

Are we measuring the right things? (Windows, viewpoints and sensitivity)

1. Are we measuring the right things?

This is a crucial question if we are ever to understand the complex way that electric and magnetic fields interact with living beings. I believe that the metrics being used at present are not only inadequate, but largely inappropriate, and suggest some of the extra ones that are needed.

"Good dosimetry" is only of any use if you measure the right things in the right ways, and then analyse the resulting data appropriately. I would have to classify much of the published electromagnetic field (EMF) science to date as "poor science" and of little real practical use at this stage of this important debate. It is based on simplistic reductionist understandings from classical physics and equilibrium thermodynamics. It is disappointing that the first-round funding by the UK Mobile Telephone Health Research (MTHR) committee [MTHR, 2002], mainly funds yet more research ideas that seem well past their "sell by" date. Thermally related effects are now generally well understood and should not need further funding.

We urgently need to adopt a more holistic approach that addresses issues at the very core of the biological organisation of life processes. These include homeostasis, ontogenesis and phylogenesis, as set out by Rosen [1967]. Presman [1970] summarised leading Soviet bioelectromagnetic insights up to that time. His work contains an outline of a holistic electromagnetic field theory of living organisms and their relationship to their environment. There is now plenty of evidence for endogenous EMFs and that significant bioeffects can result from external EMFs. One western scientist who has regularly explored these areas since the 1970s is Ross Adey [e.g. Adey, 1990]. It is now established that living organisms can react sensitively to weak EMFs. We know that weak endogenous EMFs are involved in the regeneration and growth of new tissue. EMFs (including biophotons [Brugemman, 1993]) are emitted from living beings, and communication using EMF signals is established for some fishes and insects, and is strongly suspected as being utilised at some level by all living organisms.

Scientists need to direct their attention to 'wholeness' and ask radically new questions. Not only is our universe electromagnetic, but we are also electromagnetic beings. When the electricity is no longer within our being, our physical body ceases to function at the level we describe as living [Ashworth, 2001]. For all our clever molecular biological genetic "fiddling" with the matter of life, we are no nearer being able to give life to a dead mass of cells.

1.1 Windows

- A 'window' is defined by boundaries (intensities, frequencies, etc) between which an external stimulus will have a biological effect on a living being.
- We are dealing with living beings constantly seeking homeostasis, and a stronger signal does not necessarily mean that it will have a larger or more serious effect. Incoming information with virtually zero energy can have a dramatic effect on a person's state of wellbeing (e.g. a doctor telling a patient that they have cancer). "Understandable

information" (such as sound level, language, visual information, etc) goes in through definable windows.

- Likewise, pulsing at a regular (coherent) rate can have a dramatic effect if the repetition rate finds a natural resonance in the system upon which it impinges. That is why troops were ordered to break step when crossing a bridge. Resonant signals go in through various, definable, windows.
- There are other windows. Some are influenced by our personal genetic history and sensitivities developed during our life.

1.2 Viewpoints

- The public want benefits and also the best protection (against every hazard, all of the time).
- The Government want a quiet life, a thriving economy, cheapness and popularity.
- Big business wants a thriving economy with maximal profits and no onerous duties or liabilities.
- Scientists want interesting problems and continued research funding.
- Pragmatists* and the insurance industry want a "fair balance".

* e.g. the ElectroMagnetic Biocompatibility Association, EMBA)

1.3 Sensitivity

Is affected by:

- Age, gender, psychosocial load and other stresses.
- Physical wellness, including skin condition and conductivity.
- The biocompatibility of the incoming signals (both in energy and informational content).
- Exposure to other insults (e.g. chemicals).
- Stability of the point of optimum homeostasis.
- Response latencies and relaxation times.
- Genetic and life-history factors.

2. Background

Over thousands of generations, life has evolved in an electromagnetic environment that ranges from the Earth's geomagnetic field, through radio-frequency and light to X-ray and gamma waves. This paper concentrates on the use of frequencies up to about 100 GHz.

We are all part of a great electromagnetic experiment. People living one hundred years ago would not have been bathed in the many unnatural forms of electromagnetic energy that we now live in. Marconi had just managed to send the first radio signal across the Atlantic and man-made EMF pollution was almost non-existent. In 1920 the Marconi Company began the first public speech transmissions from their Chelmsford (UK) factory, amplitude modulated on the long wavelength of 2750 metres (109 kHz). Most of Great Britain still did not have electricity and some areas that did were supplied with Direct Current that did not vibrate 50 or 60 times every second. The large Cambridgeshire village where I live in did not receive mains electricity until the autumn of 1939, just over 62 years ago. Amazingly, my grandmother chose not to have mains electricity in her London house until the mid-1970s.

The real growth of commercial radio broadcasting started in the early 1930s. In December 1932 the **Wireless Constructor** magazine was reporting: "*Every week one reads of some station planning to radiate enormous power, some fiddling little continental (station) will suddenly develop into an overpowering giant*". It warned "*you may find yourself in the position of a paralysed man watching the rising of a tide which will ultimately drown him.*" Prophetic words?

The world's first public television service was started in November 1936 from Alexandra Palace in London. Regular TV broadcasts in Sweden did not start until 1957 [Andersson and Westlund,1991]. It is important to keep these short timescales in mind.

An otherwise unexplained (by staffing or treatment protocols) downturn in the survival time of patients treated for Chronic Myeloid Leukaemia (CML) coincided with the start of high-powered television broadcasting in Western Australia. From 1950 to 1963 the survival time was fairly static, with 50% of patients surviving 55 months from diagnosis. From 1964-1967 this fell to only 21 months [Woodliffe and Dougan, 1980].

Leukaemia, breast cancer and some other cancers and neurodegenerative diseases such as Alzheimer's Disease, Amyotrophic Lateral Syndrome (ALS, a form of motor neurone disease) and miscarriage are among the adverse health problems that have been found to be associated with EMFs. The incidence of all these are increasing, despite better (and often expensive) "cures". Pharmaceutical company thinking has a considerable influence on cancer research and drug-curative research dominates funded projects, with very little money going into environmentally related preventative research.

3 Windows

Childhood (mainly acute lymphoblastic) leukaemia first appeared in the 1920s and is recognised as a "modern industrialised society" disease. The incidence is continuing to rise. Dr Sam Milham published a paper tracing the rise of childhood leukaemia with electrification across the U.S.A. [Milham and Ossiander, 2001].

This suggests that either the electric field component is the more important, or that there is a very low threshold effect with magnetic field exposure, which does not follow a conventional, relatively simple, (e.g. linear, supralinear, logarithmic, etc) dose-response relationship. It has already been proven that incidence is not associated with the total electrical power used by society (with the higher current producing higher magnetic fields).

I propose that it is likely that adverse health effects caused by EMFs have a biphasic response curve causing a low level dosage window response.

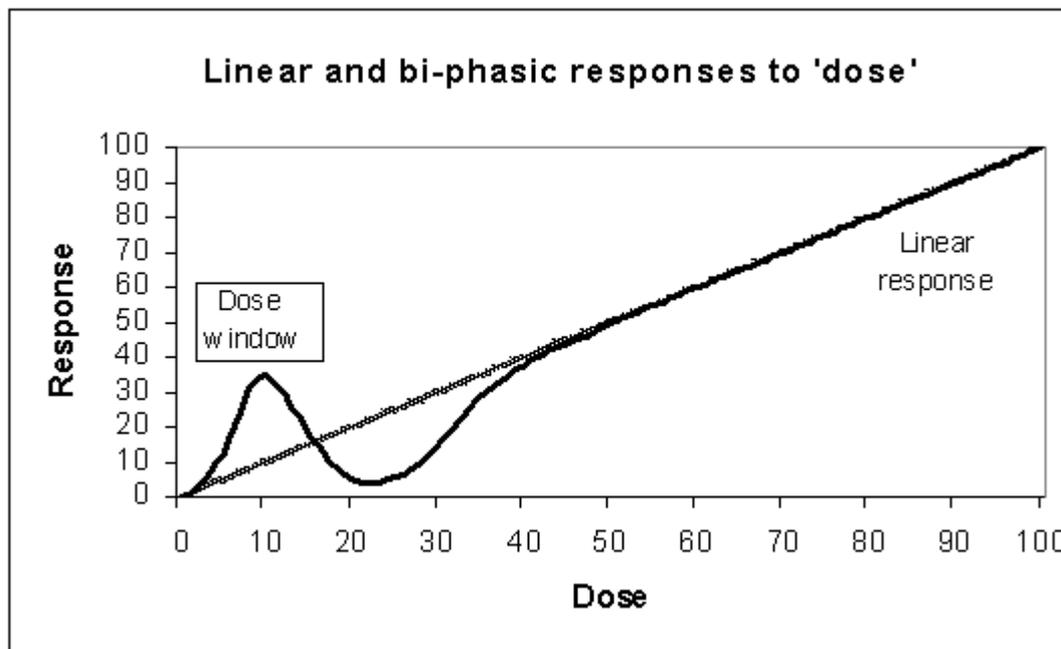


Figure 1: Biphasic and linear dose-response curves

This may be deduced both from the regular anecdotal reports of electrical hypersensitivity (discussed later), and from a substantial amount of published peer-reviewed research into the biological responses of animals and humans to very low doses of many pharmacological substances [Biphasic, 2002].

It is quite possible that cancers caused by exposure to low-levels of ionising radiation also follow this type of response curve. There are real low-level exposure effects that may initiate cancer and other adverse health effects before the living system starts to detect and repair the damage.

The sides of the early response peak define the dangerous exposure window. Damage starts to occur at very low levels of long-term chronic exposure in ways that are not detected by the immune system. Then, a level is reached where cellular repair mechanisms start to operate. These provide protection until the exposure reaches high levels when there can be too much damage to be repaired. The response then follows a more typical dose-response curve.

I suggest that this is the case with childhood leukaemia, and the 0.3 or 0.4 microtesla power frequency exposure level that is now internationally agreed as a point where the incidence doubles [Ahlbom, et al, 2000] [Greenland et al, 2000], is actually the main curve threshold. There are also, however, numbers of leukaemia cases caused by the (*probably co-*)carcinogenic EMF exposure that occur at very much lower levels. These have not been identified, as they are lost in normal statistical analyses that assume a single increasing dose-response relationship.

Dr Alice Stewart proposes that the ionising radiation limits, as set by the Hiroshima and Nagasaki atomic bomb data, were based on a 'radiation hardened population' who had survived the first few months when susceptible people died of many 'problems'. [Stewart, 1998, 2000] Military electronics are purposely 'radiation hardened' to minimise the effect of ionising radiation exposure.

3.1 Resonance Windows

A number of possible frequency bands have been suggested. There is some research-based evidence of types of "ion cyclotron" and "Larmor" resonance effects that occur at various low frequency magnetic fields. These are caused by molecular resonances in the Earth's geomagnetic field. They include, amongst other effects, important cellular calcium efflux changes that have been reported by many laboratory studies. These were recently discussed in considerable detail by a leading EMF-bio-effects expert, Professor Ross Adey [Adey, 1999].

3.2 Endogenous, Entrainment & Interference Windows

We also know, mainly from (originally classified) military work [e.g. DIA, 1976], that certain frequency bands are more psychoactive than others. Signals pulsing in the range of normal brainwave and other bio-system signals have more impact, especially if they are amplitude modulated on to RF carrier frequencies.

Primarily these are in the range from one to a few hundreds of hertz, though brainwave activity extends to at least several kHz.

3.3 Natural EMF Noise Windows

Examples of different kinds of window are the naturally "electromagnetically quiet" regions in the ambient EMF spectrum. The main cosmic quiet "radio window" happens to be just in the place where we locate the mobile phone bands (900 and 1800 MHz) and the microwave oven frequency (2450 MHz). This can be seen in Figure 2 (overleaf). [derived from NASA 1994, and also Kraus and Fleisch, 1999]

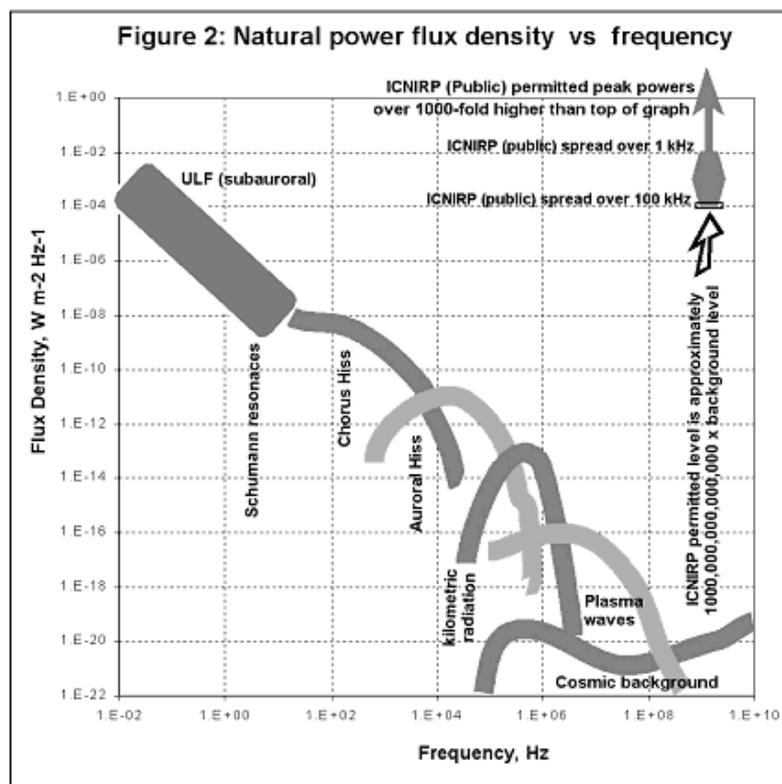


Figure 2

Using basic physics we can calculate that the ICNIRP exposure guidelines allow radio signals in the mobile phone bands some 10^{15} or more times higher than the natural background levels that we were exposed to only 50 years ago.

Non-modulated (i.e. CW) and FM (e.g. VHF radio) signals are merely likely to mask the subtle signals in which Mankind has evolved. The pulsing amplitude of many modern data signals (e.g. mobile phone GSM TDMA signals) vibrate strongly at ELF/VLF frequencies similar to those of our own bodies' endogenous signals. These are very likely to have biological consequences.

4. Viewpoints

"The time has come," the Walrus said, "to talk of many things: of shoes - and ships - and sealing wax - of cabbages and kings - why the sea is boiling hot - and whether pigs have wings." [Carroll, 1832-98] Some of the EMF-Health debate has been just as strange and disjointed as that quotation.

THE PUBLIC want the benefits of the latest technologies, but want them to be risk-free. Unfortunately, life is a risky process. The only thing we can be sure about is that we will eventually die. Before that happens, most of us wish for a long and healthy life. People want to be told "safe" or "not safe". They do not want to make personal risk-benefit choices. They want to rely on the government and legislation to protect them.

GOVERNMENTS want a quiet life, a thriving economy, cheap solutions to problems, and popularity. Governments backed industry in denying that smoking caused lung cancer; tax income from tobacco greatly exceeds smoking-related NHS costs and smokers live shorter lives (saving billions in extra pension payments).

The time scale for disease caused by chronic environmental exposure to insults is often very long. In the UK, mesothelioma deaths from the inhalation of asbestos fibres, again a long-denied cause of lung disease, are not expected to peak until about the year 2023. This is despite UK human exposure to these fibres being strictly controlled since the 1970s.

A UK Government Minister force-fed his young daughter on TV with a beef-burger roll to "prove" that (n)vCJD was not related to eating beef products. In fact, many thinking scientists and lay people had already decided that a real link was likely. As a result of inadequate official action, we now have an unknown number (1000s to 100,000s) of cases of vCJD likely to develop over the next 30 years. Such examples leave the public with little faith in advice from official scientists and politicians.

BUSINESS wants a thriving economy with maximum profits and no liabilities. The dangers of cigarette smoking and asbestos exposure were long denied, with government support.

When tetra-ethyl lead (an anti-knock agent and also a recognised brain poison) was removed from petrol by law, the petrochemical industry lobbied hard to replace it with benzene as "by far the cheapest and best option". It just so happens that benzene is a toxic waste product from petrochemical refining and the industry was paying to dispose of large quantities of it. It is one of the few known causes of myeloid leukaemia. A brain poison was removed and replaced with a known carcinogen purely due to industry lobby pressure.

Now, despite good evidence [e.g. Hansson Mild, et al, 1998] that some people are experiencing adverse health effects from cell phone use, the industry denies that any problems exist other than alarm caused by activists.

SCIENTISTS want interesting problems and continued research funding. There has always been a gulf between 'biologists & clinicians' and 'physicists & engineers'. The majority of members of both groups generally give up the other's area of science before university. Chemistry is between the two, but biochemistry has a much larger following than biophysics. This has greatly slowed the development of a holistic science and has led to life-processes being mainly seen in terms of biochemical reactions.

At the deepest level, however, it is electronic forces that control the shape of molecules and how they interact with each other. Electric and magnetic field interactions are the known physical fundamental manifestations of curved space-time that shapes our universe. The presence of man-made electromagnetic fields can change the outcomes of naturally occurring biophysical interactions, especially in living beings. It is not easy to persuade eminent scientists that they may have to change their views built up over many years of mechanistic science.

Science that provides technological advances or finds ways of saving money is usually popular. Science that points out problems that will cost extra money to solve is not. This has affected science for at least the last two centuries, and the effects of funding changes in the last 20 years means that scientists' work is more and more being decided by the commercial interests of multinational companies.

Epidemiology looks for health effects in the community. In the 1840s, the doctor John Snow, credited with starting modern epidemiology, identified the cause of a cholera outbreak in London as a particular water pump - citing the results of his field investigations. Despite being proven correct, during his life he was attacked and outcast by the medical establishment and it was not until 15 years after his death that they started to accept his methods.

When Dr Alice Stewart first tried to publish her findings in the late 1950s that X-rays in early pregnancy caused abnormalities and childhood leukaemia, it was vigorously denied. She was ostracised by the UK medical establishment, as she was being critical of standard medical radiography practice; by the mid-1970s great care was being taken to avoid X-ray exposure of pregnant women [Green, 1999].

In 1998, the Doll-Hill [Doll and Hill, 1956] smoking risk figures were re-examined by Sam Milham [Milham, 1998]. The Relative Risk (RR) for heavy smokers with respect to non-smokers is 23.7; compared with light smokers it falls to 3.5 and with medium smokers to a mere 1.9. These are typical RRs we see in many epidemiological studies into possible EMF related adverse health outcomes. We are all exposed to light or medium levels of EMF pollution, so even if EMFs cause a lot of chronic health problems, they would be unlikely to stand out from the background noise in whole (or random) population studies.

The gulf between conventional mechanistic-world-view scientists (and regulatory authorities) and most leading edge EMF-bio-effects scientists is a large one. I believe that we need a change of scientific paradigm regarding what "life" is all about. It is not just a matter of tinkering at the edges and trying to decide at what level an effect occurs, but accepting that living beings interact with the universe in ways far more complex than was thought possible. Quantum mechanics has established the primacy of the inseparable whole.

Being alive changes things. Being conscious can change them even more.

PRAGMATISTS. The insurance industry often has to pay the final bill for inaction. Swiss Re, one of the largest re-insurance companies, published a report in 1996 called **Electrosmog - a phantom**

risk [Brauner, 1996]. This is a landmark publication and contains much wisdom that is missing from official documents on the possible risks of EMFs.

They asked the question: "Do electromagnetic fields (EMFs) Impair Health?" and came to the conclusion that the only reliable answer is "Perhaps".

A living organism can amplify coherent incoming signals to levels where information patterns that they contain triggers a biological response. Swiss Re acknowledge this: "It is necessary to distinguish between energy effects and signal effects as two different dangers posed by electromagnetic phenomena."

The relationships between EMF exposure and disease are not merely complicated but are so complex that we cannot yet identify them even using modern tools and methods.

Bioscience has moved on from "Yes" or "No" answers to deep questions, to the realisation that all causal laws are merely statistical observations, and there is a fundamental and qualitative difference between "certain" and "highly probable", between "must" and "can", and between "yes/no" and "perhaps". It is the difference between "knowledge" and "conjecture". Swiss Re write: "Because all scientific knowledge is based on statistical observations, the knowledge of science is mere presumptive knowledge. While classical science considered a cause to be only that which must necessarily bring about an effect as a result of the causal principle, today a cause is also considered to be that which may bring about an effect. The possibility that electromagnetic exposure might favour the incidence of certain diseases cannot be excluded. According to our present understanding, electromagnetic fields would then be a cause of disease just like a flu virus which may, but need not necessarily, result in influenza." [Brauner, 1996]

5. Electromagnetic Biocompatibility

All living beings detect and use information in order to survive. This essential fact is not taken into account in most of the EMF research that has assumed "averaged energy" is the active factor. Our direct senses of sight, sound, etc., are only of use because we extract information from the physical responses of our sensors. Language, music, art, science and other human endeavours only exist because we interpret and use informational input.

If we could send a modern computer data Compact Disk, with an encyclopaedia on it, back one hundred years, and ask the best scientific minds of the time to try to work out what it was, even with unlimited financial resources they would not have been able to succeed in this task.

We could take these analogies further. Imagine attending a performance of the Swan Lake ballet. Conventional physical and medical science could record the movements and sounds and analyse them into data sets and look for patterns. It could also analyse the clothes of the dancer, and the ballet shoes, their materials and method of construction. But it would completely miss the whole point of the ballet, and would be able to say nothing about the human (invoked) response to the ballet.

6. Sensitivity

The auditory vibration sensitivity of a normal human ear is quite amazing at around 10^{-11} m, about the diameter of a hydrogen atom. This quantum limit to detection is achieved despite large amounts of thermal noise. To achieve this the inner ear must possess amplifiers whose noise performance could only be achieved by traditional electronics circuitry working at near 0°K. The

only way that this performance could be achieved at normal body temperature is if large numbers of cells are working in a highly co-operative and coherent way. This sensitivity cannot be described by any mechanistic chemical kinetic model, and may be representative of a more general 'living tissue' property. [Adey, 1998]

We are now surrounded by unnatural pulsing electromagnetic signals millions of times stronger than were present only 50 years ago. We are "broad-band receivers" whose cells and tissue can act in non-linear ways [e.g. Wessel, 1999] to "detect" incoming RF signals; we are not frequency selective, though resonances do occur (e.g. body size resonances at VHF frequencies, and under-wired bras can resonate at cell-phone frequencies) providing windows where effects will be enhanced.

Electronics is used in almost everything now. Current trends are to make everything work faster so that we will soon even be able watch the latest movies in colour on our multipurpose phone handsets.

A potentially much more bioactive change has also taken place. The "digital revolution" has caused signals to become "lumpy", with bursts of full amplitude data pulses often emitted at human endogenous bio-signalling rates. The form of our exposure has changed dramatically over the last 15 years. GSM phone signals are very different in character from analogue TV and FM radio transmissions.

Are these changes relevant? There is good evidence that they are. As higher speeds were introduced in the 1980, so were reports of cases of electrical hypersensitivity. [Katajainen and Knave, 1995; Smith and Choy, 1986; Choy, Monro and Smith, 1987]

People, animals and even plants, can be amazingly sensitive to environmental fields. There is much we still do not know, and most main-line scientists do not seem to be even looking in the right directions.

Professor Eric Laithwaite (Electrical Engineer) gave a Friday Evening lecture at the Royal Institution in 1970. Stimulated by a theory of Dr Callahan, a professor of entomology at the University of Florida who had published an article suggesting that moths and butterflies communicated using far-infra-red (terahertz) microwaves. [Callahan, 1965] Conventional wisdom stated that butterflies locate their mates only using their sense of smell.

Laithwaite repeatedly placed caged breeding-ready females in the middle of a field and waited to see if males would arrive. They did when the females were in the air-sealed plastic box, but did not when they were in the open sided but electromagnetically screened 'Faraday Cage', showing that it was most likely that radio-wave communication was involved, certainly with the initial long-range mate detection process.

THE EARTH's ambient geomagnetic field varies around the world and ranges over about 20 to 70 microtesla (20,000 - 70,000 nanotesla or gamma) range. The level in any one location varies slightly in diurnal, lunar and sidereal time frames.

At super-low frequencies we have magnetic noise from changes in the Earth's magnetic core current flows. These come to the surface of the Earth in various ways depending on the magnetic and electrical properties of the underlying strata. Old "country wisdom" has long recognised that some places are not good to live and sleep in. People used to pen cattle into fields in areas where they wanted to build a house and watch to see which parts they would choose to settle in (=good) and which parts they would avoid (=bad). Cancers and other serious illnesses were thought likely

to result when people lived and slept in geopathically active areas. In Germany it is common practice for oncologists to work with dowsers to check the houses and bed places of cancer victims for geopathically active zones.

As we approach the extremely low frequencies (ELF) we have low level, but fairly coherent, waves generated by lightning strikes powering natural Earth-Ionosphere cavity resonances. These Schumann resonances are in the range 8 to 40 Hz, i.e. the frequency range of most endogenous human and animal body "vital signs" signals and are claimed to be important to life and health.

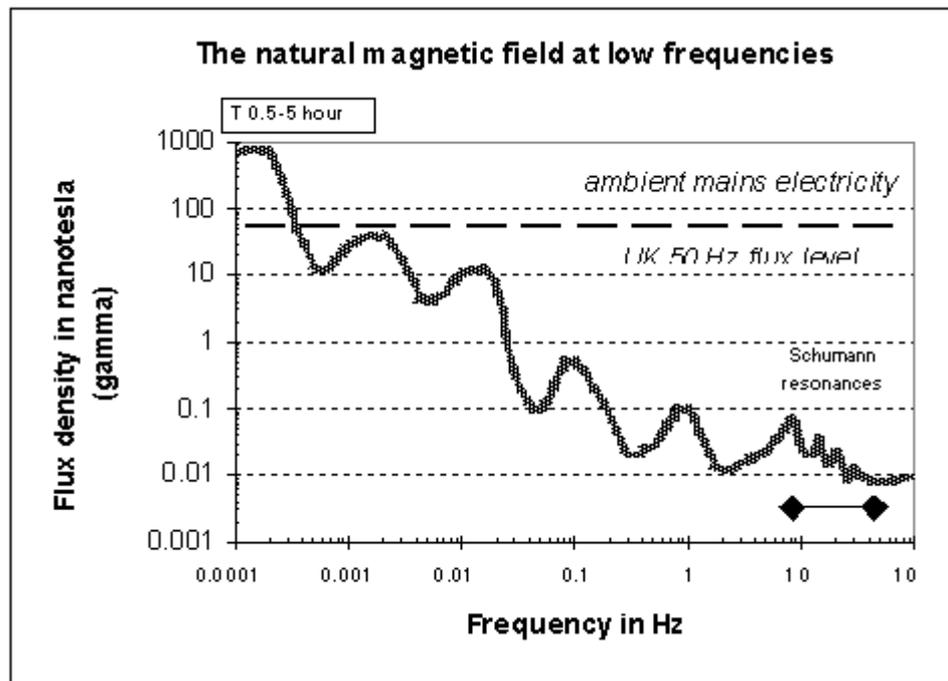


Figure 3: Geomagnetic fields [derived from Campbell, 1997; Spaceweb, 2002]

Figure 3 shows average geomagnetic variations, and the main Schumann resonances, against frequency. The current ambient power-frequency 50 Hz magnetic field in most UK homes and offices is around 30 - 50 nanotesla, whereas the natural Schumann signals are a factor of 1000 lower, around 50 picotesla. If bodily awareness of the Schumann rhythm is important and necessary for wellbeing, then swamping this rhythm with power-frequency or pulsing microwave fields may be unwise. Because GSM mobile phone base stations pulse at ELF and VLF (217 Hz, etc) and the ICNIRP safety guidance allows 138 nT at 900 MHz and 195 nT and 1800 MHz, these 'pollutant' pulsing signals can effectively be detected by biological tissue as over 10,000 times higher than natural ELF/VLF fields.

The human pineal gland synthesises melatonin and may be one of our main magnetic field sensors. Though some laboratories have found no effects, at least six have published the results of studies that show low-intensity ELF EMFs can suppress night time melatonin levels. We also have evidence that low levels of melatonin are associated with a number of cancers, including breast cancer.

Dr Cyril Smith calculates [Smith, 1985; Smith and Best, 1989] that a quantum of magnetic flux through a typical human pineal gland would result in a flux of 75 picotesla (pT), and that the minimum detectable magnetic flux needed to overcome the random thermal energy in the pineal

would be 240 pT. This suggests that we would only be aware of the 50 pT Schumann waves if several parts of our body were co-operatively involved with the detection process.

We do know that some birds and insects are very sensitive to the background magnetic field while flying, being able to detect changes in the order of 1 nanotesla [Keeton, 1979].

NOT EVERYONE IS AFFECTED. As initial biological effects as well as any associated adverse health effect depend on aliveness, they depend on the state of the person when being exposed to the radiation. This can be seen in the mobile phone study cited earlier [Hansson Mild, 1998]. The factors include the person's already prevailing level of stress, the robustness of their immune system, and the stability of their brain rhythms in the presence of external interference. Unlike the case of electronic measuring instruments, identical exposure to exactly the same radiation will result in different responses in different people. This variance is not specific to EMF exposure as, even with smoking, not everyone develops smoking related health problems. Exposure to an electromagnetic field may simply supply the final contribution that raises a particular person's level of stress above some critical value, thereby triggering the manifestation of a particular pathology [Hyland, 2001; Rea, 1991].

At the 2001 Bradford-Hill Memorial Lecture [Strachan, 2001], Dr David Strachan proposed that the modern task of epidemiology is to help provide "safety for the susceptible". In Sweden, Professor Kjell Mild has estimated that about 2% of the population are hypersensitive (that is they get idiopathic or allergic stress reactions) to environmental pollution (electrical and chemical sensitivities) [Hansson Mild, 2001]. This group shows a high Relative Risk (RR) when exposed to such pollution, but when data is averaged over the whole population the rise in RR becomes very small and is usually statistically insignificant.

From my contact with sufferers over the last 25 years, I believe that up to about 5% of the general population are highly sensitive to EMFs, with maybe a third, or more, of the population experiencing undiagnosed symptoms. These include headaches, poor sleep quality, general lassitude and asthenias, and probably a compromised immune response. I suggest that the problem is a hidden cost for industrialised countries of billions of pounds per year.

This cost is rising. A Swedish Trade Union (SIF) has found that the number of people reporting symptoms associated with hypersensitivity is rising rapidly [SIF, 1998]. The number of members reporting serious symptoms rose from 11% in 1993 to over 20% in 1996, when 8% reported that their symptoms were extremely serious.

7. What Metrics Should we Use?

Most EMF regulatory guidance around the world today is only intended to protect against electric shock, radio-frequency heating, and the induction of currents that directly affect neurological processes in gross ways.

When I first started digital electronics design in the 1970s, clock rates (the timing of binary bits) were around 100 kHz. Early computer designs clocked at 1 or 2 MHz. The latest PC computer chips clock at over 2 GHz - that is a higher frequency than the microwaves used to carry mobile phone conversations (900 and 1800 MHz or 1.8 GHz). These fast clock rates cause electromagnetic noise that can interfere with both equipment function and people's health. In addition, many systems now use 'bursts' of data that cause amplitude modulation of these microwave signals by low frequency (ELF/VLF) components.

Both electric and magnetic fields induce signals that are proportional to the rate of change of the field (i.e. to dV/dt and dB/dt). Yet almost all published studies have used magnetic flux levels corrected for frequency, as if 1 microtesla at 5000 Hz will have the same effects as one at 50 Hz. This is most surprising as both the ICNIRP and the older NRPB exposure guidance levels (for gross effects) do have frequency dependent terms. Also, the few studies that have looked at transients (fast, often short lasting, changes) have shown increasing levels of ill health with increasing transient activity.

7.1 – Electric and Magnetic Induction Potential

As the traditional metrics of electric and magnetic field strengths (or flux density) we need to use ones of electric and magnetic induction potential based on some measure of the rates of change of these fields. (Proportional to dV/dt and dB/dt).

7.2 – Amplitude Modulation

We should also investigate the amplitude modulation patterns of different types of radio-frequency signal. In particular we should identify coherent (i.e. regular) pulsing frequency components that are allowed, by ICNIRP Guidance, to be over 10,000 times higher than naturally occurring ELF/VLF magnetic flux signals.

It is noteworthy that the Salzburg Resolution on Mobile Telecommunications Base Stations, dated 8th June 2000, highlights concern over low frequency pulsing, stating: "For preventative public health protection a preliminary guideline level for the sum total of exposures from all ELF pulse modulated high-frequency facilities such as GSM base stations of $0.1 \mu W/cm^2$ ($0.6 V/m$) is recommended." This is 100 times lower power than they recommend for the total of all RF radiation. [Salzburg, 2000]

7.3 - We should look for low-level window effects when analysing our data.

To identify these we will need to identify susceptible sub-groups of the population, otherwise they will get lost in the noise floor of data from the whole (or random) population under study. I believe that it will be necessary to properly investigate anecdotal reports of adverse health problems, and robustly defend the accusation of "Texas sharp shooting" by conventional epidemiologists.

7.4 - We should look for living biological system sensors.

It is clear that living beings respond very differently to environmental insults than does dead tissue. It is also clear that some people are far more sensitive than others. I suggest that we need to consider real long-term health effects from, presently generally unrecognised, (sub/supra)consciousness and other subtle 'living being' factors. The way to assess these factors will be to include actual people in the sensory loop - combining selective epidemiology and biophysics.

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