

Effects of mobile phone radiation upon the blood-brain barrier, neurons, gene expression and cognitive function of the mammalian brain.

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Life on earth was formed during billions of years, exposed to, and shaped by the original physical 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. This results in an artificially produced general microwave background in our environment in the order of 10^{11} to 10^{18} times the levels generated by the MW background radiation from space.

Since 1988 our group has studied the effects of *non-thermal* RF-EMF upon BBB in rats, and has shown significantly increased leakage of the rats' own blood albumin through the BBB at energy levels of 1W/kg and below, as compared to non-exposed animals—in a total series of about two thousand animals. The lowest studied energy levels, (below 10mW/kg), give rise to the most pronounced albumin leakage. SAR 1 mW/kg exists about one meter away from the mobile phone antenna and about 200 meters from base-stations. This we have described as “passive mobile phoning”

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 one study including 96 animals (exposed and sham) which 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 also 0.2 mW/kg. In a recent study 48 animals were included and sacrificed 7 days after the same exposures. Significant neuronal damage is seen after 28 days and albumin leakage after 14 and 7 days. 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.

In the majority of our studies, EMF exposure of the animals has been performed in transverse electromagnetic transmission line chambers. 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 also 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 ($p = 0.02$). Interestingly, we could not demonstrate any significant histopathological differences regarding: BBB permeability; Neuronal damage; or Increased or accelerated ageing between exposed and sham controls when these animals were sacrificed six weeks after the cognitive tests.

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..

The mechanisms by which the non-thermal EMFs may alter BBB permeability are not well understood. 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. 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.

Having demonstrated a long series of significant effects of RF-EMF in the animal models, I sincerely believe, 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.