Attitudes to the health dangers of non-thermal EMFs

A review of the polarisation in attitudes towards research into the health dangers of non-thermal electromagnetic fields (EMFs).

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1. Introduction

The investigation of the health effects of electro-magnetic fields (EMFs) is unusual among most areas of scientific study in generating a distinct polarisation in attitudes among scientists. The depth of this division is apparent to the general public and has led to a sharp decline in the public's confidence in many scientific studies and related government pronouncements. For instance, according to research of 2007 in Europe, 76% of 27,000 people surveyed believe there are health dangers associated with mobile phones.[1] In contrast, the 2007 UK government MTHR report declared that there was no health danger for the first 10 years' use of a mobile phone, although admitting a risk of cancer and neurological illnesses thereafter.[2] This degradation in the status of both the science and the scientists is becoming increasingly serious as human health is exposed to ever-greater threats from irradiation by non-thermal EMFs. Too often the absence of any proof of harm is wrongly assumed to show the proof of the absence of harm.

The current crisis of the two divergent approaches appears to be the most serious dichotomy in science since the 1940s, given that both approaches cannot be simultaneously correct. In many ways, the current crisis in polarised attitudes is the direct consequence of Schwan's arbitrary decision in 1953 to ignore much existing research and to propose US exposure limits which were purely thermal. By assuming *a priori* that exposure to EMFs at non-thermal levels produced only beneficial results, he did not research the non-thermal effects at all.

It appears that at first military involvement hid much of the medical research into the dangers. Thus the public polarisation covers mainly the last 20 years of some 85 years of sustained research into health effects of EMFs. It seems to reflect the reaction of business interests to the ever-growing evidence of serious non-thermal EMF health effects. In turn it raises issues about the workings of western democracies where business interests can dominate governments and regulators who would otherwise be expected to protect their own citizens from major health risks.

In fact most of the international scientific community researching in the field of bioelectromagnetics seem to have accepted non-thermal EMF effects for over 20 years. Only parts of the telecommunications industry and some governments and regulators, supported by a small minority of the media, prefer to cling to outdated science in the hopes of maximising short-term profit at the expense of long-term illness. Thus, for instance, a standard textbook on bioelectromagnetics (2007 edition) states that 'the biophysical lore prevailing until the late 1980s and lingering to this

day' was that external EFs had no effect on human tissue unless they could trigger an excitable membrane, such as in the heart by a pacemaker, produce heating (thermal), or move an ion along a field gradient. 'However, the position had to be changed as the evidence for weak (nonthermal) EMF bioeffects became overwhelming'.[3] Thus, for the last 20 years or so the balance of evidence has suggested that exposures to radio frequency, ELF and microwave EMFs at non-thermal levels, all well below the ICNIRP thermal guidelines, cause significant adverse health effects to the general population.[4]

Professor Henry Lai, who in 1995 discovered that non-thermal EMFs can break DNA and could thus be linked with cancer, reportedly said in 2007, 'I think it's irresponsible to just set standards using a thermal standard'. The current standard in the UK and USA, following the W.H.O., is thermal and not non-thermal, and thus originates in the arbitrary assumptions made by Schan in the 1940s and 1950s. Professor Lai added, 'if you set it just based on a thermal effect you are neglecting a large amount of data.'[5]

Although the subject of environmental bioelectromagnetics has been researched for some 70 years, it still does not feature highly in much medical training. This is despite trends such as the overall cancer incidence 55 years ago being 1 in 12, whereas now it is nearly 1 in 2, and brain cancer is probably now the leading cause of cancer death among people aged under 20 in industrialised societies.[6] Equally worrying is the reduction in research in the USA because of industry fears. In addition the subject is still misguidedly perceived in some quarters as 'a physics or an engineering problem', whereas 'at its core, this is a medical issue'. In 2002 an American commentator argued that the research will in future be led from Europe and elsewhere in the world, even though the US still has a considerable influence on decisions by international regulators such as ICNIRP: 'Even before September 11th, American EMF policy was hamstrung by military influence. It is even more so now. America is also too corrupted by industry dollars in our political process. There is virtually no unbiased research being conducted in America today. Five independent bioelectromagnetic research laboratories have closed in the U.S. in recent years due to lack of funds. I would hazard to say this is not an accident. Without the European sphere of influence to counterbalance this, we will continue to be hapless participants in what has been described as the greatest global experiment in the history of the human race.'[7]

Dr H.C. Scheiner in 2006 wrote that this mass exposure to non-thermal EMFs is 'certainly the biggest environmental scandal of the outgoing 20th and on going 21st century, which will dwarf any other environmental scandal of the past.'[8] The Swedish neurosurgeon Dr Salford has called it 'the longest human biological experiment ever'.[9]

2. Polarisation

(a) Historical background

Thales, the Greek scientist of the 7th century BC, was the first to propose that living things were animated by a vital spirit evident in electricity, as in the static electricity he knew from rubbing amber, and magnetism, as in a lodestone.[10] Electrical experiments gained momentum in the 18th and 19th centuries and the health effects of EMFs were first recorded in the late 19th century when electrical generation was being commercialised. In 1875 Caton discovered electric brain signals in animals which he soon correlated with light stimulus.[11] In 1877 Danilevsky published a monograph on the reactions of a dog's central nervous system to EMFs.[12] In 1892 Dr d'Arsonval studied EMF effects on the human body and later started diathermy and other forms of electrotherapy with Tesla.[13] In the early 1920s Berger identified alpha brain waves and in the 1930s showed how brain waves appear in a baby at about two months when the brains neurons have been sheathed in myelin.[14] At this stage there was no polarisation in attitudes. In fact a large body of evidence on the effects of EMFs on plants, animals and humans was accumulated as measuring devices became more sophisticated. Some interesting theoretical advances were made in the 1930s by the application of Einstein's theories of relativity to the body's endogenous EMF and each cell's potential difference, but the significance of such a concept that 'the field is the only reality' was not immediately developed.[15]

Adverse health effects from EMFs were also observed from an early stage. In 1868 Beards noted neurasthenia (enervation) among telegraph workers in the USA.[16] In 1928 workers at a General Electric plant in New York who were building an experimental radio transmitter complained of ill health. The main effect was heating, but when radiotherapy was, within two years, used as diathermy for therapy, the side effects noted were dizziness, nausea, weakness and sweating. These effects were defined further by Schliephake in 1932; he recorded symptoms of 'Radio Sickness' induced near a radio transmitter at below thermal levels.[17] These symptoms were later described in greater detail and called 'Microwave Sickness' or 'Electro-sensitivity'.

(i) Military interference

A major development came with the practical deployment of radar using pulsed microwaves during the 2nd world war. The US navy conducted studies health studies on radar from 1942 and 1945, showing the usual sensitivity effects.[18] During the war

the US Bureau of Ships documented infertility and other adverse outcomes in midshipmen exposed to radar. Further evidence of the dangers from EMFs came in 1948, when a link was noted between microwaves and testicular degeneration in dogs.[19] In 1948 it was shown that non-thermal levels of EMF exposure could produce cataracts in animals 42 days later. In 1949 a US army signal worker was accidentally exposed to radar and he later became blind, deaf and crippled. In the late 1940s the US Institute of Radio Engineers formulated safer standards than those later adopted in 1953 and 1965.[20] By the early 1950s it was apparent that many radar workers were suffering 'Microwave Illness', and the Hughes Aircraft Corporation in the USA conducted an investigation into ill health, including leukaemias, brain tumours and unexplained bleeding, among its radar workers in 1953.[21] In 1952 Hirsch reported cataracts among Sandia Corporation microwave workers and in 1953 the Bell Laboratories, following reports of sterility and baldness among its workers and radar operators, proposed a 100 microwatt limit, 100 times lower than Schwan's.[22]

In 1953 Herman Schwan, who had come to the US from Germany in 1949 to work for the US navy, suggested a thermal exposure limit of 10,000 microWatts.[23] This was based on the physical properties of the heating effects he had noted when radar operators cooked hot dogs in their microwave beams, although Schwan admitted this limit would be safe for only one hour's exposure. In fact Schwan and Knauf did not conduct any experiments below his proposed thermal limit, so they failed to record the biological effects of EMFs at non-thermal exposures. His proposed limit was subsequently adopted by the US army and air force in 1965 and the American Standards Council in 1966. Thereafter it became difficult to lower it from thermal to more realistic non-thermal levels in case there were legal liability claims.[24]

An early example of a cover-up came in 1954, when Barron at a Lockheed factory later ascribed changes in white blood cell counts in 226 microwave workers to 'laboratory error' and also stated that eye damage was 'unrelated' to radar.[25] Soon after the secret meeting of 1952 in New Mexico between US and USSR scientists, Russia started to use pulsed microwaves against the US embassy in Moscow. The US government discovered this attack in about 1962 but did not tell the public until 1976 and the Russians closed the transmitter in 1978-79.[26] Two US ambassadors died from cancer and a third developed a leukaemia-type disease. The exposure level was said to be below the US safety limits, meaning that the US had few grounds for either legal or moral redress. In the early 1980s the US air force in turn used pulsed microwaves against protestors at Greenham Common at non-thermal levels.[27] The UK government

is said to have used similar microwave weapons in Northern Ireland during the troubles.

From 1955 to 1969 eleven conferences were held in the USA entitled 'Microwaves – Their Biologic Effects and Dangers to Health'. The dangers were becoming so well established, while doctors were noting links with cancer, chromosome breakages, leukaemia, gastric bleeding and cataracts, that the US government set up the Electromagnetic Radiation Management Advisory Council in 1968. In 1959 chromosome abnormalities had been shown in garlic sprouts after EMF exposure at 27 MHz, in 1961 a link was established between EMF exposure and leukaemia in mice, and in 1965 a correlation was noted between Down's syndrome and parental EMF exposure.[28] In 1964 Dr Zaret showed that non-thermal EMFs can cause cataracts, but his research funding was then removed.[29] The US government report, *Program for Control of Electromagnetic Pollution of the Environment*, was published in 1971. This report concluded that 'undervaluing or misjudging the biological effects of long-term, low-level exposure' could lead to 'a critical problem for the public health, especially if genetic effects are involved'.

Much research on Microwave Sickness was also done in Russia during the 1950s. In 1958 the Soviet Institute of Public Health issued security measures for microwave exposure. During the 1960s several researchers in Poland confirmed chromosome damage from chronic low-level microwave exposure, while others discovered that brain functions were especially sensitive to microwave EMFs. In Russia the safety limits for EMFs were over three times lower than the level set in the USA in 1953, because the USA took into account only the heating effect of microwaves.[30]

In 1971 a primate study for the US navy led by Zaret found that a monkey died after only a few hours' exposure at twice the US safety limit. The research was, apparently, almost immediately halted but the limit remained.[31] In the early 1970s the US EPA commissioned a study near FM radio transmitters which found a link between field intensity and nonlymphatic leukaemia, but the EPA took no action.[32]

In 1973 the World Health Organisation called an international congress in Warsaw, under the auspices of the Polish government and the US Federal Drug Administration, subsequently publishing *Biological Effects and Health Hazards of Microwave Radiation*. Moreover, the former Office of Technology Assessment of Congress in the USA recommended a policy of 'prudent avoidance' of EMFs. By the mid 1970s almost all aspects of electro-sensitivity or Microwave Sickness had been identified and interest

began to move into researching more serious illnesses, especially cancer-related and neurological, which were becoming associated with EMFs. By 1977 US army scientists had duplicated Russian experiments using mobile phone microwaves to show weakening of the blood-brain barrier, but this research was not made public for many years.[33] In 1979 the first clear association between leukaemia and electricity power lines was made, a link now accepted by most scientists after many further studies.[34] Previously childhood leukaemia had been associated with ionising radiation rather than non-ionising radiation such as EMFs. Even before this, the health dangers from power lines were well established and it is said that in 1974 Becker's research grant was not renewed after he testified about power line dangers before the New York Public Services Commission. This followed his role as part of the US navy's Sanguine study of 1973 into their proposed antenna with a field strength similar to that of power lines. Of the 30 studies considered nearly 2/3^{rds} showed biological effects from EMFs. When he later tried to access the research data, the US navy apparently denied that his secret committee and its reports had ever existed. It was said that one of the team, Dr Beischer, who had been a leading naval researcher since the late 1940s, was retired early and all his work was classified.[35]

The power of the military interest was apparent in 1975 in preventing safer EMF exposure standards. Arguing partly from monetary concerns, the summary of the US Department of Defence *Tri-Service Electromagnetic Radiation Bioeffects Research Plan* concluded that safer standards would restrict military electromagnetic radiation use in peacetime and would require the purchase of 498,000 acres of land to form buffer zones around radar establishments.[36] In the early 1980s the US air force funded a $5M study of rats exposed to non-thermal EMFs at 20 times below the safety thermal level, but it was revealed that unusually the rats used were gnotobiotic (germ and virus free), apparently deliberately to reduce the incidence of cancer. Despite this the incidence of cancer was four times greater in the exposed rats than in the controls.

In the early 1980s there was willingness in some quarters to move towards non-thermal limits. In 1982 the American National Standards Institute recommended a RF safety limit of 1,000 microwatts and a microwave limit of 5,000 microwatts. The Environmental Protection Agency's rumoured proposal of 100 microwatts anticipated in 1984 was indefinitely postponed, apparently from pressure by an outside party. Nevertheless Massachusetts did adopt a limit of 200 microwatts, although even this was way above the USSR 1950s' RF limit of 1 microwatt. In 1987 the New York Power-Lines Project released its results, showing that 20% of childhood cancers were associated with exposure to 3 milligauss magnetic fields, and that these exposures

also stimulated cancer-cell growth and caused nervous-system effects. In 1986 it was shown that 60 Hz magnetic fields increased the permanent growth-rate of human cancer cells by up to 1600%. The US Public Services Commission, however, did not then adopt a commensurate safety standard but instead imposed an arbitrary limit of 100 milligauss. While the New York project was underway, the commercial Battelle laboratories were contracted by the Electric Power Research Institute to research developmental abnormalities caused by 60 Hz transmissions. The results were disputed, although almost all the first group of exposed animals were lost to an epidemic assumed to be stimulated by their exposure.[37]

In 1986 the Hawaii Department of Health conducted its own survey and found the incidence of cancer significantly higher close to broadcasting transmitters than in areas of Honolulu further away. The Department, however, took no immediate action.[38]

(ii) Commercial interference

The biggest change in attitude came in the late 1980s and early 1990s when the use of microwave technology allowed the introduction of the first mobile phones and the Telecommunication Act of 1984 opened up the market in the UK. The power of even the earliest mobile phones was far below a level likely to cause heating. It has been claimed that it was assumed at the time that the only known adverse EMF health effect on human tissue was heating, but it is evident that non-thermal adverse health effects had already been established for over 40 years. Even the German Federal Radiation Protection Agency stated in 1992 that 'specific effects which are not related to heating have been described in the scientific literature for approximately 15 years. If a high frequency radiation is amplitude-modulated with another frequency, field effects can occur, which do not exist under un-modulated radiation. These manifest mostly as changes in the permeability of the cell membranes.'[39]

There were no safety trials before the release of this new technology on the public market. Soon, however, people using mobile phones began to suffer headaches, tumours and other ill health, so the US government commissioned a $26M Wireless Technology Research project into their safety, from 1993. This followed media coverage of David Reynard's legal case that his wife died from a brain tumour caused by her mobile phone. This had resulted in a sudden fall in the sale of mobile phone and the shares in mobile phone companies.[40] Meanwhile the use and sale of mobile phones became one of the biggest commercial markets around the globe, so that when EMF health dangers were confirmed, instead of governments insisting on setting

much more stringent health limits, many governments were persuaded to allow the technology to remain in place. In fact the Russian government, which had previously adopted much more stringent safety levels because of their research, was persuaded to change its standards to the more lax levels of most of the west. A few governments, however, did take the research seriously and adopted increasingly stringent limits. Russia, for instance, in 2002 apparently recommended that children under 18 and pregnant women should not use mobile phones.[41]

One of the first instances of commercial influence on polarisation in attitude towards the dangers of non-thermal EMFs came in 1988. This was, according to reports, the cover-up by a subsidiary company of Ericsson, when 49 of its employees became electro-hyper-sensitive after three microwave transmitters were installed on their workplace's roof. Two years before, in 1986, the TCO (the Swedish white-collar union's central organisation) newspaper published colour photographs of facial burns suffered by VDT workers from non-thermal EMFs. This skin condition had already been noted by Dr Lagerholm in 1985, a discovery also matched by research in Canada and the USA, where it was noted that the skin injuries from VDTs appeared similar to those from X-rays. In the USA Dr Wallach also showed VDT effects on the central nervous system. A junior researcher, however, apparently appropriated Dr Lagerholm's results and re-interpreted them as normal by publishing them first without the crucial evidence.[42]

In 1990 Professor Jerry Phillips was recruited by Motorola to research cell phone radiation in California but, when he found an interaction between non-thermal EMFs and living tissue, the company tried to stop him publishing the results and demanded the removal of references to DNA damage.[43] The company later switched its research funding to another university which never found a positive link. In 1992 Professor Adey, a former Director of the NASA Space Biology Institute, reportedly said, 'I think that the British authorities' reaction is a living dinosaur attitude, that it absolutely avoids confronting the evidence as it now exists.' [44]In 1995 the US NCRP draft report of 800 pages recommending low exposure limits was apparently suppressed by the US government and the mobile phone industry.[45] When, therefore, the World Health Organisation (WHO) set up its EMF project in 1996, there was speculation as to which side of the divide it would support. The first director, from 1996 to 2006, was apparently sponsored before and afterwards by the phone industry and the project received perhaps half its funding from the phone industry, raising questions about its degree of independence.[46] The WHO Legal Department stated that no person with a vested interest could be involved in any scientific working group or its committee.[47]

In the USA the phone industry realised legitimate health concerns at local level could prevent the siting of cell towers. In 1993, therefore, the industry petitioned the Federal Communications Committee (FCC) to override local zoning, but the FCC refused, on the grounds that it was outside their authority. All public health or zoning decisions had so far been taken at local level. The industry therefore lobbied Congress for Section 704 to be added to the Telecom Act of 1996, with a limitation that 'no State … may regulate the placement … of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions'. Indeed, the FCC auctioned off the public airways to private business, but neither the FCC nor the EPA had or has the funds to monitor non-thermal EMF emissions properly or undertake the necessary health research. Planners and local zoning officials still retain the freedom to discuss health issues for ionising radiation but not for non-ionising radiation, despite the fact that they can have apparently similar effects on human tissue.[48] In the UK it is stated that planners 'should not need' to consider health facts, although they can legally reject mast applications on aesthetic opinions. In the US the industry pressed Congress even further for three years, resulting in additions to the Emergency-911 Act of 1999. This act made 911 the universal emergency number for all states. The industry wanted mobile phones declared an emergency response 'public utility', by having wireless services given interstate commerce status, thus overriding local zoning. The bill also gave the industry the same liability protection as for wired services, presumably including health and environmental effects of EMFs, despite the much greater health risks from wireless already then known.[49]

In 1990 low frequency EMFs were considered in a two-year study by the US EPA as 'probably human carcinogenic', alongside PCBs, formaldehyde and dioxin, but this recommendation was apparently deleted from the final draft at the insistence of the White House Office of Policy Development.[50] Thus, by 1998, despite the increasing reliability of the evidence, industry and government insisted, apparently, that they were downgraded in the US to 'possibly carcinogenic'. In a vote to classify EMFs (Power Frequency) as a class 2B carcinogen, based partly on evidence known to US naval researchers, some of whom had been involved in the 1973 Sanguine project, it was noted that 19 voted for and 8 against, but of these 8 objectors 5 were 'tied' to the electricity industry. The US rating was accepted by the IARC, part of the WHO, in 2001.[51]

More cover-ups may well be found. A report by BECTa, a UK government educational agency, dated about 2000, included a note under Health & Safety that some of its

engineers complained of headaches at the end of a working day while testing wi-fi installations for schools, but this warning was removed from later versions of the report.[52] In September 2007 it was revealed in the USA that microchips implants had been shown to cause significant numbers of malignant tumours in mice and rats, from studies going back to at least 1996. The companies involved in selling microchip implants for human use, however, had apparently decided not to inform the public or, it is said, the regulators.[53]

Since the 1990s, therefore, a growing division based on commercial interests has emerged. Some studies have shown the effect of the source of the money behind research, with independent scientists pitted against those sponsored directly or indirectly by the mobile phone industry and, it has been claimed, even by some governments in complicity with them. Ironically, even the American Cancer Society, it has been said, supports the phone industry because of grants received directly or indirectly from the industry.[54]

(iii) Denial or demands for infinite research

By the mid to late 1990s the process of polarisation was almost complete. Faced by the steadily accumulating evidence of serious health damage from non-thermal EMFs, one might expect governments and regulators to take serious action to safeguard the general population. Instead two responses have emerged from the industry and some regulators. Often there is a cult of simple denial in the face of the facts. The alternative response, one which is, of course, inconsistent with the former, is an ongoing demand for an infinity of further research before the conclusions reached by the research scientists can be accepted by the regulators, despite the apparent incongruity of the regulators presuming superior knowledge over such scientists.

(a) Denial

In 1999 the phone industry tried to influence the research programmes and findings of experts like Professor Adey and Professor Lai, who had, in 1994, made a crucial discovery that EMFs cause DNA breaks and thus could cause cancers, an announcement the phone industry publicly denounced. Also in 1999 the mobile phone industry simply ignored the health warnings from its own $26M 6-year research programme led by Dr Carlo.[55] This blatant disregard of such massive scientific evidence was a major escalation in the process of denial.

In 1996 the German Federal Institute for Telecommunications commissioned Professor Hecht to review the Russian technical literature from 1960 to 1996 about the health-damaging and biological effects of microwave EMFs. Professor Hecht and his co-author examined 878 scientific studies. Their report, produced in 1997, was overwhelming in its conclusions about dangers but it 'immediately disappeared into the archive'.[56] In fact the refusal of the industry to accept the scientific evidence of the dangers of EMFs was not entirely genuine. At the same time it introduced shielding devices for mobile phones, along with remote headphones, and started to provide SAR figures for each phone model, presumably because the industry was aware of genuine rather than imaginary adverse health effects at non-thermal levels.

The Ecolog study of 2000 based on 220 studies found that non-thermal EMFs can cause cancer. It is said, however, that the report was 'buried' by its sponsor, the mobile phone company, T-Mobile.[57]

An example of denial came in 2003. The director of the Danish Health Council apparently said in a press statement, after being told of many of the health dangers, that 'there are no health risks due to EMF from any source, and we have chosen to ignore the scientific evidence that shows that there are biological and health effects'.[58] Even in 2007, when the European Environmental Agency called for reduced EMF exposure, the regulators and most governments did not take immediate action.[59] Also in 2007 the Danish regulators disparaged the major BioInitiative report, for no good reason, much to the frustration of the EEA.[60] In 2002 the US EPA's Radiation Protection Division's chief environmental scientist admitted that the current guidelines are only for thermal effects and therefore the current generalisation by many, that these guidelines protect human beings from harm by any and all mechanisms, is not justified.[61]

(b) Demands for infinite research

The alternative strategy now adopted by some of the industry and regulators is to admit to some non-thermal adverse effects but simultaneously to demand further research. This is, of course, illogical, since, if adverse health effects are admitted, then action should follow to protect the general population from these dangers, and not delay. Moreover, it is not made clear what level of further evidence is needed before protective action is taken, raising the possibility that the intention is simply to delay decisions indefinitely so as to maximise immediate profits.

Thus in 1993 the WHO IRPA Task Group on Electromagnetic Fields admitted that 'a substantial body of data exists describing biological responses to amplitude-modulated RF or microwave fields at SARs too low to involve any response to heating' but, instead of taking action, in 1996 the European Commission Expert Group recommended a €24 million research programme.[62] Again, in 1998, the WHO admitted that that there was evidence for non-thermal adverse health effects from a variety of studies. It still concluded, however, despite the 50 years' of research, that 'these effects are not well established, nor are their implications for human health sufficiently well understood to provide a basis for restricting human exposure'.[63] In 2000 the UK's Stewart report stated that 'there is now scientific evidence' suggesting possible biological effects at non-thermal levels.[64] The word 'now', however, implies that such evidence had just been discovered, rather than existing for some 50 years.

In addition, the source of funding for research can affect the outcome of the research. A 2007 study found among 59 studies that there was a nine times increase in the likelihood of a 'no harm' result for research funded by the mobile phone industry, compared with independent funding.[65]

Many scientists feel that the typical government ploy of instigating yet another committee or enquiry is a further example of delaying tactics, when enough is known of the dangers of non-thermal EMFs to warrant effective action to reduce the radiation exposure of the general population, and especially children. In October 2007 the HPA announced an enquiry into wi-fi, something welcome in itself in that it at last seemed to recognise the dangers of non-thermal EMFs at low levels.[66] Nevertheless it appeared to prejudge the outcome by stating that the results were likely to be 're-assuring', a curious approach to a supposedly scientific enquiry. Commentators have suggested that, if the re-assurance is to state that wi-fi operates at non-thermal levels and that these levels are below the existing thermal limits set by ICNIRP, then the results would be self-evident before the enquiry begins, since the data for typical wi-fi exposure levels is published internationally. Moreover, it is unlikely that checking the published data would take two years.[67] Scientists argue that such an enquiry needs to investigate non-thermal dangers, or it could be seen as simply an attempt to buy more time for what some observers now cynically call the 'Profit Protection Agency'. In fact the HPA accepts that EMFs are dangerous at non-thermal levels, since it has already advocated a precautionary approach over mobile phones and mast signals, especially for children.[68] It has been noted that Dawn Primarolo, the Public Health Minister in the Department of Health, announced on 8th October 2007 that there would no inquiry into Wi-Fi Health Hazards.[69] This attitude was reversed four days later.

Scientists in the meantime had pointed out that the HPA's existing policy on safeguarding children from non-thermal radiation meant that they should not be exposed to hand-held learning devices with similar exposures, especially when the MTHR report had highlighted the health dangers after 10 years' use.[70]

If an independent committee of scientists fails to satisfy the government line, it has been known for the committee to be dissolved and replaced by a more compliant one. In 1999 the Standards Australia TE/7 Committee was dissolved after 15 years because it failed to agree health standards. It was replaced in 2002 by the non-voting ARPANSA – RHC, which, as with ACMA in 2005, simply adopted ICNIRP thermal exposure standards with no reference to non-thermal dangers.[71]

A further issue is the background of the scientists. Several recent provocation studies in the UK, for instance, have been undertaken by psychologists, rather than biological experts. This perhaps limits the range of clinical readings taken. In addition, some of these psychologists have been said to work also for telephone companies and the Ministry of Defence.

Even in botanical, zoological and climate studies commentators have argued that some scientists are anxious not to implicate EMFs in causing damage. Thus deforestation has been associated with acid rain but the studies which also show arboreal damage from EMFs are not included in much of the literature.[72] Some types of virus are said to spread more vigorously under EMF exposure, but this is rarely discussed publicly. The same is said to be true of studies on colony collapse disorder among bees, ornithological losses[73] and even on climatic extremes associated with the introduction of high levels of EMR. Thus in 1983 it was claimed, for instance, that power-line harmonic resonance over North America had created a duct, observable from weather satellites, from the magnetosphere down into the upper air, accounting in part for the higher incidence of thunderstorms and other climate changes in recent decades.[74] Other scientists, however, still prefer to base climate change only on global warming from carbon usage.

There are three major problems with the type of evidence being demanded for adverse health results from non-thermal EMF exposure, two of which have not applied to previous environmental pollution, except for some forms of chemical pollution, GM innovations and the long-term predictions for global warming. Firstly, for pollutants like tobacco smoke and asbestos, the nature of the pollutant is essentially a determined constant. For EMF pollution, however, there is almost an infinite range of

types of exposure, with regard to intensity, frequency, modulation and pulsing. Since these various form of radiation are being developed in ever-increasing numbers, there is potential for ever-increasing harm.

Secondly, whereas tobacco and asbestos cause, or are linked with, a limited number of observable adverse health effects, the range of damage from EMFs is considerably greater, not least because it involves genetic change through damaged DNA. This means that the full consequences cannot be known for many human generations, by which time it may prove impossible to rectify the damage already induced.

The third problem is the limited knowledge of scientific processes, a problem in common with biological effects from other pollutants. It may take several more years before the full mechanistic pathway for EMF damage is shown, but this need not halt preventative action now. It is said that the full mechanisms by which tobacco smoke induces some types of cancer is similarly not yet fully known, but this has not prevented regulators taking action. Furthermore, the tobacco industry scientists long claimed that there was no causal connection, even after epidemiological studies and parts of the mechanistic story showing harm had been accepted by leading scientists.

(iv) Appropriate action

It would be wrong to suggest that all governments and regulators are dominated by commerce or the military. There are many signs over recent years that the research of the last 60 years into non-thermal EMF dangers is increasingly being accepted internationally. Mobile phone manufacturers have tried to shield antennae, and in 2001 SAR values for mobiles were introduced to help consumers reduce non-thermal EMFs. In 2007 the German Federal Government recommended the use of cable connections rather than wireless, based on a precautionary reaction to the scientific evidence.[75] The EU's European Environment Agency in 2007 called for questioning of the scientific basis of ICNIRP EMF exposure limits, following the findings of the BioInitiative Working Group.[76] The 2004 Spanish study confirming the trebled risk of cancer near phone masts in a dose-dependent relationship led Salzburg to adopt the 0.02 V/m indoor limit for GSM frequencies.[77] Other countries, such as Switzerland, Russia and parts of Australia, have adopted much lower limits than the US and the UK in reaction to the evidence of non-thermal EMF adverse health effects, and other parliaments, such as Frankfurt and Brussels, have followed or are soon to do so. The BioInitiative report of 2007 will doubtless continue to bring a swifter recognition of the range of non-thermal EMF dangers.

Moreover, since 2000, the Precautionary Principle has been the basis for EU environmental legislation. Thus Italy adopted a precautionary exposure limit of 3 μT for new powerlines and homes in 2003, while in 2001 Israel adopted 1 μT for new facilities. Irvine in California has a realistic limit of 0.2 to 0.4 μT.

Governments also remove non-thermal radiation causing illness. In 1998 the short-wave radio transmitter at Schwarzenburg near Berne was closed down after studies showed it disturbed sleep patterns among nearby residents. The government of Taiwan undertook to remove 1,500 mobile phone base stations during 2007. This was to safeguard the health of the general population especially in residential areas and schools, against cancer, miscarriages, neurological diseases and depression or suicide.[78] Also in 2007, Paris switched off wi-fi installations in six public libraries after workers suffered typical sensitivity symptoms and placed a moratorium on further installations.[79] In 2007 Israel banned new cellular antennas from living quarters, including balconies. All existing antenna permits must now be renewed every five years to allow for action resulting from further evidence of the dangers of non-thermal EMFs. In addition, four major cities have banned any further small antennas.[80] In Bangalore, India, it is now illegal to sell mobile phones to children aged under 16.[81]

(b) Psychohypothesis

A curious aspect of the study of non-thermal EMF health effects is the apparently high incidence of a psychohypothetical condition among some members of the general public and even some 'scientists'. These people appear to deny credibility to evidence that EMF health effects can be found at non-thermal levels and may thus be significant for human health. As a result, research scientists and others have found it very hard to have a rational discussion with such people about the health effects of non-thermal EMFs, since such people display an irrational prejudice which they do not employ in other areas of study. Although it is true that most people are, at times, inclined to be guided to their deductions by their preconceived mental attitudes rather than by the relevant evidence, the high prevalence of 'psychohypothesis' in this area of study may suggest some scientific misunderstanding, irrational phobias or external pressures. There are at least five attitudes which can be categorised by their different underlying influences, as follows.

(i) Monetary influence

The most obvious external pressure appears to be monetary influence. The commercial interests of mobile phone companies can make them minimise or even

disregard the health dangers from non-thermal EMFs. Some governments become involved in this approach, perhaps because of the threat of reduced revenue from such commercial sources. Thus some commentators have noted that of the 23 commissioned projects in the UK HPA/MTHR study, financed by the phone industry and the government, none showed any health dangers.[82] This, it is said, is odd because, from the outcomes of the thousands of independent studies already done world-wide, one would expect statistically that up to 80% of the new studies would also reveal adverse health effects. In fact the MTHR report of 2007 did raise concerns about cancer and neurological illnesses from prolonged use of mobile phones, but this evidence came from other research, not directly its own.

(ii) Military and political factors

There are sometimes military and political factors. Some scientists wish to obscure knowledge of health effects of non-thermal EMFs because of perceived advantages for military use in lethal and non-lethal weapons, such as microwave ray-guns and electromagnetic pulse bombs.[83] Microwave radiation, for instance, was used covertly as a weapon against the US embassy in Moscow. Other scientists have been attempting cognitive or behavioural control of human subjects by means of radiation.[84] Some governments are even said to believe that the convenience for their intelligence services to track potential terrorists through mobile phones outweighs the known adverse health effects on the whole population they are supposed to be safeguarding, quite apart from the risk of changing the human genome. To others, however, the risk of terrorists exploiting lax limits on microwave radiation and EMP devices appears a much greater threat. Covert use of cell phone radar with enhanced signals for vehicular, aircraft and human detection is another health danger, as are high-powered aircraft radars without sufficient surrounding buffer zones.

(iii) Scientific misunderstandings

There are also instances of scientific misunderstandings about the dangers of non-thermal EMFs among many members of the general population. These misunderstandings can be seen as acting to the advantage of the above two groups. Some of the most common misunderstandings include the following.

1. At a basic level, many people do not realise that the radiation which they cannot see or seem to feel can be a serious threat to health. Surprisingly few people, even with high levels of education, realise precisely how EMF radiation can pass through walls, roofs, clothes and their own bodies.
2. A common belief is that natural background radiation from the sun is greater than man-made non-thermal EMFs. In fact it is something like 100 million times less powerful than the level at which humans feel conscious ill health from man-made EMFs. In contrast, the 3 milligauss magnetic field near power lines, which scientists

now agree can cause childhood leukaemia, is many times smaller than the earth's normal magnetic field.

3. People can mistakenly believe that the only danger from microwave EMFs is heating, without realising that low-power radiation below the thermal level can be used to help speed the healing of bones or can cause DNA breaks which could lead to cancers and neurological effects. EMFs have been associated with ADHD, Alzheimer's, ALS, asthma, autism, CFS, depression, EOD, infertility, Motor Neurone, MCS, Multiple Sclerosis, ME, miscarriages, Parkinson's, SIDS and suicide, among other diseases and problems. Other illnesses occasionally linked with EMFs as a synergen in their aetiology include some types of epilepsy, obesity, obsessive-compulsive disorder and schizophrenia. The effects of EMF time derivatives have been implicated in the leaching of mercury from amalgam dental fillings. There is no single new disease or syndrome caused by EMF exposure apart from Microwave Sickness or Electro-sensitivity; rather, EMF exposure triggers and stimulates many common illnesses and viruses.

4. Some think that all EMFs must have an effect directly relative to their power, without realising that such radiation can have windows of effects and may even operate in an opposite way at one power or frequency compared with another.

5. Few people understand how the health effects of non-thermal EMFs can be cumulative and thus delayed. It is, therefore, usually impossible to detect exactly when illnesses like some cancers or Alzheimer's are triggered after initial irradiation.

6. Many people still think that EMFs affect health according to traditional theories of physics, whereas the application of Einstein's theories of relativity from the 1930s provides a much more promising way of understanding the variety of their impact on living organisms. In particular this helps to explain how the conscious effects of EMFs are not apparently consistent but seemingly relate to the way the body's own EMF reacts with external radiation. In addition many people do not understand the different nature of pulsed radiation, where the pattern of packets of information seems to affect the body's cells differently from, or perhaps more intensely than, some other EMFs.

7. It is easy to expect that EMFs have direct effects and that the pathways for the illnesses they can cause are straightforward. It seems increasingly likely, however, that the actual mechanisms are relatively complex, with cellular structure affected so that processes like calcium efflux or mast cell degranulation occur at a secondary stage with more overt symptoms at a tertiary stage. Each of the 100 trillion cells in the human body has an electrical potential difference between its inside and outside, making the resulting impact on the whole body difficult to predict unless quantum-like pathways are postulated. Given the reaction at cellular level, more than one of the body's 100 nervous systems could react simultaneously to non-thermal EMFs.

(iv) Social convenience and conscious rejection of the scientific evidence

There is sometimes a conscious rejection of the scientific evidence. For some people social convenience can be the prime factor in persuading them to ignore the science and keep using mobile phones, Wi-Fi, blue-tooth, internet routers, DECT phones, sat. nav., radio mikes, etc. Some are honest enough to admit that they know the dangers theoretically but prefer the convenience of these new devices, so long as they do not see others dropping dead immediately after use. Curiously, some people have been much more affected by research showing the harm done by such non-thermal EMFs on plants, bees and birds than they have been in relation to themselves and fellow human-beings.

(v) Ignorance and blind trust

There is still a surprising number of people who have never even thought about the biological implications of non-thermal EMFs. They assume that their government will have alerted them to, or protected them from, all such dangers, as they believe is the case with foods, drugs and environmental pollution from other sources.

Further complications over accurate understanding of the health dangers of non-thermal EMFs have also arisen in two areas of the media. In recent years science reporting in the UK media has been expected to include an opposite view-point for any given theory. In practice most media have now abandoned this device when they report the findings of most scientific studies, from DNA markers to global warming. It is, however, sometimes used for scientific studies showing adverse EMF health effects. Conversely, where a study has supposedly shown no adverse EMF health effects, often no attempt is made to quote a scientist who believes such a study to be flawed. The whole concept of such an insistence is, of course, illogical since, if a study finds a true discovery on how EMFs affect health and reports it accurately, it is impossible to present an opposite viewpoint except as an invalid argument, something both pointless and misleading. Some observers have commented on the supposed *a priori* assumption of reports like the MTHR of 2007 and the attitude of the SCI which released the MTHR report and apparently has admitted that it does not invite independent scientists who are likely to disagree with its approach.

Secondly, internet any-contributor encyclopaedia articles such as those in Wikipedia can be further examples of bad ‘science’, producing biased and inaccurate entries. Supporters of the mobile phone industry are said to keep changing such entries whenever someone else tries to correct an error or give a more balanced view-point. If articles on health effects of EMFs started by saying non-thermal EMFs have been

shown for over 100 years to be biologically active, readers could be given a greater chance of understanding the key issues.

Many people have noted some striking similarities between the realisation of the health dangers of non-thermal EMFs and the realisation of health dangers from smoking. In the latter case the relevant industry, the governments which profited from tax, and addicted smokers were often among the last to accept the scientific research. Instead they attempted to muddy the waters with spurious research and constant demands for ever more detailed scientific evidence.

3. Anecdotal studies

Whenever a new illness or area of environmental pollution is discovered, anecdotal evidence forms the first means of identifying and defining the problems and, sometimes, the solutions. Much research in social science is based on assembling anecdotal evidence or case studies to provide the paradigms by which more general hypotheses can be established. The dangers of non-thermal EMFs have provided many relevant case studies. Nevertheless, partly because of the very widespread occurrence of non-thermal EMFs and the large number of symptoms associated with exposure to EMFs, it has proved more difficult than in some other areas of investigation to construct in a short time-frame a theoretical approach which covers the many variables. Indeed, there have been few attempts to collate and analyse the data in a way which would reveal either the extent of the problem or the variety of ways in which individuals react to such exposure. Studies show that about 30% of the general population suffer sensitivity symptoms of ill health from electrical fields at exposure levels under 0.06 V/m (P/P), rising to 95% at under 0.6 V/m..[85] If this is correct, then it would seem appropriate for ill health from non-thermal EMFs to be added to the annual UK HSE survey for factors causing illness in the workplace. It would also make sense for GPs to collect data on EMF ill health for a central research base, so as to build up a picture from anecdotal and clinical evidence of what is clearly a growing national and international problem.

Some anecdotal evidence can be of high quality. In fact anecdotal evidence among experienced observers and sufferers of electro-sensitivity is especially helpful and may be more useful than some other types of data collection. This is because such people may help to identify the particular source of the EMF exposure which has triggered a given symptom. In contrast it is far more difficult for a member of the general population to do this, because of the complex way in EMFs can inter-react. People sensitised by EMFs include Nikola Tesla, following his numerous electrical experiments, Dr William Rae, a Texas surgeon who has gone on to study the syndrome,[86] Dr Hugo Schooneveld, a Dutch neurobiologist,[87] and Dr Gro Harlem Brundtland, a medical doctor and a former Prime Minister of Norway and until 2003 Director-General of the World Health Organisation.[88] In fact Dr Rae became the world's first professor of environmental medicine in 1988 and since 1974 has treated some 28,000 patients, including chemical sensitives, at his Environmental Health Centre in Texas, as well as publishing research based on more than 100,000 patients worldwide. In many European countries medical doctors have been among the most outspoken of scientists about the adverse health effects of non-thermal EMFs, perhaps partly

because they are well trained in making appropriate causal associations in diagnosing patients' conditions.

4. Epidemiological studies

Most early EMF health studies in the 1940s and 1950s were of radar and electrical workers. Although these were clearly defined in their results of serious health dangers from these particular EMFs, few scientists in the early years seem to have realised their significance for a wider understanding of EMF health effects. In addition, many of the research results were kept secret, so there was little motivation for epidemiological studies of EMF health effects on the general population. Only in the last decade have sufficient studies been made to reveal a clear pattern. By then, however, commercial interests encouraged some 'scientists' to ignore such evidence or to try to disprove its relevance to mobile phones and later to wi-fi. As at 2008, many western countries are in the extraordinary position of having safety limits for EMFs based essentially on the 1950s assumption that the only danger is heating, and not the cancer growth and neurological illnesses revealed by numerous epidemiological studies. Moreover, in the light of the flawed Essex study of 2007, it is difficult to understand how 'scientific' it is to limit analysis to the peculiar and accepted difficulties of conscious provocation studies without considering also many other epidemiological studies, both cohort and case studies, along with animal, plant and mechanistic studies.

(*a*) *Subconscious or subliminal effects*

(i) Power lines

Some of the earliest epidemiological work was done on magnetic fields (MFs) and power lines. An association between proximity (< 200 m) to power lines and leukaemia was discovered in 1979, with exposure to 3 milligauss causing 20% of childhood leukaemia.[89] By 1989 a report for the US Congress Office of Technology Assessment stated that 'it is now clear that 60 Hz and other low frequency electromagnetic fields can interact with individual cells and organs to produce biological changes'.[90] Since about 2002 most scientists have accepted that this proximity increases the risk of leukaemia by about 2, although the mechanism is still not fully agreed. Attention has now turned to evaluating the increased risks of leukaemia later in life from short-term childhood exposure to power lines and low MFs. There is also further research into related issues, such as the location of household supply cables and the design of domestic and public-area wiring circuits to reduce general non-thermal EMF exposure.

(ii) Mobile phone masts and wi-fi

Once mobile phone masts became widespread and in use for more than 10 years, it was possible to undertake studies of the increased incidence of cancer, which typically has a latency period of more than 10 years. From about 2002 to 2005, therefore, a

number of studies from around the world appeared, all showing a fairly consistent figure of about 3 times the risk of cancer after 10 years living within about 400 metres of a phone mast, rising to about 10 times the risk for female cancers, typically at about 1.0 – 1.5 V/m or less.[91] These studies all show a dose-response relationship with distance from the mast. There could be higher cancer risks with more recent technology: when digital phone masts were switched on in 1996-97 in the USA, mortality rates rose by 10 – 15% for the first three months in each city for which data were available.[92] Although mast transmitters are much further from the human head than mobile phones themselves, their steady intensity of emissions over long periods appears to have a greater effect, perhaps because they can produce a more powerful cumulative affect when people are relatively stationary, either asleep or sedentary.

No epidemiological studies, apparently, have yet been made of illness resulting from wi-fi, since it became legal in the UK only in 2000 and became widespread only from a few years later. As with mobile phones and their masts, no safety studies were made into the dangers of the non-thermal EMF radiation of wi-fi before the general population was exposed to it. Some information is emerging, however, which suggests that there are similar dangers to those from mobile phone masts. Thus in 2007 Paris removed wi-fi from six public libraries when librarians suffered the usual microwave sickness or electrical sensitivity symptoms of headaches, dizziness, nausea and fatigue, and imposed a moratorium on future use of wi-fi.[93] The effects of the aggregation of different EMF sources rather than those from just a single transmitter is becoming an area of interest as well. In Oakland County, Detroit, it has been suggested that the microwave sickness symptoms to be seen in children using an elementary school playground may have been related to the location of the playground midway between four transmitters.[94] There seem to have been no studies yet of the biological effects of Wimax imposed in addition to exposure to radiation from localised wi-fi, mobile phone masts and digital radio and TV transmitters. In addition there seem to have been no studies of the known cumulative and chronic effects of radiation exposure as it applies to domestic and workplace environments.

(iii) Mobile phone handsets

From the start of mobile phones there have been numerous anecdotal reports of serious ill health, including fatal brain tumours, from the use of mobile phone handsets. From 2000 there have been studies showing adverse health effects for use of handsets in the form of lateral influence on brain tumours. These types of studies have now become more refined and now concentrate on particular tumours, comparing incidences of acoustic neuromas, gliomas and others. Since 2004 they have

shown a dose-response relationship to phone usage. The Reflex project showed that 24 hours' exposure to mobile phone signals caused serious damage to DNA human cell cultures.[95]

Even studies of handset health dangers have not been free from bias, it is said. Thus in the European €7.35M Interphone study of mobile dangers, with about half financed by the industry, the funders were given the right to see the results one week in advance of publication. In one case, in August 2005, the publication did not include all the findings, omitting what some scientists thought was the significant 80% higher risk after 10 years of acoustic neuroma on the side of the brain where the phone was held. Another finding, that of a 2.4 increased risk of non-Hodgkin's lymphoma in mice exposed to EMFs was not published for 2 years after its completion. It is said that all Interphone studies defined 'regular use' as an average of one call per week for at least 6 months. When mixed with many other users this unusually weak definition biases findings towards 'no risk'. In contrast, an 'occasional user' would be below once a week.[96] Although other categories are used in the individual studies, the conclusions are presented with reference to the morbidity of the 'regular user', as in the German study. The Danish study of 2006 apparently did not include people with contract phones supplied by their company on the grounds that the phones could have been used by others. Instead, these people, who would probably be among the heaviest users overall, were included among the average control group, thus distorting the results against finding ill health effects. In the Scandinavian-British study 'heavy users' apparently meant a total of 113 hours during 10 years, whereas Hardell's independent study of 2006 was based on participants with 1 hour's use per day for 10 years, at a total of some 2,000 hours. His results showed a 4.2 increased risk of acoustic neuroma or a 2-times risk for the other side of the head from phone use.[97] A 2007 meta-study of 11 other studies showed raised risks of brain tumours after 10 or more years' use of mobile phones.[98]

(iv) Radar, radio and TV transmitters

Epidemiological studies have been done on the effects of radar since its development in the 1940s, all showing a variety of ill health and some showing a clear dose-dependent relationship.[99] A few studies have also been undertaken for radio and TV transmitters.[100] A correlation, for instance, with a greater incidence of Down's syndrome, where fathers have been exposed to radar, appeared in a study of 1965.[101] Brain tumours were linked to radar exposure in 1985[102] and another study in the same year showed an increase in brain tumours among children under two years old where their fathers had been exposed to radiation but the children had not been, either

before or after birth.[103] Increased incidences near FM transmitters of nonlymphatic leukaemia were shown in the 1970s and of all cancers in 1986, with a two-fold increase in childhood leukaemia from AM-FM found in 1996[104] and confirmed in 2007 for children within 2 km as opposed to more than 20 km from an AM radio mast,[105] and a two-fold increase in adult leukaemia from AM-FM found in 1997.[106] Apparently the Royal Signals research unit at Malvern has had a brain tumour incidence of six times the national average.[107] Furthermore, conscious effects, especially disturbed sleep patterns, have been shown in a dose-relationship for the general population living near a radio transmitter at Schwarzenburg, although few of the general population were individually able to attribute their symptoms to exposure from this non-thermal radiation. Collectively the evidence was overwhelming and led to the removal of the transmitter.[108]

Attention has now turned to re-examining incidences of cancers and other illnesses, especially neurological, respiratory and developmental, from data available when radio and TV transmitters were installed, especially VHF ones. Correlations have been found between the precise location of such transmitters and increases in incidences of illness, including neurological illnesses like Motor Neurone Disease.[109] A 2002 retrospective study showed an increase in cancer following the introduction of FM radio, including skin cancer.[110] Research has now turned to the aggregation of EMF sources which cause biological effects now so apparent from a single source. Thus the increase in risk of melanoma from near zero in 1955 appears to correlate not with the proximity to a single radio or TV transmitter mast, but the total number of such masts effective in a particular area. Moreover countries like Japan which use different frequencies for their FM radio and TV signals have a melanoma rate of 3% of Sweden's, although Japanese people moving to other countries begin to suffer increased melanoma rates.[111]

(b) Conscious effects

(i) General EMF ill health

Apart from the early studies on radar and electricity-supply workers, there have been relatively few studies of self-reported symptoms to assess ill health in the general population from exposure to EMFs, although there have been four recent studies into sleep. All four studies showed that non-thermal EMF exposure has an affect on sleep from SAR levels of 1.4 W/Kg down to 0.133 W/Kg.[112] As electrosmog increases, comparative studies are becoming more difficult in industrialised countries. Nevertheless the Oberfranken study (2005) showed that 30% of the general population reported typical electro-sensitivity symptoms at under 0.06 V/m, and 95%

did so in the range 0.2 – 0.6 V/m..[113] Accordingly the BioInitiative Report of August 2007 called for a limit of 0.06 V/m, close to that adopted by Salzburg of 0.02 V/m..[114] In comparison, the human nerve impulse or neuron action potential is said to be about 0.1 volt and lasts only 0.001 second.[115] It should be noted that some of the leading researchers into non-thermal EMFs health effects, such as Dr Carlo and Professors Cherry and Margaritis, believe there is no safe level for man-made EMFs.

(ii) Electro-sensitivity (ES) studies

There have been several attempts at epidemiological studies of people who are sensitised to EMFs, including ones in Sweden and California. One problem such studies face is the definition of electro-sensitivity. It seems likely, from evidence of the Oberfranken study and mechanistic studies, that all humans are electro-sensitivitive to a certain extent, with 95% consciously reacting to radiation exposure as low as 0.6 V/m (RF, P/P).[116] At higher levels 100% conscious reaction would be likely. This raises problems for the definition of electro-sensitivity. It may be that the next stage of sensitisation, often termed electro-hyper-sensitivity, is what some of the surveys are seeking to define. Much research from the 1950s to the 1980s did not often distinguish between electro-sensitivity and electro-hyper-sensitivity, because the latter condition was not commonly defined until 1994, when interest turned to the progression of Microwave Sickness from electro-sensitivity to electro-hyper-sensitivity in three or four stages. It is the latter condition which is particularly worrying, since it seems to be permanent and at present has no cure. In this document, however, the convention is adopted of labelling both as electro-sensitivity. Research in Sweden produced a figure of 3.1% of the population as electro-sensitive. The latest UK MTHR report gives a range of 1% to 4% of the population.[117] Some recent predictions of the growth of electro-sensitivity include the staggering projection that half the population could become electro-sensitive by 2017,[118] although this must depend, again, largely on definitions.

Alongside ES studies have come self-help groups formed by people sensitised to non-thermal levels of EMF exposure. These groups have accumulated large quantities of anecdotal information all substantiating the research since the 1930s into Microwave Sickness. The first group was formed in Sweden in 1989 with 10 members (FEB: the Swedish Association for the Electrically and VDT injured). By 1994 this group had grown to 1,800 paying members, along with sensitised children.[119] By 1994 there were other groups in Norway, Denmark, Germany (2) and the USA (4). Now there are similar groups in most industrialised countries around the world. The Electrosensitivity-UK charity was founded in 2003 at a meeting of the Electromagnetic

Biocompatibility Association at the Royal Society of Medicine in London by some 40 concerned medical doctors and scientists. It has seen a rapid growth in the number of people contacting it for help with sensitivity problems arising from exposure to a wide variety of electrical appliances and environments. According to official Swedish statistics in 2001, about 12.5% of engineers in the electronics industry were hypersensitive to electricity.[120]

(iii) Provocation studies

In themselves provocation studies are irrelevant to whether non-thermal EMFs are biologically active or even if EMFs produce the set of sensitivity symptoms classified as Microwave Sickness by the Russians and Americans in the 1950s. EMFs clearly do cause considerable ill health independent of whether the sufferer knows of their existence, because the same sensitivity symptoms can be seen in children, babies and animals independently of any psychological influence which may and sometimes does affect adults under test conditions. In 2000 it was shown that small children can become ill with electro-sensitivity symptoms at levels down to 0.06 V/m.[121] Indeed the growth effect of very low levels of EMFs on plant cells, where there is no nervous system, has been measured since the 1930s.[122]

Moreover there have been probably up to one hundred 'provocation' studies showing how far people claiming to be sensitised to EMF can identify the presence of EMFs, with some achieving 100% accuracy. The most accurate studies seem to have been those most attentive to the particular frequencies to which the patients are sensitive and those where extraneous EMFs have been most effectively removed both geographically and temporally.[123]

The question, therefore, should not be whether provocation studies are relevant to affirming ES symptoms but, rather, why the 2007 Essex study and some others have failed to find the association which bioelectromagnetic studies and other provocation studies have successfully done.[124] Sometimes the reason for failure is quickly apparent. In a recent MTHR study a handset in 'sham' exposure mode actually allowed SAR values of up to 5mW/Kg, although the TNO study showed health effects at below 0.1 mW/Kg.[125]

All provocation studies face the common problem that ES symptoms are highly variable because of the way in which exogenous EMFs inter-react in a quantum-like manner with edogenous EMFs. Symptoms can be delayed, sometimes for many hours, and the effects of exposure are cumulative, but not linearly so. In some cases intense

exposure will take many months to rectify through absence from further exposure, where that is possible. Moreover, where there is exposure to more than one source of EMF, the body will react in a complex way, and where the wave formation is modulated unusually, as with many mobile phone and wi-fi signals, the body's defence mechanisms will create even more complex reactions.

Since the 1930s, Einstein's theories of relativity have been applied to the human body's own endogenous EMF, suggesting that the way human bodies respond to invasive EMFs is far more complex than a simple tit-for-tat reaction.[126] For Einstein, 'the field would be the only reality in a future new physics', not the chemical reactions or nuclear particles which supposedly constitute material substance.[127] Interestingly, such a variety of responses suggested by this theory appears to match the experiences of people suffering from the unusual pattern of EMF-induced pains around the body, although little recent research has attempted to apply Einsteinian theories because of current difficulties of measurement. Moreover, it must be remembered that electric fields and magnetic fields are essentially human constructs designed to help the interpretation of the evidence of forces which are otherwise unseen. The dimension of time is critical to our understanding of these forces and yet it is this very dimension which Einstein also challenged so effectively.

All these variables make it difficult to devise provocation tests when they use conscious and self-reported responses. Pathological tests already used in animal, plant and a few human studies are more likely to produce a higher degree of correlation than the variable and subjective nature of provocation studies. A few psychologists, however, seem naturally to prefer cognitively subjective tests, despite the inherent problems. It has been suggested that the reason for this is that some psychologists are naturally sceptical of any supposed influence on the brain other than chemical because they are heavily biased towards the use of drugs, even though EMF effects on EEGs has long been shown, and EMFs have been show to enhance or reduce the effectiveness of certain drugs.

Another factor is the tendency among some practitioners to explain any new illness outside the known range of existing ones by means of a psychological aetiology. This was the case, apparently, with a number of conditions for which later advances in medical diagnosis have allowed a different understanding, including ME, MS, CFS (although some doctors dispute such a diagnosis and terminology), fibromyalgia, MCS and sensitivities to light and sound.[128]

The reality of electro-sensitivity, of course, is independent of provocation tests. Its symptoms were extensively identified in the 1950s and its natural progression in a few instances into a condition sometimes termed electro-hyper-sensitivity was also established at this early period. It is said that the progress of this condition is parallel to that of similar environmental sensitivities, such as chemical.

With regard to the Essex study, therefore, its significance is not any negative correlation, since a negative findings can never prove anything substantive, but the question of why it failed to replicate the 100% correlation which other provocation studies and numerous biological studies have already shown. In fact, even the comments by the authors of the study admit to one correlation, that of the significantly higher skin conductance among those patients claiming electro-sensitivity compared with the controls. This factor had already been confirmed in other studies of ES patients outside of provocation studies and suggests that the way EMFs enter and affect the body may be partly related to the nature of the skin and its electrical properties.[129] Indeed, the studies into the ways that EMFs are 'biologically active' and affect the general public mean that it is unreasonable to expect any clear dichotomy between provocation results for the two sets of subjects once levels of EMFs over 0.05 V/m are used. As explained above, at this level 30% of all subjects drawn from the general population are said to reveal conscious health effects under normal conditions. It is also said that those who have suffered from ES for a long time are more likely than others to have significantly delayed symptoms.

At least three different further explanations for the Essex study's failure have been proposed by independent commentators. (1) The data was wrongly interpreted. Some scientists who have subsequently analysed the results say it shows exactly the opposite of the interpretation given by the report's authors (i.e. there actually was a significant correlation in subjective awareness). Professor Fox apparently admitted that there was a '30% chance' that the experiment missed a real effect because of small numbers involved. There was a high drop-out rate of over 20%. Indeed, 44 self-reported individuals seem a very small sample on which to build a new theory and reject 70 years of bioelectromagnetic research.[130] (2) The parameters (physical, EMF, patient, timing, etc.) were not sufficiently formulated or enacted on this occasion, and it has been claimed that only 3.6% of electrosensitives are likely to suffer ES symptoms from mobile phone mast radiation.[131] (3) It was partly sponsored by the phone industry and government and was conducted by psychiatrists and not general medical doctors, so it was unlikely to show any correlation anyway. In contrast to this particular provocation study, it has been said that 80% of the World Health

Organisation's epidemiological data on health effects from microwave transmitters show illnesses ranging from electro-sensitivity to a 4-times increase in cancer.

5. Mechanistic studies

A major problem for the study of EMF health-effects and especially the acceptance of their findings is the interdisciplinary nature of the subject. Few scientists have the time or training to comprehend the whole range of relevant research, from pulsed microwave radiation and low frequency powerline configuration to Einsteinian relativity of bioelectromagnetic fields and subatomic neurological cellular membrane analysis. Some physicists could be tempted to assume a linear progression of effect from known power intensities without realising the nonlinear and window effects of radiation on living organisms, while some medical practitioners could be tempted to omit some types of EMF from their consideration of the relevant parameters when assessing a patient. The latest research by nuclear physicists and others in Russia and the USA is in applying non-linear quantum biology to possible observations of subtle energy phenomena, taking Einsteinian relativity a stage further.

Nevertheless, the progress of unravelling the complex mechanisms by which EMFs affect different parts and aspects of the human body continues at an ever-increasing pace. The Bioelectromagnetics Society (BEMS) was founded in the USA in 1980 and the European Bioelectromagnetics Association (EBEA) was founded in 1992, both fostering international research in this area. By 1962 there were already 44 studies dating from 1892 on biological effects of magnetic fields alone. Now there are said to be some 200,000 overall.[132] From 1972 Information Ventures Incorporated under Dr R.B. Goldberg has compiled an online computerised *EMF Database* containing, by 2002, over 25,000 summaries of EMF research.[133] The online *EMF-Portal*, run by the Research Centre for Biolectromagnetic Interaction and supported by the German Federal Government, has over 11,000 research summaries available.[134]

Research into biolectromagnetics faces peculiar problems which have apparently not yet been fully understood by all those interpreting the results. The way that exogenous electromagnetic fields affect the endogenous electromagnetic fields of a plant, animal or human is not a process of traditional particle physics but essentially an inter-reaction of numerous electromagnetic fields. It is likely, therefore, that there are almost an infinite number of potential pathways, given that each cell has its own field. In addition, it is likely that the process of measuring these fields distorts them in a way which is more problematic than with chemical or particle reactions. Moreover, since Lai and Singh confirmed in 1997 that EMF exposure has cumulative effects and there are now few if any organisms left on the surface of the earth which have not been exposed to manmade non-thermal radiation from terrestrial or satellite sources, it is probable that no true comparative studies can be made in future. This becomes

even more of a problem since the discovery in 1995 that non-thermal EMFs can cause DNA breaks and that these can be transmitted to the next generation. Although the international conference of doctors and other scientists in the Netherlands in December 2006 reckoned it would be 10 to 15 years before scientists can measure the precise factors which could explain most of the relevant electric and magnetic fields and their effects, it may be more realistic to admit that mechanistic and particle-based research may never succeed in fully quantifying the inter-reaction of the forces which are currently labelled as electromagnetic.

Most mechanistic research has focused on mainly detailed aspects of biological pathways, and not on the type of wave or frequency modulation. The quantum-like interplay of so many stages in any pathway makes it difficult to prove which ones are the most prevalent or powerful in the way EMFs affect human tissue at below thermal levels, since small effects at cellular level can lead to multiple cascade effects on larger organs. Any such uncertainty, of course, does not mean that there are no such effects, and many convincing stages along a variety of lines have already been established. Since 1995 these pathways have been shown to include DNA damage, which could in turn lead to a whole range of cancers and neurological diseases. Other scientists have used recent technology to gain evidence for brain entrainment from natural causes, such as the Schumann waves, suggesting yet further pathways for interference from man-made EMFs which are still partially unexplored.

Current research suggests that EMFs relate particularly to cellular shutdown under stress, irradiated cells splintering into micronuclei (a definitive pre-cursor of cancer and involved in damage to blood cells). free radicals, some stress hormones, calcium-ion flow, oxygen deprivation, heat shock proteins and nitric oxide synthase. The last is an enzyme generating nitric oxide, which acts as a vasodilator and neurotransmitter, causing the suppression of serotonin and melatonin; it may also relate to an increase in mast cells leading to their degranulation and increasing histamine. In 1980 it was found that EMFs affect pineal cells, crucial for the production of melatonin. By 2005 more than 19 studies showed reduced melatonin from EMF exposure. In 2004 it was shown that mitochondropathy is involved in many chronic illnesses, such as MS, Alzheimer's, Parkinson’s, fibromyalgia, diabetes and obesity. In 2005 it was shown that chronic non-thermal EMF microwave exposure induces chronic nitrosative and oxidative stress which damages the mitochondria of each cell in the body and, as shown in 2004, leads to irreversible DNA damage. Mitochondria DNA is irreparable and this mitochondropathy is transmitted to children through the maternal egg cell.

There is also interest in the different pathways instigated by different types of EMFs. Low frequency magnetic fields have been associated especially with melatonin decrease and free-radical increase along with depression, whereas calcium efflux and micronuclei damage may relate more to higher frequencies, electrical fields and pulsed radiation. The inter-relationship of the two fields, however, means that all elements are probably involved simultaneously but in differing degrees. Sometimes the results can be opposite: the (pulsed microwave) Skrunda radar study showed a preponderance of girl births, whereas the (magnetic fields) Hydro-Quebec study showed more boy over girl births; both environments have been shown to produce genetic birth defects. It has been proposed that iron-mediated processes deriving from magnetic fields lead to increased free radical formation in brain cells. Iron-rich brain tissues such as glial cells, neurons and myelin may thus be susceptible to EMF-induced damage. The developmental process of myelination, often lasting into young adulthood, could thus be involved in developmental syndromes as well as neurodegenerative diseases such as Alzheimer's and Parkinson's. Other effects, such as the ionised corona, are associated especially with power-lines. Since exposure to man-made EMFs can affect every human cell and thus every human organ, bioelectromagnetic scientists are learning to look at numerous concurrent and inter-related effects and not one simple solution, however attractive the latter may seem to those brought up on traditional models of particle physics.

EMFs seem both to trigger and to increase the growth of cancers, stimulating cancers up to 20 years earlier than average. EMFs have also been particularly associated with developmental conditions, suggesting prenatal exposure could be dangerous or that it causes DNA changes before conception. In several cases the cell and tissue damage done by low-level EMF radiation, such as in mast cells, is said to be similar to that done by ionising gamma-wave radiation from nuclear reactions, suggesting that the supposed division between the two types of radiation, ionising and non-ionising, may be more blurred than previously thought, at least in resulting damage. The processes by which the human body can be affected by levels of EMFs below those normally in the environment, such as the earth's magnetic field, the Schumann waves, or solar UV radiation, are also beginning to be researched.

Individually some of the mechanisms already identified as linked with exposure to non-thermal EMFs are said to be sufficiently well established according to standard scientific research postulates as to warrant the conclusion that they are caused by EMFs. Leading scientists in this field thus feel that regulators and governments should act now to safeguard the present and future well-being of the general population.

6. Meta studies

Because of the sheer number of scientific studies in the area of EMFs, perhaps over 200,000, alongside some dozens of books, with perhaps 10,000 studies directly relevant to the health effects of EMFs on humans, it is now difficult for any one person to read, understand and remember all the relevant data and hypotheses. As a result there has been a growing number of meta studies which do not undertake new research themselves but simply seek to review the studies relevant to one particular area of interest and draw a conclusion from the evidence and interpretations of other scientists.

In addition, there is a new specialism in meta studies, with published papers, analysing the results of EMF studies according to their funding. The conclusions are usually clear-cut: where industry sponsorship can be shown the results are nearly always indeterminate or negative.[135]

Although it might be expected that the various national and international groups of scientists which meet regularly to examine the worries over health effects of non-thermal EMFs would be able to undertake this work of compiling meta studies, in practice they rarely do so. In fact, they are probably unable to do so because of the little time they have available for such an extensive survey. Instead, they tend to review any new studies brought to their attention at their next meeting. Which studies are presented can be the result of pre-selection based on factors such as the particular interests or concerns of the constituent members of the group and not the wish to review all relevant literature. Moreover, because of their episodic congress, such groups are inclined by their very constitution to support the status quo.

Sometimes regulatory bodies adopt arbitrary limits on the scientific research they will consider. In 1991 the US IEEE C-91.1 committee revised its standards based on studies up to 1985. Their revised standard was adopted in part by the FCC in 1996, meaning that the new standard was based on research at least 11 years out of date.[136] During this time many hundreds of studies were published, with about 80% apparently showing biological effects at non-thermal levels.

It is therefore usually an ad hoc committee which is better placed to conduct a fuller literature review and to formulate necessary action, as with the Stewart Report of 2000, updated in 2005, although any such report is soon out of date as new evidence becomes available. Also in 2000, T-Mobile commissioned the German Ecolog Institute

to review all the evidence concerning wireless dangers. They found over 220 valid papers showing cancer-initiating effects of EMFs.

A recent meta study was the international BioInitiative Report of August 2007. It was compiled by 14 international scientists, including three former presidents of the Bioelectromagnetics Society (the leading research society on EMF health effects), and was based on over 2,000 studies, thus possibly one of the most extensive and authoritative so far conducted. It revealed considerable concern over established and possible health effects of non-thermal EMFs and called for an international indoor exposure limit of 0.06 V/m (RF, P/P).

There is a need for more meta studies on suitable levels for non-thermal limits. The threshold of human subconscious sensitivity has been shown to be as low as 0.00002 V/m (RF, P/P), with lateral influence on brain tumours at mobile handset levels from 0.00003 V/m. These need to be reconciled with Salzburg's 0.02 V/m and the seemingly high limit of the BioInitiative report of 0.06 V/m, above conscious ill health at 0.05 V/m for a significant proportion of the general population. Like radioactive gamma radiation, RF and microwave radiation is now regarded by many scientists as carcinogenic and genotoxic to the cellular roots of life, since any exposure level can appear to trigger a damage response by the cells.

As stated above, it has been reckoned that some 80% of the scientific studies have shown biological dangers from EMFs. In addition, there is increasing agreement about the exposure dangers in close proximity to power lines, mobile phones after 10 years, mobile phone masts after 10 years, and the typical symptoms of electro-sensitivity. The onus is therefore now on those scientists who still believe, against the weight of the last 85 years' research, that EMF effects on humans are unique among their effects on other living organisms, either in that they are harmless, or because they have no effect. Most scientists who have spent their lives researching in this area would apparently see non-thermal EMFs as biologically active and potentially dangerous, with several leading experts arguing that there are no safe exposure limits for human beings.

7. Multiple studies

The ideal meta study would be combined with original research to fortify areas of weakness. Such studies occurred with the $26 1993 to 1999 Wireless Technology Research programme led by Dr G. Carlo in the USA. It involved a team of 200 doctors and other scientists, and was notable in showing that human blood exposed to cell phone radiation had a 300% increase in genetic damage in the form of micronuclei. In 2002 the Californian Department of Health Services issued their report of 560 pages following a nine-year study at a cost of £4.5M and authored by three epidemiologists. The Californian report concluded that raised levels of EMFs increased the risk of cancer, particularly childhood leukaemia, miscarriages, adult brain cancer and ALS, a progressive form of motor neurone disease also known as Lou Gehrig's disease. The 2004 Reflex report summarised 12 research projects from seven European centres on the genotoxic potential of EMFs, showing human single and double-strand DNA breaks and chromosomal abnormalities. The Interphone study, run in 16 countries by the IARC under the WHO, started in 1997; one of its reports already released shows an increased risk of brain tumours on the side phones are held. As might be expected, therefore, all these major studies have found significant health risks.

The UK MTHR interim report of September 2007 on mobile phones and their masts was based mainly on its own 23 studies. Its conclusion was merely that there should be more research on cancer risks after 10 years' use of mobile phones, although even that implies that the cancer growth could start occurring earlier, a factor already well established by other studies since 1994.

A major problem with all research limited by time constraints into non-thermal biological effects of EMFs is that short doses of EMFs at higher intensities do not necessarily have the same effects as chronic EMF exposure at lower intensities. The general population is typically exposed to the latter type of irradiation. Because the latency period in humans for the development of cancer and some other conditions such as neurological ones can be 10 to 15 years, there are few epidemiological and almost no mechanistic studies. Studies on five generations of mice in Greece in 1997 exposed to non-thermal levels of EMF from mobile masts found a progressive decline in fertility with irreversible infertility by the fifth generation, with alterations in the prenatal development of newborns.[137]

8. Clinical studies

Few clinical studies into the health effects of EMFs has been done in the UK, despite the considerable volume of research in Russia from the 1960s, although the dangers have been relatively well known among military personnel for many decades. In practice, of course, very few people were sensitised to EMFs, apart from some radar and electrical workers, until the spread of mobile phones and wi-fi from the 1990s. In response to the rapid increase in numbers consciously suffering from electro-sensitivity, the charity Electrosensitivity-UK was established by concerned health workers and scientists in 2003. An HPA report on electro-sensitivity appeared in 2005, attempting to adopt an ambivalent attitude.

With an ever-increasing number of people being sensitised, perhaps reflected in an almost doubling of victims seeking help from the ES-UK charity during 2007 alone, the UK government, in the form of the HPA/MTHR report of September 2007, has now followed the WHO report of 2005 and conceded that, like other environmental sensitivities, electro-sensitivity symptoms are a genuine and disabling condition. Although this MTHR report admits, however, that electro-sensitivity is a genuine condition, nevertheless it then goes on to state that electro-sensitivity is not caused by electricty in the form of non-thermal EMFs. This, as argued above, is against substantial evidence accumulated around the world over the last 60 years. Clearly such a hypothesis appears blatantly flawed unless some other trigger is suggested for the defined set of symptoms which occur only in the presence of EMFs, a trigger which hundreds of scientists working on this issue for so long have apparently missed. In fact the main reason given by this anomalous 2007 report was the Essex provocation study of 2007 based on self-reported symptoms. This, of course, is the study which some scientists who have re-evaluated the data claim actually proves the very point it was supposed to disprove (see above, section 4, b, iii), while others claim it was seriously flawed.

If there were some other cause for the same symptoms as those caused by Microwave Sickness or electro-sensitivity, then it would be logical to name this new sensitivity by its causative agent to differentiate it from the syndrome already established as caused by electricty in the form of non-thermal EMFs. If, however, as is likely, this supposition of another aetiological explanation is a mistaken hypothesis of the MTHR report, then it raises questions about other hypotheses in this report, such as the suggestion that there is no health danger from mobile phones until after 10 years' use.

This odd refusal by the UK government to accept the link between non-thermal EMFs and ES illustrates the need for a clinical research centre into all EMF health effects and especially sensitisation to EMFs. If there is some other cause, so far undetected by any scientist, it is of major significance for every human being. It also contrasts with all the other countries which accept the scientific evidence from the 1950s onwards showing that electro-sensitivity or Microwave Sickness is caused by EMFs. Sweden, for instance, reckons 3.1% of population could be electro-hyper-sensitive. Whatever the cause, it seems important that medical data should be collected from all people who have already been sensitised and its analysis used to identify those most at risk. Research also needs to be done on finding possible cures for the condition. Furthermore, if, as at present, the only way to make life bearable for most ES sufferers is for them to be removed from or shielded from exposure to non-thermal EMFs, then societies which allow this type of environmental pollution should provide safe areas and appropriate protection. These safe areas should be available to people already sensitised or likely to be sensitised.

An obvious solution to help sensitised patients would be for the NHS to establish clinics with good practice based on the medical research already done elsewhere. The Safe Wireless Initiative in the USA undertakes such a mission and is said to be treating tens of thousands of people across the USA who have already been sensitised. Secondly, much work still needs to be done in informing bad 'scientists' of the need to stop being so prejudiced that they cannot see how much human suffering they are causing by denying genuine research and experience (see section 3 on anecdotal evidence).

9. Doctors' and scientists' appeals

One feature of the faster progress in recognising the dangers of non-thermal EMFs in parts of continental Europe than in the UK has been various doctors' and scientists' appeals to their respective governments. These have become more frequent over the last ten years as the health dangers of non-thermal EMFs have become more apparent. Although it seems extraordinary that doctors and scientists have to make formal appeals over any medical issue of such importance, it has raised general awareness of how much 'we have observed in our patients ever more frequent health complaints that are being caused by mobile telecommunications radiation' (Dr. Markus Kern, trans.).

Some of these appeals include:
the Vienna Resolution (1998, by 16 international scientists),[138]
Salzburg (2000, by 19 international scientists and public health doctors),[139]
Catania ICEMS Resolution (2002, by 16 international scientists),[140]
Freiburger (2002, now by 1,500 doctors),[141]
Maintaler (2004),[142]
Bamberger (2005, by 175 doctors),[143]
Coburger (2005, by 96 doctors),[144]
Freienbacher (2005, by 54 doctors and others),[145]
Haibacher (2005, by 8 doctors and others),[146]
Helsinki (2005),[147]
Hofer (2005, by 64 doctors),[148]
Irish Doctors' Environmental Association (2005),[149]
Lichtenfelser (2005, by 32 doctors),[150]
Oberammergau (2005, by 32 doctors),[151]
Pfarrkirchener (2005),[152]
Stockacher (2005, by 38 doctors and others),[153]
the ICEMS Benevento Resolution (2006, by 31 international scientists),[154]
'Wimax' (2006, by 16 doctors and others),[155]
Kompetenzinitiative (2007, 18 organisations, 56 international scientists),[156]
Allgäu-Bodensee-Oberschwaben (2007, by 360 medical doctors and 150 psychologists and others from that region).[157]

In 2007 the European Environment Agency added its voice to those calling for an immediate reduction in non-thermal EMF exposure.[158]

If so many public health scientists and doctors who are trained in diagnosing both illness and its likely causes are so concerned about non-thermal EMF health dangers, it seems strange to many people that governments and regulators still choose to ignore them. Even individual scientists have been reduced to making appeals. Professor Adlkofer of the Verum Foundation, who computed that UMTS (3G) has a 10 times greater risk of causing DNA breaks and cancer than GSM, called for an immediate change of policy in 2007, arguing that mobile phone radiation was an 'uncontrolled and unplanned field experiment' on humans.[159]

10. Ethical, legal and financial issues

Although the world-wide impact of health damage from non-thermal EMFs has been generally known for only about 10-15 years, there are already moves to initiate consideration of the ethical, legal and financial issues involved.

(a) Children

Enforced irradiation of children through wi-fi in schools and public places like shopping centres and transport areas raises problems for parents who wish to exercise their duty of care to their child, especially when they perceive their child as already being, or likely to become, sensitised to non-thermal EMFs. It also raises issues about how far schools should exercise a duty of care when the latency period for malignant tumours after 10 years' exposure is becoming so clearly established. For instance, Hardell (2006) showed a dose-dependent link between phone use and tumour development, with the greatest risk for those starting phone use before the age of 20. Gabriel (2000) argued that the SAR produced by a given EF is larger in children than adults because their tissue normally contains more ions and has higher conductivity. Some people argue, therefore, that 'allowing children under the age of sixteen to regularly use a cell phone may best be described as parental negligence, or possibly child abuse'. In 1995 Lai showed DNA breaks in cultured human cells after 16 hours' EMF exposure, but there have been no tests to see if, or how soon, this can be replicated in a wi-fi enabled classroom with laptops in use. In 2004 a spokesperson for the HPA agreed that people in general are being treated like 'guinea-pigs' in the way they are being exposed to pulsed microwaves. This terminology could also be applied to the irradiation of UK children in many schools without safety testing, a situation which appears unparalleled and unethical.

(b) Electro-sensitivity as a disability

The perception of electro-sensitivity as a disability has led to a report of 2007 for the Canada Human Rights Commission. This report deals with practical ways to help people suffering from environmental pollution like chemical and electrical sensitivities. The report recognises that people who suffer from these conditions deserve and need primarily physiological and not psychological help, arguing that, like many such illnesses, they are somapsychotic, not psychosomatic. In Sweden electro-sensitivity is regarded as a functional impairment and provision is made for such people with alterations, for instance, in housing, workplaces and transport. Salzburg has attempted to avoid conscious ill-health from non-thermal EMFs by setting the indoor limit at 0.02 V/m.

In the UK electro-sensitivity has been accepted *de facto* as a medical condition or disability for acceptance by DSS tribunals as a reason for the award of Incapacity Benefit. In practice, however, the DSS at present apparently often prefer to label electro-sensitivity as, for instance, inflammatory dermatitis, skin dermatitis, CFS or fibromyalgia, according to how close the symptoms are to other conditions. This oddity will doubtless change as the medical and other professions become more aware of the nature of electro-sensitivity and how it is now accepted elsewhere.[160] Since 2007 the VAT tribunal has been said to accept electro-sensitivity as a reason for exempting from VAT the purchase of certain items designed solely for the protection of sufferers from EMFs. It was reported in 2005 that a girl in Wales developed severe epilepsy when a mobile phone mast was erected near her home. When a TETRA mast was installed on a police station under 1 km from her school in Haverfordwest, however, it caused her so many seizures that the local council agreed to her mother's request for home tuition.[161]

(c) Cost benefit and insurance

The usual attitude to environmental pollution is that the polluter pays not only to stop the source of pollution but also to put right the damage done by the pollution. Some industry scientists, however, try to argue for retaining high levels of non-thermal EMFs on the grounds that reducing them could involve extra expense and prevent only a relatively small number of deaths. A supposed cost-benefit analysis for interventions for power lines was based on utilitarian arguments in the Netherlands in 2002. Such a callous argument, where the value of a human life was estimated in the US in 1999 typically at $4.8M, usually ignores the far greater number of debilitating illnesses now associated with low levels of non-thermal EMFs, leading to early mortality, such as cancers and Alzheimer's. In contrast, there have been few if any attempts to quantify the substantial proportion of the UK's NHS budget now going towards EMF-related illnesses, and the savings to public expenditure and industry costs if illnesses from non-thermal EMF exposure were reduced. If 10% or 20% of the NHS's primary health-care provision in the UK were related directly to illnesses triggered or stimulated many years earlier than usual by non-thermal EMFs, then it is clear that the cost savings from reducing the general population's EMF exposure would bring enormous savings in government expenditure.

Insurers have been more alert than governments and regulators to the likely financial implications of adverse health effects from non-thermal EMFs. From 1999, once the dangers of non-thermal EMFs in mobile phone use were clearly established, some Lloyds underwriters refused to cover mobile phone manufacturers for damage to

users' health. Some power-line companies are said to have rejected insurance advice against the siting of overhead cables and substations close to housing because of up-front cost-savings compared to potential long-term compensation, disregarding the research findings since 1979 which show links with adverse health effects and which are now accepted by most scientists worldwide. In the US there is no statute of limitations on health claims for EMF damage, meaning that anyone involved in decisions over siting could be sued if damage is shown to occur.[162]

In 1985-89 the Houston Light & Power company was found liable by a Texan court for damages and was required to move its transmission lines away from a school.[163] In Sweden compensation was granted in 1985 to Marianne Berg, a bank employee, injured by non-thermal EMF exposure at work. The Swedish National Insurance Board, however, tried repeatedly to overturn this decision and eventually in 1994, nine years later, the National Insurance High Court reversed the earlier judgement.[164]

In July 1996 two workers, Alan Davis and John Docherty, suffered from the usual sensitivity symptoms caused by non-thermal electromagnetic radiation while installing TV antennae for Channel 5 on a BBC mast in Cornwall. The following month Dr Chris Schilling, an occupational doctor with NTL, the telecom company concerned, examined them and concluded that they were suffering from radiation sickness.[165] This diagnosis was confirmed by an expert, Dr Bruce Hocking, another occupational doctor and a former chief medical officer to an Australian telecom company. The defendants called on a neurologist and member of the UK government's NRPB Advisory Group on Non-Ionizing Radiation. He apparently agreed with the plaintiffs that the exposure was at non-thermal levels and the symptoms did not match thermal tissue damage but suggested that the symptoms must have been the result of a simultaneous viral infection. The first judge, who in 2001 ruled against the claimants, was said by the appeal lord justice in 2002 to have been 'impressed by his expertise' and the appeal was rejected. According to the *Independent* newspaper this was the first case of its kind.[166] With the availability of substantial new data on similar symptoms from similar radiation over the last six years, in addition to the much more rigorous study of the research literature into non-thermal radiation sickness from the 1930s onwards, it seems less likely that such an apparent miscarriage of justice would occur in the future.[167]

Since 2002, however, the tide has begun to turn. In California Sharena Price suffered from a brain tumour as a result of non-thermal EMF exposure as a programmer for new cell phones. In May 2005 an administrative law judge awarded her $30,000 in a

worker's compensation claim to cover her medical expenses, on the grounds that her illness was caused by non-thermal EMF exposure.[168]

(d) Human rights and crimes against humanity

Interest has now turned in some quarters, from South America to China, to how far exposing a whole population to dangerous levels of non-thermal EMFs can be regarded as an infringement of basic human rights and a crime against humanity. The argument is that man-made non-thermal EMFs have been found not only to trigger electro-hyper-sensitivity in 1-4% of the general population, but also to cause other illnesses on a scale comparable with some other major health epidemics. Terms such as 'genocide' or 'holocaust' may seem provocative in parts of the USA and western Europe, but people elsewhere around the world are prepared to use them over the deployment of non-thermal EMFs. The charge, it is said, could be against regulatory authorities such as national governments and international commissions such as the WHO and ICNIRP. The grounds would be, apparently, that they failed to safeguard large numbers of people from exposure against their will to non-thermal EMFs which have been shown repeatedly to have adverse health effects.

It took the WHO 28 years after scientists showed the link between power lines and leukaemia to accept a precautionary approach, but even now the WHO refuses to suggest appropriate limits. The WHO reports that 'epidemiological literature has consistently found elevated risk of childhood leukaemia at ELF magnetic field exposure levels above 0.3 μT for the arithmetic mean'.[169] Campaigners therefore argue that it should not be impossible to quantify the numbers of people who have suffered from leukaemia associated with power lines during these 28 years of prevarication by the WHO and government regulators. Similar cases of moral culpability arise over health dangers from other EMFs. The origin of Microwave Illness was established by the early 1950s and evidence of DNA breaks, cancers, respiratory illnesses such as some types of asthmas, and neurological diseases such as Alzheimer's, Parkinson's and autism was made public by the 1990s. Many leading scientists have called the whole mass irradiation of human populations the largest involuntary biological experiment ever on the human race and the one most likely to endanger its future.

In fact bioelectromagnetic 'proof' is not needed for some legal actions. In 2005 a high court upheld a 1997 claim against Iberdrola at Murcia in Spain, ruling against any radiation from a transformer into a nearby property.[170] In 2007 a judge approved residents' requests for the removal of a phone mast on a block at Calle Ingeniero de la Torre Acosta in Malaga, based on 30 cases of cancer in proximity to the antenna.[171]

11. Asbestos – a case study

(a) Parallels in the attitudes to the dangers of asbestos and EMFs

There are said to be some parallels between the attitudes taken towards the health dangers of asbestos and those of EMFs. It is reckoned that asbestos will have killed 0.3 million people in the USA before the current epidemic ends, the worst occupational health disaster in the USA. In fact the dangers of asbestos were known from the start, and asbestos companies and government appear to have colluded in trying to ignore or hide these dangers from those working in the industry for many years. Like ES, the immediate ill health arising from exposure to asbestos was identified first, a disease named asbestosis. Like the dangers from EMFs, links with cancers came later, and the mechanisms of these links and even some of the links are still disputed. Also like EMFs, there is a delay between first exposure and the manifestation of illness, often with a latency of 20 to 40 years. Like ES, asbestosis is a chronic and debilitating disease, sometimes fatal; the cancer mesothelioma is nearly always fatal. Again, like fibre-optic cables and other devices in place of pulsed microwave radiation, alternatives to asbestos were developed early on but were not used early enough by an industry intent on short-term profit.

(b) History of attitudes to research on the dangers of asbestos

The dangers of asbestos were recorded in the first century A.D. by Strabo and Pliny the Elder, who associated it with lung disease. In 1879 modern commercial mining started and these dangers were again noted by a Viennese doctor in 1897. In 1918 the US Bureau of Labor Statistics and the Prudential Insurance Company published a report on early deaths and two years later some insurance companies began refusing life cover to asbestos workers. In 1922 the US Navy included asbestos work among hazardous occupations. The disease called asbestosis was identified in 1924 by a British pathologist. In 1929 a coroner called for a public enquiry and in 1930 the report of a two-year study was presented to the UK parliament, resulting in a law of 1931 increasing ventilation for asbestos workers. In 1932 the US Board of Mines issued its own warning, but the asbestos industry expanded rapidly.

During the 1930s research linked asbestos with cancer, but the industry tried to cover up the health dangers, perhaps worried by silicosis litigation. Fibreglass was developed as a safer insulating material at this time but the industry ignored it to maximise immediate profits. Even as late as 1950 some of the industry lobbied against stricter legislation and in 1952 asbestos companies refused to attach warning labels to their products. In 1964 further research again linked asbestos with induced diseases but US asbestos production continued to rise, peaking in 1973. In 1970 the US Occupational

Safety & Health Act introduced strict exposure limits, but it was not until 1973 that the tide turned, when the US Court of Appeal found the manufacturers liable for workers injured from workplace exposure. Even in the 1970s, however, it is said that the US Navy forbade its shipyard asbestos workers from talking to lawyers about asbestosis. In 1987 it is said that a Russian shipyard doctor was removed because he warned workers of the dangers. In the US asbestos-related deaths peaked in 1991 but the epidemic is likely to continue to 2027. Workers began to win large settlements in the late 1970s, although the US government is said to have blamed the industry for funding research and then suppressing the most damning results. Nevertheless the government and its agents admitted they had not enforced strict safety standards, especially during the 1940s. Asbestos litigation is said to have threatened the stability of Lloyd's underwriters in the early 1990s.[172]

12. Conclusion

(a) Long-term dangers to the human race

The dangers of non-thermal EMFs to human health are said to be a greater threat to the future of the human race than global warming. Yet the last 60 years have seen the longest refusal in the history of science to accept increasingly clear scientific evidence, on the part of a relatively small number of regulators, governments and scientists. Robert Becker, a life-long research scientist into non-thermal EMF effects on the human body, twice nominated for a Nobel prize, and a pioneer of using non-thermal EMFs to regenerate human tissue, wrote about the future of the human race as follows. 'There is a strong possibility that increasing electropollution could set in motion irreversible changes leading to our extinction before we are even aware of them.' With regard to the need for regulators and governments to react urgently to the dangers of non-thermal EMFs, he stated that: 'Our survival depends on the ability of upright scientists and other people of goodwill to break the military-industrial death grip on our policy-making institutions.'[173]

(b) Ill-health and early death among the general population

It is immoral and irresponsible for any society to follow a few regulators and scientists who adopt an attitude to the evidence of adverse health effects of non-thermal EMFs which ignores the dangers revealed by research. The result is that the general population is then exposed against its will to non-thermal EMFs which have been shown to trigger many illnesses reducing the quality and the length of life.

(c) Suffering for people sensitised to non-thermal EMFs

To foster ignorance or deliberately to obscure the valid research already done into the health dangers of non-thermal EMFs is immoral in the effects it has on those people who become sensitised to non-thermal EMFs. They are then unable to receive the medical help and the protection from non-thermal EMFs which they deserve from the rest of society which has caused their suffering.

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