MORE PROBABLE THAN UNLIKELY, THAT NON-THERMAL ELECTROMAGNETIC FIELDS FROM MOBILE PHONES AND BASE STATIONS DO HAVE EFFECTS UPON THE HUMAN BRAIN.

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The world's largest biological experiment ever? This was one of my messages in a lecture to the European Parliament in 2000 when the number of mobile phone users approached one fourth of the World's population (Salford et al 2001). Today one third relies for the daily communication on mobile phones and base stations which send their energy into our bodies. Is this only of good? Or might it impose effects upon biology. Effects that we must anticipate and evaluate as far as possible, and if needed, reduce or avoid!

Life on earth was formed during billions of years, exposed to, and shaped by the original physical forces such as gravitation, cosmic irradiation, atmospheric electric fields and the terrestrial magnetism. The existing organisms are created to function in harmony with these forces. However, in the late 19th century mankind introduced the use of electricity, and high frequency RF was introduced in the 1950-ies as FM and television and during the very last decades, microwaves of the modern communication society spread around the world. Until then microwaves had principally never been experienced on Earth.

Since 1988 our group has studied the effects upon the mammalian blood-brain barrier (BBB) in rats by non-thermal radio frequency electromagnetic fields (RF-EMF). These have been shown to cause significantly increased leakage of the rats' own blood albumin through the BBB of exposed rats, at energy levels of 1W/kg and below, as compared to non-exposed animals—in a total series of about two thousand animals (Salford et al. 2007).

It should be noted that all our work and other work, here referred to, exclusively deals with *non-thermal* effects for EMF.

One remarkable observation is the fact that the lowest energy levels, with whole-body average power densities below 10mW/kg, give rise to the most pronounced albumin leakage. If mobile communication, even at extremely low energy levels, causes the users' own albumin to leak out through the BBB, also other unwanted and toxic molecules in the blood, may leak into the brain tissue and concentrate in and damage the neurons and glial cells of the brain. **The SAR value of around 1 mW/kg exists at a distance of more than one meter away from the mobile phone antenna and at a distance of about 150 - 200 meters from a base station.** This was described as the "passive mobile phoning" of the bystanders (Salford et al. 2001)

Another remarkable observation in our studies is the fact that a significant ($p<0.002$)

neuronal damage is seen in rat brains 50 days after a 2 hour exposure to GSM at SAR values 200, 20 and 2 mW/kg (Salford et al. 2003). We have followed up this observation in a study where 96 animals were sacrificed 14 and 28 days respectively after an exposure for 2 hours to GSM mobile phone electromagnetic fields at SAR values 0 (controls), 200, 20, 2 and now also 0.2 mW/kg. Significant neuronal damage is seen after 28 days and albumin leakage after 14. Our findings may support the hypothesis that albumin leakage into the brain is the cause for the neuronal damage observed after 28 and 50 days. (Submitted manuscript)

In the majority of our studies, EMF exposure of the animals has been performed in transverse electromagnetic transmission line chambers (TEM-cells) (Salford et al. 2007). These TEM-cells are known to generate uniform electromagnetic fields for standard measurements. The experimental model allows the animals, which are un-anaesthetized during the whole exposure, to move and turn around in the exposure chamber, thus minimising the effects of stress induced immobilization.

In our continued research, also the non-thermal effects on tissue structure and memory function of long-term exposure have been studied. Fischer 344 rats were exposed for 2 hours to GSM 900, and sham exposed in our TEM-cells once a week for 13 months. After this they were studied for cognitive functions and compared to cage controls. Significant effects of exposure upon episodic memory function were demonstrated. The GSM-exposed rats had significantly impaired memory for objects and their temporal order of presentation ($p=0.02$). (Nittby et al. 2008a).

We have also performed micro-array analysis of brains from rats exposed alive to short term GSM both at 1,800 MHz and at 900MHz and have found significant effects upon gene expression of membrane associated genes as compared to control animals (Belyaev et al. 2006, Nittby et al. 2008b).

Most of our findings thus support that living organisms are affected by the non-thermal radio frequency fields. The fact that gene expression is significantly influenced may also support the recent epidemiological studies that indicate that long term exposure (10 years mobile phone use**)** increases the risk for developing tumours in the exposed brain hemisphere, both the benign vestibular schwannoma arising from the balance nerve and the highly malignant glioblastoma multiforme (Lönn et al., 2004; for a review see Kundi et al. 2004, Hardell et al. 2006a)**.** Regarding the development of vestibular schwannoma, the relative risk seen ten years after the start of mobile phone use, was 1.9 (with confidence interval 0.9-4.1) (Lönn et al. 2004). When only tumours occurring at the same side of the head as the mobile phone had been normally used, the relative risk increased to 3.9 (with confidence interval 1.6-9.5). In a pooled analysis of case-controlled studies on malignant brain tumours, cumulative life use of > 2, 000 hours of mobile phoning revealed an odds ratio of 3.7 (confidence interval of 1.7-7.7) (Hardell et al. 2006b).

The mechanisms by which the EMFs may alter BBB permeability are not well understood. At low field strengths, the effects on body temperature are negligible and thus heating effects are not involved. A change in the physicochemical characteristics of membranes has been suggested as a cause (Shivers at al. 1987).

We have performed experiments to verify a quantum mechanical model for interaction with protein-bound ions. Our results show that controlled frequency and amplitude of ELF EM fields upon spinach plasma vesicles can steer transport over the membrane (Bauréus-Koch et al. 2003). This may be a first proof of a resonance phenomenon where appropriate levels of frequency and amplitude in the right

combination have the potency to communicate with the biology of membranes and transport systems.

Concluding remarks:

The mammalian BBB is anatomically the same in the human as the rat's brain. Enzymatic functions in the BBB may be different between the species, even if very little is known about this.

With a long series of significant effects of RF-EMF demonstrated in the animal models, it is my sincere belief, that it is more probable than unlikely, that non-thermal electromagnetic fields from mobile phones and base stations do have effects upon the human brain and finally I will try to answer the specific questions raised by the First Hellenic conference on the effects of non ionizing radiation May 2008:

Q: Can we extrapolate from animal or cell culture studies into effects on humans?
A: As stated above: More probable than unlikely.

Q. How harmful are the base stations when located near houses and schools.
A. If our results, which show effects at even less than 1mW/kg SAR value, are valid also for the human brain, even distances 100 m or more from the base station (in the beam from the tower) are not safe.

Q: Are the so called "safety levels" as suggested by ICNIRP and WHO really safe or does every country have to follow Salzburg's values of 0,2 volts/meter?
A: If our results, which show effects at even less than 1mW/kg SAR value, are valid also for the human brain, these "safety levels" are still not safe.

Q: Are there strong scientific evidence supporting the notion that long term exposure of people in eclectic field values below ICNIRP standards is dangerous for public health?
A: Very little scientific evidence is collected so far. But as we notified in Environmental Health Perspectives 2003: "If mobile communication, even at extremely low SAR values, causes the users´ own albumin to leak out through the BBB, which is meant to protect the brain, also other unwanted and toxic molecules in the blood, may leak into the brain tissue and concentrate in and damage the neurones and glial cells of the brain. It can not be excluded that this, (especially after many years intense use) may promote the development of autoimmune and neuro-degenerative diseases, and we conclude that the suppliers of mobile communication – and our politicians – have an extensive responsibility to support the exploration of these possible risks for the users and the society". (Salford et al. 2003).

Q. Are children in schools more susceptible to the effects of nearby masts even if they do not spend the whole day in school?
A: It is generally held that the young, developing brain is more vulnerable than the adult brain. Concerning the masts placed on the school houses, it should be kept in mind, that it is the directed beam from the mast that carries the microwaves and that in many instances, the beam is directed above the school houses and yard to reach mobile phone users at distance from the mast itself.

Q: What is the case with other sources of radiation including the wireless phones, the wifi computer communication, the metropolitan internet access wireless network, the power lines, the domestic appliances.
A: All these systems add to the microwave environment and produce SAR values that may be harmful if our and other scientist's results from in vitro and in vivo experiments in animals are translatable to humans.

Q: Are cell phones harmful and which precaution measures should we suggest that users should take and especially children?
A: Cell phones have been proven harmful to experimental animals. According to our opinion, it is reasonable to believe that the results can be translated to the human situation – even if this is not proven!
Therefore we believe that the use of mobile phones and other microwave producing devices should be minimized as much as possible. The good old telephones working through electrical cords should if possible be spared! The use of hands-free devices reduces the SAR values reaching the brain – but it should be remembered that the values of 1mW/kg which reach the most central portion of the human brain when the mobile phone antenna is held 1.5 cm from the head, by the use of a hands-free kept 1 meter away, still reaches into the brain, but now more superficial areas!

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