg/ml, 0.15microg/ml and 0.20microg/ml) in human B-cell lymphoblastoid cells."

Endocrine System

Kesari KK, Kumar S, Behari J. (2011). **900-MHz microwave radiation promotes oxidation in rat brain.**

Electromagn Biol Med. 30(4), 219-234**.**

- Significant decrease in the enzyme activities of glutathione peroxidase and superoxide dismutase, and an increase in catalase enzyme activity. Protein kinase C enzyme activity was significantly decreased in the samples of the exposed group (hippocampus and whole brain).
- A significant decrease in the level of pineal melatonin and a significant increase in creatine kinase and caspase 3 enzyme activities was observed in the exposed group (whole brain).
- A significant increase in the level of reactive oxygen species was also recorded.

Kesari KK, Kumar S, Behari J. (2012). **Pathophysiology of microwave radiation: effect on rat brain. Appl Biochem Biotechnol** . *Appl Biochem Biotechnol*. 166(2), 379-88.

- A significant decrease in the level of pineal melatonin of the exposed group.
- A significant increase in creatine kinase, caspase 3, and calcium ion concentration was observed in whole brain of exposed group of animals.
- The study concludes that a reduction in melatonin or an increase in caspase-3, creatine kinase, and calcium ion may cause significant damage in brain due to chronic exposure of these radiations. These biomarkers clearly indicate possible health implications of such exposures.

Koyu A, Cesur G, Ozguner F, Akdogan M, Mollaoglu H, Ozen S.(2005). **Effects of 900 MHz electromagnetic field on TSH and thyroid hormones in rats.** *Toxicology Letters.*157(3), 257-262.

- TSH values and T3-T4 at the 900 MHz EMF group were significantly lower.
- These results indicate that 900 MHz EMF emitted by cellular telephones decrease serum TSH and T3-T4 levels.

Kumar S, Kesari KK, Behari J.(2011). **The therapeutic effect of a pulsed electromagnetic field onthe reproductive patterns of male Wistar rats exposed to a 2.45-GHz microwave field.** *Clinics (Sao Paulo)*. 66(7), 1237-45.

- Significant increases in caspase and creatine kinase.
- Significant decreases in testosterone and melatonin in the exposed groups.
- This finding emphasizes that reactive oxygen species (a potential inducer of cancer) are the primary cause of DNA damage. However, pulsed electromagnetic field exposure relieves the effect of microwave exposure by inducing Faraday currents.

Mortavazi S, Habib A, Ganj-Karami A, Samimi-Doost R, Pour-Abedi A, Babaie A. (2009). **Alterations in TSH and Thyroid Hormones following Mobile Phone Use**. *Oman Med J. 24(4), 274–278.*

- A higher than normal TSH level, low mean T4 and normal T3 concentrations were found in mobile users.
- “It may be concluded that possible deleterious effects of mobile microwaves on hypothalamic-pituitary-thyroid axis affects the levels of these hormones.”

Reviews of the Research:

Blank M, Goodman R.(2009). **Electromagnetic fields stress living cells.** *Pathophysiology. 16(2-3), 71-8.*

- "Electromagnetic fields (EMF), in both ELF (extremely low frequency) and radio frequency (RF) ranges, activate the cellular stress response, a protective mechanism that induces the expression of stress response genes, e.g., HSP70, and increased levels of stress proteins, e.g., hsp70.
- While low energy EMF interacts with DNA to induce the stress response, increasing EMF energy in the RF range can lead to breaks in DNA strands. It is clear that in order to protect living cells, EMF safety limits must be changed from the current thermal standard, based on energy, to one based on biological responses that occur long before the threshold for thermal changes".

Carpenter DO. (2013). **Human disease resulting from exposure to electromagnetic fields.** *Rev Environ Health.* 28(4), 159-72.

- This review summarizes the evidence stating that excessive exposure to magnetic fields from power lines and other sources of electric current increases the risk of development of some cancers and neurodegenerative diseases, and that excessive exposure to RF radiation increases risk of cancer, male infertility, and neurobehavioral abnormalities.
- In summary, current extensive evidence shows that exposure to excessive levels of ELF and RF EMFs results in elevated rates of cancer and some other diseases, and such evidence is rapidly growing.

Cucurachi S, Tamis WL, Vijver MG, Peijnenburg WJ, Bolte JF, de Snoo GR. (2013). **A review of the ecological effects of radiofrequency electromagnetic fields (RF-EMF).** *Environ Int.* 51, 116-40.

- A systematic review of published scientific studies.
- In about two third of the reviewed studies ecological effects of RF-EMF was reported at high as well as at low dosages.
- "We propose in future studies to conduct more repetitions of observations and explicitly use the available standards for reporting RF-EMF relevant physical parameters in both laboratory and field studies."

Davis DL, Kesari S, Soskolne CL, Miller AB, Stein Y. Swedish review strengthens grounds for concluding that radiation from cellular and cordless phones is a probable human carcinogen.Pathophysiology. 2013 Apr;20(2):123-9

- Recent analyses not considered in the IARC review find that brain tumor risk is significantly elevated for those who have used mobile phones for at least a decade. Studies carried out in Sweden indicate that those who begin using either cordless or mobile phones regularly before age 20 have greater than a fourfold increased risk of ipsilateral glioma.
- High resolution computerized models based on human imaging data suggest that children are indeed more susceptible to the effects of EMF exposure at microwave frequencies. If the increased brain cancer risk found in young users in these recent studies does apply at the global level, the gap between supply and demand for oncology services will continue to widen.
- Brain cancer is the proverbial "tip of the iceberg"; the rest of the body is also showing effects other than cancers.

Martin Pall. (2013). **Electromagnetic fields act via activation of voltage-gated calcium channels to produce beneficial or adverse effects,** *Journal of Cellular and Molecular Medicine.17(8), 958-65.*

- This paper reviews 24 different studies in which EMF exposures produce biological effects that can be blocked by using calcium channel blockers, drugs that block the action of voltage-gated calcium channels (VGCCs).

- EMF exposures act by partially depolarizing the electrical charge across the plasma membrane of cells, activating the VGCCs and it is the increased intracellular calcium levels that are responsible for the reaction to EMF exposure.
- This review explains a mechanism for non-thermal biological effects from EMFs whereby voltage-gated calcium channels are opened up in the cell membrane, allowing calcium to leak into the cells.

Markovà E, Malmgren L, Belyaev I, (2010). **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.* 118(3), 394–399.

- "The strongest microwave effects were always observed in stem cells. This result may suggest both significant misbalance in DSB repair and severe stress response. Our findings that stem cells are most sensitive to microwave exposure and react to more frequencies than do differentiated cells may be important for cancer risk assessment and indicate that stem cells are the most relevant cellular model for validating safe mobile communication signals."

Morgan L, Kesari S, Davis D. (2014). **Why children absorb more microwave radiation than adults: The consequences.** *Journal of Microscopy and Ultrastructure*. 2(2).

- Computer simulation using MRI scans of children is the only possible way to determine the microwave radiation (microwave radiation) absorbed in specific tissues in children.
- Children absorb more microwave radiation than adults because their brain tissues are more absorbent, their skulls are thinner and their relative size is smaller.
- International Cancer registries are showing increased incidence of Cancer. Because the average latency time between first exposure and diagnosis of a tumor can be decades, tumors induced in children may not be diagnosed until well into adulthood.
- The fetus is particularly vulnerable to microwave radiation. Microwave radiation exposure can result in degeneration of the protective myelin sheath that surrounds brain neurons.
- The 20 cm rule for tablets/laptops violate the "normal operating position" regulation.
- Conclusions: Adolescent girls and women should not place cellphones in their bras or in hijabs. Selling toys that use wireless should be banned.
- Government warnings have been issued but most of the public are unaware of such warnings. Exposure limits are inadequate and should be revised such that they are adequate.

Yakymenko I, Sidorik E, Henshel D, Kyrylenko S. (2014). **Low intensity radiofrequency radiation: a new oxidant for living cells.** *Oxidants and Antioxidants in Medical Science.* 3(1), 1-3.

- The group reported that of 80 studies, they had assessed, 92,5 % (= 76 studies) confirmed that mechanism of inflicting damage. "Unexpectedly, a strong non-thermal character of biological effects" had been documented.
- Low intensity radiofrequency radiation (RFR) emitted by mobile phone end-user devices "could lead

to mutagenic effects through expressive oxidative damage of DNA".

- "it is clear that the substantial overproduction of ROS in living cells under low intensity RFR exposure could cause a broad spectrum of health disorders and diseases, including cancer in humans. Undoubtedly, this calls for the further intensive research in the area, as well as to a precautionary approach in routine usage of wireless devices."