March 26 2018 Peer Review of the Draft NTP Technical Reports on Cell Phone Radiofrequency Radiation

Rodbell Auditorium, David P. Rall Building, NIEHS, Research Triangle Park, North Carolina

Speaker #5 in Session 1 (**Exposure System**) (**5 min**)

My name is Paul Héroux, trained as a physicist, I teach graduate courses in Toxicology *and* Health Effects of Electromagnetism *at the Faculty of Medicine in Montreal, Quebec, Canada.*

The NTP reverberation chamber delivered to the test animals a stable challenge over a *specific integrated time frame*, related to the necessity for reverberant room mixing. This is important because various physiological systems in the animals react to the EMF challenge over times ranging from nanoseconds to months.
A variation of ± 2.5 dB of in the exposure was quoted in the report, depending mainly on location in the cage racks, and I assume that this could have been reduced by using larger chambers, so that the objects would occupy less of the total chamber volume.
(IEC 61000-4-21 now has a requirement for less than 8% occupation).
Nevertheless, this ± 2.5 dB is excellent performance.

That survival is higher in the non-exposed animals in the NTP results is commonly considered by the media as an artefact. I submit that it is not.
I know of two other large animal studies that show indications of the same tendency, and this lifespan lengthening is compatible with interference of EMR with oxidative phosphorylation, and activation of physiological defenses.

Le Bars published in 1983 a 20 month study in which 220 AKR female mice (which spontaneously develop leukemia) were exposed to 50-Hz electric fields of 50 kV/m. The fields were applied by large diameter tubular electrodes a considerable distance apart, which meant field uniformity characteristics similar or better than those of the NTP test cells.
The animals were 4 groups of 55 mice, two sham, one exposed 8 hours per day, and one 18 hours per day.
For both exposed groups, mortality appeared one month later than in the sham groups, which showed the survival expected in this species (Fig. 3). At 7 months, the number of dead animals in the sham group, 10, is significantly different than in the exposed, 2.

In **Chou** 1992, exposure is administered in a circularly polarized waveguide operating at 2,450 MHz and delivering 0.15 W/kg to 0.4 W/kg, 21.5 h/day, for 25 months. The system delivered exposures less reliably than the NTP setup, because they relied on a sum of measurements, rather than direct dipole signals.
Still, “There is some indication that survival times were longer in the exposed animals” and “median survival time was 688 days for exposed animals and 663 days for the sham-exposed” (Fig. 13).

The **NTP** Rat and Mouse data both show a trend towards longer survivals with increasing exposures. The trends vary in strength, but are valid, as a function of intensity, for All Rats, All Mice, All GSM, All CDMA, All Male and All Female.
So increased exposed survival occurs in three different studies, where numbers of rats or mice were respectable:

- Le Bars, two separate experiments involving a total of 220 female AKR mice,
- Chou, 200 male rats,
- NTP, 421 CDMA Mice, 420 GSM Mice, 420 CDMA Rats and 420 GSM Rats.

A second interesting aspect is that effects are stronger for males than females. In Rat studies, either with GSM (page 89) or CDMA (page 131), exposed males reap a longer survival advantage than females from the exposure.
In both Mice studies, either with GSM (page 72) or CDMA (page 88), exposed males also show a slightly larger survival advantage than females from the exposure. This sex difference is expected because males rely on a higher metabolic rate. Therefore, males would be more affected by the fields. This suggests that the effect is not an artifact, and that more precise exposure systems allow the detection of the activation of basic cellular defenses, which we documented *in vitro* in K562 cells (Li, 2013).
You are being criticized for your success.
I note that in the reports, there is no mention of control of the background ELF environment. GSM and CDMA telecommunications signals contain prominent ELF components that dominate the biological impacts of these signals. So the exposure system is very successful in displaying a particular aspect of EMF action, using specific challenges, and they turn out to be different for GSM and CDMA.
No NOEL was identified in the NTP study, although this was probably not the intent of the test.

Le Bars et al. 1983. Les effets biologiques des champs électriques. Effets sur le Rat, la Souris, le Cobaye. *Receuil de Médecine Vétérinaire*, Octobre 1983, pp. 823-837.

C.-K. Chou, Long-Term, *Low-Level Microwave Irradiation of Rats*. Bioelectromagnetics 13:469-496 (1992).

Ying Li, Paul Héroux. *Extra-Low-Frequency Magnetic Fields alter Cancer Cells through Metabolic Restriction*. Electromagnetic Biology and Medicine, DOI:10.3109/15368378.2013.817334, 2013. http://www.tandfonline.com/doi/full/10.3109/15368378.2013.817334.

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Draft NTP Technical Reports on Cell Phone Radiofrequency Radiation

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Speaker #9 in Session 2 (**Toxicology**) **(5 min)**

My name is Paul Héroux, trained as a physicist, I teach graduate courses in Toxicology *and* Health Effects of Electromagnetism *at the Faculty of Medicine in Montreal, Quebec, Canada.*

The Page 13 of the Rat data can be re-worked to group results according to *tissues types*: brain and nervous tissues, heart, and other organs.
This cell/tissue type classification highlights that brain and nervous tissues show carcinogenic action at various stages in various locations within the body, particularly if one accepts *hyperplasia* as one of the stages of cancer development.
The mechanisms of metabolic disruption by electromagnetic fields proceed through the Lorentz force, interference with hydrogen bridges and electron tunneling, and is understood down to the quantum mechanical level (Bioinitiative 2012, Section 16). From a very basic mechanism of action on free electrons and protons, EMFs have downstream effects that reflect the complexity of cell metabolism. EMFs cannot be expected to have dose-responses that are similar to those of alkylating agents, because instead of destroying chemical structures, they interact with enzymes, and restrict and disorganize metabolism.
Therefore, observations of tumor incidence that are considered in your report as "equivoqual" because they failed to display a classic dose-response (the most cases of schwannomas of the heart among the rats in the lowest RF exposure group) should be taken more seriously because the agent at hand operates in a different way than expected in traditional chemical toxicology.
Our work (Li, 2013) has found that past given threshold of action, EMFs can, for some variables, have an almost flat response over two orders of magnitude.
Soon after the work of Wertheimer in 1979 on ELF, a number of scientists documented the mechanisms of action of pulsed microwaves at the level of mitochondria. **Aaron Sanders** at Duke University pointed already in 1985 to "microwave inhibition of mitochondrial electron transport chain function of ATP production". His work was ignored.

We pointed to the same oxidative phosphorylation inhibition, associated with ELF magnetic fields (Li, 2013), describing the impairment of ATP

Synthase and its downstream effects on AMPKα. The changes produced by fields were similar to those of oligomycin administration and of oxygen deprivation (Li, 2012).

The NTP results seem to target organs with high specific perfusion rates. Heart at 84, brain at 54 and liver at 58 ml/100g.min, and consequently with the highest availability of oxygen, seem to be earlier or predominantly affected.

When oxidative phosphorylation in mitochondria is inhibited at the level of ATP Synthase, $\Delta\Phi_m$, the mitochondrial membrane potential, is increased. A 7% increase in this potential increases ROS production by 70% (Miwa, 2003). Further, enzymatic reactions (dehydrogenases) that depend on deep proton tunneling (Inagaki, 2013), are modified, leading to difficulties in ROS detoxification that have been extensively documented my numerous authors (for example, Yakymenko, 2016 and Dasdag, 2016).

The susceptibility of the brain to oxygen deprivation is well known. In the context of this project, where multiple observations surround the cells providing myelin, it should be remembered that myelin vesicles contain functional F_oF_1-ATP synthase and respiratory chain complexes, and are able to conduct aerobic metabolism, to support axonal energy demands.

In myelin vesicles, F_oF_1-ATP synthase activity decreased in the presence of specific inhibitors such as olygomicin (Ravera, 2015), the substance that in our hands (Li, 2013) suppressed oxidative phosphorylation, under very small ELF magnetic fields.

Although some have claimed that exposures used in the NTP study are high in comparison with the human exposures, this criticism ignores the fact that in the study, 2 years of rodent life are meant to represent the full human lifespan. If anything, the study under-estimates the effects, and I would expect more cancers, as well as other health problems (diabetes) to manifest later on, should we use rodents with 70 year longevity.

Whether it is AM, FM, phase modulation, or pulse modulation, biology always finds a way to extract the data from the carrier. If you have some doubts about phase modulation, review the work of Theodore Litovitz formerly at Catholic University in Washington, and related to ornithine decarboxylase expression and signal coherence.

The unfortunate resulting equation is that as you increase signal bandwidth, so increases the chance of interference with biological systems also increases.

There are also risks of genetic drift to the biota as a whole related to the inhibition of mitochondria and the weakening of genetic selection barriers.

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Aaron P. Sanders, William T. Joines, and John W. Allis. *Effects of Continuous-Wave, Pulsed, and Sinusoidal-Amplitude-Modulated Microwaves on Brain Energy Metabolism*. Bioelectromagnetics 6:89-97 (1985)

Ying Li, Paul Héroux. *Extra-Low-Frequency Magnetic Fields alter Cancer Cells through Metabolic Restriction*. Electromagnetic Biology and Medicine, DOI:10.3109/15368378.2013.817334, 2013.

S. Miwa and M.D. Brand, 2003. *Mitochondrial matrix reactive oxygen species production is very sensitive to mild uncoupling*. Biochemical Society Transactions (2003) Volume 31, part 6, pp 1300-1301.

Taichi Inagaki and Takeshi Yamamoto. *Critical Role of Deep Hydrogen Tunneling to Accelerate the Antioxidant Reaction of Ubiquinol and Vitamin E.* dx.doi.org/10.1021/jp410263f | J. Phys. Chem. B 2014, 118, 937−950

Silvia Ravera, and Isabella Panfoli. *Role of myelin sheath energy metabolism in neurodegenerative diseases.* Neural Regen Res. 2015 Oct; 10(10): 1570–1571. doi: 10.4103/1673-5374.167749

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