Radiofrequency EMFs and Health Risks

This article is separated into 8 sections, each of which can be individually downloaded. It is a 'work in progress' incorporating new information whenever time permits.

Section 3

The research – Heart to thyroid effects, other biological changes & precaution for children

1. Introduction; RF broadcast transmitters (radio & TV); DAB transmitters; radar; mobile phone masts; Internet of Things (IoT); safety zones; Lloyd's of London insurance refusal

2. The research – General; addiction; autism; behaviour changes; blood-brain barrier; blood changes; blood pressure; bone and muscle development; brain activity; cancer; Non-Hodgkin's lymphoma; cellular changes; central nervous system; cognitive changes; dementia; diabetes; DNA; emotional effects; epilepsy; eyes; headaches; hearing

3. The research – heart; effects on heart pacemakers; immune system; kidney effects; lifespan; limb changes in utero; liver damage; medical interference; microwave therapy; multiple sclerosis; neurological changes; effects on the nose; occupational exposure, including pulsed RF; oxidative stress; pain; psychiatric symptoms; skin effects; effects on sleep; spine; spleen and thymus; synergistic effects; thyroid effects; other biological changes; protection; the need for precaution with respect to children; synergistic effects; campaigning organisations

4. General reproductive effects; Radiofrequency (microwave) (RF) exposure and reproductive effects; Mobile phones or phone-type exposure and male sperm; Radiofrequency exposure and effects on female reproduction; Radiofrequency exposure and effects during pregnancy

5. Driving – car systems; tracking vehicles; when your car lock doesn't work; driverless vehicles; road trains; charging electric vehicles; mobile phones; motorbikes; speed limiting devices; traffic control sensors; other in-car devices; interference with electric vehicles

6. Animals; birds and bats; tadpoles; fishes; insects; ants; bees; cockroaches; flies; effects on plants

7. References – 595 references

8. Appendix; table of symptoms, by study; Santini 2002; Freiburger Appell 2002; Navarro 2003; Oberfeld 2004; open letter to Edmund Stoiber, President of Bavaria; Balmori 2005; Hutter 2006; Abdel-Rassoul 2007; Preece 2005; UK Parent-Teacher study 2000; Bortkiewicz 2004; Eger 2004; Wolf & Wolf 2004;

Eberhardt 2008; Augner 2010; Alazawi 2011; Santini 2003; Eger & Jahn 2010; Singh 2016; Kato & Johansson 2012; Gomez-Perretta 2013; Bortkiewicz 2012

The Research 2

Heart

Bortkiewicz (2012) found that exposure to radiofrequency RF in radio and TV broadcasting stations workers affected the heart rate variability. Elmas (2016) in a review of heart effects by EMF emitting devices concluded "*Until the effects of EMF on heart tissue are more fully explored, electronic devices generating EMFs should be approached with caution.*" It was felt by the author that differences between results of studies may be due to a compensatory response developed by the body over time. At greater EMF strengths or shorter exposures, the ability of the body to develop compensation mechanisms is reduced and the potential for heart-related effects increases.

Zhu (2015) found that microwave radiation has and adverse effect on rabbit hearts. The team felt that the possible mechanism may induce cell apoptosis by changing the stress level in myocardial cells. Further research by Zhu (2016) showed that microwave irradiation could induce myocardial cell apoptosis by interfering with oxidative stress and cardiac energy metabolism.

Exposure to EMF in the prenatal period causes oxidative stress and histopathological changes in male rat pup heart tissue (Türedi 2015).

In a study by Lednev (2008) magnetic field exposure was found to both increase and decrease the magnitude of stress in humans, particularly with respect to the spin of hydrogen atoms. This could be one of the ways in which adverse effects are caused on the human cardiovascular system by magnetic fields.

Effects on heart pacemakers

Tiikkaja (2103) recommends testing work environments as levels of EMFs can be quite variable, and an individual risk assessment is needed to see if the person's heart pacemaker may be affected.

The following sources of RF have been reported by pacemaker wearers to have the effects noted.

- **Car bluetooth** ~ Had to be returned when it interfered with the pacemaker and made the wearer unwell.
- **IPOD** ~ In most cases when the IPOD was held within 50 mm of the pacemaker for 5-10 seconds, it interfered with its functioning. One instance of interference still at 450 mm, and in another, the pacemaker stopped working altogether. Study by the Cardiovascular Institute at Michigan State University. Portable digital media players such as iPODs, or worse, iPhones, can interfere with the operation of implantable loop recorders used for diagnosis of intermittent cardiovascular symptoms (Thaker 2008, 2009a, 2009b).
- **Microwave oven** ~ At 3 feet from the oven, the wearer experienced a small vibration that felt like a slight 'buzzing' in the centre of their chest, coinciding with the time of operation of the oven.
- **Security scanner** ~ The 'wand' part of a security scanner can stop pacemakers; one wearer felt dizzy when exposed, but the feeling passed off.
- Airport security systems have been found to interfere with implanted medical devices, with sometimes serious repercussions (Hours 2013).
- **TV wireless headphone** ~ Caused one wearer to pass out at once.

- **Wii games** ~ Pulse rate went down to 54, though the pacemaker usually keeps it at 60. General 'interference'.
- **Wireless router for for broadband internet connection with laptop** ~ Pacemaker went 'crazy' even at 1.5 feet away, from the little 'radar switch'; the router had to be switched off after 5 minutes.

Salvatore Terranova, a pensioner in Niscemi, Sicily, has to drive to Palermo every 6 months to get his pacemaker re-calibrated. He says it won't keep time because he lives near the USA Navy's Niscemi Naval Radio Transmitter Facility antenna farm and Mobile User Objective System (MUOS) satellite ground station, with its two 495-foot-high antennas and the 40 other smaller sensors, used to send low-frequency radio signals to USA and NATO ships nearby.

Immune system

Exposure of human blood samples to a 900 MHz electromagnetic field might trigger neutrophil activation (Lippi 2016).

Kidney effects

RF radiation was found to interfere with gene expression during early rat gestation and resulted in aberrations of a particular bone protein, known to affect the development of the kidney. The authors felt that this may reflect a delay in the development of the kidney in newborn rats. The protein was affected differently depending the timing of exposure (Pyrpasopoulou 2004).

Prenatal exposure of rat kidneys to 900 MHz EMF resulted in increased total kidney volume, and decreased the numbers of glomeruli (filtering units). Melatonin prevented adverse effects of EMFs (Ulubay 2014).

Lifespan

In an experiment by Bartsch (2010), the survival time for female rats was significantly shortened by RF exposure by nearly 10%, though the month of birth also affected results. The authors concluded *"Chronic exposure to a low-intensity GSM-like signal may exert negative health effects and shorten survival time if applied for sufficiently long a time and the period covers the full life span.*

Limb changes in utero

Polydactyly, (more then 5 digits), induced by electromagnetic pulses was accompanied by gene changes and decreased percentage of programmed cell death during limb development (Yang 2013).

Liver damage

Exposure to RF radiation led to some oxidative destruction in liver tissue in rabbits (Tomruk 2010, Ozgur 2015). A study by Topal (2015) showed that a 900-MHz EMF applied in the prenatal period caused oxidative stress and pathological alterations in the liver of the rats in the postnatal period.

Mortazavi (2016) concluded as a result of his study that exposure of rats to a 900 MHz electromagnetic field (GSM) could induce histopathological changes in the liver and pancreas.

Medical interference

Seidman (2011) reported that *"In a hospital setting decreased throughput and communication breakdowns can cause wireless medical devices to fail. It is therefore vital to have an understanding of the effect EMI can have on wireless communication devices."* In a study of 4 large teaching hospitals, Morrissey (2002) concluded *"Overall, no cell phone signal was exempt from producing electromagnetic interference effects."*

Medical electromagnetic radiation devices have been found to interfere with implanted medical devices, with sometimes serious repercussions (Hours 2013).

Microwave therapy

A study by He (2013) concluded that there are non-ionising radiation hazards from physiotherapy equipment in the 16 medical institutions investigated and effective prevention and control measures are necessary.

Multiple sclerosis

Microwave exposure was identified as a risk factor for multiple sclerosis in a study by Abbasi (2017).

Neurological changes

Gerd Oberfeld and his colleagues in the Public health Dept in Salzburg measured brain wave changes in volunteers exposed to 1 V/m pulsed radiation from a GSM base station 80 metres away. The changes in relative strength of alpha 1, alpha 2 and beta brain waves were documented from EEG measurements. It was suggested that these findings verified the prediction by Gerard Hyland (2000) that the pulsing pattern of GSM phone systems would resonate with the lower frequency human brainwaves.

Significant EEG changes implying that brain functioning had been affected by low-frequency microwaves was found in a study by Vorobyov (2010). Alpha band activity was found to be altered by RF exposure (Perentos 2013). Low frequency RF was found to change EEG, depending on frequency (Hinrikus 2008).

In a study looking at the spectral power coherence (SPC), which reflects the pattern of co-ordination of delta, theta, alpha and beta EEG bands, when exposed to 900MHz and 1800MHz signals, the delta rhythm was less consequential than the others. In the absence of radiation, males exhibit higher overall SPC than females. These differences disappear in the presence of 900MHz and are reversed in the presence of 1800MHz (Hountala 2008).

Qiao (2014) stated that the abnormal release of neurotransmitters after microwave exposure can cause learning and memory deficits.

Rats exposed to low power density microwaves had significant deficits in spatial learning and memory performance (Wang & Lai 2000, Li 2008). The authors believed that glucocorticoids contributed to the effect. Cognitive processes such as attention and short-term memory were affected by microwaves modulated at 7 Hz (Lass 2002).

Some of Calvente's results (2016) may suggest that low-level environmental RF-EMF exposure has a negative impact on cognitive and/or behaviour development in children.

When Hocking & Westerman (2003) searched 11 original articles investigating neurological effects, they found that threshold studies found neurological abnormalities, though only a small proportion of exposed people develop the symptoms. Changes were found in neurobehavioral function in workers exposed to high-frequency radiation which resulted in important adverse effects (Duan 1998).

WiFi exposure exerted gender-related alterations on neural activity associated with the amount of attentional resources engaged during a linguistic test adjusted to induce working memory (Papageorgiou 2011).

F Xu (2017) found that interference with stem cell proliferation upon short-term exposure to an 1800 MHz electromagnetic field depends on the developmental stage of the brain.

Effects on the nose

Radiofrequency radiation at 2100 MHz damaged the nasal septal mucosa, and disturbed the mucociliary clearance (Aydogan 2015), which has an important role in voiding the airways from inhaled foreign substances.

Occupational exposure, including pulsed RF

Metro engine-drivers in Warsaw can experience RF levels up to 2.5 V/m, from mobile phones, their infrastructure, WiFi and staff radiophone transmitters (Gryz & Karpowicz 2015).

Jiang (2013) found that electromagnetic pulse exposure at levels found in some occupational environments could cause long-term impairment in cognition and memory of rats, resulting in Alzheimer's disease-like symptoms.

Daily occupational EMF exposure was positively associated with poor sleep quality (Liu 2014).

Results from the daily activities diaries of personnel employed on radio & TV transmitters and mobile phone masts suggested that riggers working for radio and television broadcasters were exposed to much longer periods as compared to colleagues working for mobile operators (Litchfield 2017). Low-power radio transmitters are one of the most common radio frequency sources and the European directive 2013/35/EU exposure limit values (ELVs) for occupational exposure may be exceeded close to them (Valic 2017). The local 10 g averaged value of the SAR can be exceeded if the worker is grounded (in direct contact with the steel structure), while the whole body ELVs can be exceeded for exposures at distances of less than 1 m from the transmitting dipole array antenna.

Oxidative stress

The results of the studies reviewed by Dasdag & Akdag (2016) indicated that mobile phones and similar equipment or radars can be thought as factors which cause oxidative stress. Some of them claimed that oxidative stress originated from radiofrequencies can be resulted with DNA damage.

Pain

Results of a study by Black (2016) substantiate patient reports of RF EMF-pain, in the case of peripheral nerve injury. Neuropathic pain in rabbits was reduced by pulsed RF (Aksu 2010).

Psychiatric symptoms

Silva (2015) reported that exposure to electromagnetic radiation from mobile phone base stations and other electronic devices was associated with psychiatric symptoms. The authors recommended that precautionary measures to reduce such exposure should be adopted.

Skin effects

Protein expression in human skin was found to be affected by exposure to RF-EMF. Analysis identified 8 proteins that were statistically significantly affected. Two of the proteins were present in the 10 people exposed (Karinen 2008).

Effects on sleep

Sleep problems affect around 10 to 12 per cent of the adult population, according to Professor Colin Espie, director of the University of Glasgow Sleep Research Laboratory. By his definition, a chronic insomniac is someone who spends at least 30 minutes trying to get to sleep or is awake for at least 30 minutes during the night, at least three times a week for three months. This is similar to what is reported by people who live near RF transmitters. Sleep recharges the brain, repairing important neuronal connections and helping it organise data. Sleep also gives the cardiovascular system a break and helps damaged cells mend themselves. So any effect on sleep quality may express itself in many different symptoms according to individual susceptibility.

Humans use cryptochrome in our biological clocks. Cryptochrome is affected by RF (Ritz 2004), and this interaction may be responsible for the poor sleep patterns often reported in people living near mobile phone masts. They suffer fatigue during the day and interrupted sleep at night. Crouzier (2007) found that RF exposure affected the quantity of time spent in REM sleep.

REM sleep is more susceptible to modulated RF than slow wave sleep (Mohammed 2013), with individual differences (Loughran 2012). The latency of REM sleep increased due to radiation exposure indicating a change in the ultradian rhythm of normal sleep cycles. It was proposed that RF had a cumulative and irreversible effect.

The Schwarzenburg radio transmitter in Switzerland was shut down in 1998, and Altpeter and his colleagues did a 'before and after' study (2006) on sleep quality and melatonin excretion (a measure of melatonin availability) in nearby residents. They found an improvement in sleep quality and melatonin excretion after the mast ceased broadcasting, depending on the previous level of RF exposure, but only in poor sleepers. They accepted that there may have been a psychosomatic element in their result. Mohler (2010) found no association between environmental far-field RF exposure and sleep disturbances or excessive daytime sleepiness; neither did Danker-Hopfe (2010) in a laboratory setting.

Studies have linked disturbed sleep patterns to heart disease and diabetes, and found that a twentysomething deprived of sleep for 36 hours will have the mental capacity of a 60-year-old.

The RAC says that sleepy drivers were to blame for 20,000 crashes last year. Sleep deprivation results in a reduced ability to make sense of what is seen. There can be severe drops in visual processing and attention. In between there may be periods of apparently normal brain functioning which can lead to a false sense of competency and security (Chee 2008). This clearly could have serious consequences if people were suffering sleep problems and engaged in work that needed a clear focus of concentration.

Disruption of sleep or insufficient sleep can lead to a significant reduction in the activity of genes displaying a circadian rhythm (Archer 2014). This disruption can affect metabolism, and inflammatory, immune and stress responses.

A study of teenagers in Nigeria (Sanya 2015) reported that 10% make regular phone calls at night and 5.5% surf internet and use computers at night. The duration of night time sleep was adequate in only 41% of students, who had the potential to develop problems due to insufficient sleep. In 7-year-old Dutch children sleep duration scores were associated with RF-EMF levels from base stations. Higher use of mobile phones was associated with less favourable sleep duration, night wakenings and parasomnias, and also with bedtime resistance (Huss 2015).

Half of the students in 5 universities of medical sciences in the north east of Iran had a poor level of sleep quality and most of them were considered unhealthy. There was a significant association between excessive use of mobile phones and general health and quality of sleep. Excessive use of mobile phones has a significant relationship between each of the four subscales of general health and quality of sleep (Eyvazlou 2016).

A study by Clark (2007) showed that there may be a sensitive subgroup of women who react to RF transmissions with a reduction in melatonin levels, especially post menopause. As this is such a potent hormone with respect to our health, this deserves further investigation.

Pulse-modulated 900 MHz RF can change EEG characteristics of sleep (Lustenberger 2015), affecting subsequent motor performance (Lustenberger 2013).

Spine

Studies by Íkinci (2016) and Kerimoğlu (2016) show that biochemical alterations and pathological changes may occur in the spinal cords of ***postnatal male*** rats following exposure to 900MHz EMF for 1h a day, Following a previous study by Odacı (2013) that this exposure applied in the ***prenatal*** period affected the spinal cord development of ***female*** rat pups.

Spleen and Thymus

Exposure to 900 MHz EMF during the prenatal period can cause pathological and biochemical changes that may compromise the development of the male rat thymus and spleen (Hancı 2015).

Synergistic effects

Cao (2009) found that the adverse effects of gamma radiation on cellular functions are strengthened by 900 MHz RFs.

The experimental results from a study by B Wang (2005) indicated 1.8GHz RFR could enhance the human lymphocyte DNA damage effects induced by MMC and 4NQO, 2 chemical mutagens. Boga (2015) suggests that the combined use of nicotine and cell phones might result in more pronounced detrimental effects on the health of smokers.

Both 1500 and 1800 MHz exposures transiently suppressed analgesic effect of tramadol (Bodera 2012).

Baohong (2007) discovered that 1.8 GHz RF exposure could increase DNA damage induced by ultraviolet C rays and some chemical agents (Baohong 2005).

Vojtisek (2005) found a significant increase in brain manganese level in rats exposed to both RF electromagnetic fields and manganese (a neurological toxin) as compared to manganese

administration only. In vivo observation of rats exposed to manganese and/or electromagnetic fields demonstrated significant behavioural changes.

Thyroid effects

Low energy microwave irradiation may be harmful as it is sufficient to alter the levels of thyroid hormones as well as the emotional reactivity (hyperactivity and aggression) (Sinha 2008).

Esmekaya (2010) found that *"whole body exposure to pulse-modulated RF radiation similar to that emitted by GSM mobile phones can cause pathological changes in the thyroid gland."*

Other biological changes

De Pomerai's team (2003) found that exposure to microwave radiation enhanced the aggregation of bovine serum albumin, in a similar way to heating, and that the effect could be inhibited in a similar way to the way heat-shock responses caused by temperature increases were inhibited.

RF-EMF exposure induced a shift in thermal preference towards higher temperatures (Pelletier 2014). The authors felt that the shift in preferred temperature might result from a cold thermal sensation and the greater amount of slow wave sleep may involve signals from thermoreceptors in the skin.

Rats were exposed for 30 days to a far-field source of RF, and antibody levels were higher on day 7 compared with day 14. The authors suggested it was an oxidative intracellular stress-reaction (Grigor'ev 2010).

Chromosome aberrations were found in people occupationally exposed to RF. The average numbers of changes in examined groups were significantly higher than that observed in unexposed individuals. A positive correlation between the total number of chromosome aberrations and cumulative 6-years dosage was also found. The data emphasized the dangerous effects of prolonged exposure and indicated that chromosomal aberration analysis should be obligatory for individuals working at radio-relay stations (Lalić 2001).

Changes in the circulatory system and a significant relationship between blood pressure and neurovegetative regulation disorders were found to be associated with occupational exposure to RF below ICNIRP limits (Bortkiewicz 2003).

Orendáčová (2009) found that 2.45 GHz radiation induced age- and dose-dependent changes in proliferating cell numbers in the nervous system of newborn rats, at levels similar to those that will be found in classrooms where there is WiFi. Del Vecchio (2009a) found reduced neurite growth and maturation after exposure to 900 MHz radiation. The team suggested that it was only under certain conditions that the exposure acted as a co-stressor for neurodegenerative oxidative damage (2009b). Avci (2012) and Bilgici (2013) found oxidative stress in blood and brain tissue following exposure to RF radiation and that garlic had a protective effect. Yurekli (2006) also found oxidative stress biomarkers in rats exposed to GSM far field signals such as those found near base stations. This suggests an interactive environmental component that makes experimental studies harder to replicate.

Sommer (2004) looked at lymphoma development in mice exposed to RF radiation, and found no link. However, she did find a significant effect on body weight gain, as did Lerchl (2008). Pelletier (2012) found that exposure to RF restricted body cooling, but increased energy intake in the form of increased daytime food intake, without affecting sleep patterns.

It is accepted that electromagnetic fields affect the behaviour of calcium in living cells. The textbook symptoms of too little calcium, such as fatigue, muscle cramps, irregular heart rhythm and gut problems are very similar to those reported by people who say they are affected by microwave radiation. As long ago as 1975, Bawin reported that RF could remove structurally important calcium ions from cell membranes at levels far too low to generate significant heat. This makes them leak. The most serious effect is on the membranes of the lysosomes. When these leak, they can release their enzymes and do serious damage to the rest of the cell, including to its DNA. One effect of DNA damage is the disruption of cell division in the bone marrow, which affects the production of healthy white blood cells and can lead to a reduced immunity to disease.

In medicine and food industries EMF is used for its bactericidal effects. The significant targets of cellular mechanisms for EMF effects at resonant frequencies in bacteria could be water (H(2)O), cell membrane and genome. The consequences for EMF interaction with bacteria are the changes in their sensitivity to different chemicals, including antibiotics. These effects are important to understand with regard to their antibiotic resistance. EMFs may also affect the cell-to-cell interactions in bacterial populations, since bacteria might interact with each other through EMF of sub-extremely high frequency range (Torgomyan & Trchounian 2012).

Rossi (2011) found that specific electromagnetic signals emitted by cells were transmitted through the polystyrene wall, affecting cell proliferation rate and morphology, even though the cells were growing in separate dishes.

Pulses carried by microwaves are particularly dangerous. This is because their very short wavelength allows the transmission of pulses with extremely rapid rise and fall times, and it is the rate of change of the fields (rather than their total energy) that does most of the biological damage; it catapults vital calcium ions away from cell membranes, which in turn makes them leak. This leakage can explain the great majority of the observed adverse health effects of prolonged exposure to electromagnetic radiation.

Augner (2010) found various biomarkers of stress in the saliva of study participants exposed to base station signals at low levels. The authors felt that these would be indicative of some of the symptoms ascribed to RF-EMF exposure from the masts.

In an occupational study by Vangelova (2002) the long term effect of exposure to low-level RF radiation evoked pronounced stress reaction with changes in the circadian rhythm. It needs to be clarified as to what possible health hazards may result.

Another occupational study by Yuan (2004) found that low-intensity VHF radiation can decrease the nervous system function in occupationally exposed personnel and induce increase in some kinds of enzymes and immunoglobulins and decreases in neurobehaviour function tests. Participants who were exposed reported symptoms such as headache, insomnia and amnesia.

Hyland suggested (2008) that it is the similarities between the characteristics of external microwave fields and the natural cellular qualities that cause the interactions between the two, interfering with the cell's optimum functioning. The incoming microwaves "*undermine the efficacy of processes that would otherwise afford natural protection against the development of pathology*". The microwaves can create ill-health effects by altering the protective effects of cellular behaviour. Interestingly, using microwaves in carefully considered therapeutic ways can enable aberrant behaviour of cells to be 'normalised' thus improving health. For more information on this, see our article "The positive effects of EMFs".

Physicists at UC Berkeley (Jensen 2007) have produced the world's smallest radio out of a single carbon nanotube that is 10,000 times thinner than a human hair. It serves as an antenna, tuner, amplifier and demodulator. The nanotube absorbs the radio transmission and physically vibrates

in response, like a tuning fork or the tiny hairlike structures inside the human ear. The multi-walled cylinders were better at picking up AM and FM transmissions and the single walled nanotubes were best for receiving the frequencies used in cell phones. It is interesting that the mechanism is by physical vibration of the nanotube in response to RF fields. This may give more pointers as to the bio-detection capability of the body, even at a cellular level and also may well invoke a bio-response. Pavicic (2008) found that 935MHz radiation affected microtubule proteins, which the authors believed could obstruct cell growth.

Khurana (2010) reviewed 10 epidemiological studies looking at potential health effects from mobile phone base stations. 7 investigated neurobehavioural effects and 3 looked at cancer risk. 8 out of the 10 studies reported increased prevalence of adverse neurobehavioural symptoms or cancer in populations living less than 500 metres from base stations. None of the studies reported exposure above accepted international guidelines, suggesting that current guidelines may be inadequate in protecting the health of human populations.

1 GHz exposure caused serious functional disorders in exposed cells in the form of a reduction of their spontaneous motor activity. The form of biological reaction observed was uncommon (Sarapultseva 2009). Her team also found (2014) low-dose exposure to RF-EMF significantly affected the motility of irradiated ciliates and their non-exposed offspring, thus providing further insights into the unknown mechanisms underlying the in vivo effects of RF-EMF. The motility remained significantly compromised, at least, across 10-15 generations, thus indicating the presence of transgenerational effects.

Exposure to 900 MHz fields caused damage that lead to death in single-cell organisms (Aksoy 2005). It is unclear whether the effects would be similar if the cells were in a living being. A small number of gene changes were found in a yeast after exposure to an intermittent 1800 MHz field (Chen 2012).

Vitamins A, C & E in the cortex were lower after exposure to 2.45 GHz radiation (Naziroğlu & Gümral 2009).

Protection

Brain damage can be induced by prolonged RF exposure with loss of interacellular Ca(2+) balance. Ginseng was found to contribute to the maintenance of Ca(2+) homeostasis, thus offering protection against RF damage Maskey 2013).

RF radiation induced chromosomal damage in experiments by Esmekaya (2011), but this damage was reduced by Gingko biloba pretreatment.

The need for precaution with respect to children

Many of the symptoms reported by people living near mobile phone base stations, that is, concentration, learning and memory problems, behavioural changes, irritability and aggression are particularly undesirable to be found occurring in school pupils. There has been a dramatic increase in the use of wireless local area network (wLAN) systems and interactive whiteboards in schoolrooms. Enclosed environments (particularly where there are microwave-reflective structures such as reinforced concrete, metal joists, steel furniture etc.) will add to the overall exposure of children to microwave radiation.

The ICNIRP guidelines (which determine the permitted exposure to RF by the general public), are relevant only to heating effects. However, the bulk of the damage is due to direct electrical effects on the stability of cell membranes and can occur at levels orders of magnitude lower. It is

generally accepted that about 3%of the population (about one child per class) will develop some form of electromagnetic hypersensitivity (EHS) and a larger number will show behavioural problems, experience learning difficulties and risk permanent genetic damage.

A study reported by Powerwatch in 2000 (Section 4, study I), showed that in a comparison of 2 schools in the North East of England, one with a mast for almost 3 years, and one without, the one with reported more children complaining of nausea, tiredness, memory loss, skin problems, anxiety, and poor concentration.

Since 1997, there has been a four-fold rise in children diagnosed with hyperactivity and Attention Deficit Hyperactivity Disorder (ADHD) - indeed the National Institute for Clinical Excellence now estimates that as many as 5% of children have this problem. It is possible that microwave exposure plays a role in this rise.

A councillor in London reported that he had been into homes where the children were *"screaming monsters"*. After he suggested to the parents that they switch off the wireless network for two days, *"the kids were transformed"*.

Children absorb more RF than adults because their brain tissues are more absorbent, their skulls are thinner and their relative size is smaller. RF from wireless devices has been declared a possible human carcinogen. Children are at greater risk than adults when exposed to any carcinogen. Because the average latency time between first exposure and diagnosis of a tumour can be decades, tumours induced in children may not be diagnosed until well into adulthood. The foetus is particularly vulnerable to RF. RF values found during the night period in a neonatal medium care unit were higher than those found during the day period (Calvente 2017). It is important to consider RF exposure levels in neonatal care units, due to evidence of adverse health effects found in children and adults.

RF exposure can result in degeneration of the protective myelin sheath that surrounds brain neurons. RF-emitting toys are being sold for use by young infants and toddlers. Digital dementia has been reported in school age children (Morgan 2014).

Redmayne & Johansson (2015) conclude that age-dependent RF-EMR study results, when considered in the context of developmental stage, indicate increased specific vulnerabilities in the young (foetus to adolescent). There appears to be at least one mechanism other than the known thermal mechanism causing different responses to RF-EMR depending upon the type of exposure, the physiological process involved, and age.

A spokesperson from the Russian National Committee for Protection from Nonionizing Radiation (Markov & Grigoriev 2015) says *"the largest group of users is the children and teenagers who "need" to communicate nearly 24 h a day. This is even more important because cell phones and tablets may be seen in the hands of children as little as two years in age. There is no way to assess and predict the potential damages of children brain, vision and hearing under exposure to RF radiation. The WHO precautionary principle and IARC classification must be applied in discussing the potential hazard of the use of today's and tomorrow's communication devices"*.

Campaigning organisations

CAVI Society www.cavisoc.org.uk UK Charity which seeks to safeguard children from the effects of electromagnetic radiation in which they spend the greatest amount of their time.

EM Radiation Research Trust www.radiationresearch.org – UK charity. The EM Radiation research trust is an independent body which aims to provide the facts about electromagnetic

radiation and health to the public and the media. It sponsors Rewire.me ES and EMFs Information Magazine.

Mast Action UK www.mastaction.co.uk - A UK organisation which campaigns for the sensible siting of mobile phone masts.

Mast Sanity www.mastsanity.org – UK charity set up in 2002 to help campaigners concerned about the rollout of mobile phone masts and TETRA and health implications.

Mast Victims www.mast-victims.org – A website dedicated to people suffering health effects from masts and antennas.

Planning Sanity www.planningsanity.co.uk – Planning Sanity is a UK organisation, set up in 1999, to help local communities tackle adverse planning and development applications that threaten to blight their areas. Includes information about mobile phone masts.

The studies that have been done on microwave exposure, both occupational and epidemiological, together with the experience of residents of communities with mobile phone masts, are sufficiently consistent to raise the question as to whether living with microwave radiation at low levels is without health effects for at least some members of the general population. More than two thousand scientific studies have shown that radiofrequency exposures can cause changes in cell membrane function, cell communication, metabolism and activation of proto-oncogenes. Production of stress proteins is triggered at exposure levels far below current regulatory limits. The resulting effects can include DNA breaks and chromosome aberrations, cell death including death of brain neurons, increased free-radical production, activation of the endogenous opioid system, cell stress and premature ageing. Other documented effects are changes in brain function including memory loss, retarded learning, performance impairment in children, headaches and fatigue, sleep disorders, neurodegenerative conditions, reduction in melatonin secretion and cancers. It may be that only a certain percentage of the population is, or will ever be affected by this form of environmental pollutant. A literature study conducted by the International Commission for Non-Ionising Radiation Protection (ICNIRP – whose guidelines are accepted by the UK government) concluded "*The epidemiologic studies have too many deficiencies to rule out an association between exposure from radio frequency fields (RFs) and any adverse health effects. Despite the ubiquity of new technologies using radio frequency fields, little is known about population exposure from RF sources, and even less about the relative importance of different sources.*"

Finding an answer will not become any easier as people choose to use DECT phones and wireless computer networks (wLANs) at home and at work, Bluetooth technology in vehicles and WiMAX and WiFi emitters in the general environment.

Sage and Carpenter in 2009 summarised their views; "*Global exposures to emerging wireless technologies from applications including mobile phones, cordless phones, DECT phones, WiFi, WLAN, WiMAX, wireless internet, baby monitors, and others may present serious public health consequences. New, biologically based public exposure standards for chronic exposure to low-intensity exposures are warranted. Existing safety standards are obsolete because they are based solely on thermal effects from acute exposures. The rapidly expanding development of new wireless technologies and the long latency for the development of such serious diseases as brain cancers means that failure to take immediate action to reduce risks may result in an epidemic of potentially fatal diseases in the future.*"

An overwhelming majority of the European Parliament voted in 2008 for a set of changes based on health concerns associated with electromagnetic fields. They note "*the limits on exposure to electromagnetic fields which have been set for the general public are obsolete.*" However, scientists representing both the World Health Organisation (WHO) and the European Commission, do not seem to have the precautionary principle in mind when they report on health risks. This seems to

conflict with European Union (EU) law, which requires that the degree of scientific uncertainty should be presented correctly. Case law, for other types of public exposure, also shows that the precautionary principle can be applied on the basis of weaker evidence than the current research is showing (Damvik 2010).

Russia and China have long ago implemented significantly stricter limits than most western countries, and Switzerland, Italy and Lichtenstein have acted unilaterally to protect their own populations from the health hazards of electromagnetic radiation.

Those of us in other countries, with ICNIRP limits, who believe they are sensitive to microwave radiation, need to have the information to help them avoid the exposure which is affecting their health and reducing their quality of life.