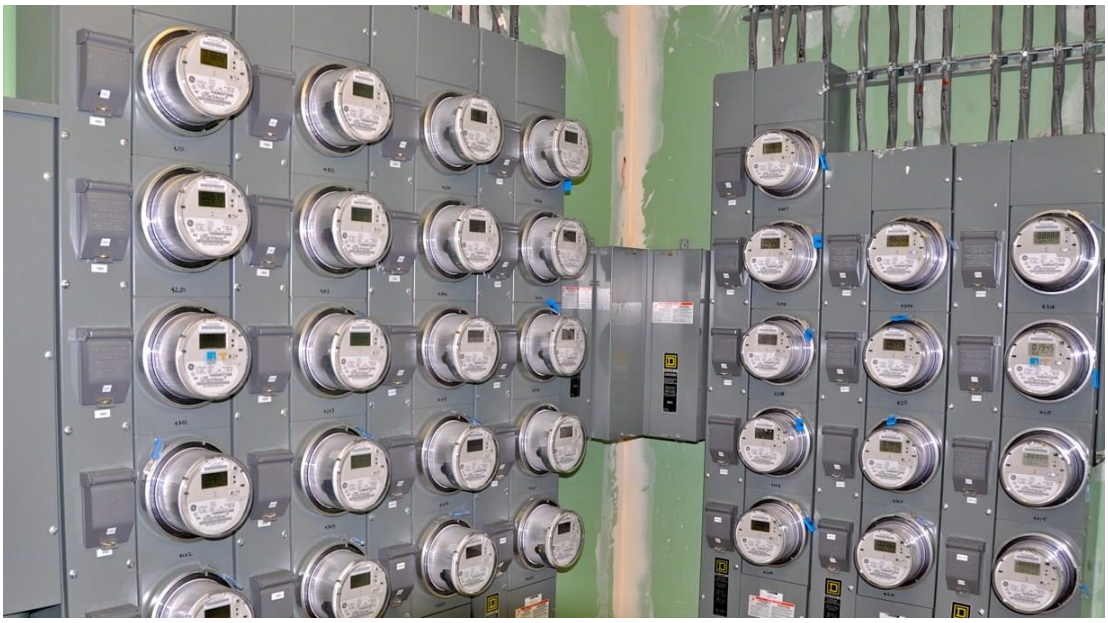
A New Paradigm in EMF Science

This article was published in 2016 in The Bent, which is the magazine for the National Engineering Honor Society. The organization has a membership of 87,000 engineers across the country and the overall response was quite positive. The article succinctly summarizes how EMF science now shows that wireless technology can harm our health and points toward solutions for our society.

I began to question the trajectory of our culture five years ago when a bank of wireless smart meters was installed below my bedroom in San Francisco. Within a week, my wife and I were experiencing headaches, insomnia, tinnitus, heart palpitations and fatigue.

We had never experienced these symptoms before and when we left our house, they diminished. After doing some research, I found the same thing was happening to thousands of people throughout California and other states and countries where wireless smart meters were being installed. [1]



Multi-family buildings often have a bank of smart meters like this next to units. Each wireless smart meter pulses on average 10,000 times per day, creating a dangerous situation for residents.

Image Credit: Karen Nevis

This set me on a journey to learn as much as possible about how electromagnetic fields (EMF) affect biology. I now have a website on this subject and recently gave a TED talk at TEDxBerkeley at the University of California, Berkeley. The talk is called "Wireless Wake-Up Call" and can easily be found through an internet search.

I encourage you to watch the TED talk before reading further as the talk is a good introduction to this subject. In this article, I dive more deeply and provide more technical analysis than a fifteen-minute talk for a general audience can allow. Below I will cover the basic problem with the recent exponential rise in EMF pollution, the evolution of EMF science and possible solutions for our society. I also provide steps that you can take today to create a much healthier home from an EMF perspective.

Jeromy at TEDx Berkeley this February. His talk was called "Wireless Wake-Up Call."

Image Credit: Repertoire Productions and Scott Snell

An Acknowledgment

Before we move on, I want to acknowledge that I realize this subject may be controversial for you. It was for me five years ago as well. The predominant world view in our society is that electromagnetic fields are completely safe as long as they do not heat or shock you. Much of our economy is based upon this assumption, so one would conclude that it *must* be true.

My intention for this article is not to be confrontational. It is to begin a discussion and to encourage some of the brightest minds in the United States to realize that we are not seeing the whole picture when it comes to the safety of wireless technology.

As you will see in this article and in your own research, there is now enough evidence that weak electromagnetic fields affect biology. This could have serious consequences for the future of our civilization; it is an issue we must begin to acknowledge so that solutions can be created. I welcome your feedback and to furthering this discussion.

The Exponential Growth in Wireless Technology

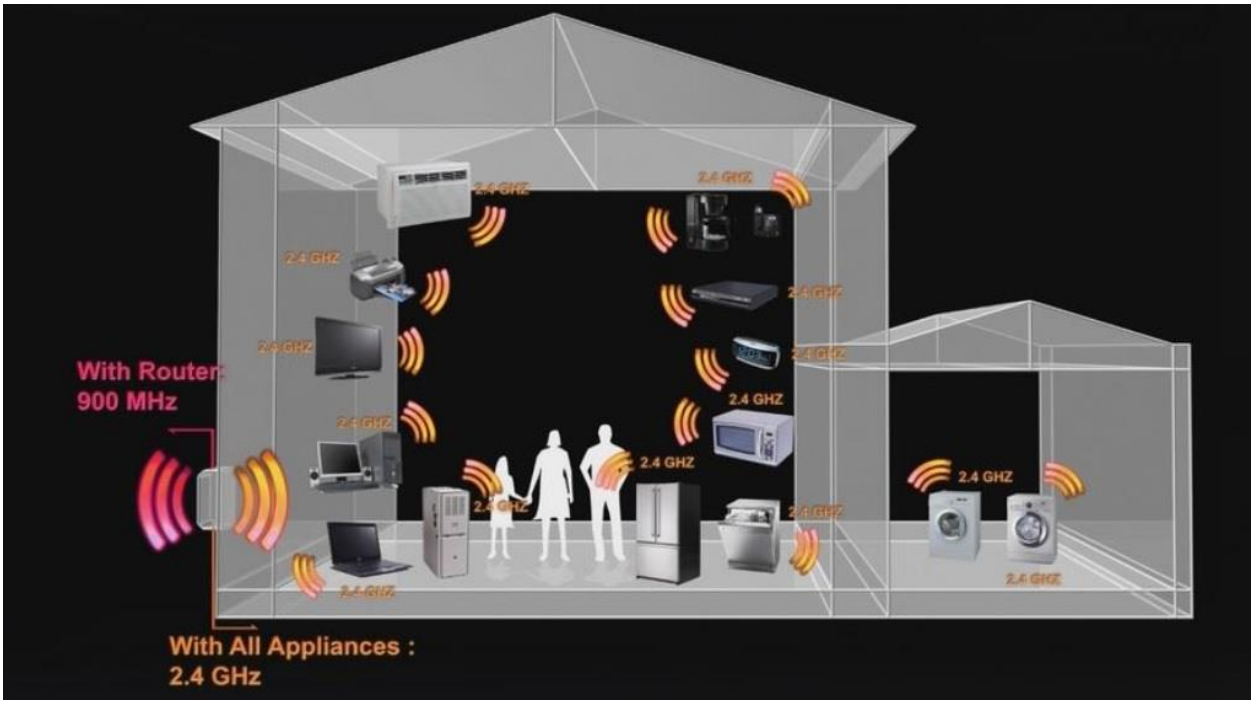
Our electromagnetic environment has changed immensely over the past ten years and wireless technology is set to expand even faster in the next five. Before the invention of the iPhone eight years ago, the electromagnetic exposure for most people was quite low unless they were early adopters of wireless technology or lived next to a cell phone tower.

However, today we have nearly ubiquitous WiFi, even in schools, and additional cell towers to provide the data to everyone's smart phone. We also have smart watches, smart utility meters, smart thermostats, smart homes and new vehicles with powerful Bluetooth and WiFi routers. This recent increase in microwave radiation is unprecedented, but it is only the beginning.

The next phase is the "Internet of Things," which will connect everything we purchase to the internet with its own IP address and wireless transmitter. The "connected home" of the future may have up to one million bursts of microwave radiation pulsing through it each day.

To make all of this work and to circumvent the community review process for cell tower siting, wireless companies are now joining with local governments to put powerful cell antennas on utility poles, often just ten to twenty feet from homes. This is the called the Distributed Antenna Systems (DAS) and is currently being rolled out in cities such as San Francisco, where new antennas are being placed on most city blocks. [2] Many cities in the United States will have this system in the coming years.

To add to this, Google and Facebook are competing to provide their own internet service to everyone. Through projects such as Google's "Project Loon," which will put up balloons with WiFi antennas at 60,000 feet [3] and Facebook's proposed 60 GHz Terragraph WiFi system, [4] our society has entered a new era of electromagnetic exposures. However, this is all being done with a holdover assumption from a previous era that pulsed microwave radiation is completely safe.

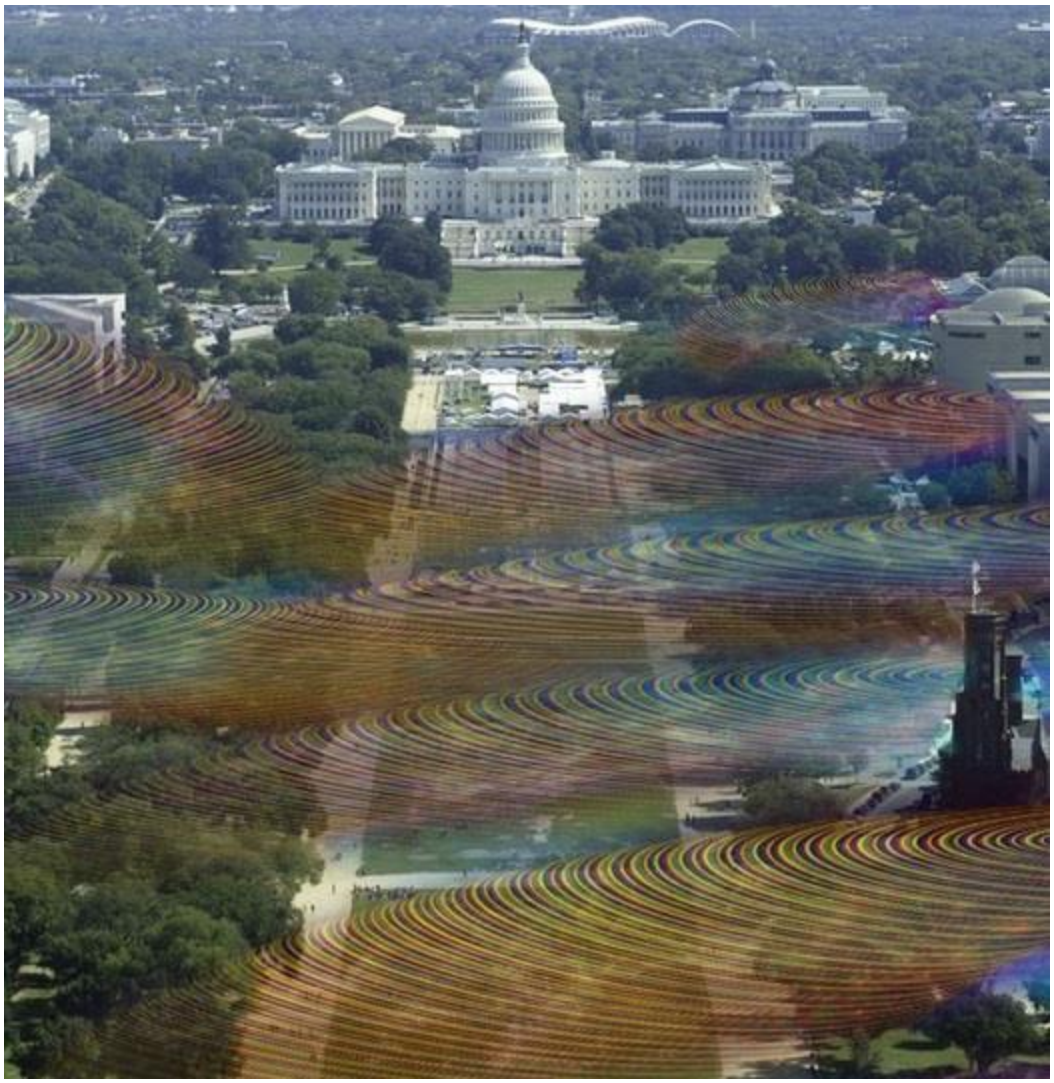


The “Smart” Home and the “Internet of Things” may be highly profitable for technology companies, but include health, privacy and internet security risks for families.

Image Credit: Take Back Your Power

A new DAS cell antenna in San Francisco. Thousands of these small but powerful antennas have recently been installed throughout the city, often directly adjacent to residences.

Image Credit: Jeromy Johnson



If we could see the explosion in wireless technology over the past decade, this is what it would look like.

Image Credit: Nickolay Lamm

The Primary Controversy with EMF

Our society's EMF safety guidelines are based on thermal standards. The idea is that if non-ionizing electromagnetic fields do not heat you, then they cannot possibly hurt you. Even though there is plenty of evidence that non-thermal EMF exposures cause biological damage, this evidence is repeatedly dismissed by the private bodies and government agencies that set the safety standards.

The reason for this is quite practical. In the 1950s, after the invention of microwave radar technology in WWII, the military and industrial applications of microwave technology were

seen as a higher priority than any potential ill effects on health. They reasoned that the Cold War and economic growth were much more important than the possibility of illness or cancer for a segment of the population twenty to thirty years in the future.

However, the people making those decisions in the 1950s and 1960s could have never imagined that sixty years later, our society would be experiencing the tremendous boom in consumer wireless technology that has occurred. Nor could they have imagined the predicament that future political and industrial leaders would find themselves in. Today we have a situation where the growth in consumer wireless technology has created some of the biggest and most profitable companies in the world. Wireless technology has quickly become an integral part of our economy and, lately, one of the few reliable growth sectors.

Wireless is also an incredibly popular technology that much of the population loves and is addicted to. [5] This is primarily because of the convenience and the fact that people simply enjoy communicating.

Plus, it provides immense tax revenue and surveillance capabilities to the government through data collection. For all of these reasons, there is no politician or industry leader who will be able to admit that the safety standards do not protect the public because they are not designed for the exposures we experience today.

The Evolution of EMF Science

The study of the biological effects of electromagnetic fields is a very complicated arena. It takes researchers who understand complex biological processes as well as the physics and engineering of electromagnetic fields. When studies find biological effects, they must then be replicated, but if just one parameter is changed slightly, the biological effect can be lost. Parameters include frequency, pulsation patterns, [6] power, polarization [7] and whether windows exist where effects can be more significant at lower power levels. Additionally, the funding to repeat studies is often not available, especially when almost all funding for this type of research now comes from industry sources that may not want to see results that might hurt their profits.[8]

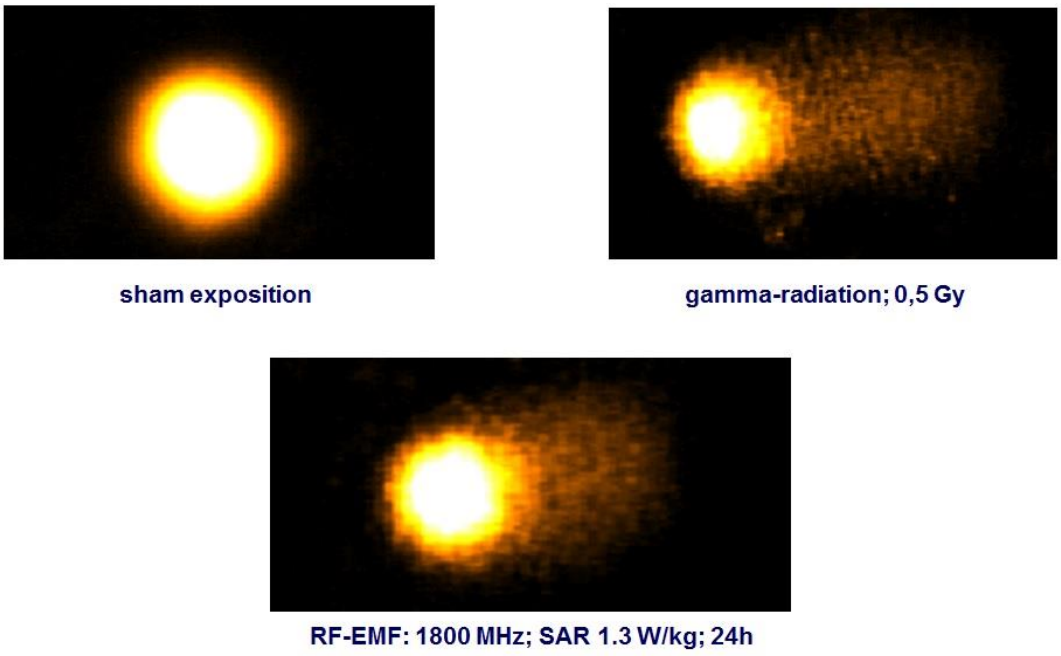
One of the first persons to discover the biological effects of non-thermal microwave radiation was Dr. Allan Frey. In 1975, Dr. Frey found that microwave radiation opened the blood brain barrier of rats, which is very similar to that of humans. [9] This experimental result has been repeated in subsequent studies [10, 11] and is of great concern because the blood brain barrier plays a vitally important role in the protection of the brain from pathogens, toxins and heavy metals.

Many other biological effects of non-thermal EMFs have been found over time. [12] They include sperm damage, nervous system disruption, cardiac/ECG changes, endocrine system malfunction, increased brain glucose levels, behavioral changes and acute symptoms such as

headaches, insomnia, tinnitus, difficulty concentrating and fatigue. In all, over 100 non-thermal biological effects have been documented in the thousands of studies that have been done on this subject. [13] As might be expected, there are also many thousands of studies that show no biological effects from electromagnetic fields. [14]

One of the most disconcerting effects of non-thermal microwave radiation is DNA damage. The reason is obvious: DNA damage can lead to cancer and this critical outcome would require that the authorities take action. The European Union funded REFLEX-Study looked at this exact issue. The 2004 study was coordinated by Dr. Franz Adlkofer in Vienna and the published results were very concerning for the cell phone industry and the public. [15] The data showed that cell phone radiation caused DNA damage. [16] This was obviously quite a surprise as it had been previously thought that non-ionizing radiation could not cause DNA damage because it was not strong enough to knock an electron off a molecule.

Not surprisingly, the study was quickly attacked and a leading industry-friendly scientist, Dr. Alexander Lerchl, publicly stated that the data must have been faked. The resulting media storm and pressure on the researchers and their universities diminished the impact of Dr. Adlkofer's study and prevented the use of European Union funds to further the research. However, after a full review and investigation, the research results stand and in 2015 the Hamburg District Court in Germany forced Dr. Lerchl to recant his allegations and convicted him of defamation and libel. [17]



REFLEX-Study comet assays show similar micronuclei results (DNA strand breaks, genotoxic effects) for both gamma radiation and microwave radiation from cell phone exposure. [16]

Image Credit: Clinical Chemistry, Free University of Berlin

Lerchl made the news earlier in 2015 for another reason. He was the head of a study that was a replica of a 2010 research project [18] that found weak 3G cell phone signals promoted tumor growth in mice. [19] The positive results of his study were another blow to the cell phone industry. They confirmed that when mice are exposed to a known cancer agent in the womb, ENU, and then also exposed to 3G cell phone radiation, there was a significant increase in tumor production over the mice that had been exposed only to ENU. [20] In a press release from Jacobs University in Bremen, Germany, Dr. Lerchl stated: "Our results show that electromagnetic fields obviously enhance the growth of tumors." [21]

This is a significant recent change for a leading scientist who has spent the past couple of decades publicly stating that there is no good science showing non-thermal biological effects from electromagnetic fields. However, if research increasingly shows DNA damage and cancer promotion from non-ionizing microwave radiation, what is the biological mechanism? For, without a mechanism, it will be difficult for the scientific community to fully accept this new paradigm.

A Mechanism for DNA Damage

In 2013, Dr. Martin Pall made a key discovery that helps us to understand this new paradigm. [22] Through a review of the scientific literature and his own meta-study, the professor emeritus from Washington State University found that one of the primary non-thermal effects of electromagnetic fields is the activation of voltage-gated calcium channels (VGCCs) in the plasma membrane of cells. When electromagnetic fields activate these channels, large amounts of intracellular calcium (Ca2+) are produced. This excess calcium within the cells produces a chain of chemical reactions leading to the production of free radicals and oxidative stress. The free radicals then culminate in DNA damage. [23]

The diagram below shows the basic outline of this mechanism. In short, the excess calcium directly increases nitric oxide (NO) within cells. The increase of nitric oxide can result in therapeutic effects, which is one reason why non-thermal electromagnetic fields are increasingly used in medical therapies. However, nitric oxide can also interact with superoxide (OO-) to create peroxynitrite (ONOO-). It has been found that when peroxynitrite breaks down, it creates reactive free radicals and oxidative stress within cells. [24] It is these free radicals and oxidative stress from peroxynitrite that are thought to be the main culprit in causing disease and DNA damage.

I encourage you to read Dr. Pall's research papers showing how this knowledge could be used to create technologies that reduce the activation of VGCCs [25] and also to watch his recent presentation at the University of Oslo in Norway. [26] In addition, the IEEE Power Electronics

Magazine recently published an article summarizing a similar mechanism for biological effects from weak electromagnetic fields. [27]

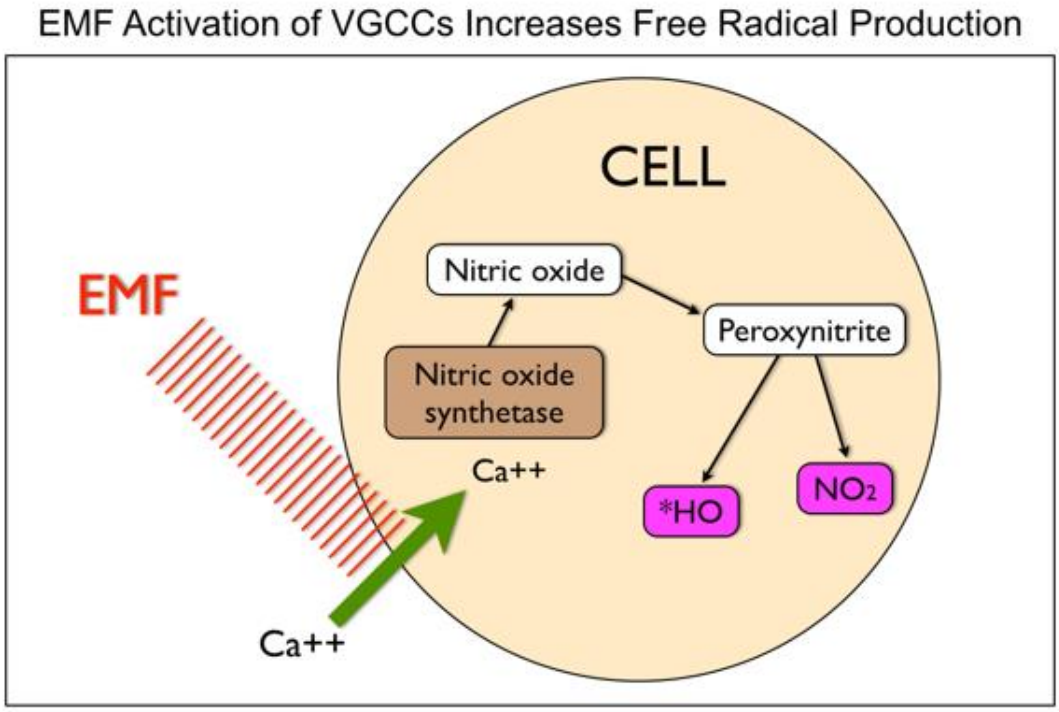


Image Credit: Dr. Paul Dart and Dr. Martin Pall

Editor's Note: This article was written before the preliminary results of the landmark $25 million National Toxicology Program study were released earlier this year. The results showed cancer and DNA damage in rats at non-thermal microwave radiation exposures. This study is so important that even the American Cancer Society said it marked "a paradigm shift in our understanding of radiation and cancer risk." When combined with the multiple high-quality studies that show increased cancer risk and reproductive harm for long-term cell phone users, those who continue to state that wireless technology is harmless are now on the wrong side of science.

Protection of the Public

We are now at the point where it is no longer tenable for regulatory bodies to claim that non-thermal electromagnetic fields are safe. This is happening simultaneously with the expansion of wireless technology at an unprecedented rate. Unless something is done, within five years much of our civilization will be filled with levels of microwave radiation that are known to cause disease.

In the United States, the one regulatory body that could change the course we are on is the Federal Communications Commission (FCC). This body sets the legal exposure limits. However, its primary objective is actually to increase and monitor the advancement of wireless technology. The health of the public is not its primary concern, nor even its job. This is likely why the FCC only protects the public from thermal exposures.

To further complicate this matter, the FCC is believed to be heavily influenced by the wireless industry. In 2015, the Harvard School of Ethics and journalist Norm Alster published a report on this situation called "Captured Agency." [28] Mr. Alster details how the revolving door between the agency and the industry it supposedly regulates is endangering the public. You have to look no further than the head of the FCC, Thomas Wheeler, who was once the top wireless lobbyist in the country. Former FCC commissioners also lead prominent wireless lobbying organizations.

It should be noted that Norm Alster wrote about the Dot Com crash and the 2008 Financial Crisis before they occurred. That he would now turn his considerable journalistic abilities toward this issue is very telling.

One of the most striking aspects about the FCC is that the agency does not have the expertise to determine the safety of electromagnetic fields. It is legally tasked with one of the most important public safety issues, but essentially takes no responsibility. Instead, it counts on private and semi-private scientific organizations to inform it. These organizations include IEEE, the American National Standards Institute (ANSI), the National Council on Radiation Protection (NCRP) and the International Commission on Non-Ionizing Radiation Protection (ICNIRP). [29]

Private Organizations Set Public EMF Safety Standards

One of the primary organizations that western governments, including the United States, use to set microwave radiation safety guidelines is ICNIRP. [30] However, there is a problem with using private bodies for something as important as public safety. Small, private clubs can be easily manipulated by lobbying and by pressure from industry and military interests.

Private organizations can also self-select members who have a certain bias toward EMF science without comment or input from the public. This is a highly un-democratic way to choose the people who are responsible for determining if the technology our children and grandchildren use on a daily basis is actually safe.

Prof. Dariusz Leszczynski of Finland is an accomplished RF scientist who has written about the dangers of this situation. He was on the thirty-one member WHO IARC (International Agency for Research on Cancer) committee that in 2011 determined non-thermal microwave radiation is possibly carcinogenic (Class 2b Carcinogen). [31] In a recent article, he noted that the current ICNIRP members and new members coming in for the 2016-2020 term are known to have identical opinions on EMF safety: [32]

- RF-EMF does not cause any health effects.
- Human sensitivity to RF-EMF does not exist.
- The only biological mechanism for RF-EMF is thermal.
- Non-thermal biological effects do not exist.

If our safety standards are set by an unaccountable private body made up of members who already have a bias against the considerable science showing detrimental non-thermal EMF biological effects, then it is likely we are setting up for a major health crisis.

A Path Forward for Society

What I have shared thus far could be considered the bad news. The good news is that solutions do exist. On a personal level, there are many things you can do to make your home, office and children's schools safe from an electromagnetic perspective. In the two sidebars accompanying this article, the basic steps you can follow are clearly laid out. By taking these steps, you can begin to minimize the exposure levels for you and your family until the political will arises to create solutions on a broad scale.

Solutions also exist on a societal level and this is where engineers can be of immense value. One of the primary solutions is to wire our society with optical fiber. Using light to transmit data creates no electromagnetic fields, except at the switches. Fiber optics is also "future proof" because it provides nearly unlimited bandwidth. This will allow our technology industries to prosper as bandwidth is no longer a limiting factor. Finding inexpensive ways to bring fiber optics to and within every home will be a boon for our society. There are already companies doing this [33, 34, 35] and a company in Germany and Austria has already developed a technology that turns existing copper wiring into fiber optics by extracting the copper and blowing in optical fiber.

We can also create safer products. This includes lowering the radiated power of consumer wireless devices so that the emissions are not just within the FCC guidelines, but at levels that are determined to be safer for users. Research will be needed for this, but based on the work of Dr. Pall and others, it may be possible that there are certain wireless frequency, polarization, pulsation and power combinations that have minimal biological effects. It will take very complicated research to determine these windows, but once we admit we have a problem, this work can begin in earnest and will help society tremendously.

For now, one of the most important things we can do is to limit the rollout of wireless technology to only necessary applications and in ways that do not directly overexpose humans, especially children. Our current carefree expansion of wireless technology must come to an end. A more intelligent path forward is needed if we are to have a technological society that is also safe for humans.

I believe that acknowledging the importance of this issue will move our society forward in a beneficial direction. It will also birth entire industries devoted to creating safer technology. Billion dollar ideas and companies can be created in this new frontier. You may already have an idea that will serve the forward-thinking parents who are now demanding safer technology for their children. As engineers, creating a healthy society with incredible technology would be a true paradigm shift and one of the greatest achievements we can accomplish. I hope that you will join me in this grand endeavor.

For links to all references, please visit: www.emfanalysis.com/tbp

Original print article: www.tbp.org/pubs/Features/Su16Johnson.pdf

Spanish and French versions of this article are also available online at:

https://www.emfanalysis.com/new-paradigm-emf-science/

About the Author:

Jeromy Johnson has a B.S. and M.S. in Civil Engineering from the South Dakota School of Mines & Technology. He was the president of the SDSM&T Tau Beta Pi chapter from 1998-1999. His focus the past five years has been the health effects of electromagnetic fields and solutions for safer technology. You can learn more and contact him at www.emfanalysis.com.

How to Create a Low-EMF Home:

When it comes to your own home, there are four different types of electromagnetic fields that can be easily remedied. They include:

- **Microwave Radiation:** Created by our wireless technology, this has crept into our homes in the past decade. See side bar for the most important steps to take to reduce this form of pollution.
- **Magnetic Fields:** Home wiring errors, stray current and major powerlines can create high magnetic fields in a home. Most homes have two to three wiring errors that can be easily corrected.
- **Electric Fields:** Standard Romex wiring can create high electric fields in a home. This can be remedied by turning off circuit breakers to the bedrooms at night. If you are remodeling or building a new home, then use MC Cable or EMT conduit with compression fittings, which will greatly reduce electric fields.
- **Dirty Electricity:** Electromagnetic interference (EMI) will be put on your home wiring by dimmer switches, CFL and LED lighting, certain electronics and solar inverters. By

reducing and eliminating these sources of EMI (you can purchase incandescent bulbs online), the power quality in your home will be much healthier.

You can measure each of these four types of electromagnetic fields or hire an EMF consultant in your area. I explain how to do this for yourself on my website. Once you locate and remedy each of these types of electromagnetic pollution, your home will be much healthier for decades to come.

10 Steps to Reduce Wireless Exposures

1.) Use your cell phone wisely. Never put it to the head. Use speaker phone or an "Air-tube" headset. Refrain from putting an operating cell phone in a front pocket of a shirt or pair of pants.
2.) Turn off all of the antennas in your settings (Cellular Data, WiFi, Bluetooth, etc.). This will allow you to send/receive calls and texts, but the phone will not ping the network every few seconds.
3.) You can use your smart phone as an alarm clock by putting the phone in "Airplane" mode while you sleep.
4.) If you have WiFi in your home, plug the router into a simple Christmas light timer so it is off while you sleep. When we sleep is the most important time to have a low-EMF environment.
5.) Move toward a wired home. You can turn off the WiFi functions of your router and use Ethernet cables to access data for your computers and devices.
6.) Know that distance is your friend when it comes to EMFs. Being 50 or 100 feet from a neighbor's WiFi router is much safer than having a router next to your desk.
7.) If you have a home phone, use a wired version rather than a cordless DECT phone that radiates 24/7.
8.) Advise new parents to ditch their wireless baby monitor. They are incredibly strong emitters and are often within a few feet of a sleeping infant. Google "Safe Baby Monitor" for better versions.
9.) Join parents around the country in demanding that schools be wired. There is no reason to bathe children in strong WiFi for years when safer Ethernet and fiber optic solutions exist.
10.) Avoid the "smart" home and wireless "smart" meters. These are part of a new push for the "Internet of Things." This technology will exponentially increase microwave radiation exposures in your home.