

Part Three:

RF/MW Bioeffect mechanisms

- *Brief history of RF/MW bioeffects and SAR.*
- 1. RF/MW suppresses immunological function
- 2. RF/MW radiation penetrates the blood brain barrier (BBB) with deleterious effects
- 3. RF/MW radiation builds free radicals in the cerebrospinal fluids (CSF)
- 4. RF/MW has cognitive effects: memory, attention, etc.
- 5. RF/MW electrosensitises people to suffer myalgias etc. from exposure (ElectroHypersensitivity: EHS).



Other Biological Effects:

Nervous system

Blood-brain barrier

Calcium

Cardiovascular

Warm sensation

Hormones

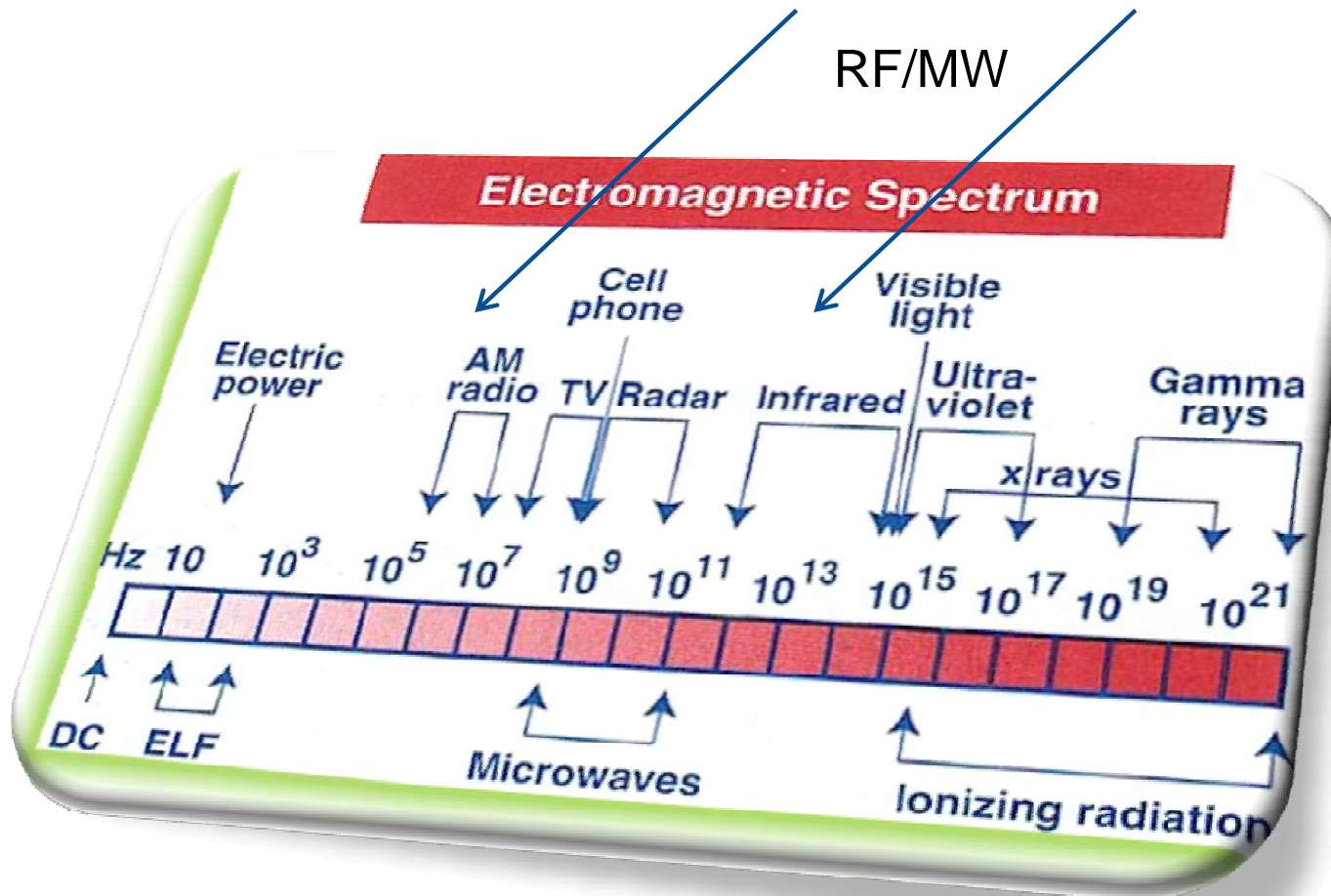
Immunology

Metabolic rate/effect

Reproduction/growth

Subjective symptoms

The Electromagnetic Spectrum



Many studies use “SAR” as an exposure metric

- * Specific Absorption Rate: the energy absorbed per unit time in a given volume of tissue from radiation: watts per kilogram.
- This metric is presently used to assess cellphone effects on users.
- As a means of assessment it is very fragile!

$$SAR = \frac{\sigma E^2}{\rho}$$

where σ is conductivity in Siemens/metre, E is the estimated internal electric field in Volts/metre, and ρ is permittivity in kilograms/metre

Example:

- SAR =
- $0.1 \text{ (conductivity)} \times 36 \text{ (6V/m}^2\text{)}/2 \text{ (permittivity)}$
- = 1.8 Watts/kg

The basic restriction recommended by ICNIRP is one tenth of 4 W/kg = 0.4 W/kg for occupational and 0.08W/kg for residential exposures, (set out in Health Physics, 1998) and relates to acute thermal effects only.

- Hubert Trzaska of Wroclaw University, Poland, points out that this approach is illogical and nonrealizable (Trzaska, 2005).

How SAR exposure guidelines were derived:

- These were derived from a handful of studies on monkeys: the criteria were to see when 1/3rd of them stopped operant behaviour when exposed. From four quite widely different results the average was 4W/kg. Dividing that by ten gave the occupational standard (0.4W/kg) and a “safety margin” of 20 times was added for exposure of the public (0.02W/kg)!
- This approach is scientific Gobbledegook!

What defines SAR?

- Thus, “values of SAR depend on the following factors:
- A) the incident field parameters, i.e., the frequency, intensity, polarization, and source– object configuration (near- or far-field);
- B) the characteristics of the exposed body, i.e., its size and internal and external geometry, and the dielectric properties of the various tissues; and
- C) ground effects and reflector effects of other objects in the field near the exposed body”.
- *Note that chronicity is missing.*

Cell Phone SAR_{max} is a fragile measure: Even the experts disagree:

Dimbylow and Mann (1994)- 2.3 and 4.8 W/kg/gm tissue per W output at 900 MHz and 1.8 GHz.

Anderson and Joyner (1995)- 0.12-0.83 W/kg

Gandhi et al. (1999)- 0.13-5.41 W/kg/gm tissue at 0.6 W output (835 and 1900 MHz)

Van de Kamer and Lagendijk (2002)- 1.72-2.55 W/kg /gm tissue at 0.25 W output (915 MHz)

The basis of ICNIRP guidelines

- **“Summary of biological effects and epidemiological studies (100 kHz–300 GHz)**
- Available experimental evidence indicates that the
- exposure of resting humans for approximately 30 min to
- EMF producing a whole-body SAR of between
- 1 and 4 W kg⁻¹ results in a body temperature increase of
- less than 1 °C.
- Animal data indicate a threshold for behavioral responses in the same SAR range.
- Exposure to more intense fields, producing SAR values in excess of 4 W kg⁻¹, can overwhelm the thermoregulatory capacity of the body and produce harmful levels of tissue heating”.



What ICNIRP says to define its guidelines

“Many laboratory studies with rodent and nonhuman primate models have demonstrated the broad range of tissue damage resulting from either partial-body or whole-body heating producing temperature rises in excess of 1–2°C.

“The sensitivity of various types of tissue to thermal damage varies widely, but the threshold for irreversible effects in even the most sensitive tissues is greater than 4 W kg under normal environmental conditions.

“These data form the basis for an occupational exposure restriction of 0.4 W kg, which provides a large margin of safety for other limiting conditions such as high ambient temperature, humidity, or level of physical activity”.

Comment (1):

- 1. This means that ICNIRP is considering only immediate thermal effects, not interference effects. (Interference effects are such as those affecting avionic instruments when cellphones are used in flight. The signals do not heat the plane!).
- In this conclusion they therefore ignore all 400 plus studies of non-thermal effects reported in the peer reviewed literature.

Comment (2):

- 2. ICNIRP's guidelines are actually hedged around with doubts, if one reads their actual text (Health Physics, 1998):

“Thus, it appears that this study suggests a non-thermal mechanism may be acting, which needs to be investigated further”...

“Several studies with rodents and monkeys have also demonstrated a behavioral component of thermoregulatory responses. Decreased task performance by rats and monkeys has been observed at SAR values in the range 1–3 W kg (Stern et al. 1979; Adair and Adams 1980; de Lorge and Ezell 1980; D'Andrea et al. 1986)”

(i.e. below 4 W/kg!)

STANDARDS and BACKGROUND LEVELS

0.08 W/Kg	IEEE standard uncontrolled environment (whole body)	IEEE
0.4 W/Kg	IEEE standard controlled environment (whole body)	IEEE
1.6 W/Kg	FCC(IEEE) SAR limit over 1 gram of tissue in a partial body exposure situation (for example, cell phone to ear)	FCC, 1996

Standards and Background Levels

Reference

Power Density

~530-600 $\mu\text{W}/\text{cm}^2$	Limit for uncontrolled public exposure to 800-900 MHz	ANSI/IEEE
1000 $\mu\text{W}/\text{cm}^2$	STANDARD for public exposure (as of September 1,1997)	FCC, 1996
5000 $\mu\text{W}/\text{cm}^2$	STANDARD for occupational exposure (as of September 1,1997)	FCC, 1996

Power Density Background Levels

0.05 $\mu\text{W}/\text{cm}^2$	Median ambient power density in cities in Sweden (30-2000 MHz)	Hamnerius, 2000
0.003 $\mu\text{W}/\text{cm}^2$	Background Level Ambient background RF exposure in US cities and suburbs 1990s	Mantiply, 1997
0.1-10 $\mu\text{W}/\text{cm}^2$	Ambient RF exposure within 100-200 feet of cell/PCS antenna array	Sage, 2000

Cellphone Biological Studies

Finally, there is evidence of industry bias in the results:

	Effect	No Effect	Total
Industry-Funded	27 (29%)	66 (71%)	93 (30%)
Non-Industry-Funded	147 (69%)	67 (31%)	214(70%)
Total	174(57%)	133 (43%)	307

$$\chi^2 = 39.93 \text{ (p} < .001 \text{)}$$

(Source: Henry Lai: personal communication, 3/3/06)

(Source:

Studies reporting biological effects of radiofrequency radiation (RFR) at low intensities

- (1) Balode (1996)- blood cells from cows from a farm close and in front of a radar showed significantly higher level of severe genetic damage.**
- (2) Boscol et al. (2001)- RFR from radio transmission stations (0.005 mW/cm²) affects immunological system in women.**
- (3) Chiang et al. (1989)- people who lived and worked near radio antennae and radar installations showed deficits in psychological and short-term memory tests.**

(4) de Pomerai et al. (2000, 2002) reported an increase in a molecular stress response in cells after exposure to a RFR at a SAR of 0.001 W/kg. This stress response is a basic biological process that is present in almost all animals - including humans.

(5) De Pomerai et al. (2003) RFR damages proteins at 0.015-0.02 W/kg.

(6) D'Inzeo et al. (1988)- very low intensity RFR (0.002 – 0.004 mW/cm²) affects the operation of acetylcholine-related ion-channels in cells. These channels play important roles in physiological and behavioral functions.

(7) Dolk et al. (1997)- a significant increase in adult leukemias was found in residents who lived near the Sutton Coldfield television (TV) and frequency modulation (FM) radio transmitter in England.

(8) Dutta et al. (1989) reported an increase in calcium efflux in cells after exposure to RFR at 0.005 W/kg. Calcium is an important component of normal cellular functions.

(9) Fesenko et al. (1999) reported a change in immunological functions in mice after exposure to RFR at a power density of 0.001 mW/cm².

(10) Hjollund et al. (1997)- sperm counts of Danish military personnel, who operated mobile ground-to-air missile units that use several RFR emitting radar systems (maximal mean exposure 0.01 mW/cm²), were significantly lower compared to references.

(11) Hocking et al. (1996)- an association was found between increased childhood leukemia incidence and mortality and proximity to TV towers.



(12) Ivaschuk et al. (1999)- short-term exposure to cellular phone RFR of very low SAR (26 mW/kg) affected a gene related to cancer.

(13) Kolodynski and Kolodynska (1996)- school children who lived in front of a radio station had less developed memory and attention, their reaction time was slower, and their neuromuscular apparatus endurance was decreased.

(14) Kwee et al. (2001)- 20 minutes of cell phone RFR exposure at 0.0021 W/kg increased stress protein in human cells.

(15) Lebedeva et al. (2000)- brain wave activation was observed in human subjects exposed to cellular phone RFR at 0.06 mW/cm².

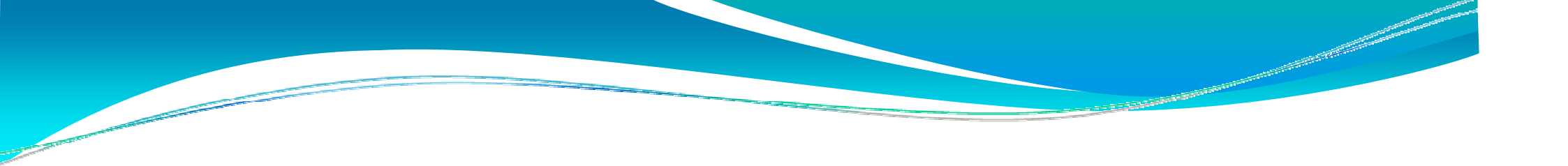
(16) Magras and Xenos (1999) reported a decrease in reproductive function in mice exposed to RFR at power densities of 0.000168 - 0.001053 mW/cm².

(17) Mann et al. (1998)- a transient increase in blood cortisol was observed in human subjects exposed to cellular phone RFR at 0.02 mW/cm². Cortisol is a hormone involved in stress reaction.

(18) Marinelli et al. (2004)- exposure to 900-MHz RFR at 0.0035 W/kg affected cell's self-defense responses.

(19) Michelozzi et al. (1998)- leukemia mortality within 3.5 km (5,863 inhabitants) near a high power radio-transmitter in a peripheral area of Rome was higher than expected.

(20) Michelozzi et al. (2002)- childhood leukemia higher at a distance up to 6 km from a radio station.



(21) Navakatikian and Tomashevskaya (1994)- RFR at low intensities (0.01 - 0.1 mW/cm²; 0.0027- 0.027 W/kg) induced behavioral and endocrine changes in rats. Decreases in blood concentrations of testosterone and insulin were reported.

(22) Novoselova et al. (1999)-low intensity RFR (0.001 mW/cm²) affects functions of the immune system.

(23) Novoselova et al. (2004)- chronic exposure to RFR (0.001 mW/cm²) decreased tumor growth rate and enhanced survival in mice.

(24) Park et al. (2004) higher mortality rates for all cancers and leukemia in some age groups in the area near the AM radio broadcasting towers.

(25) Persson et al. (1997) reported an increase in the permeability of the blood-brain barrier in mice exposed to RFR at 0.0004 - 0.008 W/kg. The blood-brain barrier envelops the brain and protects it from toxic substances.

(26) Phillips et al. (1998) reported DNA damage in cells exposed to RFR at SAR of 0.0024 - 0.024 W/kg.

(27) Polonga-Moraru et al. (2002) change in membrane of cells in the retina (eye) after exposure to RFR at 15 mW/cm².

(28) Pyrpasopoulou et al. (2004) exposure to cell phone radiation during early gestation at SAR of 0.0005 W/kg (5 mW/cm²) affected kidney development in rats.

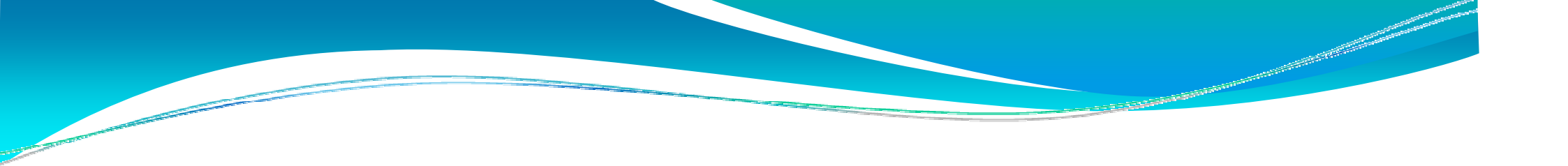
(29) Salford et al. (2003)- nerve cell damage in brain of rats exposed for 2 hrs to GSM signal at 0.02 W/kg.

(30) Santini et al. (2002)- increase in complaint frequencies for tiredness, headache, sleep disturbance, discomfort, irritability, depression, loss of memory, dizziness, libido decrease, in people who lived within 300 m of mobile phone base stations.

(31) Sarimov et al. (2004)- GSM microwaves affect human lymphocyte chromatin similar to stress response at 0.0054 W/kg.

(32) Schwartz et al. (1990)- calcium movement in the heart affected by RFR at SAR of 0.00015 W/kg. Calcium is important in muscle contraction. Changes in calcium can affect heart functions.

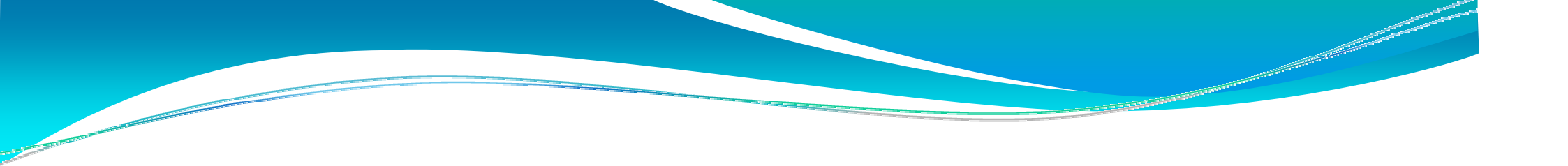
(33) Somosy et al. (1991)- RFR at 0.024 W/kg caused molecular and structural changes in cells of mouse embryos.



(34) Stagg et al. (1997)- glioma cells exposed to cellular phone RFR at 0.0059 W/kg showed significant increases in thymidine incorporation, which may be an indication of an increase in cell division.

(35) Stark et al. (1997)- a two- to seven-fold increase of salivary melatonin concentration was observed in dairy cattle exposed to RFR from a radio transmitter antenna.

(36) Tattersall et al. (2001)- low-intensity RFR (0.0016 - 0.0044 W/kg) can modulate the function of a part of the brain called the hippocampus, in the absence of gross thermal effects. The changes in excitability may be consistent with reported behavioral effects of RFR, since the hippocampus is involved in learning and memory.



(37) Vangelova et al. (2002)- operators of satellite station exposed to low dose (0.1127 J/kg) of RFR over a 24-hr shift showed an increased excretion of stress hormones.

(38) Velizarov et al. (1999) showed a decrease in cell proliferation (division) after exposure to RFR of 0.000021 - 0.0021 W/kg.

(39) Veyret et al. (1991)- low intensity RFR at SAR of 0.015 W/kg affects functions of the immune system.

(40) Wolke et al. (1996)- RFR at 0.001W/kg affects calcium concentration in heart muscle cells of guinea pigs.

The late Dr Neil Cherry's reviews

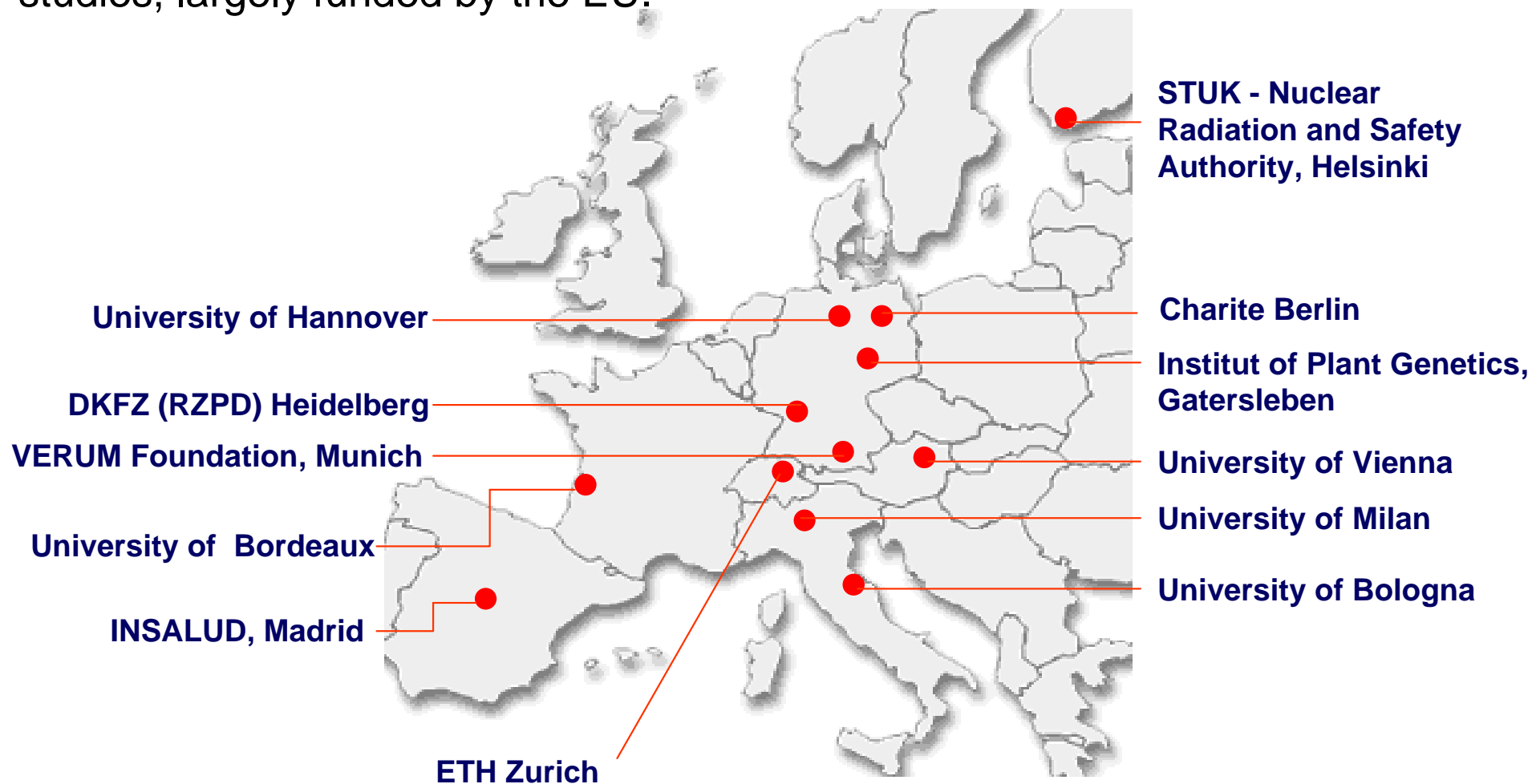
- Neil Cherry of Lincoln University, Canterbury, New Zealand also reviewed the literature in great detail, and concluded that the present ICNIRP guidelines relating to RF/MW exposure were far too high.
- He presented the evidence to the NZ Parliament, and to European Governments as well as to the European Parliament in Brussels.

From Cherry's paper "Evidence that Electromagnetic Radiation is Genotoxic,
June 2000"

- Cherry concluded:
- "Cellphones will probably increase many neurological diseases and brain tumours over the next 10-20 years.
- "Thousands of cell sites being installed in communities are significantly raising the exposure of millions of people to RF/MW at levels known to cause serious adverse health effects.
- Cherry recommended a limit of 10nW/cm^2 ($0.01\mu\text{W/cm}^2$), one tenth of even the former Soviet PELs.

The REFLEX Programme Research teams

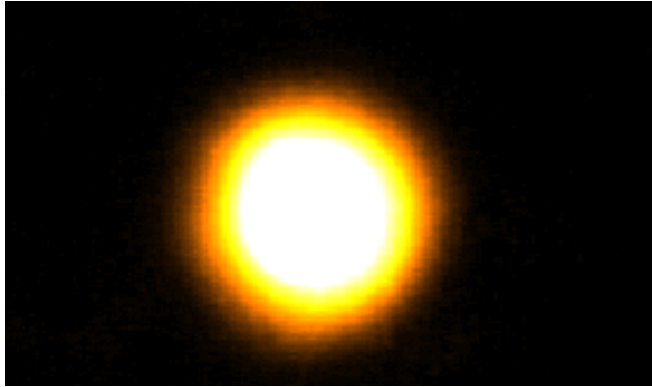
This was a Europe-wide series of *in vitro* studies, largely funded by the EU.



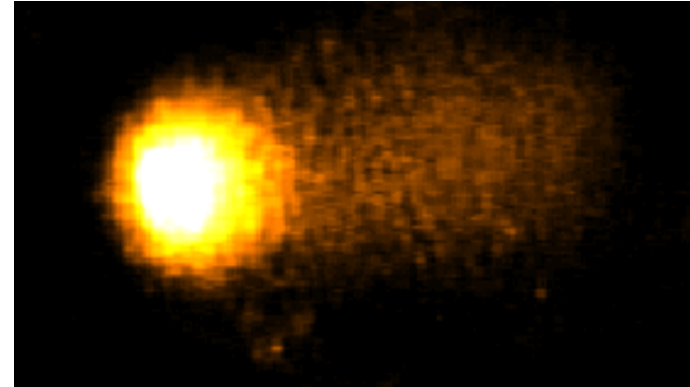
THE REFLEX REPORT RESULTS

- “Twelve institutes in seven countries have found genotoxic effects and modified expressions on numerous genes and proteins after RF and ELF EMF exposure at low levels, below current international safety guidance, to living cells in-vitro.
- “These results confirm the likelihood of long-term genetic damage in the blood and brains of users of mobile phones and other sources of electromagnetic fields. The idea behind the REFLEX study was to attempt replicate damage already reported to see if the effects were real and whether, or not, more money should be spent of research into the possible adverse health effects of EMF exposure.
- **“They concluded that in-vitro damage is real and that it is important to carry out much more research, especially monitoring the long-term health of people”.**
- *Quoted from Powerwatch website., 2004*

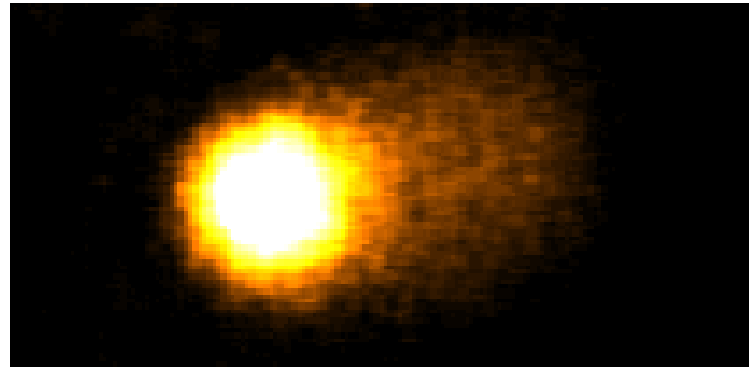
Alkaline Comet assay using HL-60 cells



sham



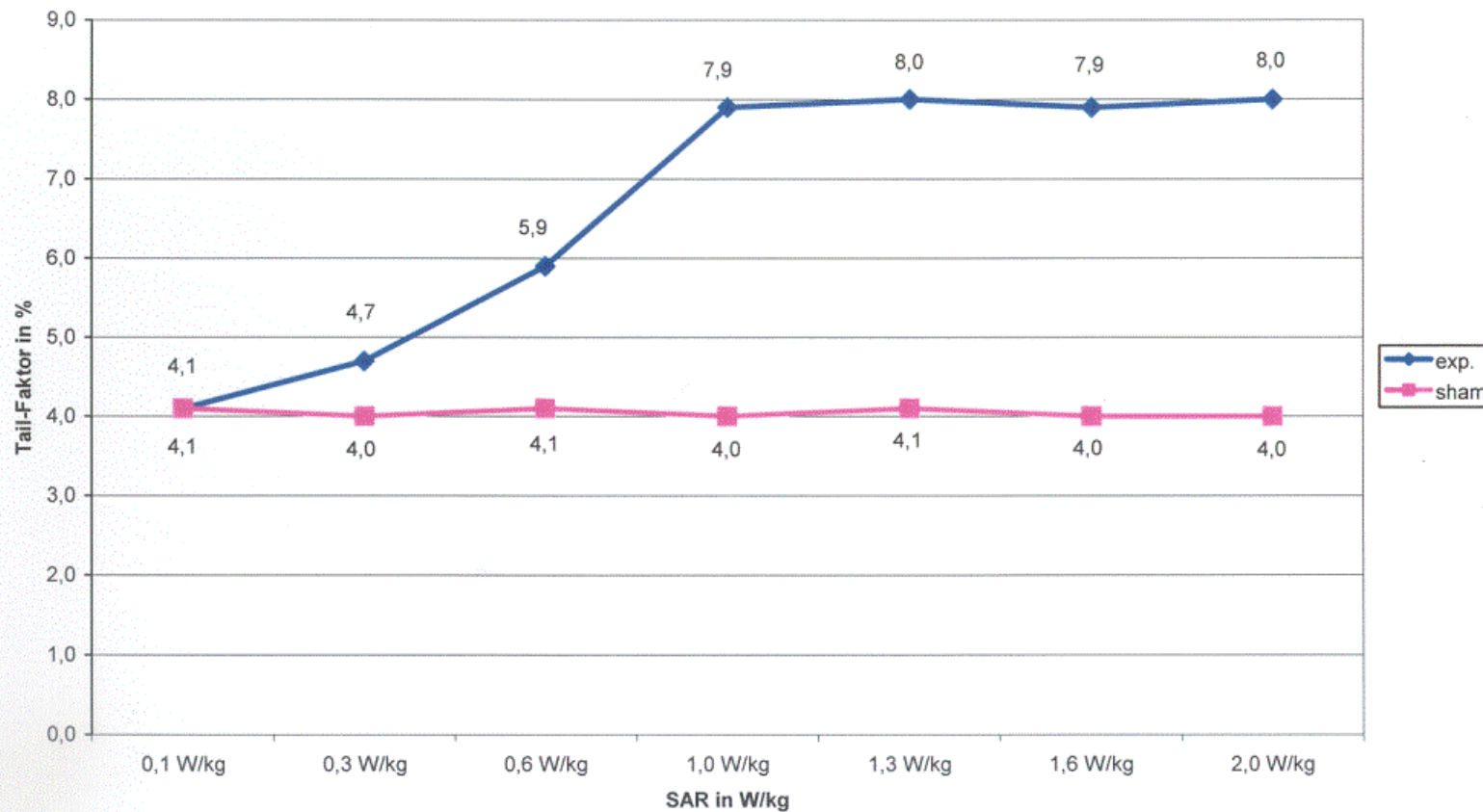
γ -irradiation, 0.5 Gy



RF-EMF, 1800 MHz, SAR 1.3 W/kg, 24h, continuous wave

Intermittent RF-EMF exposure at increasing SAR values (0 - 2 W/kg) (1950 MHz, 5 min on / 10 min off, 24 h)

Outcome of the alkaline Comet assay with human fibroblasts



Vijayalaxmi (2004) reviewed genotoxic effects from low level RF radiation

- This looked at the 56 studies researching major genotoxic effects from exposure to RF in animals and cells.
- An increased in damage was seen in 23 percent of the studies, and 33 percent were inconclusive. 50 percent reported no effect, mainly funded by the cellphone industry or the USAF.

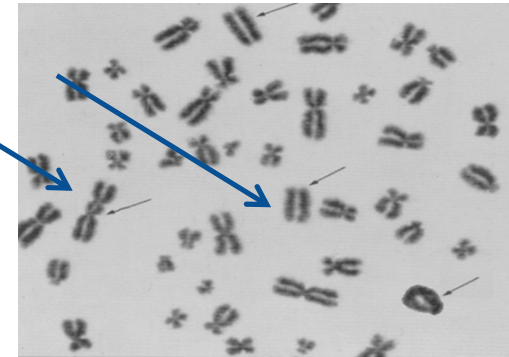
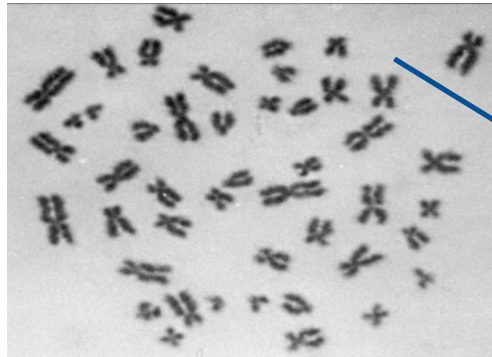
Source: Vijayalaxmi & Obe, *Radiat Res.*, 162, 481 - 496, 2004

Established kinds of genotoxicity

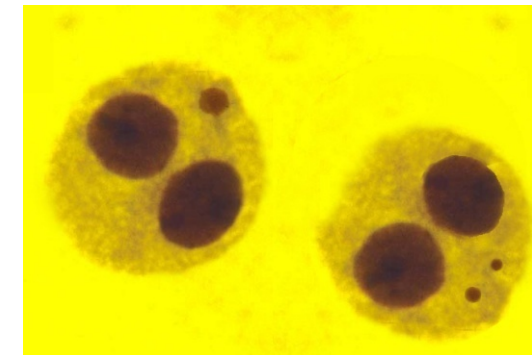
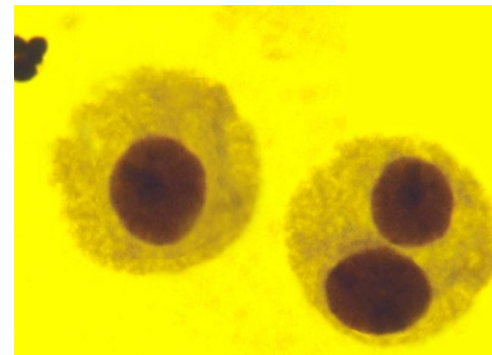
DNA Strand
Breaks
(SSB / DSB)



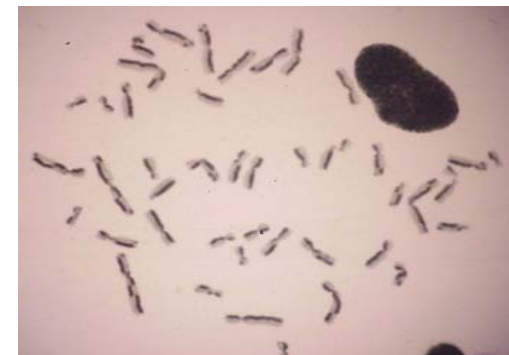
Chromosomal
Aberrations
(CA)



Micronuclei
(MN)



Sister Chromatid
Exchanges
(SCE)



1. Immunological damage from RF/MW exposure

- **Boscolo et al. (2001)- RF from radio transmission stations ($0.005 \mu\text{W}/\text{cm}^2$) affects immunological system in women.**
- The object of this Italian study was to investigate the immune system of 19 women with a mean age of 35 years, for at least 2 years (mean = 13 years) exposed to electromagnetic fields (EMFs) induced by radiotelevision broadcasting stations in their residential area.
- In September 1999, the EMFs (with range 500 KHz-3 GHz) in the balconies of the homes of the women were (mean \pm S.D.) 4.3 ± 1.4 V/m. Forty-seven women of similar age, smoking habits and atopy composed the control group, with a nearby resident EMF exposure of < 1.8 V/m. Blood lead and urinary trans-trans muconic acid (a metabolite of benzene), markers of exposure to urban traffic, were higher in the control women.
- The EMF exposed group showed a statistically significant reduction of blood NK CD16 $^{+}$ -CD56 $^{+}$, cytotoxic CD3(-)-CD8 $^{+}$, B and NK activated CD3(-)-HLA-DR $^{+}$ and CD3(-)-CD25 $^{+}$ lymphocytes. 'In vitro' production of IL-2 and interferon-gamma (INF-gamma) by peripheral blood mononuclear cells (PBMC) of the EMF exposed group, incubated either with or without phytohaemoagglutinin (PHA), was significantly lower;
- *Source: Boscolo, Di Sciascio et al (2001) Sci Total Environ. 273: 1-10*

RF effects on immune system cells

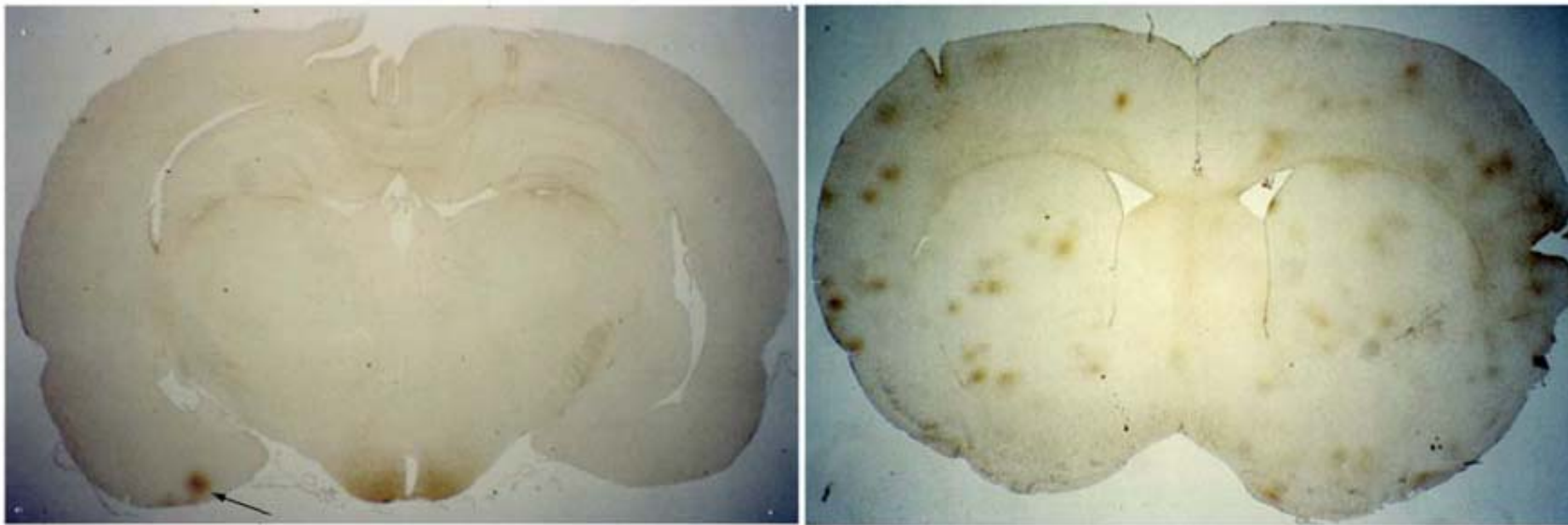
- However, at least four negative studies have also been reported in relation to cellphone frequencies:
- **Chauhan, Mariampillai et al (2006) Canada**
- **Stronati, Testa et al (2006) Rome**
- **Tuschl , Novak et al (2006) Austria**
- **Zeni, Romanò et al (2005) Naples**

So what mechanisms, if any?

- The answer could also point to melatonin: it is known to accelerate lymphocyte proliferation by cytokine receptor sensitization (see Carrillo-Vico, Reiter, et al (2006) for review) which the negative studies did not address: if melatonin synthesis is inhibited by RF EMF there would be a lowered or compromised lymphocyte response to mitogenic challenge, as shown by Lyle, Schecter et al (1983).
- “Significant inhibition was observed when the 4-hour cytotoxicity assay was conducted in the presence of a 450-MHz field sinusoidally amplitude-modulated at 60 Hz”.

2. The Blood Brain Barrier (BBB)

- Nine studies by 2000 had reported permeability of the blood brain barrier as a result of RF/MW radiation.



(a) Example from Salford, Brun et al, 1995: the RF exposed brain is on the right (*note dark neurons*)

3. Free radical effects

- The issue first arose in the 1950s:
- “Blood samples were taken from the staff of the U.S. Embassy in Moscow. They had been
- chronically exposed to a low intensity radar signal. Significant increases in chromosome damage was reported, Tonascia and Tonascia (1966) cited in Goldsmith (1997a).”

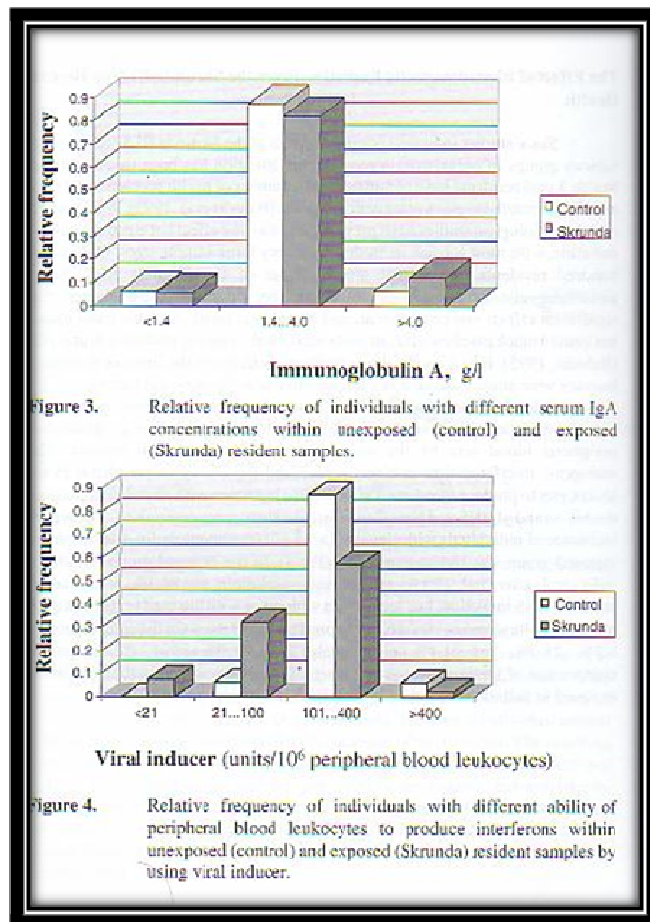
Anecdotal evidence is also copious:

- The media and scientific studies frequently report stories of ill health, mainly cancer, clusters reported around cellphone mast installations, within 400 metres:
- RMIT, Melbourne, Australia (6 brain tumours on top floor)
- Wishaw, near Sutton Coldfield (breast cancers)
- The 1999-2004 Naila study, Germany
- Crediton, Devon (4 cancers, 3 leukaemias)
- Gainsborough, Lincs (4 brain haemorrhages)
- Milford Haven, Pembrokeshire (6 cancers)
- Tolworth, Surrey

Earlier epidemiological studies also implicate other types of mast:

- E.G:
- Childhood cancer clusters were reported near radio towers in Honolulu, Hawaii (Maskarinec, Cooper and Swygert (1994)
- Dolk et al (1997) reported elevated incidence of adult leukaemias near BBC high power transmitters
- Abelin and Altpeter reported sleep disturbance near a shortwave mast at Schwarzenberg (2006)
- Hocking' (1996) report childhood cancer elevations near TV towers in Sydney, Australia, 1996
- A leukaemia cluster reported near the Vatican Radio mast, 1998.

4. Cognitive effects: the Skrunda Studies



Children living in this huge radar's beam were less able to remember or to concentrate, compared with similar children behind the beam.

Source: Kolodinski and Kolodinska, 1996

TETRA frequencies

- Despite clear advice from the Stewart Reports (2000, 2002) to avoid RF/MW frequencies close to those emitted by the human brain, the TETRA system uses 17.6 Hz as a carrier frequency. These frequencies are known to have psychotropic effects (see Becker, *The Body Electric*, 1984).

5. Electrohypersensitivity (EHS)

- There is also indication that an animal becomes more sensitive to the radiation after long-term exposure [e.g., see de Lorge and Ezell, 1980; de Lorge 1984, D'Andrea et al. 1986a,b; DeWitt et al., 1987]. The conclusion from a series of experiments on 'disruption of behavior' in animals after one-time exposure to RFR is that 'disruption of behavior occurred when an animal was exposed at a SAR of approximately 4 W/kg, and disruption occurred after 30-60 minutes of exposure'.
- However after long-term exposure (7 hr/day, 7 days/week for 90 days14 weeks), the threshold for behavioral and physiological effects of RFR was found to occur between 0.14 W/kg and 0.7 W/kg.
- Thus, RFR can produce an effect at much lower intensities after an animal is chronically exposed. This can have very significant implications for people exposed to RFR in the environment. The conclusion from this body of work is that effects of long-term exposure can be quite different from those of short-term exposure.

SUMMARY OF RF/MW MECHANISMS

- RF/MW exposure inhibits immune response (e.g. Chiang, Yao et al (1989): lowered phagocytic index)
- RF/MW penetrates the BBB/CSF, causing free radical damage against a background of lowered anti-oxidant defence, and tumours
- RF/MW has deleterious cognitive effects (learning, memory, attention span) in children
- RF/MW may interfere with regulatory control and fertility (low sperm count, developmental abnormalities)
- RF/MW exposure can cause low grade cataracts

Our lab has developed high antioxidant food supplements to combat RF/MW

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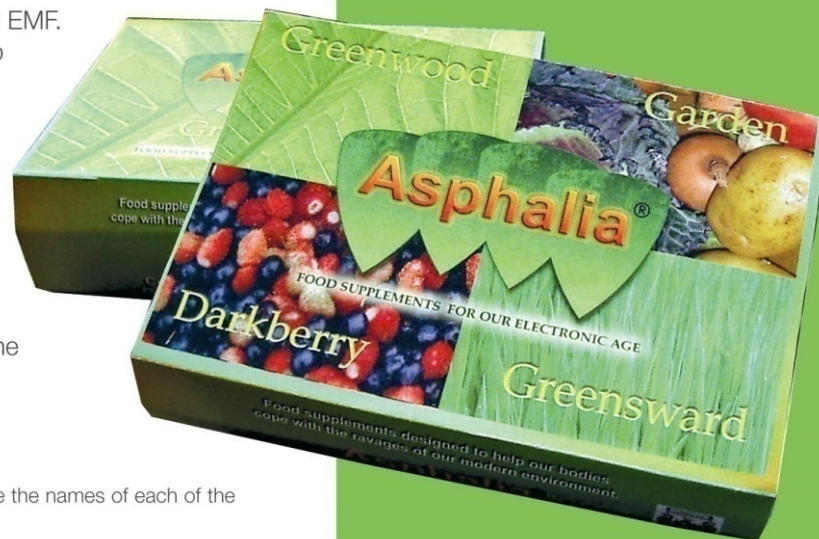
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