Keywords: Keywords:

- Radiofrequency radiation; amplitude modulation;
- ELF;1 6 Hz; 60 Hz; modulation; enolase activity

Abstract-I

Some neurochemical effects of low-intensity electric and magnetic fields have been shown to be nonlinear functions of exposure parameters. These effects occurred within narrow ranges of frequency and intensity. Previous studies on membrane-associated endpoints in cell culture preparations demonstrated changes in calcium efflux and in acetylcholinesterase activity following exposure to radiofrequency radiation, amplitude modulated (AM) at 16 and at 60 Hz, at a specific absorption rate of 0.05 W/kg. In this study, these modulation frequencies were tested for their influence on the activity of a cytoplasmic enzyme, enolase, which is being tested clinically for detection of neoplasia. *Escherichia coli* cultures containing a plasmid with a mammalian gene for enolase were exposed for 30 min, and cell extracts were assayed for enolase activity by measuring absorbance at 240 nm. The enolase activity in exposed cultures was compared to the activity in paired control cultures. Exposure to 147 MHz carrier waves at 0.05 W/kg, AM at 16 Hz showed enolase activity enhanced by 62%, and AM at 60 Hz showed enolase activity reduced by 28%. Similarly, exposure to 16 Hz fields alone, at 21.2 V/m_{rms} (electric) and 97 nT_{rms} (magnetic), showed enhancement in enolase activity by 59%, whereas exposure to 60 Hz fields alone, at 14.1 V/m_{rms} (electric) and 65 nT_{rms} (magnetic), showed reduction in activity by 24%. Sham exposures as well as exposure to continuous-wave 147 MHz radiation at 0.05 W/kg showed no change in enolase activity. Although the underlying basis for these field effects in the cytoplasmic compartment has not been established, differential sensitivities to 16 Hz and to 60 Hz signals provide a clear focus for additional research to determine the responsible mechanism. © 1994 Wiley-Liss, Inc.

Keywords:

- Electromagnetic field;
- Cardiovascular system;
- ECG

Summary

1- We examined whether extremely low frequency electromagnetic fields (ELF-EMF) affect the basal level of cardiovascular parameters and influence of drugs acting on the sympathetic nervous system.

2- Male rats were exposed to sham control and EMF (60 Hz, 20 G) for 1 (MF-1) or 5 days (MF-5). We evaluated the alterations of blood pressure (BP), pulse pressure (PP), heart rate (HR), and the PR interval, QRS interval and QT interval on the electrocardiogram and dysrhythmic ratio in basal level and dysrhythmia induced by β-adrenoceptor agonists.

3-In terms of the basal levels, there were no statistically significant differences among control, MF-1 and MF-5 in PR interval, QRS interval, mean BP, HR and PP. However, the QT interval, representing ventricular repolarization, was significantly reduced by MF-1 ($P < 0.05$).

4- (−)-Dobutamine (β_1-adrenoceptor-selective agonist)-induced tachycardia was significantly suppressed by ELF-EMF exposure in MF-1 for the increase in HR (ΔHR), the decrease in QRS interval (ΔQRS) and the decrease in QT (ΔQT) interval. Adrenaline (nonselective β-receptor agonist)-induced dysrhythmia was also significantly suppressed by ELF-EMF in MF-1 for the number of missing beats, the dysrhythmic ratio, and the increase in BP and PP.

5- These results indicated that 1-day exposure to ELF-EMF (60 Hz, 20 G) could suppress the increase in HR by affecting ventricular repolarization and may have a down-regulatory effect on responses of the cardiovascular system induced by sympathetic agonists.

Keywords:

- **Human sperm; ELF-EMF; energy metabolism; mitochondrial activity**

Abstract-II

It has recently been reported that the exposure of human spermatozoa to an extremely low frequency (ELF) electromagnetic field (EMF) with a square waveform of 5 mT amplitude and frequency of 50 Hz improves sperm motility. The functional relationship between the energy metabolism and the enhancement of human sperm motility induced by ELF-EMF was investigated. Sperm exposure to ELF-EMF resulted in a progressive and significant increase of mitochondrial membrane potential and levels of ATP, ADP and NAD^+ that was associated with a progressive and significant increase in the sperm kinematic parameters. No significant effects were detected on other parameters such as ATP/ADP ratio and energy charge. When carbamoyl cyanide *m*-chlorophenylhydrazone (CICCP) was applied to inhibit the oxidative phosphorylation in the mitochondria, the values of energy parameters and motility in the sperm incubated in the presence of glucose and exposed to ELF-EMF did not change, thus indicating that the glycolysis was not involved in mediating ELF-EMF stimulatory effect on motility. By contrast, when pyruvate and lactate were provided instead of glucose, the energy status and motility increased significantly in ELF-EMF-treated sperm. Under these culture conditions, the inhibition of glycolitic metabolism by 2-deoxy-D-glucose (DOG) again resulted in increased values of energy and kinematic parameters, indicating that gluconeogenesis was not involved in producing glucose for use in glycolysis. We concluded that the key role in mediating the stimulatory effects exerted by ELF-EMF on human sperm motility is played by mitochondrial oxidative phosphorylation rather than glycolysis. Bioelectromagnetics 32:15–27, 2011. © 2010 Wiley-Liss, Inc.

Following table shows the electromagnetic spectrum, with some of the main sources of electromagnetic pollution.

ELECTROMAGNETIC SPECTRUM

	TYPE		FREQUENCY (Hz)	WAVELENGTH	ENERGY	SOURCES (partial list)
NONIONIZING	**Radio** (RF)	LF	3-300,000	100,000-1km	0.00126-126neV	▪electricity ▪ ultrasound ▪ electronic devices ▪ broadcasts ▪ radar ▪ body screening
		MF	300,000-3million	1km-100m	0.126-0.0126μeV	
		HF	3million-300billion	100m-1mm	0.0000126-1.26meV	
	Infrared (IR)		300 bill.-430 trill.	1-0.0007mm	1.26-1800meV	▪ fiber telecom ▪ remotes ▪sunshine
	Visual		430-750 trillion	0.0007-0.0004mm	1.8-3.1eV	▪ sunshine ▪ lighting
IONIZING	**Ultraviolet** (UV)		750 trill.-300qdrl.	0.4-0.001μm	3.1eV-1.2keV	▪ sunshine ▪ tanning
	X-rays		300qdrl.-50qntl.	1-0.006nm	1.2-200keV	▪ medical diagnostic (X-ray, CAT) ▪ baggage screening
	Gamma-rays		over 50 quintillion	under 0.006nm	over 200keV	▪ PET imaging

Hz=Hertz=1 cycle per second; 1,000Hz=1**kHz (**kilohertz**,** 10^3Hz**)**,
1million Hz=1**MHz (**megahertz**,** 10^6Hz**)**, 1billion Hz=1**GHz (**gigahertz**,** 10^9Hz**)**,
1trillion Hz=1**THz** (terahertz, 10^{12}Hz); 1quadrilion .Hz=1**PHz** (petahertz, 10^{15}Hz),
1quintillion .Hz=1**EHz** (exahertz, 10^{18}Hz); quintillion=1,000 quadrillions=1 million trillions
LF=low (radio) frequencies, **MF**=medium frequencies, **HF**=high frequencies
1mm=1,000μm (micrometer, micron)=1 million nm (nanometer)
1eV (**electronVolt**)=0.001keV=1,000meV=1 million μeV = 1 billion neV

February 2009

Is power pollution making you sick?

It was all fine while we were only using animals and steam to do the work for us. Then combustion engines came along, with coal and gas, opening the era of *power pollution* - that is, contaminating our environment with by-products of power production: smoke,

particulate matter, harmful chemicals and gasses. Then we learned how to use electromagnetic fields (EMF).

For a while, it was thought that this latest form of power source -the most common form of which is electricity - is a step ahead of messy combustion. Clean and safe, except for its high-energy end (i.e. ionizing radiation, from UV and X-rays to nuclear energy), it seemed to be just what doctor ordered.

Well - what do we ever know? For decades, officials were downplaying growing, mainly scientific evidence, indicating that this new, clean form of power may not be safe, even at the common levels of exposure. At this point, the evidence of its ability to cause multitude of adverse health effects is all but impossible to ignore.

Can something that we can't sense in any way hurt us? Officially, it can't; for long time now, the government maintains that the only EMF health danger comes from radiation strong enough to significantly raise body temperature, or to cause direct neuromuscular disturbance by inducing currents strong enough to affect neural function.

All safety standards for electromagnetic field (EMF) exposure are based on that assumption.

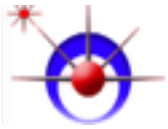
The real world, as usual, doesn't fit into simplistic schemes. One simple truth we all learned is that no thing is only good. There is always the negative, no matter how small. Should we expect the electromagnetic power to be an exception? Electricity and electronics that we have surrounded ourselves with have made our lives much easier, more comfortable and enjoyable. What is the negative here, besides it costing us money?

It is becoming all but certain that we are also paying for what we're getting with our health. Some people more than the others, but no one is really spared. The culprit is the enormous level of electromagnetic energy use in developed countries, and its invisible companion - the EMF pollution.

These days, we are living in the environment filled with electromagnetic radiation of various frequencies and intensities, with no place to hide. Power lines, electrical wiring, appliances, tools and equipment, radios, telephone, cars, stereo, television, fluorescent lighting, computers, office equipment, medical imaging, cell phones, PDAs and other forms of wireless technology, as well as countless other electronic companions of modern lifestyle, have saturated our living environment with various forms of tissue-penetrating energy fields, **to which our bodies haven't been exposed never before.**

The question is, how this new environmental pollutant affects health? We already know that high-energy *ionizing radiation*, such as UV light, X-ray, or radioactivity, can be damaging to health. Until now, it was believed that low-energy, non-ionizing radiation, from visible light and infrared to radiofrequencies, does not present health danger at commonly encountered exposure levels.

However, first indications that this assumption could be wrong are now three decades old. Back in 1979, Wertheimer and Leeper became aware of a link between exposure to power-frequency fields and the rate of incidence of childhood leukemia. Ever since, the evidence was mounting that the exposure to this form of EMF radiation **can also present serious health hazard,** particularly to the children, sensitive individuals and those with chronic illnesses.



As mentioned, the official medical/governmental safety standards recognize two mechanisms through which non-ionizing radiation can adversely affect the body. One, for mid and higher radio-frequencies, is raising tissue temperature by heating the water molecules. The other, for lowest frequencies, too weak to produce appreciable heating, is causing acute behavioral and neurological symptoms as a result of EMF induced electrical currents. Either requires levels of exposure much higher than those that we commonly encounter.

Officially contested but with too many scientific confirmations to be ignored, are immediate and long-term adverse health effects of much weaker fields resulting from their **interference with bioelectricity,** a very low-power, low-frequency electrical currents and potentials within the body, vital to the flow of life.

Do low-level energy fields, such as those typical of our common-level non-ionized radiation exposure, have the capability to interfere with these tiny electrical currents?

Do they affect resting potential of cellular membranes, or generating action potentials needed for signaling and communication, or pace and efficacy of the electron transport chain?

Can they disturb highly sensitive process of creation and use of free radicals (ions, electrons) by the body, increase uncontrolled leaks of these potentially harmful particles and cause increased rate of cellular damage?

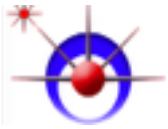
If low-level energy fields do interfere with bioelectricity, they also interfere with basic biological processes at the cellular level, including gene expression. Do these fields have enough energy to affect bioelectricity? Let's take a look at the common electricity.

Average residential exposure to power-frequency (50/60Hz electricity) field - which is a very low intensity field - is around 40 V/m, with the official safety limit for these frequencies being 10,000 V/m. In comparison, average resting membrane potential is between -40 to
-80mV (millivolt, 0.001V), and it is activated by differences in electrical potential on the order of 10mV, or less. That is **4,000 times, or more, lower than the average power-frequency field we are exposed to.**

Even considering that EMF quickly weakens as it penetrates the body, there is still more than enough field energy left to be sensed - and reacted to - by energy field-sensitive components in and around body cells.

It is no different with respect to stray voltage and high-frequency transient currents leaking from electrical lines and wiring. All human bio-electricity is of very low voltage and frequency. It is so low that galvanic currents created between different dental metals placed in your mouth - for instance, gold crowns and silver/mercury fillings - are capable of aggravating or even producing epileptic symptoms, or causing heart arrhythmia.

Why would we assume that weak currents and fields produced by electricity - as well as stronger fields produced by sources using higher EMF frequencies - will not disturb proper body function, make you feel unwell, and ultimately cause or contribute to a full blown disease?



In fact, all these questions are rhetorical. The evidence of low intensity non-ionizing EMF, often **many times bellow current official safety standards,** interfering with cellular processes, altering cellular function, or being linked to adverse health effects and diseases, has been piling up for decades, and more is added by newer, more sophisticated studies every year. Some studies, on the other hand, have not confirmed these findings.

Nevertheless, small but growing segment of population doesn't need any proof: they are convinced that EMF exposure, such as that to the EMFs created by power lines, appliances, home wiring, and other sources, as well as stray currents originating from power lines and wiring, negatively affect their health and wellbeing.

The variety of symptoms related to this new form of environmental illness is known as electromagnetic hypersensitivity. Its actual mechanism is still unknown, but it is officially acknowledged as "real" by the World Health organization (WHO, *International Workshop on EFM hypersensitivity*, Prague, 2004).

That the effect of weak non-ionizing radiation on biological tissue is real is also supported by most in-vitro (test tube) studies. At present, Sweden is unique in that it, in fact, recognizes the common-level EMF exposure as a **legitimate cause of debilitating diseases.**

In fact, it is well known - and utilized - for decades that weak electromagnetic fields can have profound bio-effect. Since as far back as 1970s, pulsating electromagnetic field has been successfully used to heal thousands of non-union fractures, when standard treatment and surgery failed; it is also effective for treatment of tennis elbow, pain of various origins, tendinitis (elbow, heel, rotator cuff), osteoarthritic knees, osteoporosis of the hips and spine, accelerating wound healing or healing resistant skin ulcers, osteonecrosis of the femoral artery (head), multiple sclerosis, even significant recovery of damaged nerves or easing Parkinson's. Known as Quantum Resonance System (QRS), originally German technology, it works by **constructively altering bioelectricity at the cellular level -** restoring healthy cellular membrane potential, beneficial flow of mineral ions, increasing cellular energy production, DNA/RNA and protein synthesis.

All this is accomplished by brief exposures to a very weak (0.3-40μT standard), very low frequency (3-1000Hz) magnetic field. For comparison, the range of residential exposure to power-frequency (50/60Hz) field in the U.S. is 0.01-0.95μT home, and up to 1.35μT workplace (Zaffanella, 1998). The only difference is that your residential exposure is constant (24-hour exposure for 99% of the population is in the 0.02-0.62μT range), and that power-frequency field is continuous-wave, not intermittent ("pulsed"), as with QRS.

Despite all that, major international health organizations, such as WHO (World Health Organization) and most governments around the Earth still maintain that there is "no sufficient evidence" proving that low energy EMF can have significant bio-effect, or that there is a direct link between exposure to low-energy electromagnetic fields and symptoms of compromised health. Consequently, they don't see the need to lower the official safe exposure limit to power-frequency fields, set at 100μT.

Maybe we should turn it around, and look for "sufficient evidence" proving that it does *not* negatively affect health? Just assuming that this new form of environmental pollution is not silently contributing to the epidemic of diseases plaguing developed countries appears to be very risky proposition. Also, a proposition that is contrary to most of existing scientific evidence.

Electromagnetic spectrum: health connection

Radio-waves, microwaves, extremely low frequencies including 50/60Hz standard electricity waves, AM, FM, light, X-rays - they all belong to the form of energy that we generally call radiation. More specifically, *electromagnetic radiation*. It comes in the wide range of frequencies, called *electromagnetic spectrum.*

This form of energy is created at the atomic level, as electrons release energy while switching from higher- to lower-energy orbits, or while freeing themselves from atomic bonds. This movement of electrons results from the need to maintain energy balance within the atom under the input of some form of external energy. Energy released by electrons propagates just like a wave sent along loose cord. A complete cycle, starting from the neutral point, through the top and bottom swing (i.e. *amplitude*) and back to the neutral level, makes a single wave oscillation. Number of oscillations per second is the *frequency*, and the length between these two points is the *wavelength* of electromagnetic wave. Since this energy moves at a constant speed - the speed of light - the product of wavelength and frequency equals the distance traveled by light in a second. The unit of energy released by electrons is called *photon*; it is proportional to the frequency, making higher-frequency fields as much more intense for given flux density (i.e. number of photons).

Thus, the radiated energy is defined by its frequency (of oscillation) or its wavelength. Since this energy comprises two distinctive forms, namely electric and magnetic force, the unit form of radiated energy is called *electromagnetic wave*, and its spatial expansion is electromagnetic field.

All forms of man-made electromagnetic radiation - electrical fields, radio waves, TV, radars, cell phones, security (screening), medical/diagnostic - are created by manipulating atoms into releasing electromagnetic radiation. As such, it is a part of electromagnetic spectrum, which encompasses the entire range of electromagnetic radiation, from its lowest to its highest frequencies. The EM spectrum is, somewhat arbitrarily, divided into a number of sub-ranges.

Following table shows the electromagnetic spectrum, with some of the main sources of electromagnetic pollution.

ELECTROMAGNETIC SPECTRUM				
TYPE	FREQUENCY (Hz)	WAVELENGTH	ENERGY	SOURCES (partial list)

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Hz=Hertz=1 cycle per second; 1,000Hz=1**kHz (**kilohertz**,** 10^3Hz**)**,

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LF=low (radio) frequencies, **MF**=medium frequencies, **HF**=high frequencies

1mm=1,000μm (micrometer, micron)=1 million nm (nanometer)

1eV (**electronVolt**)=0.001keV=1,000meV=1 million μeV = 1 billion neV

Specific division of the electromagnetic spectrum vary from one source to another. For instance, the World Health Organization (WHO) limits "radio-frequency" to 10MHz-300GHz range, with 10MHz-300Hz frequencies being called "intermediate", and those bellow 300Hz "extremely low frequencies" (ELF). *Microwave* range, form 300MHz to 300GHz (1m to 1mm wavelength range) is often presented as an independent range. Some sources present the lower portion of infrared, from 300GHz to 10THz (terahertz, 1,000MHz) as a separate range - *terahertz* - and so on.

The most accurate division of electromagnetic spectrum, used by the industry, divides it into 20 sub-ranges within the 3Hz-300EHz span, starting at 3Hz frequency, with every next sub-

range starting at ten times higher frequency that the previous.

											visual							
ELF	SLF	VF	VLF	LF	MF	HF	VHF	UHF	SHF	EHF	FIR	MIR	NIR	NUV	MUV	EUV	SX	HX	Y
3 to 30 Hz	30 to 300	.3 to 3 kHz	3 to 30	30 to 300	.3 to 3 MHz	3 to 30	30 to 300	.3 to 3 GHz	3 to 30	30 to 300	.3 to 3 THz	3 to 30	30 to 300	.3 to 3 PHz	3 to 30	30 to 300	.3 to 3 EHz	3 to 30	30 to 300
100 to 10 Mm	10 to 1	1 to .1	100 to 10 km	10 to 1	1 to .1	100 to 10 m	10 to 1	1 to .1	100 to 10 mm	10 to 1	1 to .1	100 to 10 μm	10 to 1	1 to .1	100 to 10 nm	10 to 1	1 to 0.1	100 to 10 pm	10 to 1

ELF-extremely low frequencies, SLF-super low, VF-voice, LF-low, MF-medium, HF-high, VHF-very high, UHF- ultra high, SHF-super high, EHF-extremely high, FIR, NIR, MIR - far, mid and near infrared, NUV, MUV, EUV - near, mid and extreme ultraviolet, SX-soft X-ray, HX-hard X-ray, Y- gamma rays; THz=terahertz, PHz=petahertz, EHz=exahertz, Mm=megameter, μm=micrometer, nm=nanometer, pm=picometer

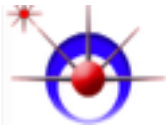
The most general division within the electromagnetic spectrum is based on the radiation energy level. High energy radiation - in excess of 10eV - can strip electrons from atoms, and break molecules and molecular bonds. Since this produces charged particles - ions - it is called ionizing radiation. Most of **ultraviolet (UV)**, as well as **X-rays** and **Gamma-rays** are ionizing radiation.

There is no disagreement about ionizing radiation being capable of inflicting damage to life at exposure levels significantly bellow those causing even mildest direct sensory effects. Segment of the population exposed to this type of radiation is small - it mainly limits to occupational exposures and medical diagnostic field - but the harm it inflicts is far from negligible (see CAT scan cancer risk).

Non-ionizing radiation, ranging from the lowest outskirts of ultraviolet, through **visual** and **infrared** to **radio** frequencies, does not have the intensity needed to directly damage biological tissues but, if sufficiently strong at frequencies over 100kHz, can significantly raise body temperature (*thermal effect,* the primary acute effect at frequencies higher than 10MHz), or induce currents causing *neurological effects* at frequencies bellow 100kHz. Since the common exposure levels are much lower than those needed to cause these immediate effects, this ever present form of radiation created by man has been, for decades, assumed to be benign.

However, number of studies implicate that non-ionizing radiation does have the capability of causing disturbances at the cellular level, **resulting in either near instantaneous or delayed adverse health effects in sensitive individuals.**

It is uncertain how exactly and at what frequencies and intensities much lower levels of non-ionizing radiation than those needed to produce thermal or neurological effects can



adversely affect health, but the evidence is both ample and very suggestive that it is taking place.

Visual electromagnetic frequencies are only a tiny window within electromagnetic spectrum, spanning 0.0003mm of the wavelength range, from 0.0004 to 0.0007mm (but with the range of frequencies greater than both, infrared and radio frequencies combined). Infrared wavelengths extend from 0.0007mm to 1mm; longer wavelengths belong to the radio frequency range, which has by far the widest span of wavelengths, ranging from 1mm to over 100,000km.

Due to many uses of radio waves, this range has a number of frequency sub-divisions. The **high-frequency** radio range, between (approximately) 300MHz and 300GHz (corresponding to 1m to 1mm wavelength, respectively), is generally known as *microwave radiation*. Among others, it incorporates HF (high-frequency, such as ultrasound), VHF (very high frequency), UHF (ultra-high frequencies) and SHF (super-high frequencies). These waves are used for anything from radio (FM, or "frequency modulated") and TV broadcasting to cell phones, radars and microwave ovens.

Part of the narrow **mid-frequency** radio range is used for AM ("amplitude modulated") radio broadcast. **Low-frequency** radio waves, bellow 300kHz include audible sound (approximately 20Hz to 20kHz). Super low (bellow 300Hz) and extremely low frequencies (bellow 30Hz) is where most of standard electricity waves are emitted (regular electric power operates at the 50-60Hz frequency).

At the very bottom of electromagnetic frequencies is bioelectricity, ranging normally from about 1 to 100Hz. For instance, electromagnetic waves accompanying normal human brain activity range from below 1Hz (deep sleep) to 31Hz (highly alert).

Evidently, the variety of man-made electromagnetic fields share common nature with bioelectricity: the two are part of electromagnetic spectrum, merely different forms of what is generally called energy field. It is a scientific fact that energy fields do interfere; also, that human cells have the capability to detect extremely weak fields, **and react to them.**

Hence, the question is not whether man-made electromagnetic fields, at any frequency or intensity level, affect functioning of the human body, but rather *how*.

The official medical and governmental stance is that there is no sufficient evidence proving that low-level EMF exposure causes adverse health effects. But growing segment of environmentally conscious population, as well as independent scientists and researchers think we have more than enough evidence to justify preventive protective action. Their call for action is increasingly difficult to ignore.

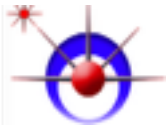
Who is right, and who is wrong?

We can only find out if we know the facts. Here they come. Before that, a few more words about the most widespread EMF pollutant - the standard electricity, and how it can affect health.

Electricity and health

Not long ago, electricity was regarded as a clean, residue-less power source, of remarkable, silent efficiency. If used properly, it produces no smell, no smoke, no sensation of any type. The relationship between electricity and health seemed to be as good as it gets.

Sure, every once in a while, another not widely publicized study would come along with a different, less rosy picture. Among the first of this kind were studies investigating possible



link between energy fields produced by power lines and increased incidence of childhood leukemia.

The news wasn't good: children exposed power fields of very moderately elevated intensity, well within the range of common exposures, had **consistently higher rate of leukemia.**

What was particularly troubling is that those exposure levels - typically around 4mG (milligaus), or 0.4μT (microtesla) - were hundreds of times bellow the official safety limit of 1000mG (or 100μT) for the general population. It provoked haunting thoughts: if this is really happening so much bellow the safety limit, there is something biologically very potent in these weak energy fields that interferes with body processes - **and no one knows what it is!** What else it might be causing? Childhood leukemia was pretty much in focus, ever since Wertheimer and Leeper's keen observation had linked it with power-frequency field exposure in 1979. Possible connection of the common power-frequency field exposures with other ailments and diseases were not investigated to any meaningful extent.

The truth is, it is hard to investigate what you know next to nothing about. How could possibly such a low energy affect body function? Decades of research later, using advances in molecular biology and laboratory techniques, we are beginning to unveil this mystery.

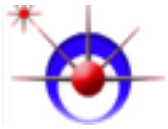
What is, exactly, electricity?

Most simply, by definition that could be applied to the entire electromagnetic spectrum - it is the energy field created by moving charges. With standard electricity, those moving charges are low-energy electrons in the outer portion (orbits) of the atomic shell, moving from one shell to another under the pressure of repulsive magnetic force (voltage) induced by generators. As the electrons move through a wire, they switch from higher to lower energy levels, releasing energy in the form of electromagnetic radiation.

The movement of electrons, called *electric current*, is very slow, a small fraction of a millimeter per second (in the alternate, or AC current, electrons only move about 2 microns back and forth). On the other hand, the energy radiated by electrons, or electricity, being electromagnetic wave, practically moves at the speed of light. Unlike the current, which remains confined within electrical wire, portion of the radiated energy spreads outside of it, in the form of electromagnetic field.

This energy field consists of two different forces, electrical and magnetic - hence the name. With standard electricity, electric field is created by the voltage differential itself, thus constantly present and steady in intensity. Magnetic field, on the other hand, is created by electrical current (moving electrons), and its strength around the wire depends on current density (for instance, magnetic field strength around power lines varies with the rate of consumption). Both, electric and magnetic field weaken rapidly with the distance from their source. However, unlike electric waves, magnetic waves are little affected (absorbed) by common building materials, or trees. In the standard, alternating current (AC), electrons move back and forth at a rate of 60 oscillation per second. This is very low frequency in the realm of electromagnetic waves. Hence, the produced wave energy is also very low (for comparison, electrons in cell phones, which operate in the much higher range of frequencies between 900MHz and 1800MHz, are made to oscillate 15-30 million times faster, creating as much shorter and more intense waves). Since AC current constantly moves electrons back and forth, both electric and magnetic fields are always present. They form around power lines, interior wiring, cables plugged into wall outlets, and around anything using electricity, from the electric can opener to vacuum cleaner.

Being exceedingly low, power of these fields is far outside the range of senses of average individual. Most people can feel 50/60Hz field stronger than 20kV (kilovolt, 1000V) as a slight vibration moving over the skin; few people can sense fields bellow 5kV. For comparison, residential exposure for about 95% of people is in the 0.009-0.12kV (9-120V)



range.Thermal effect at this exposure level is entirely negligible; it is also negligible at the level when the induced charge can be sensed on the surface of the skin. But there are **other than skin-deep effects.**

They are caused by the penetrating electromagnetic field, which induces electrical currents and affects bioelectric potentials throughout the body. As tiny as these energy fields are, they are strong enough to affect biological processes. This has been demonstrated on thousands and thousands of patients since 1970s, with often spectacular healing effects, by the therapeutic use of pulsed magnetic fields. In the range of intensity and frequencies, they overlap with power-frequency fields.

The simple rule is that anything with the power to produce beneficial effect in the body, has also the power to harm it. Since literally all body processes depend on bioelectricity, from the cellular level up, there are many possible forms through which these fields can negatively interfere with body functions, and as many possible symptoms.

For instance, studies have found that electromagnetic field induced to the body reduces heart's resting rate by 3-5 bits per minute, but only at a particular field intensity: 9kV electrical and 20μT magnetic field. No effect was recorded at 33%/50% stronger (for electrical and magnetic field, respectively), or weaker fields (Cook et al. 1992; Graham et al. 1994).

Studies of occupational exposure to power-frequency fields are mainly consistent in establishing significantly higher incidence of some forms of cancer - leukemia and brain tumor being the frontrunners, but also other diseases like breast cancer (Demers et al. 1991; Matanoski et al. 1991; Tynes et al. 1992; Loomis et al. 1994) or Alzheimer's (Sobel and Davanipour 1996).

A group of electrical utility workers exposed to 0.17-0.34kV electric field combined with 32-70mG magnetic field (yearly average values) had the risk ratio for cancer and leukemia of 1.2 (small group, with confidence interval 0.8 to 15). With identical electric field exposure, and magnetic field over 70mG, risk ratio skyrocketed to 7.8. And with identical magnetic field exposure as the first group combined with stronger electric field (<0.34kV), the risk ratio went even higher, to 11. In all, there was 1484 cancer and 50 leukemia cases among these workers (Miller et al. 1996).

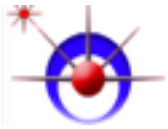
In another occupational study, significantly lower exposure to magnetic field (10.5-12.1mG) resulted in the brain cancer risk ratio increase to 2.38 (Savitz et al. 2000).

Evidently, there is no shortage of suggestive evidence about these weak fields being bioactive, and harmful to some people. Keep in mind that all these exposures, while elevated, still are **much bellow the official "safety" limit of 1,000mG and 8.3kV** for magnetic and electric field at this frequency, respectively.

Also, even these few examples illustrate quite well how complex and unpredictable is health effect of these energy fields. This, of course, is a direct consequence of the complexity of body's bioelectricity, with unknown number of variations in electro-potentials, electricity-based functions, triggers and interactions.

These findings imply certain conclusions, which reflect both complexity and uniqueness of the way that energy fields affect human body. Some of those conclusions are:

- It can be expected that certain field intensities will have adverse effect at some frequencies, but not the others (that pretty much invalidates the dose-response epidemiological criterion in establishing causal relationship).
- Or that such effect for given frequency will show at a specific intensity, but not at either higher or lower intensities.



- Or that adverse health effect will be caused only when the two fields are specifically combined, or either one or both are combined with some non-EMF factor.
- Or that adverse effects are caused by two or more different frequencies, acting synergistically.
- On top of it, individual sensitivities to any of possible effects vary rather widely, as they generally do for any agent capable of affecting body processes.

All this is, obviously, a major factor behind the inconsistencies in study results. What is very much certain, though, is that these tiny energy fields are capable of causing serious adverse health effects. Using inconsistencies in study results as a "reason" not to change official safety limits, so much higher than the levels where it is evident that serious adverse effects are possible, simply has nothing to do with the reason.

What is really behind it, can be found easily by answering the right question: "Who is it that benefits from the status quo?". Turns out, rather powerful set of players - huge commercial, and highest-profile political interests, partnering up with the exploitable segment of the scientific community.

For all we can see, the evidence shows that power-frequency fields, created by 50/60Hz electricity, are not harmless. Much is still left to be determined, but the two most important facts should be clearly stated:

✍ Energy fields created by electricity do interfere with body functions

✍ In sensitive individuals it can cause, or contribute to a variety of adverse health effects, including the most serious diseases, such as cancer

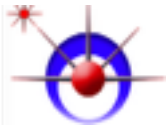
EMF safety standards - are they safe?

Call it electrical pollution, electropollution, dirty electricity, stray voltage, microwave radiation, or any other of its many informal names and forms, the question is just the same: Do all those energy fields around us adversely affect health, possibly at the exposure levels much bellow current official safety standards?

Officials say: "Worry not". But the existing evidence falls seriously short from fully supporting their view, which is based on mere assumption that these fields are biologically inactive.

In all likelihood, electromagnetic pollution is stepping onto the stage of a historic battle between special and global economic interests coupled with ignorance on one side, and facts, sanity and health preservation of the broad population on the other. Following text examines the facts surrounding this mega-controversy. There are many sources of electromagnetic fields (EMF) pollution these days. High-energy radiation, such as that produced by X-rays or radioactive materials, is officially recognized as health hazard. On the other hand, health effect of low-energy electromagnetic fields is, at least officially, dimmed as insignificant at common exposure levels. These low-energy fields - specifically, non-ionizing radiation - include the most widespread EMF pollutant, the **energy field created by electricity,** such as those radiating from power lines, wiring, appliances and electronics inside your home, work, or from your cell phone.

Following chart shows ICNIRP (*International Commission on Non-Ionizing Radiation Protection*) safety limits for non-ionizing radiation. Added are levels of exposure to electrical and magnetic fields linked to adverse health effects in a few out of a large number of studies that did establish such link over the last few decades.

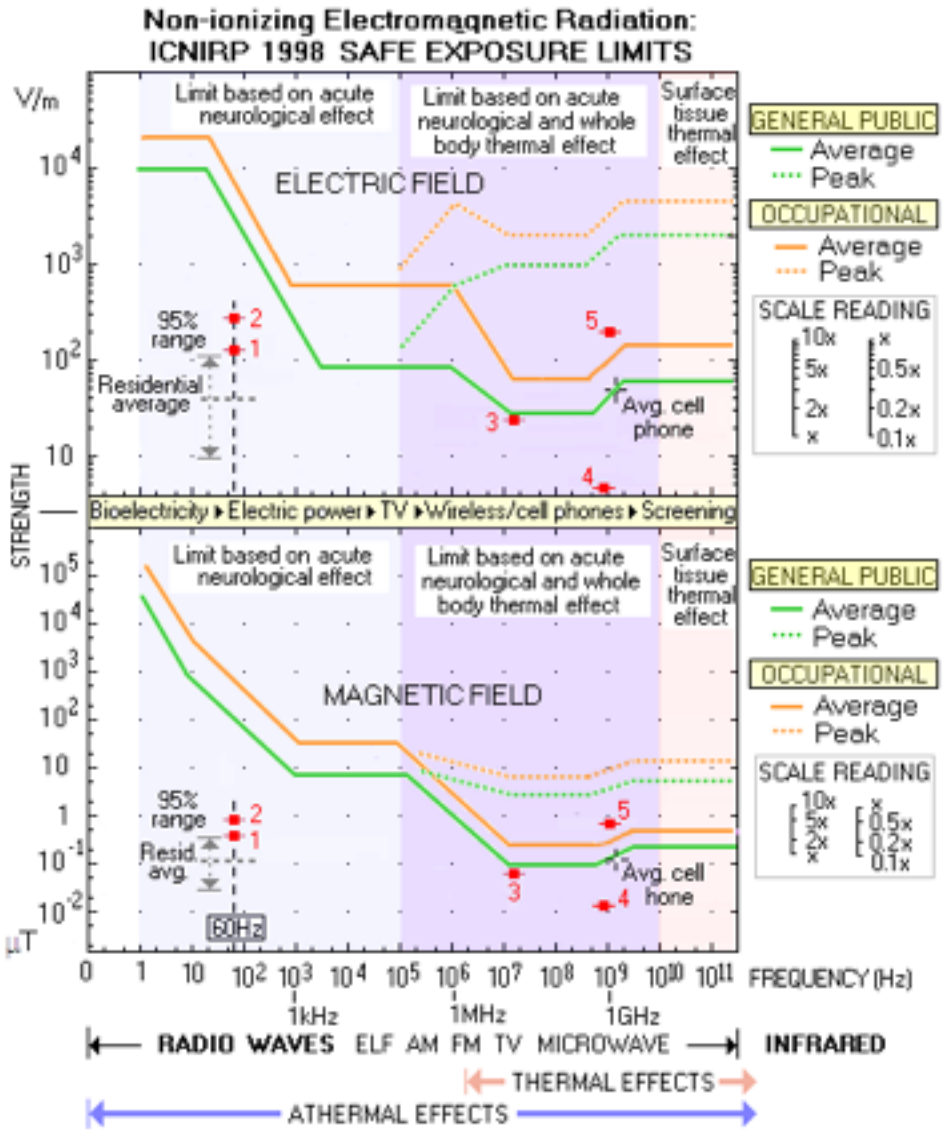


These safety limits are nearly identical to those issued by the Institute of Electrical and Electronics Engineering (IEEE. *Standard C* 95.1-1999), and represent internationally adopted standards. They are also the basis for the FCC (*Federal Communications Commission*, U.S.) non-ionizing radiation exposure limits, with the exception being that FCC does not regulate frequencies bellow 300kHz.

For reading the chart, as well as EMF-related texts in general, following commonly used terms and conversions may be helpful.

EFM-related TERMS	
frequency (**v**)	in hertz, 1Hz=1 oscillation per second
wavelength (**λ**)	λ=300,000,000/v meters
current (flow of electrical charge, **I**)	in ampere (A)
current density (**J**)	A/m^2 or Am
electric field strength (**E**)	V/m or Vm
magnetic field strength (**H**)	A/m or Am
magnetic flux density (**B**)	T (tesla)
power density (**S**)	W/m^2 or Wm
specific energy absorption (**SA**)	J/kg or Jkg
specific energy absorption rate (**SAR**)	W/kg or Wkg
CONVERSIONS	
magnetic (H) to electric (E) field strength	E(V/m)=377H(A/m)
magnetic field strength (H) to flux density (B)	B(μT)=1.256H(A/m), 1μT=10mG (milligauss)
electric field strength (E) to power density	S(W/m^2
magnetic field strength (H) to power density	S(W/m^2
power density or internal E-field to specific absorption rate (SAR)	SAR=P/
SAR to specific energy absorption (SA)	SA=SAR x exposure time

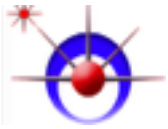
[a] valid only in far field (>10
two fields - they need to be determined separately
[b] density of the conductive medium, ~1,000kg/m
[c] varies with the medium and frequency (for the body, from the minimum of 0.05 to 0.08 for fat tissue to near-maximum of 0.94 to 1.4 for brain from 900-1800MHz, respectively)



The red marks are the exposure levels at which significant link to adverse health effect has been found. There is many studies on this subject; these few shown are only to illustrate how much bellow the official safety levels various energy fields are biologically active and implicitly harmful. Here's a brief on each mark, by the number:

1 - Majority of studies since 1979 (Wertheimer and Leeper) did establish consistent link between exposures of ~4μT (well over 100 times bellow the ICNIRP safe limit) and higher with significantly (approximately 2 to 4 times) increased risk of childhood leukemia; for vulnerable children, such as those recovering from leukemia, even lower exposures (1-2μT) significantly - 280% - decrease survival rate vs. children exposed to less than 1μT fields (Foliart et al. 2006). Expectedly, adverse effects may not be limited to childhood: children raised within 300m from high-voltage power line also have 3-5 times higher risk of developing some form of cancer later in life (Lowenthal et al. 2007).

2 - Canadian study of occupational exposure of electricity utility workers (Miller et al. 1996) establishes significantly increased risk of leukemia and other forms of cancer at exposure levels dozens of times bellow the official safe level.



3 - Occupational study of communication equipment handlers exposed to 3-30MHz microwave radiation roughly at the safe limit level for general population establishes significantly higher rate of adverse pathological changes vs. unexposed group (central nervous system 3.8, cardiovascular 5.2, gastrointestinal 1.7, peripheral nervous system 1.4, respiratory 2.8), in addition to early aging syndrome. Incidence of adverse health effects was significantly related to employment duration, regardless of individual age. Long-term exposure (over 10 years) effects remained after cessation of the EMF exposure (Nikitina, 2000)

4 - Recent Israeli study (Friedman et al. 2007) demonstrates that mobile phone EMF fields change cellular functions (protein formation and protein-based regulatory mechanisms) starting at field intensities nearly 100 times bellow the average cell phone radiation level. For the first time, this study determines molecular mechanism through which this type of low-level microwave radiation effects cellular processes. Initially, radiation stimulates mitochondrial membranal enzyme (NADH oxidase) into production of ROS (reactive oxygen species). This in turn initiates specific chain of events resulting in altered transcription, as well as stability and expression of a number of regulatory cell proteins. For instance, the radiation activates *extracellular signal-regulated kinases* (ERK) and *epidermal growth factor*, both important factors in cellular division and growth.

Among a number of factors capable of activating the ERK cellular pathway are viral infections and carcinogens. Disruption/alteration of this pathway is **common in cancer.**

The study does not prove that cell phone microwave radiation causes cancer, but it does show that very low level radiation of this type significantly alters cellular processes, including those commonly altered in cancer. At this point, we can only speculate about specific health consequences it can cause, but the possibility of it contributing to cancer development cannot be excluded.

This study is only a continuation of the long string of studies establishing that officially "safe" levels of non-ionizing radiation exposure have the capacity to affect cellular function, and inflict cellular damage in humans and other animals (enzyme reaction rates, Blank and Soo, 1996/98, Mullins et al. 1999, electron transfer rate, Blank and Soo, 2001, stress protein synthesis, Goodman et al. 1994, Lin et al. 1998, DiCarlo et al. 2000, melatonin inhibition, Liburdy et al. 1993, interacting with DNA, dePomerai et al. 2000, Kwee et al. 2001, Lin et al. 2001, Leszczynski et al. 2002, Weisbrot et al. 2003, DNA damage, Lai and Singh, 1997, Phillips et al. 1998, Mashevich et al. 2003, REFLEX 2004, and others).

5 - Another Israeli study (Dovrat et al. 2005) finds that exposing eye lens to near continuous (50min each hour) microwave radiation in the typical cell phone frequency range (~1.1GHz), at about double the average occupational safe limit, causes both significant macro-degeneration (deteriorated focusing ability) and micro-degeneration (formation of microscopic bubbles within the lens) evident after 48 hours and progressing to its saturation level after 6-8 days. Macro-degeneration was reversible within days after radiation ceased, but micro-degeneration (within 15-day period of the study) remained.

These effects were also evident at less than half the intensity (0.89 vs. 2.2 mW/cm^2), only with the period needed to reach specified stages of degeneration doubled. Consequently, applying ICNIRP criteria of the average occupational safety limit as 1/10 of the radiation intensity beginning to cause degradation to biological tissue, the safety limit should be, according to this study results, more than 12 times lower than what it is currently. In addition, the study has found out that pulsed radiation with identical total energy causes 4.7 times more damage, also through a thermal mechanisms, indicating that safety standards for this type of non-ionizing radiation are even more inadequate.

Adverse health effects in these selected few examples have occurred across the radio-frequency range. It implies that **no radio frequency, or exposure level can be assumed harmless.**

Although these studies were selected, somewhat randomly, to illustrate this point, they are not an exception: majority of studies to this date did find that exposure to non-ionizing radiation much bellow the official safety level resulted either in a direct adverse health effect, or significant biological effect of uncertain implications and consequences.

Why is it, then, that the officials in international organizations and governments did not act accordingly, by drastically tightening current official safe exposure levels to man-made electromagnetic fields? Let's hear their side. Following page presents the official basis of current EMF safety standards and details how ICNIRP answers this question in their 1998 Guidelines for limiting exposures to non-ionizing radiation up to 300GHz. ☑

EMF health threat and the politics of status quo

Is it by accident that all major international health organizations, part of the scientific community, governmental bodies and, of course, the industry, all find themselves on the same side - that for preserving the status quo for non-ionizing EMF exposure safety standards - and against the rest of scientific community and concerned public, demanding official reaction to the piles of evidence of non-ionizing radiation being a health threat at the common levels of exposure?

Not really. The status quo proponents may have different motives, but they all share this common goal, combining their powers and influences into a formidable opposition to safer standards. Very much like EMF, **this force is invisible, but very efficient and, when it comes to your health - definitely capable of inflicting harm.**

The **industry**, of course - whether it is a part of electro-distribution, mobile/wireless, electric appliances, electronics, or any of many other branches based on the use of electromagnetic force - will do all in its power to prevent additional expenses and constraints due to more stringent regulations, let alone eventual downsizing due to public concerns and accelerated replacement by alternative technologies.

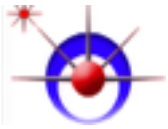
Governments, on their part - aside from being very much directly influenced by industry's lobbyists, at least in this country (USA) - have to protect economic stability and growth, and are generally reluctant to risk placing them under considerable constraints without having a very good reason for it.

Clear scientific and public indications of the harm from non-ionizing EMF to the wellbeing of general population, obviously didn't count as big enough reason for them to risk economic downturn. In addition, they are likely to bear responsibility for compensating millions of people if standard EMF exposures are proven detrimental to health.

Mainly for these two reasons, governments around the world that did impose significantly more strict safety limits for public (and occupational) EMF exposure can be counted on the fingers of one hand (still with fingers to spare).

As for the **scientific community** - whose members also mainly populate international organizations involved in determining safety limits for EMF exposure (ICNIRP, IEEE) - it is divided in two camps.

One consists of those that are against any changes because they have interest in preserving existing order - whether due to it being part of their legacy, reputation or beliefs, or because they are dependant (employed by the industry or government), because they are



influenced, manipulated, or simply paid by the proponents of status quo (scientists are still only humans). In the other scientific camp are those free, willing and capable of pursuing the truth.

This gross polarization within scientific community, in addition to the mechanisms of athermal biological effects of non-ionizing EMF being still only partly understood, is the **main reason for the inconsistency in study results.**

Probably the majority of studies that haven't found significant link between "safe" EMF exposure levels and adverse health effects, or significant biological effect of such exposures, are due to the lack of knowledge with respect to the actual mechanism leading from EMF-caused biological interference to adverse health effects. It makes designing properly controlled study much more difficult.

The rest of "no effect" studies are simply poorly designed judging by what we already know. And, every once in a while, they are **purposely designed with a bias toward producing negative result,** often as a follow-up to a positive-result study, or studies, that have received wider publicity.

Such practices, of course, are not limited only to the EMF safety arena. One recent example is a study of studies on the efficacy of pneumococcal vaccine for adults.

On the EMF safety battlefield, this has likely happened just before the last confirmation of the official safety guidelines in 1998 (Linet et al., National Cancer Institute, 1997), and again after a 2004 study by a research team from Karolinska Institute (Sweden) has arrived to the conclusion that long-term (over 10 years) use of cell phone increases the risk of *acoustic neuroma* (benign brain tumor).

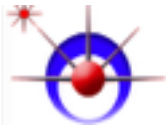
Due to enormously widespread use of cell phones, this news was highly publicized. It was also followed by a string of studies (Lönn et al. 2005, Schoemaker et al. 2005, Schüz et al. 2006, Takebayashi et al. 2006, Lahkola et al. 2007), with no increased risk found neither for neuroma nor other common brain cancer forms (although usually with some form of "more research is needed" follow-up phrase).

In 2007, a review of 18 studies by Dr. Lennart Hardell (Örebro University, Sweden) and group of researchers has found that the data shows long term cell phone users having 20% higher risk of malignant *glioma*, with the risk doubled for tumors on the side habitually exposed during phone use (*ipsilateral* exposure), as well as 2.4 times increased risk of *acoustic neuroma*. But they had to filter out relevant data since the "no-risk" studies have not combined all the compounding factors, such as heavy use, use over 10 years and longer, or they lacked/disregarded data on tumor size and/or latency, side of brain actually exposed to radiation, or some other important factor.

More specifically, risk ratio for 14 participants that used cell phone over 10 years in Lönn et al. was 1.8 (due to a small sample, 95% confidence interval - or interval within which the actual ratio is expected with 95% probability - was 0.8-4.3), Schoemaker et al. was limited to "regular users", Schuz et al. (the 20-year Danish study) had only 32 participants and no data on latency or laterality of tumor with respect to cell phone use, and Takebayashi et al. also was limited to "regular users".

One doesn't have to wonder for long, as to why is there so many shortcomings in the design of these studies, nearly all biased toward underestimating the risk.

But that is not all; a large Japan-based multi-study international project called "**Interphone**", after somewhat lengthy period of consolidation between the two opposing groups of scientist participating in it, has reported that they found no increased risk of brain tumor for cell phone users, based on novel approach that attempted measuring SAR levels in the tumor area.



Long before its conclusion, this study was portrayed in the media as a decisive step toward resolving the cell phone radiation vs. cancer risk controversy. Was it up to that task? Let's take a closer look at how the studies were conducted (from detailed analysis of 10 - out of 13 - Interphone studies by Lloyd Morgan). Here are some of the main flaws they somehow let slip in:

- Use of cell phone by **control groups** that should have remained unexposed
- Treating **unexposed tumors** (i.e. outside the radiation plume within head) as exposed
- Too short **latency times** (for known cancer initiators, like ionizing radiation, smoking, or asbestos, latency times are 20 to 40 years)
- Biased definition of "**regular user**" (at least 1 cell phone use a week for at least 6 months in a year)
- General policy limiting **age** of participants to 30-59 age (the rate of adverse effects is highest under 30 years of age)
- **Controls** exposed to cordless phone radiation, walkie-talkie, amateurs radio, situated in proximity of TV/radio transmitters, etc. treated as unexposed
- Exclusion of lymphoma and neuro-epithelial **brain tumors**
- Exclusion of tumor cases due to death
- Short cancer **diagnosis eligibility time** (2.8 years vs. 6 years in Hardell et al.)
- Not fulfilling **blindness requirement** (interviewers and controls aware of study purpose)
- Too **small sample size** for statistical significance (18 averages)

This many flaws, nearly all biased toward underestimating the risk, cannot possibly be accidental. The risk underestimation by design of Interphone studies was so effective that it as produced the risk ratio for cell phone users bellow 1, indicating that cell phone use is **cancer-protective.**

Or led to paradoxical conclusion that the cancer ratio is lowest for users with highest exposures *or* longest period of use (over 10 years), while the risk becomes significant for highest exposures *and* longest period of use combined.

But the lack of respect for the facts, logic and common sense is not exactly a news when it comes to the side maintaining that we're just fine exposed as we are to non-ionizing radiation. Best example is probably set by the **ICNIRP** (*International Commission on Non-Ionizing Radiation Protection*) itself, which in its 1998 Guidelines states, among other, the following facts:

"*Many studies have suggested that the transduction of weak electrical signals in the ELF range involves interactions with the cell membrane, leading to cytoplasmic biochemical responses that in turn involve changes in cellular functional and proliferative states.*" (p501)

"*There are numerous reports in the literature on the in-vitro effects of ELF fields on cell membrane properties (ion transport and interaction of mitogens with cell surface receptors) and changes in cellular functions and growth properties (e.g., increased proliferation and alterations in metabolism, gene expression, protein biosynthesis, and enzyme activities) (Cridland 1993; Sienkiewicz et al. 1993; Tenforde 1991, 1992, 1993, 1996). Considerable attention has focused on low-frequency field effects on Ca++ transport across cell membranes and the intracellular concentration of this ion (Walleczek and Liburdy 1990; Liburdy 1992; Walleczek 1992), messenger RNA and protein synthesis patterns (Goodman et al. 1983; Goodman and Henderson 1988, 1991; Greene et al. 1991; Phillips et al. 1992), and the activity of enzymes such as ornithine decarboxylase (ODC) that are related to cell*

proliferation and tumor promotion (Byus et al. 1987, 1988; Litovitz et al. 1991, 1993). However, before these observations can be used for defining exposure limits, it is essential to establish both their reproducibility and their relevance to cancer or other adverse health outcomes. This point is underscored by the fact that there have been difficulties in replicating some of the key observations of field effects on gene expression and protein synthesis (Lacy-Hulbert et al. 1995; Saffer and Thurston 1995)." (p502).

This is of crucial importance. The existing safety limits for ELF (extremely low frequencies, range of radio wave frequencies bellow 300Hz in the WHO classification) were - and still are - based on the assumption that **the only significant biological effect possible with these energy fields is a direct neuromuscular stimulation.**

This, however, requires fields an order of magnitude (into hundreds of times) stronger than common exposure levels.

Now, the Guidelines author themselves are presenting ample evidence of much weaker fields interfering with very basic processes at the cellular level. Is there any doubt of the right course of action: **reduce the safety exposure limits bellow these levels,** or as much as is realistically possible to enforce - which would still be a drastic reduction?

Instead, ICNIRP decides that it cannot use the information of weak non-ionizing radiation interfering with and/or damaging bio-cells for determining safety limits **because it is only "suggestive," and not "convincing."** Playing with words. Not even symbolic tightening of the safety limits ensued.

What this attitude clearly shows is that ICNIRP, in accord with most of the world governments and, of course, the industry, have higher priorities than protecting public health and wellbeing. And they still have it their way, masking their disregard for the scientific evidence and growing EMF-related public complaints by their formalistic spins.

Protection from EMF: you're on your own

As newer and more sophisticated studies continue adding to the decades long research overwhelmingly suggesting that low level non-ionizing radiation is capable of causing all kinds of adverse health effects, the question of protection from this type of EMF (electromagnetic field) exposure has become very important.

Everyone is exposed. Sources of radiation are everywhere, subjecting you to various EMF frequencies around the clock. Degree of exposure and individual vulnerability vary widely. What is all but certain, is that non-ionizing radiation many times bellow the current official safety levels have the capability to alter the very basic cellular functions, which may result in various acute or long-term adverse health effects.

In people with chronic diseases, or any type of adverse health symptoms, exposure to low-level energy field can be significant contributing factor to their symptoms. Not knowing what your personal threshold is, **only prudent to have your exposure minimized.**

And you have to do it on your own. Waiting for the official resolve is not an option - it is a part of the huge, conflicted global process that will take years to to produce even minor changes.

The man-made electromagnetic energy in non-ionizing frequencies produces exposures in three different forms:

- electromagnetic fields that spread through space, inducing low-level currents in conducting materials, including biological tissues; the two major sources are nearly at the opposite ends of non-ionizing radiation range, one created by production, distribution and

use of electric power (extremely low frequencies, ELF), and the other by mobile phone/ wireless technology (microwave radiation, the high-frequency end of radio waves)

- irregular higher-frequency currents/micro-surges created around the main 50/60 Hz current, which tend to leak out of electrical wiring and move through conducting media (wiring, pipes, floors, human body); the main phenomenon behind the newly coined term "dirty electricity"
- stray voltage, the electricity escaping power lines and the hot-neutral wire loop of electrical wiring, most of which ends as ground currents that may travel for miles, drawn to conductive mediums such as metal pipes, fences or building frames (estimates are that about 2/3 of all electricity returning from the point of use becomes ground current)

There we have it: it is in the air, in the structures surrounding us, in the ground beneath our feet and, of course, in our bodies. Table bellow summarizes basic information about these new forms of environmental pollutants which, according to the large body of evidence, are capable of interfering with basic body processes at the cellular level.

ENERGY FIELD POLLUTION BASICS						
ELECTRO-POLLUTANT			TYPE	SOURCES	POSSIBLE HEALTH EFFECTS	MINIMIZING EXPOSURE
EMF	**power-frequency (wired)**		▪ 50/60Hz electric/magnetic field ▪ variable higher-frequency fields	▪ power lines, transformers, distribution lines ▪ electrical wiring ▪ electric devices	↗ leukemia ↗ cancer (occupational) ↗ EHS ↗ cellular processes	▪ avoidance ▪ minimized use
	WIRELESS	**broadcast**	0.6-700MHz	radio, TV	unlikely	-
		2-way	▪ 900-2400MHz electric/magnetic field	▪ cordless phone ▪ cell phone ▪ WiFi, WLAN, WiMAX	↗ brain tumor ↗ EHS	▪ minimized use ▪ avoidance ▪ shields
		other	200-10,000GHz	▪ surveillance ▪ medical	?	▪ minimized use
Power-frequency residuals ("dirty electricity", micro-surges)			▪ 4-100kHz current/field	▪ switched-power converters (in PCs, TVs, energy-efficientappliances/lights, variable-speed motors...)	↗ various EHS-like symptoms ↗ worsened chronic health conditions	▪ avoidance ▪ filtering
Stray voltage			▪ 50/60Hz current/ field	▪ voltage leaks from power lines and indoor/outdoor wiring	↗ EHS-like symptoms	▪ better power-distribution ▪ improved indoor wiring ▪ avoidance

Obviously, it is impossible to avoid exposure to these energy fields altogether. But the exposure level can be significantly reduced, and with it the risk of adverse health effect caused by this new form of environmental pollution. Here's how

_____Power-frequency energy fields_____

The standard electricity routes - power lines, inside and outside wiring, and electrical devices - create weak electromagnetic field in 50/60Hz frequency range. Electrical devices often create additional higher frequency fields. Plenty of evidence suggests that these energy fields, by interfering with bioelectricity, significantly increase the risk of childhood leukemia, occupational cancer, or some form of EHS.

To minimize your exposure to power-frequency fields:

- avoid proximity of permanent stationary sources such as power lines, transformers, indoor and outdoor wiring, (particularly important in your bedroom environment), and
- minimize the use of electrical devices

_____Wireless technologies energy fields_____

Electromagnetic fields created by wireless technologies are generally in 1-2400MHz frequency range. They are of higher intensity, and in addition to athermal effects, in higher frequencies can also produce low-level tissue heating. In the lower range of frequencies, up to 700MHz, the main source is broadcast transmission (0.6-1.6MHz AM radio, 88-108MHz FM radio, 54-700MHz TV). These are what most people relate to as "radio waves".

Being generally very weak - a small fraction of 1V/m away from the emitting antennas - the ever-present energy fields of **radio and TV broadcasts** are unlikely to interfere with biological processes for the majority of population. However, those living in the proximity of the emitting antennas are on the increased risk from EHS; within 1 mile from emitting antennas electric field strength of the signal can reach up to a few tens of V/m. As some studies (Dovrat et al. 2005) indicate, these energy levels are capable, at higher frequencies, of altering cellular function.

If we draw a parallel to the power-frequency (60Hz) field strength limit of 4167 V/m (1,000 milligauss in terms of the far field magnetic field equivalent),with adverse health effects (childhood leukemia) being repeatedly linked to over 200 times weaker fields. The corresponding level at FM/TV frequencies and with the safety limit for general population of 28 V/m would be closer to 0.1 V/m. This means that broadcast radiation level may not be safe within a few miles from emitting antennas.

The next level of wireless sources of higher-frequency EMF exposure are **voice** and **Internet** related: cordless phones, cell phones, cell phone base stations, as well as WiFi (Wireless Fidelity), WLAN (Wireless Local Area Network) and WiMAX (Worldwide Interoperability for Microwave Access) wireless networks, providing wireless access to cell phones and computers within about 300 feet to 10 miles area.

These devices operate in the so-called microwave range. Their use has become widespread, resulting in the exposure volume comparable to that of power-field frequencies. The focus is on the possible adverse health effects of cell phones, particularly in children and adolescents. They absorb more of the radiation, which is by the most reliable studies linked to s**ignificantly increased risk from brain cancer, as well as EHS symptoms.**

The risk is highest for long-term ipsilateral (same side of the head) users.

To protect you from this type of exposure:

- use cell phone only when really necessary

- use headphones instead of placing phone next to your head
- use it alternately on both sides when not using headphones
- use protective cell phone shield
- don't carry cell phone on you, and if you have to, use a protective shield

Other wireless EMF exposure sources include **medical testing devices**, **surveillance** and **body screening**. These types of exposures are less frequent, but can be significant. A recent study (Kjellsson et al. 2002) measured radiation levels emitted by surveillance system at library exit, as well as tag-activation/deactivation system inside. The former emitted 10μT field at 920Hz, 60% over the limit for general public; the latter emitted field of several mT at 50Hz, much over 0.5mT safety limit for occupational exposure for this frequency, and 0.1mT (100μT) limit for general public.

Radiation by a shop surveillance system was also measured. It emitted dual field, 200-300μT at 17Hz and over 100μT at 6.25kHz. Official safety limit (general public) for the former is 294μT, and for the latter 6.25μT, roughly 20 times lower.

These numbers indicate that this type of EMF exposure, fairly common, although usually - but not always - sporadic, could be a health hazard due to indiscriminate use of electronic systems used by businesses, not adhering even to the official safety levels, long criticized as being grossly inadequate.

Medical tests using some form of non-ionizing EFM field (ultrasound, bio-imaging) should be used only when really necessary. It is already known for those using ionizing radiation (X-rays, including CAT scan, PET scan), but there seems to be more than enough evidence to go by the same rule with non-ionizing radiation medical tests. This includes MRI (Magnetic Resonance Imaging), emitting strong static (up to 5 Tesla, or 100,000 times stronger than Earth's magnetic field) as well as time-varying magnetic and radio-frequency fields.

_____Dirty electricity_____

Next in the lineup of EMF exposures is so called "dirty electricity". It is made of transient currents and harmonics, produced mainly by switched-power mode converters - a part of most modern electronic appliances - and also some other forms of ever more complex electrical circuitry. These irregular currents form around the main 50/60Hz current, with their components also present in the magnetic and electric fields.

In other words, standard electricity is contaminated by irregular higher-frequency currents. These tend to leak out of the electrical system, moving through surrounding conductive media which, of course, include human bodies. Take a look at dirty electricity roaming through a Michigan farm house. According to the growing body of evidence, these currents can adversely affect health in sensitive individuals - and quite a few of us could be belonging to that group.

For example, Dr. Magda Havas (Trent University, Ontario, Canada) has done substantial research on health effect of dirty electricity in homes and schools (*Dirty Electricity and Electrical Hypersensitivity: Five Case Studies*, presented to the 2004 WHO Workshop on EHS). She has observed significant link between "dirty electricity" and variety of EHS symptoms (fatigue, depression, headaches, body aches and pains, ringing in the ears, dizziness, impaired sleep, memory loss, confusion, attention deficit disorder in children), as well as with severity of chronic degenerative disorders like diabetes and multiple sclerosis.

While the long-term effects of exposure to "dirty electricity" remain to be determined, there is already more than enough reason to minimize your exposure to this form of electrical pollution. Dirty electricity is present pretty much whenever there is electricity, but levels can

vary significantly from one location to another. Fortunately, means for measuring and significant reduction are available:

▶ **Graham/Stetzer meter** (co-invented by Dr. Martin Graham, University of California, Berkley, and David Stetzer, Stetzer Electric Inc., WI, USA) can measure the level of dirty electricity; acceptable level is below 50 GS (Graham/Stetzer) units, optimally below 30 GS

▶ Excessive level of dirty electricity can be effectively reduced simply by plugging appropriate capacitors, like **Graham/Stetzer filter**, in electrical outlets

For comparison, levels of dirty electricity in the above paper by Dr. Havas ranged from 190 to over 2000 GS in homes (300-800GS mean), averaged 400 GS in an office, and measured 13-1011 GS (23GS mean) in a school. After G/S filters were installed, the levels dropped to 10 to 290 GS (40-70GS mean), 100GS and 8-24 GS (13GS mean), respectively.

A single significant dirty electricity maker such as dimmer switch would nearly double the mean, and more than double the peak value in unfiltered home. While increasing the mean by 75% and the peak value by nearly six fold in G/S filtered home (the filtered home 290GS peak level is with the dimmer switch on; it was only 50GS with the switch off).

Note that dirty electricity may be also coming - through the electrical wire - from neighboring homes, or offices; this portion of it can be reduced only by placing filters in those locations.

Stray voltage

Finally, stray voltage refers to the electricity escaping the power line/wire circuit. It becomes ground current, attracted to conductive media in homes and buildings (metal structures, water pipes, ventilation systems, etc.). It is often referred to as "dirty electricity" as well, but since it also includes the standard 50/60Hz current/field, it is good to have it differentiated from irregular higher frequency forms. Hence, stray voltage here is simple electricity - either standard or "dirty" - that leaked out of the system.

Its two main sources are low quality power/distribution lines (outdoor) and wiring (indoor). In addition, it is increased by sub-optimal power distribution schemes, which often require higher voltage to deliver needed power to the user. Both, the amount of grounded current, and the extent of its in-ground movement also vary with ground type.

Stray voltage currents, and associated energy fields, just as any other form of electromagnetic energy, can adversely affect health. They can also affect behavior and biological functions of domestic animals (for instance, milk production in cows) and, if strong enough, cause obstructions and damage to electronic equipment.

Reduction in this form of EMF exposure requires upgrading quality of delivery system and both, outdoor and indoor wiring. Neither alone will solve this problem, so a concerted action of private citizens, electric companies, and governmental bodies is needed in order to minimize this form of EMF pollution, for better protection of people's health and wellbeing.

This wraps up a series of articles on the subject of non-ionizing EMF pollution. Hopefully, the increased awareness of the harm they are capable of will put on the agenda and speed up the official process of drastic reduction in the exposure levels allowed. For the protection of everyone, but especially those most vulnerable, and at the same time least able to protect themselves: the children. ☑