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The Harmful Effects of Electromagnetic Fields Explained

Analysis by Dr. Joseph Mercola ✔ Fact Checked | July 09, 2023

STORY AT-A-GLANCE

- Exposure to microwave EMFs, like cellphones, causes massive mitochondrial dysfunction due to damage done by free radicals from peroxynitrite that also cause single and double stranded breaks in your DNA
- Excessive free radicals triggered by low-frequency microwave exposure from cellphones and Wi-Fi networks have been linked to chronic diseases such as cardiac arrhythmias, anxiety, depression, autism, Alzheimer's and infertility
- Excessive calcium signaling produced by EMF exposures also has important roles in producing pathophysiological effects of EMFs including each of the effects listed above
- Strategies that may help reduce the harmful effects of EMFs include optimizing your magnesium level, certain Nrf2-boosting foods, exercise, calorie restriction and strategies that boost nitric oxide signaling (which acts, in turn, by raising Nrf2)

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I've often noted that electromagnetic fields (EMFs) are a pernicious, hidden health risk. But exactly how does this kind of microwave radiation damage your health? Martin Pall, Ph.D., has identified and published research describing the likely molecular mechanisms of how EMFs from cellphones and wireless technologies damage plants, animals and humans.[1,2,3,4]

Pall has a bachelor's in physics from Johns Hopkins and a Ph.D. in biochemistry and genetics from Caltech, and is uniquely qualified for this type of research. For the past 18

years, he's been scouring the medical literature, integrating and drawing parallels between work done by others to answer this pressing question. Pall explains:

> *"There is a huge amount of information out here that nobody has the time to integrate, digest and make connections [between]. That's what I've been doing … I was interested in EMFs before I could understand how they worked. Then I stumbled onto two papers that told me, 'Well, this looks like the way they work,' and then I dug out more and more papers …*
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> *What the [initial two] studies showed was that you could block or greatly lower the effects [of EMF] by using calcium channel blockers … That was the key observation …*
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> *Now [I have found] 26 [papers] … They all show that EMFs work by activating what are called voltage-gated calcium channels (VGCCs). These are channels in the outer membrane of the cell, the plasma membrane that surrounds all our cells. When they're activated, they open up and allow calcium to flow into the cell. It's the excess calcium in the cell which is responsible for most if not all of the [biological effects]."*

EMFs and Intracellular Calcium

When you expose cells to EMFs, there's increased intercellular calcium. You also get increases in calcium signaling, which is important as well, in terms of explaining the damage EMFs cause. For the past 25 years, the industry has claimed that non-ionizing radiation is harmless and that the only radiation worth worrying about is ionizing radiation. Pall's research unequivocally proves that this assumption is false.

> *"It's been very clear, going back all the way to 1971 and even before that, that this wasn't true. But we didn't know what the mechanism was. Now, we do. I think it's very important, because the industry's been trying to hoodwink everybody for decades. Now we know how it works.*

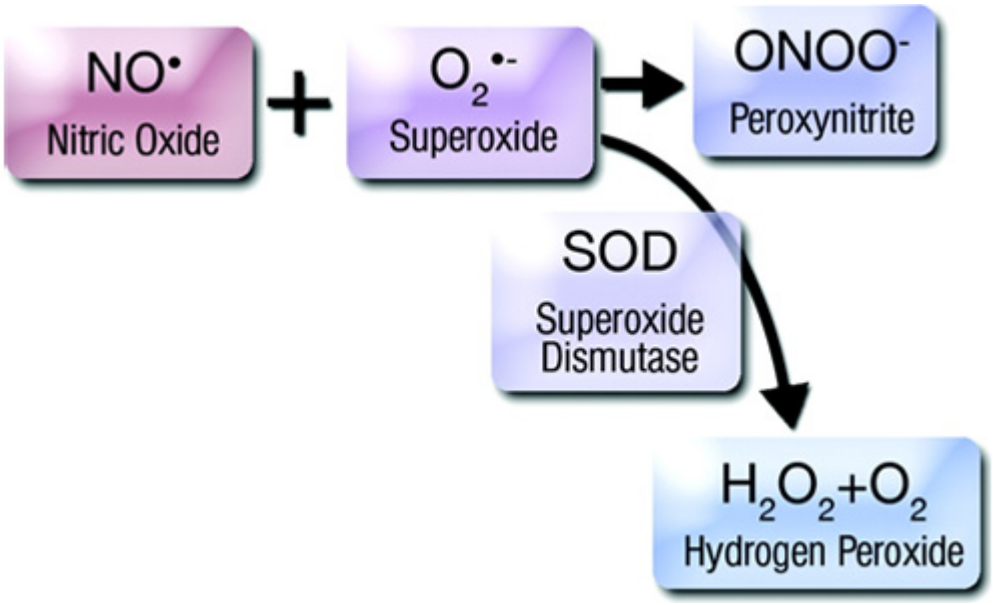
One of the other things that's very important about this is that there is a wide variety of different health impacts that have been reported. Now we can explain how [these problems arise]."

How EMFs Damage Your Health

When your VGCCs are exposed to EMFs, they open up, allowing abnormally large volumes of calcium ions into the cells — about 1 million ions per second per channel. Each VGCC has a voltage sensor, a structure that detects electrical changes across the plasma membrane and opens the channel. EMFs work through the voltage sensor to activate the channel and radically increase intracellular levels into dangerous ranges.

"Because of the structure of the voltage sensor and its location in the plasma membrane, one can predict from basic physics that it's extraordinarily sensitive to the electrical forces from EMFs," Pall notes. On average, these forces are approximately 7.2 million times stronger on the voltage sensor than they are on singly charged electrical groups in the aqueous (watery) part of the cell. What this means is that current safety standards are off by a factor of about 7 million.

That's how these very weak EMFs, which industry claims can't possibly cause you any harm, are actually taking you out prematurely. They work by activating VGCCs. This turns out to be absolutely critical, because when there's excess calcium in the cell, a number of things happen. Not only do you get excess calcium signaling, you also get increased nitric oxide (NO). While NO has many beneficial health effects, massively excessive NO reacts with superoxide.



Superoxide levels also rise in response to increased intercellular calcium. Together, they form peroxynitrite, which is an extremely potent oxidant stressor. While not a free radical, peroxynitrites break down to form reactive free radicals, both reactive nitrogen species and reactive oxygen species (ROS) including hydroxyl free radicals.

"You get both, because you get hydroxyl radicals and carbonate radicals and NO2 radicals," Pall explains. All three do damage. According to Pall, most of the damage is likely done by excessive free radicals, but some damage is caused directly by the peroxynitrites.

The end result is rather massive harm, as excessive oxidative stress and nitrosative stress are involved in nearly all chronic disease. Much of the pathophysiology also has to do with the excessive calcium signaling, independently of peroxynitrite.

NO Signaling Pathway Versus Peroxynitrite Pathway

It's important to realize that not all oxidative stress is harmful. There's a certain baseline of free radicals that's biologically useful and necessary. NO, for example, is a free radical, yet it has many very beneficial effects. The problem is excessive oxidative stress. Interestingly, Pall notes that the NO signaling pathway and the peroxynitrite pathways inhibit each other, which I never previously knew.

Why You Cannot Depend on Industry Claims

Many are unaware that the telecommunications industry is perhaps more well-funded than the pharmaceutical industry, and just as powerful politically. Their lobbyists are very effective in disseminating and protecting the industry's version of the truth. Needless to say, the industry will also actively discredit research that demonstrates harm and/or defund research projects that start to reveal problems.

In fact, the current head of the Federal Communications Commission was formerly the chief lobbyist for the telecommunications industry — one of the worst cases of the disgusting revolving door between industry and government and the fox guarding the hen house that I have seen in sometime.

> *"I know how they've attacked various people,"* Pall says. *"In the U.S. … the funding for the EMF research [by the Environmental Protection Agency] was cut off starting in 1986 … The U.S. Office of Naval Research had been funding a fair amount of research in this area [in the '70s]. They [also] … stopped funding new grants in 1986 … And then the National Institutes of Health (NIH) a few years later followed the same path …*
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> *[I]t's actually shocking to say there are only two countries in the world that are doing a lot of research in this, well beyond their normal scope … Turkey and Iran … they're doing quite a bit of good research in both of those countries on EMFs … What I've been doing is I've been doing it on my own. I've been contributing my time to it and my efforts and, at least to a small extent, some money to it. But it doesn't cost that much, so I can do it.*
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> *So, we have the fact that the money was cut off. One strongly suspects the industry had a role on that. The industry, with the 1996 Telecommunications Act, gave the regulation to the Federal Communications Commission (FCC), which has done nothing in terms of protecting the public.*
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> *In addition, they prevented the public from protecting their health with regard to their exposures from the cellphone towers. We cannot sue to prevent cellphone*

towers from being put near our workplace or homes. Basically, what the Congress did was to say our health makes no difference … So, we're in extremely deep trouble," Pall says.

Neuropsychiatric Effects of EMF Exposure

And this brings us to the crux of the problem, namely the physical locations where VGCCs are the densest, and the subsequent diseases you can expect from chronic excessive exposure to EMFs. The highest density of VGCCs are found in your nervous system and, indeed, studies dating back to the 1950s and '60s show the nervous system is the organ that is most sensitive to EMFs.

Some of these studies show massive changes in the structure of neurons, including cell death and synaptic dysfunction. When the VGCCs are activated in the brain they release neurotransmitters and neuroendocrine hormones. Hence, consequences of chronic EMF exposure to the brain include the following, which Pall details in a 2016 paper:[5]

- Anxiety
- Depression
- Autism
- Alzheimer's

In animals exposed to EMFs, there are massive, cumulative effects in the brain. Genetic polymorphism studies also show that elevated VGCC activity in certain parts of the brain produces a variety of neuropsychiatric effects.

"I reviewed a [large number] of studies on various kinds of EMF exposures, each of them showing neuropsychiatric effects. What you find is that these effects have been repeated many times in these epidemiological studies.

It's the same thing that everybody's complaining about, 'I'm tired all the time,' 'I can't sleep,' 'I can't concentrate,' 'I'm depressed,' 'I'm anxious all the time,' 'My

memory doesn't work well anymore.' All the things everybody's complaining about.

We know all those things are caused by EMF exposures. There's no doubt about that. Because we know their effects on the brain, we know that the VGCCs' excessive activity can produce various neuropsychiatric problems.

Here we've got all of these epidemiological data that confirms this is happening in humans who live near cellphone towers, who were exposed to Wi-Fi, who were exposed to broadcasting radiation, who use cellphones, tablets and so on. That's very important. I think we should care about this."

Cardiac Effects

Your heart is also very sensitive to EMFs, particularly the pacemaker cells of your heart, as they have the highest density of VGCCs. As a consequence of this, we find that EMFs tend to trigger the following conditions. If you have any of these conditions (or any of the ones discussed above and below), you need to know that EMF exposure is a major contributing factor and take immediate and aggressive steps to remediate your exposure.

- Cardiac arrhythmias (associated with sudden cardiac death)
- Atrial fibrillation / atrial flutter
- Premature atrial contractions (PACs) and premature ventricular contractions (PVCs), also known as heart palpitations
- Tachycardia (fast heartbeat) and brachycardia (slow heartbeat)

Reproductive Effects

A third area with densely populated VGCCs is the reproductive system, particularly the male testes. A consequence here is impaired or reduced fertility. There is evidence showing EMFs can cause both male and female infertility, but male infertility has been

more studied. Pall describes a classic reproduction experiment published 19 years ago by Ioannis Magras and Thomas Xenos in Greece:

> *"They took young pairs of mice, one male and female. They put them in a little cage on the ground outside in an antenna park … The [radiation] levels at the ground were well within our current safety guidelines … They put them in two different locations, one with a higher level of exposure and one with a lower level of exposure.*
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> *What they found was that at the higher-level exposure, each pair produced one litter that was approximately normal sized, then a second litter that was clearly down in numbers and then complete infertility — not a single mouse born …*
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> *At lower level exposure, it was basically the same story, except it took twice as long. They produced four litters with decreasing numbers, and then complete infertility. We have now, in humans in many countries around the world, decreased male sperm count — down by over 50 percent in Western countries, and about half of that amount in other countries around the world.*[6,7]
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> *The senior author in that paper is saying, 'If this keeps going, we're going to become extinct,' just from the drop in male sperm count. We know that that occurs in humans — in people who carry their cellphones in their front pockets, men who use their laptops with the Wi-Fi on sitting on their lap. We know that occurs. But of course, industry denies everything."*

Indeed, studies have linked low-level electromagnetic radiation (EMR) exposure from cellphones to an 8% reduction in sperm motility and a 9% reduction in sperm viability.[8,9] Wi-Fi equipped laptop computers have also been linked to decreased sperm motility and an increase in sperm DNA fragmentation after just four hours of use.[10]

EMFs and Cancer

Studies on cancer have also been blocked by the industry in a number of ways, including preventing researchers from obtaining real-world data on cellphone usage. Obviously,

people who use their cellphones the most are at greatest risk. While not at the top of the list of concerns associated with EMF exposure, cancer is yet another potential consequence of mitochondrial damage.

Women who carry their cellphones in their bra, for example, risk cancer in the upper inner quadrant of the breast, which is very atypical and not the usual upper outer quadrant.

Brain cancer is another possibility from extended cellphone use if you keep the phone to your ear. That said, emphasizing the cancer risk is likely counterproductive, as most people use cellphones and those who develop brain cancer are few and far in between.

The problem is brain cancer has a latency period of a decade or more. Arrhythmias, autism, anxiety and Alzheimer's, on the other hand, are extremely prevalent these days, and we now have a mechanism that explains how EMF contributes to all of them.

So, even though two U.S. senators likely got brain cancer from cell phones (Ted Kennedy and John McCain), it's important to understand that cellphone dangers are not just about brain cancer. It's all these other problems as well, including infertility. "In my judgment, cancer is down around No. 4 or No. 5 on the list of my concerns. It's not that cancer is not important. It's very important. We're just looking right now at the early stages because of long latencies," Pall says.

What Is More Dangerous, Cellphones or X-Rays?

If you are like most, the answer is obvious: X-rays. That is because you have been convinced by the deceptive lies of the telecommunications industry that have lobbied the government to reinforce this delusional myth. The reality is that there is compelling evidence showing cellphones are more dangerous than X-rays — by several orders of magnitude.

Some of the best evidence comes from a German study (headed by professor Franz Adlkofer), in which the effects of ionizing radiation equivalent to 1,600 chest X-rays were compared to 24 hours on a cellphone. Surprisingly, they found both produced roughly

equivalent amounts of DNA breaks in in-vitro assays. According to Pall, this actually vastly underestimates the effects of cellphones, because they used a continuous wave EMF, not pulsed.

There's extensive evidence showing pulsed EMFs are far more damaging than continuous wave EMFs. That's important for a number of reasons, including the fact that all wireless communication devices communicate by pulsations. In another paper, the group showed that when you use pulsations designed to be similar to the pulsation from a real cellphone, damage occurred at far lower intensities.

> *"This raises the question, 'How can this possibly happen?' I think the answer comes from the kind of diagram I've published, which is how EMFs produce free radicals,"* Pall says. *"Both ionizing radiation and the microwave frequency EMFs produce DNA damage through free radicals. They're similar in that way. Where you get the free radicals is through the peroxynitriate pathway.*
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> *It turns out that when you go from EMFs to the free radicals on that pathway, there are three steps that involve high levels of amplification. One of them is when you open up the channels, you get about a million calcium ions flowing in per second. The second is that you get increases in NO and superoxide.*
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> *Those, in effect, will be the calcium acting catalytically, because once it's in the cell, as long as it's elevated, you keep getting more and more [NO and superoxide]. And then those two react with each other to form peroxynitrite. The reaction rates are the product of the two concentrations. So you have three levels of amplification. If you have three levels of amplification, you get a hell of a response to a very small stressor."*

Ionizing Radiation and DNA Breaks

The industry says there's not enough energy in microwave radiation to cause direct damage to covalent bonds in DNA. This is true. There isn't. It's the biological amplification resulting in excessive oxidative stress that causes the damage.

Interestingly, even most of the damage caused by ionizing radiation is actually due to secondary free radical formation that breaks DNA. It's not directly from the energy within the radiation. Pall explains:

> *"That was published by Arthur Compton. He got the Nobel Prize for it in 1927. The way in which ionizing radiation works, it basically gets molecules and atoms and knocks electrons out, and then you get pairs of free radicals generated. That's called Compton scattering.*
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> *There is amplification from ionizing radiation, but it's only at one level. One energetic photon can produce a chain of free radicals. You've got three levels of amplification with the microwave frequency EMFs. The amount of damage you get based on those studies is truly extraordinary. Of course, Adlkofer and [Pilger] Rudinger were severely attacked by the industry."*

Practical Strategies to Limit Your Exposure

Naturally, to reduce your risk of harm, you need to reduce your exposure to EMFs. Cellphone towers should be a major concern if you work or go to school within 300 meters (about 1,000 feet) of one. Even just driving around can expose you to substantial cellphone tower radiation.

Your cellphone is a major source of exposure, as are cordless phones, Wi-Fi routers, Bluetooth headsets and other Bluetooth-equipped items, wireless mice, keyboards, smart thermostats, baby monitors, smart meters and the microwave in your kitchen. Ideally, address each source and determine how you can best limit their use.

A simple remedy is to turn off your Wi-Fi each night. That's just unnecessary exposure. Not carrying your cellphone on your body, and not using your laptop directly on your lap are other simple measures.

You can get cellphone pouches that are shielded on one side, so putting that side toward your body gives you some protection. Use your cellphone with a headset or on speaker phone. Work toward hardwiring your devices so you don't have to be in a Wi-Fi

field and don't get unnecessary radiation from cordless mice, keyboards and printers. It is also possible to put up shielding in your house or apartment to lower exposures.

Once you know the mechanism of harm, you have a better idea of how to remediate the problem. In this case, since we now know the effects of EMFs are reduced by calcium-channel blockers, a natural solution would be to make sure you're getting enough magnesium. Most people are deficient in magnesium, which will worsen the impact of EMFs. As noted by Pall:

> *"It is clear that when you're deficient in magnesium, you get excessive activity of the VGCCs. You also get excessive calcium influx through the N-methyl-D-aspartate receptor, caused by magnesium deficiency, which is also problematic, so it's important to allay that deficiency.*
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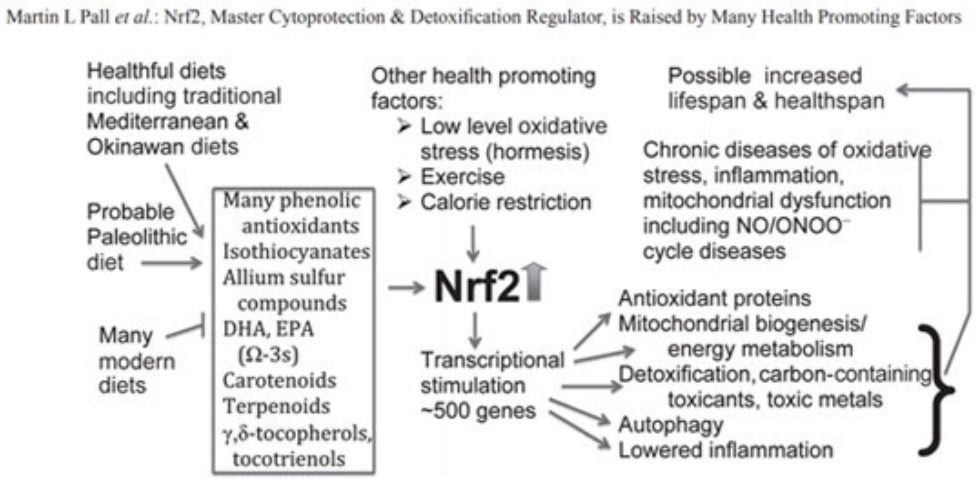
> *Now, I always tell people I'm a Ph.D. and not an M.D. None of these [suggestions] should be viewed as medical advice. But I think one approach to dealing with these things is to raise the level of nuclear factor erythroid-2-related factor 2 (Nrf2), which I published [a paper[11]] on."*

How to Activate Nrf2 to Reduce EMF Impact

I am in the process of writing a very comprehensive paper on Nrf2, which is a vitally important biological hormetic that upregulates superoxide dismutase, catalase and all the other beneficial intercellular antioxidants. It also:

- Lowers inflammation
- Improves mitochondrial function
- Stimulates mitochondrial biogenesis
- Helps detoxify the body from xenobiotics, carbon-containing toxicants and toxic metals
- Activates the transcription of over 500 genes in the human genome, most of which have cytoprotective functions. This includes the three genes that encode enzymes

required for synthesis of reduced glutathione, which is one of the most important antioxidants produced in your body



One simple way to activate Nrf2 is to consume Nrf2-boosting food compounds, such as sulforaphane from cruciferous vegetables, foods high in phenolic antioxidants, the long-chained omega-3 fats DHA and EPA, carotenoids (especially lycopene), sulfur compounds from allum vegetables, isothiocyanates from the cabbage group and terpenoid-rich foods.

Exercise, calorie restriction (such as intermittent fasting) and activating the NO signaling pathway (one way of doing that is the NO dump exercise) will also raise Nrf2. In his paper, Pall notes:

> *"The important detoxification roles of Nrf2 mean that raising Nrf2 activity is likely to be of particular importance to the hundreds of millions of people around the globe who are regularly exposed to toxic chemicals that cause diseases characterized by oxidative stress, inflammation and mitochondrial dysfunction, diseases which include most of the chronic diseases of 21st century life."*

"One of the things I argued in that paper is that the two most helpful diets known — the traditional Mediterranean diet and the traditional Okinawan diet — are both high in nutrients that raise Nrf2," Pall adds.

Take-Home Message

I personally believe EMF exposure may be one of the most significant factors for the observed decrease in male sperm count, and the increased prevalence of anxiety, depression, autism and Alzheimer's. It is also highly likely a contributing factor to cancer.

While not widely publicized, in May 2011, the cancer research arm of the World Health Organization, the International Agency for Research on Cancer, classified radiofrequency EMF — such as the radiation from cellphones — a class 2B carcinogen, meaning it is possibly carcinogenic to humans.[12]

Pall has made a significant contribution to public welfare with his discovery of how EMFs cause biological harm, and it would be wise to take notice. I personally believe he deserves a Nobel Prize for his contribution to the science.

Again, the damage is not done through heat or ionizing radiation; it's done by activating your VGCCs, thereby triggering a chain-reaction that produces excessive amounts of ROS, peroxynitrites and hydroxyl free radicals — the most destructive free radicals known to man, as well as through excessive calcium signaling.

Hydroxyl free radicals decimate mitochondrial and nuclear DNA, their membranes and proteins. Too much calcium in the mitochondria can also impact their function. The end result is mitochondrial dysfunction, which we now know is at the heart of most chronic disease. Since your brain, the pacemaker in your heart and male testes have the highest densities of VGCCs, these areas are the most prone to damage when exposed to EMFs.

What this research tells us is that excessive microwave exposure can be a direct contributor to conditions such as Alzheimer's, anxiety, depression, autism, cardiac arrhythmias and infertility.[13] So, if you care about your heart, brain and reproductive health, avoid carrying your cellphone in your pocket or on your hip, avoid using portable computers and tablets on your lap and take measures to limit or eliminate as many unnecessary EMF sources as you can, in your home and at work.

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