

## Electromagnetic Fields/Radiation and Health

Lyn McLean, Director of EMR Australia interviews Dr. Leendert Vriens, physicist, retired Philips Research Fellow, webmaster <https://www.stopumts.nl> (database since 2004)

**1. You are a physicist who has studied the scientific literature on the effects of electromagnetic (wireless) radiation. Thank you for talking with me today. I'm sure you have many interesting ideas to share with our listeners.**

Hello Lyn, I'm pleased to be here.

**2. To start with, can you tell us what harmful effects of wireless radiation have been observed?**

Yes, I will start with some information from the past.

Already in 1932 a book about microwaves was published wherein the author, Dr. Schliephake, described various health problems of people working close to microwave transmitters.

After the second world war and before the year 2000 detailed reports were published by all three US Defence organisations, the Navy, the Army and the Air Force (1 – 3). From the 1994 Air Force report I quote:

*“Experimental evidence has shown that exposure to low intensity radiation can have a profound effect on biological processes. The nonthermal effects of RF/MW radiation exposure are becoming important measures of biological interaction with EM fields.”*

In that report reference is made also to Russian investigators who, and I quote: *“have placed a great emphasis on the nonthermal effects of biological exposure to RF/MW radiation. They contend that electromagnetic interactions with the bioelectrical and biochemical functions of the body constitute a more serious health risk than effects from thermal heating”.*

Part of this early work was based on observation of health effects, mainly with microwave and radar workers. These observations initiated the interest in military applications, to use microwaves as a military weapon. Hence the US Defence reports, which describe both observations and the results of the scientific studies available at that time. A detailed inventory of the various health effects can be found in these reports.

Since the early nineties non-military wireless communication has become more important and nowadays that is the main problem as far as health is concerned. The inventory of health effects has not changed much since then.

The **short-term health effects** include:

*Neurological effects*, like fatigue, headaches, dizziness, memory and concentration problems, insomnia and anxiety.

*Cardiac effects*, such as heart arrhythmias and high blood pressure.

*Eye problems*, such as pressure in the eyes, deteriorating vision and cataracts.

*Ear problems*, such as ringing and low-frequency noise.

*And a range of other effects*, such as skin problems (allergic reactions, burning), digestive problems and nosebleeds.

This list is based mainly on experiences and observations of people who suffer from one or more of these effects. An important criterium for adding a health effect to the list is that it occurs repeatedly when one is exposed to the radiation and that the effect is reduced or vanishes in a few days when the radiation source(s) is (are) removed or when one goes to a different place where there is no or a very small radiation level. Furthermore, there should not be an alternative explanation.

The **long-term health effects** partly overlap the **short-term effects**. Fatigue, pains, high blood pressure, hearing disturbing noise and digestive problems, to mention a few, can become permanent.

Other **long-term effects** include cancer, neurological diseases, genetic effects such as male sterility, miscarriage and birth defects. Scientific research has been very important in establishing the link between the exposure to RFR and these long-term effects. I will come to that later.

Also keep in mind that that this radiation may not be the only cause. Several environmental factors can be responsible, enhance each others' effects and may occur only or mainly in combination.

**3. Thank you. That's quite a list of problems linked with exposure to wireless radiation. Do you think we, as a society, should be taking notice of these observations?**

Yes, for two reasons. Firstly because the health effects can be of a very serious nature and secondly because history teaches us that observations of health effects almost always preceded scientific explanations and should therefore be taken seriously.

It took often a long time after the observations to find explanations and thereafter to get these accepted by the establishment. I will give a number of examples.

- The first preventive (smallpox) vaccination by Edward Jenner in 1796 was based on his observation that milkmaids, who came in contact with cowpox, were generally immune to smallpox. There was no 'scientific proof', viruses were unknown and the 'scientific explanation' came almost 100 years later.
- In 1847, the doctor's wards in the Vienna Maternity Hospital had three times the mortality of midwives' wards. Based on this observation Semmelweis proposed the practice of washing hands with chlorinated lime solutions. He had made the connection with the procedure that doctors, after postmortem examinations of women who had died of puerperal fever, directly went to the maternity wards without washing their hands. There they performed vaginal examinations, as required. The midwives did not undertake postmortem examinations nor vaginal examinations. There was no 'scientific proof', bacteria were unknown. Semmelweis's observation conflicted with the established scientific opinions and his ideas were rejected by the medical community. The 'scientific explanation and acceptance' came 40 years later.
- In 1854 there was a cholera outbreak in London. By observation (talking to local residents) John Snow identified the source: a public water pump with germ-contaminated water. This observation was in conflict with the then-dominant miasma (bad-air) theory. There was no 'scientific proof' and the 'scientific explanation' (bacteria in water) came 40 years later.
- X-rays (Röntgen radiation) were discovered in 1895. Widespread experimentation by scientists and physicians followed. This led to many stories of burn, hair loss and worse in technical journals of the time. The observations preceded the 'scientific explanation' and for a long time many physicians claimed there were no effects from X-ray exposure at all.
- Even in my own field, physics, the two most important theories of the 20th century - general relativity and quantum mechanics - were highly controversial for many years and were met with strong opposition from the 'old' professors.

Einstein did not get his Nobel price in physics in 1921 for the theory of general relativity of 1916 - that was too controversial.

- The drug thalidomide (softenon) was used from 1957 on in many countries, resulting in an epidemic of malformations of limbs, ears and internal organs. It took five years to link the observation of malformations to thalidomide. The producer denied the effects of thalidomide for years.

- The DES hormone was given to pregnant woman from 1940 to 1971. In the latter year, a report was published showing that seven of eight girls and young women (ages 14 to 22) who had been diagnosed with a rare vaginal tumor had been exposed prenatally to DES. Subsequent studies showed a 40-fold increased risk of vaginal/cervical cancer (clear cell adenocarcinoma) in women exposed in utero to DES. These so called DES daughters also suffered from other serious health problems. In the historical Wikipedia description, the word combination 'scientific proof' is absent.

- More recently, starting from 2007, we have had in the Netherlands an outbreak of Q-fever with about 100.000 infections. At least 25 persons died and many are chronically handicapped. It took the Dutch government three years to take action, because there was no 'scientific proof', as was said, that the infected goats could transfer the infection to humans.

I can add more examples, smoking to mention one. The tobacco industry denied for a very long time the connection between lung cancer and smoking.

**4. It's often said that the radiation used for wireless communication can't harm us because it is non-ionizing radiation, as opposed to ionizing radiation like X-rays that is known to be capable of causing health problems. As a physicist, do you agree?**

No, I will explain.

The photons of ionizing radiation, such as X-rays, indeed have enough energy to cause ionization and breaking of molecular bonds in our body. This can be harmful for our health.

The photons in non-ionizing radiation, such as in the RFR of wireless communication, don't have enough energy to cause biological effects. Their energies are 6 orders of magnitude smaller than those of the photons in the visible part of the spectrum and even more orders of magnitude smaller than those of X-ray photons.

On basis of this information the conclusion is frequently drawn, as you said, that the radiation of wireless communication cannot be harmful. This conclusion is completely incorrect.

The RF photon energies are indeed too small to be harmful, but one thing is missing, namely that these photons are not alone. They are emitted by an antenna, have one carrier frequency, one polarization direction and the same phase. In a classical description of photons they are waves. Having the same phase, next to the same frequency and polarization direction, means that the maxima and minima of these waves coincide and that their individual electromagnetic field components add up. Together they give a macroscopic electromagnetic field (EMF).

To some extent this is similar to water molecules piling up locally to result in waves on a water surface.

For a radiation intensity of  $3 \text{ mW/m}^2$ , coming from a cell tower and composed of 1 GHz photons, the number of photons passing this surface of one square meter per second is equal to  $5 \times 10^{21}$ . In their interaction with biological material these gigantic numbers of photons don't act individually, but together as one EMF, with an electric field strength of 1 V/m. This EMF penetrates in our body, is largely absorbed there and can cause harmful reactions. The individual photon energy is irrelevant.

### **5. So, you're saying that these packets of energy, these photons, act in concert with each other and do have the power to cause harm?**

Yes, that is what I was saying. I can make it more clear with an analogy. That is with a bridge (molecular bond), a very large weight (X-ray photon) and a peleton of 10.000 soldiers (RF photons). When the large weight is put on the bridge, the bridge collapses (breaking of the molecular bond). When one soldier (one photon) is standing on the bridge (RF photon hits a molecular bond) nothing happens. Even when all 10.000 soldiers are standing on the bridge nothing happens (still not enough weight). However, when they march at a fixed step (one frequency) over the bridge and when that frequency matches a vibration frequency of the bridge it starts to vibrate and then can collapse. So the processes are completely different and that is just the same for the interactions of X ray photons and RF EMF with our body, the processes are completely different, but both can lead to damage.

**6. There's also a view that we don't need to worry about wireless radiation because it exposes us to much less radiation than we get from natural sources like the sun. Do you agree?**

No, we certainly have to worry about the low-intensity wireless radiation.

The intensity of the man-made wireless radiation is indeed orders of magnitude smaller than the intensity of the natural radiation from the sun.

(on a summer day the radiation intensity deposited by the sun on earth can be over  $1000 \text{ W/m}^2$ . The radiation intensities we are subjected to by cell towers are almost everywhere less than  $0.025 \text{ W/m}^2$  and now after the introduction of 5G less than  $0.10 \text{ W/m}^2$ )

But, as I told you, the photons coming from a cell tower have one (carrier) frequency, one polarization direction and the same phase. Their individual field components therefore add up to a macroscopic EMF.

(with electric field strengths of 3 and 6 V/m for the mentioned radiation intensities of  $0.025$  and  $0.10 \text{ W/m}^2$ )

The photons from the sun, however, are mutually independent. They have different frequencies, different polarization directions and different phases. Their individual EMF components therefore don't add up and don't yield any macroscopic EMF.

The EMF from wireless communication penetrates in our body and induces currents, resonant interactions and interferences - involving charged and polar particles and magnetic particles.

The EMR from the sun does not yield any EMF and the individual photons don't penetrate in our body. Their only reactions are heating, sunburn when being exposed too long and vitamin D production, and of course make it possible for us to see.

**7. Another argument that we often hear is that wireless radiation can't hurt us because it's not strong enough to heat our bodies by 1 degree Celcius. Do you think that makes it safe?**

No, not at all. Let me first tell you where this  $1^{\circ}\text{C}$  comes from.

In this field of '*EMF and Health*' there are international standards for '*limiting exposure to time-varying electric, magnetic and electromagnetic fields*', as it is

said. This includes the radiation from wireless communication. The standards adopted by Australia and by most Western-European countries (not by all) are the guidelines of the *'International Commission on Non-Ionizing Radiation Protection'* (ICNIRP). Only heating of our body, with a temperature rise of 1°C within 6 or 30 minutes, is recognized therein to be harmful for our health.

This is in conflict with all the observations and experiences I told you about. The radiation intensities from cell towers, which radiate 24 hours a day, are too low to cause any heating.

With mobile phones, held close to the ear, heating is not always negligible. For some of these phones the radiation levels exceed those of the guidelines. Nevertheless, according to the experiences and observations of people, the orders of magnitude lower radiation levels from cell towers are already enough to cause the health effects mentioned.

Heating has almost never been a criterion for determining whether a biological effect is harmful or beneficial to our health.

- The harmful effects of tobacco (smoking), DDT, asbestos, glyphosate and many other chemicals, to mention some examples, are not based on heating.
- Beneficial effects of drugs are not based on heating.
- To be less vulnerable to the yearly flu epidemic many people take a daily dose of vitamins, like D3 and C. These doses are always so small that heating of our body is negligible. The recommended doses of different vitamins can also be very different, like 25 µg vitamin D3 and 1000 mg vitamin C.
- The same goes for toxins; 20 µg of botulinum toxin can kill about 1000 people, while it takes about 500 mg bee sting venom to kill one person.

In each case, heating of our body is negligible, but the doses needed to get a measurable positive or negative effect on our health can be extremely different and can also be extremely small.

Hence, not the energy of the dose is most important but the information contained in it, i.e. the molecular structure of its main ingredient(s). And this is, I think, almost always the case for things we eat, drink, inhale or are injected or inoculated with.

**The information is most important, the dose comes second.**

The doses can be very small and still have a large effect. Heating effects are almost always negligible (except of course for our normal food consumption).

**8. You mentioned that not all countries have adopted the ICNIRP guidelines for wireless radiation. Can you tell more about that?**

Yes you are right. The ICNIRP guidelines (4, 5) are adopted, as I said, by many Western-European countries and by Australia, but not in Italy, Belgium, Poland, Switzerland, Bulgaria, Russia, China and some other countries. The radiation limits in these countries are factors of 10 to 100 lower than those of the ICNIRP.

(in the USA the radiation limits of the Federal Communication Commission (FCC) are similar, but not exactly the same, to those of ICNIRP).

These stricter limits imply that the harmfulness of non-thermal biological effects is recognized to some extent in these other countries.

Finally there are the SBM-2008 and SBM-2015 radiation limits (6, 7), where SBM stands for 'Standard der Baubiologische Messtechnik'. These limits, from a private German organization, are the only ones that fully take into account people's 'observations' and 'experiences', especially those of the EHS persons. The recommended SBM radiation intensities are about a factor of one million smaller than those of the ICNIRP.

From what I have told you so far it should be clear that wireless communication and the continued expansion thereof are not compatible with the health of many.

Taking health effects into account would have made it impossible to roll out 3G, 4G and 5G in way it has been done and is still being done. 3G, 4G and 5G with wired (non-radiating) connections would have been possible of course without any health problems.

**9. So it sounds like you don't think that international standards protect us adequately, is that right?**

Yes, that's right. The ICNIRP guidelines as adopted by many countries only protect the Telecom industry and the Government licence income.

**10. So, if our standards for wireless radiation shouldn't be based on heating alone, what should they be based on?**



They should be based on the damaging non-thermal biological effects which occur at orders of magnitude lower radiation intensities and which were referred to already in the US Defence Reports from before the year 2000.

Almost all reactions in our body and all reactions with external material entering our body are determined by electromagnetic forces. That is because molecules, atoms and ions are composed of positively charged nuclei and negatively charged electrons. The wireless communication also introduces electromagnetic forces in our body. So, this is similar.

The information contained in molecules can be very complicated, such as in the extreme diversity of drugs and toxins. Our body can recognize this information and can learn to recognize and respond, within limitations. The EMF of wireless communication are also very complicated, with all the pulsed information needed for the communication. We know that people can become electrosensitive and electrohypersensitive (EHS) after long-term exposure to these EMF. So our body can therefore also learn to recognize and respond to these EMF, again within limitations.

There is no a priori reason why heating should be the only health problem with EMF exposure from wireless communication. And in order to understand in any detail how the radiation damages our body we have to go to the available scientific information.

### **11. Before doing so can you tell us whether you have any particular concerns about 5G?**

Yes, in every step from 2G, 3G, 4G there were and are more people with more serious health complaints. We are already seeing this with 5G, not only for the higher frequencies, but in the Netherlands also for the 700 – 800 MHz frequency band in which higher intensities and different modulation schemes are used.

### **12. Is what you have told us supported by peer-reviewed science?**

Yes, certainly. The scientific research on the effects of electromagnetic fields (EMF) is summarized, for example, in a database (EMF-Portal) of the University of Aachen in Germany (11). It contains thousands of scientific publications on the effects of the EMF used for wireless communication (10 MHz – 300 GHz) on health. These are subdivided into the following categories:

*‘Cancer, electromagnetic hypersensitivity (EHS), EEG/brain activity, cognitive, psychomotor and memory function, sleep, blood-brain barrier, fertility, genotoxicity, microwave hearing, indirect effects and therapeutic applications.’*

It is impossible to give a complete overview of the available scientific information, so I make a selection of some of the more important results. I add more detailed information in Appendix 1 of the written version of this interview.

#### • **Cancer**

In 2011 the WHO/International Agency for Research on Cancer (IARC) classified RF EMF as possibly carcinogenic to humans (Group 2B). This was based on an increased risk for glioma, a malignant type of brain cancer, associated with wireless phone use. In the 2013 IARC monograph (102) acoustic neuroma was added as a possible carcinogen. These classifications (12, 13) were mainly based on epidemiological studies.

Since then, much research has been done into the carcinogenicity of RF EMF, also with laboratory animals. In addition to brain gliomas, non-thermal RF EMF exposure has also been shown to lead to malignant heart tumors and DNA damage (14, 15).

#### • **Oxidative stress**

In a 2015 paper by Prof. Yakymenko and co-workers an analysis was made of the 100 then available studies dealing with oxidative effects of low-intensity RFR (16). Of these, 93 confirmed that non-thermal RFR induces oxidative stress in biological systems.

In a 2021 review paper (17) by members of the Swiss government expert group on EMF and non-ionising radiation, it was concluded that the increased levels of reactive oxygen species (ROS), induced by exposure to EMF, interfered with, and I quote:

*‘many vital cellular processes and functions, such as inflammation, cell proliferation and differentiation, wound healing, neuronal activity, reproduction and behavior. This interference involves altering of biochemical processes and leads also to DNA damage or peroxidation of fats.’*

It should further be mentioned that damages from EMF exposure are not only a matter of increased cell damage but also of reduced repair.

- **Fertility**

From a 2018 review paper by Dr. Santini et al. (18) I quote:

*'Numerous studies revealed the detrimental effects of EMFs from mobile phones, laptops, and other electric devices on sperm quality and provide evidence for extensive electron leakage from the mitochondrial electron transport chain as the main cause of EMF damage.*

*In female reproductive systems, the contribution of oxidative stress to EMF-induced damages and the evidence of mitochondrial origin of ROS overproduction are reported, as well.'*

(ROS stands for reactive oxygen species)

To keep it simple as far as men are concerned: both the sperm count and the sperm motility have been measured to be reduced by exposure to RF EMF.

- **Other**

Exposure of test persons to non-thermal RF EMF, of electrosensitive test persons in particular, has been shown to cause changes in ECG and EEG recordings and in cognitive performance.

Some test persons became more alert, while the accuracy of performing assigned tasks decreased. They also suffered from memory problems and from reduced sleep.

Much research has further been done with laboratory animals. I will mention the results on two topics.

\* Prenatal exposure of mice to RF EMF from cell phones was found to lead after birth to ADHD-like behavior, a reduced memory capacity and a reduced prefrontal cortex volume (19).

\* Exposure to low level microwave radiation from wireless devices can cause the blood-brain barrier (BBB) to become leaky and to open up, so that toxic molecules can pass (20). This can lead to lasting effects with an ultimately toxic result on critical neural structures in the brain.

### **13. Do you have any suggestions for our listeners about how they can reduce their exposure to wireless radiation?**

Yes, I will be happy to do so.

Quite generally, one should reduce one's exposure to the radio frequency EMF from wireless communication (frequently referred to as wireless radiation) as much as possible. One should preferably also reduce one's exposure to low-frequency (LF) electric and magnetic fields, but that topic is not included in this interview. So we confine ourselves to the RF EMF.

First, try to avoid carrying radiating devices, such as mobile (smart) phones and smart watches, on your body. Smart watches are not necessary, mobile phones cannot always be avoided but they have standby, sleep and airplane modes, next to completely off. Keep in mind that airplane mode doesn't always turn the radiation completely off. Use always the mode with the least energy consumption and, if you can, put your mobile at some distance. The radiation intensity you are exposed to decreases quadratically with distance to the source of radiation. Remove apps you don't use to further reduce the radiation intensity.

Next minimize the radiation levels in your home by replacing wireless connections with non-radiating wired connections. Many home appliances, consumer electronic devices in particular, are referred to as 'smart', implying usually that they have wireless connections. Wiring these devices does not necessarily mean that the radiating wireless part is turned off or even that it can be turned off. In buying consumer electronics devices for entertainment and communication make sure that they can be wired and that the radiating part can be turned off. Wired connections have the advantage over wireless connections that they are more stable, require less energy, cannot so easily be hacked and are better for your health. The wired connections must be made with ethernet cables. Internet connections via the electricity grid (with so called homeplugs) should not be used. These are known to be responsible for health problems. There are other devices such as smart meters and smart thermostats. Where possible choose non-radiating meters and thermostats. Bluetooth applications must also be avoided and wireless baby monitors should not be used (and certainly not be placed close to babies).

Minimizing the radiation levels in your own home (and work place) may not be enough. You may have neighbours (next door and/or above and below in apartments) with radiating devices and there may be cell towers nearby (e.g. within 800 meters with no obstacles in between and less with obstacles). A problem with RF radiation is that it does not only enter your home through windows, such as visible light, but also to a significant extent through brick

walls, floor/ceilings and (even more) through wooden walls. It is possible to shield from this radiation by applying conductive material. To assess whether and where shielding should be placed or whether or not it should be electrically grounded, you usually need a measurement specialist. Please note that shielding from the outside world will not work properly when you have radiating devices inside.

These are my suggestions for reducing your exposure to the RF EMF from wireless communication.

This part of what I told you was about how to reduce your exposure to RF EMF. The reason I haven't said anything so far about the many fancy gadgets being sold to neutralize your exposure (or something like that) is that they really don't do anything to reduce this exposure.

There are two possible exceptions. Some metallic stickers placed on mobile phones (in the near field) may change the shape of the emitted EMF. Some users report a positive health effect. The second possible exception is that adding a special additional field might reduce the negative health effects of exposure to the EMF of wireless communication. There might then be an analogy with adding the soothing sound of the murmur of the sea to the disturbing sound of a sound source which emits at one or a few disturbing frequencies. This is still questionable. So far my impression is that 99% of the gadgets on the market now does not have a positive health effect and may even have a negative effect.

**14. Thank you, Dr Vriens. You've given us a great deal of very interesting and useful information.**

**For everyone listening, Dr Vriens has kindly provided us with a written version of this interview that includes additional information as well, including some of the important and fascinating research on the health effects of wireless radiation. You'll see the link for this on our blog and I encourage you to take a look.**

**Thank you again, Dr Vriens. It's been a pleasure to talk to you.**

Lyn, I like to conclude my contribution with the hope that the information I have given is useful to many of you and thank you again for inviting me for this interview and for your questions of course.

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## Additions to the oral text

### Appendix 1.

Extended version of section 12 with answers to the question *“in how far is what you have told us supported by scientific information”*.

The EMF-Portal internet information platform (11) of the Aachen University in Germany summarizes scientific research data on the effects of electromagnetic fields (EMF). It contains a literature database with more than 34,900 publications and almost 7000 summaries of individual scientific studies (January, 2022). Included are effects of static, low-frequency (0.1 Hz – 1 kHz), intermediate (1 kHz – 10 MHz) and radio-frequency (10 MHz – 300 GHz) fields. The wireless communication falls into the RF category and in this category alone there are many thousands of scientific publications.

In the EMF-Portal database these are subdivided into the following categories:

*‘Cancer, electromagnetic hypersensitivity (EHS), EEG/brain activity, cognitive, psychomotor and memory function, sleep, blood-brain barrier, fertility, genotoxicity, microwave hearing, indirect effects and therapeutic applications.’*

This list partly overlaps the lists given earlier for the short-term and long-term effects I told you about. It is impossible to give a complete overview of the available scientific information, so I make a selection of some of the more important results.

- **Cancer**

In 2011 the WHO/International Agency for Research on Cancer (IARC) classified RF EMF as possibly carcinogenic to humans (Group 2B). This was based on an increased risk for glioma, a malignant type of brain cancer, associated with wireless phone use. This classification (2B, identical to that of DDT and leaded petrol) was made by a Working Group of 31 scientists from 14 countries that had been meeting in Lyon, France, to assess the potential carcinogenic hazards from exposure to RF EMF. These assessments were published in 2013 in IARC monograph 102. Acoustic neuroma was added therein as possibly carcinogenic. These classifications (12, 13) were mainly based on epidemiological studies.

Since then many studies on the carcinogenicity of RF EMF were published, the best well known are those of the US National Toxicology Program (NTP) and the Italian Ramazzini Institute (14, 15). In these studies malignant schwannomas (heart tumors), malignant brain gliomas and DNA damage were observed in rats and mice at non-thermal RF EMF exposure.

DNA damage (single- and double-stranded DNA breaks) due to non-thermal RF EMF exposure was also reported already in 1997 by Prof. Lai and in 2004 in the REFLEX study (21) performed in 12 institutes in 7 countries in the EU and in many later publications. DNA damage was found to occur simultaneously with formation of micronuclei, an indication of cancer, and with an increase in the number of free oxygen radicals, an indication of oxidative stress.

A recent review of the scientific literature in this field (22), a 176-page expert report including 443 references, was prepared for the plaintiffs in a major product liability lawsuit in the USA. The author, Dr. Portier, was a member of the already mentioned WHO/IARC Working Group and he was former director of the National Center for Environmental Health at the Centers for Disease Control and Prevention (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR), both in the USA. In his expert report he concluded:

*'In my opinion, RF exposure probably causes gliomas and neuromas and, given the human, animal and experimental evidence, I assert that, to a reasonable degree of scientific certainty, the probability that RF exposure causes gliomas and neuromas is high'.*

#### • **Oxidative stress**

In a 2015 paper by Prof. Yakymenko and co-workers (16) entitled '*Oxidative mechanisms of biological activity of low-intensity RF radiation*' an analysis was made of the, according to them, 100 then available peer-reviewed studies dealing with oxidative effects of low-intensity RFR. 93 of these confirmed that non-thermal RFR induces oxidative stress in biological systems.

In a 2021 review paper (17) '*Manmade Electromagnetic Fields and Oxidative Stress—Biological Effects and Consequences for Health*', Dr. Schuermann and Prof. Mevissen - members of BERENSIS, the Swiss expert group on electromagnetic fields and non-ionising radiation - identified and summarized the relevant animal and cell studies published between 2010 and 2020.

The increased levels of reactive oxygen species (ROS), induced by exposure to EMF, were said to interfere with, and I quote:

*'many vital cellular processes and functions, such as inflammation, cell proliferation and differentiation, wound healing, neuronal activity, reproduction and behavior. This interference involves altering of biochemical processes and leads also to DNA damage or peroxidation of fats.'*

It should further be mentioned that damages from EMF exposure are not only a matter of increased cell damage but also of reduced repair.

- **Fertility**

From a 2018 review paper (18) *'Role of Mitochondria in the Oxidative Stress Induced by Electromagnetic Fields: Focus on Reproductive Systems'*, by Dr. Santini et al. I quote:

*'Numerous studies revealed the detrimental effects of EMFs from mobile phones, laptops, and other electric devices on sperm quality and provide evidence for extensive electron leakage from the mitochondrial electron transport chain as the main cause of EMF damage.*

*In female reproductive systems, the contribution of oxidative stress to EMF-induced damages and the evidence of mitochondrial origin of ROS overproduction are reported, as well.'*

(ROS stands for reactive oxygen species)

To keep it simple as far as men are concerned: both the sperm count and the sperm motility have been measured to be reduced by exposure to RF EMF. This can be measured in a simple way with a microscope. Measuring DNA damage, such as with the Comet assay test, requires some more laboratory equipment in addition to the microscope.

- **Other**

Exposure of test persons to non-thermal RF EMF, of electrosensitive test persons in particular, has been shown to cause changes in ECG and EEG recordings and in cognitive performance.

Some test persons became more alert, probably due to the induced (oxidative) stress, while the accuracy of performing their assigned tasks decreased and in some cases did so significantly. They also suffered from memory problems. The electrical signaling in their brains was apparently disturbed by the electrical signaling from the applied RF EMF.

Test persons also suffered from reduced sleep, probably related to reduced production of melatonin in the pineal gland. Reduced melatonin levels were measured e.g. in the urine.



In this regard, sleep and melatonin levels, the RF EMF have an effect similar to that of blue light exposure in the evenings.

In addition to the studies with test persons, much research has been done with laboratory animals. This provided a lot of information. I will mention the results on two topics.

\* In one by Prof. Taylor et al., published in Nature in 2012, it was found that prenatal exposure of mice to RF EMF from cell phones led after birth to ADHD-like behavior, a reduced memory capacity and a reduced prefrontal cortex volume (19). According to the authors such a reduced prefrontal cortex volume has also been found with children with ADHD.

\* In many investigations, by Dr. Salford and others (20), it has been shown that exposure to low level microwave radiation from wireless devices can cause the blood-brain barrier (BBB) to become leaky and to open up, so that toxic molecules can pass. This can lead to lasting effects with an ultimately toxic result on critical neural structures in the brain. A connection has been made, for example, with the exponentially growing number of autistic children in the USA, from about 1 in 10,000 in the seventies of the last century to 1 in about 40 to 60 in 2016. This might be due to the combination of:

- the steadily increased cell phone use leading to increased leakage of the BBB,
- adding more vaccines to the children's vaccine schedule, which led to an about 4-fold increase of inoculated aluminum, one of the ingredients in vaccines, and
- the increased use of glyphosate in agriculture.

Due to this combination, increased amounts of aluminum and glyphosate can traverse the BBB to selectively accumulate in brain tissues, where they can increasingly induce unwelcome changes in brain biochemistry (23).

## **Appendix 2**

### **One may question how is it possible that so little is known to the general public about the problems we have been talking about?**

For long-term effects such as cancer one can understand that it is difficult to find the cause or causes; one may have been exposed to many environmental effects in the 10 to 30 years before cancer was diagnosed, while genetic factors also play a role.

For short-term effects one may think that it should not be that hard to link these to the radiation of wireless communication. Making this link in this case is, however, also more difficult than one might expect.

I will clarify that with another analogy: burn-out. People can be subjected for a long time to stress in different forms, in relations, at work, problems with children, with health and there can be financial problems. And then suddenly there is a burn-out. Is burn-out then a short-term problem? No, it is often the end of long-term exposure to stress factors.

Similarly, almost all of us have by now been exposed for many years to the gradually increasing intensity of RF EMF from cell phones, cell towers, DECT phones, WiFi and other wireless devices.

The number of people with unexplained health problems has also increased in a gradual way. But there is usually a time lag, often many years, between the first exposure to EMF and the first possibly related health problems. Because of this time lag it can be very difficult to make the connection. The result is that many of those with serious unexplained health problems and almost all of those with minor unexplained health problems are not aware of the possibility that wireless radiation could be responsible or partly responsible for their problems. For those who have been able to make the connection, this was usually by being informed by others.

But even then many just don't believe it, the government and the physicians would warn us if it would be so, they think.

Furthermore, a significant fraction of the population is by now addicted to their smart phones, they simply don't want to hear about health problems being caused by wireless communication.

Even for those who have become EHS without knowing the source of their problems it is not easy to link these to RF EMF because they are exposed to it permanently and never alternate days or weeks of exposure and no exposure.

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