

## Electrical Hypersensitivity (ES)

The Electrical hypersensitivity set of articles is separated into 8 sections, each of which can be individually downloaded. It is a 'work in progress' incorporating new information whenever time permits.

### Section 4

#### The biology of ES

1. Electrical Hypersensitivity, a reaction to the environment; introduction, should ES be diagnosed as an illness? Should ES be diagnosed as an allergic (atopic) condition? Should ES be diagnosed as a 'functional impairment'?
2. What ES is and what produces it; ES and the problems of diagnosis; Allergy/functional impairment; what produces ES? The Hum; ultrasound
3. The Triggers and Symptoms; what can provoke symptoms; the symptoms; behavioural disturbances; haematological (blood) effects; breathing problems; cardiac problems; cognitive changes; eyes; headaches and migraines; other symptoms experienced on the face or in the head; ingestion and digestion disturbances; joint, muscle, limb and nerve sensations; light sensitivity; psychological effects; skin; sleep disturbance, tiredness & dizziness; other reactions
4. The Biology: the living being; what effects do EMFs have on living beings? Why do only some people become ES if all people are coping with increasing EMF stress? Research problems; what different countries have found, or are finding
5. What you can do; Reducing your exposure to EMFs, in the home, in the work place, in the community; treatments and other things that can help, acupuncture, chiropractic, diet including supplements, pulsed electromagnetic field therapy, exercise, geopathic stress, grounding, holidays, homeopathy, hydration, injections, ionised environments, medication, oral treatment, osteopathy, oxygen therapy, plants, prayer and healing, protection 'devices', provocation therapy, psychological improvements, water supply; screening products; raising public awareness; campaigning and information organisations
6. The Challenges; what can the ES person do? Recognition by the general public; employment and benefits advice; Disability Discrimination Act 1995, words (or phrases) defining disability according to the DDA, mobility, memory or ability to concentrate, learn or understand; accidents, incidents and liability; policy makers abroad; normal day-to-day activities; education needs; employment needs; medical needs; housing needs; transport needs
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## 8. Appendices:

Appendix 1- The Powerwatch response to the October 2005 Health Protection Agency–Radiation Protection Division report on Electrical Sensitivity; definition of ES; epidemiology of ES; management of ES

Appendix 2 - Powerwatch Comments on Rubin et al study, 2006

Appendix 3 - Study Flaws (Essex), Flaw counter-arguments, discussion, conclusion, Essex University study on Health Effects from TETRA radiation (2010)

# The Biology of ES

## The living being

Living creatures are integrated systems, in a delicate dynamic balance, not only with other life forms, but with the physical environment as well. All living beings detect and use information in order to survive.

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.

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.

Each cell in an individual's body can survive outside it, or scientists would not be able to carry out laboratory tests on cells. They respond to the environment they are in, and have the capacity to change to meet environmental challenges, which can be passed to successive generations, via RNA & DNA changes. Enriched environments can override genetic mutations in mice (Waterland & Jirtle [2003](#)). Charles Darwin in 1876, said *"In my opinion, the greatest error which I have committed has not been allowing sufficient weight to the direct action of the environment, independently of natural selection."*

Single-gene disorders affect less than 2% of the population. Most diseases are a result of complex interactions among multiple genes and environmental factors. Genes do not control life, as they cannot turn themselves on or off. Something in the environment has to trigger gene activity. However, people who develop ES may have genes which are different from the beginning. In a personal communication, Charles Claessens of Verband Baubiologie, said that a lot of people with ES have a contamination of heavy metals. He suggests that having a particular gene allele, Apolipoprotein E epsilon-4, rather than epsilon-2 or -3 could create greater susceptibility to Hg-based (mercury) pathologies like ES (Godfrey [2003](#)), amongst other conditions. Andrew Goldsworthy comments that there is a general consensus that most heavy metals are toxic because they sit on the sensing regions of ion channels and prevent their normal function, either by increasing or decreasing their normal activity. This might increase the rate at which potassium ions leak out of cells down their electrochemical gradient so that the cells become partially depolarised. Were this to happen in sensory cells, it could make them more responsive to any leakage induced by electromagnetic fields by adding to their effects. Ghezal-Ahmadi ([2010](#)) suggests that heavy metal load is of no concern in most cases of ES but might play a role in exceptional cases.

It does seem that some people are more sensitive and more responsive than others to magnetic field exposure. Subjects with high amplitude postural tremor seem to be more responsive to MF exposure (Legros [2006](#)). Binhi & Prato ([2017](#)) propose a general physical mechanism of magnetoreception of weak magnetic fields. This may indicate that we are all able to perceive weak EMFs, but on a scale of sensitivity.

The function of the specialised cells of the nervous system is to perceive the environment and co-ordinate the behaviour of all the other cells in the vast cellular community.

## What effects do EMFs have on living beings?

The National Institute of Environmental Health Sciences (NIEHS) and the US Department of Energy (DOE) state that human exposure to electric and magnetic fields (EMFs) from electrical wiring and appliances produces weak electric currents between cells in the body.

When nerve cells malfunction, they can, in turn, adversely affect muscle function. A way that EMFs cause this stress is that they seem to trigger an opening of calcium flow through cellular membranes in the nervous system. This causes a strong signal in the nervous system producing an overreaction in a lot of muscles and other things controlled by the nervous system. The effect can occur at fantastically low energy levels. Calcium ion alteration of cells by EMR is linked to neurological degeneration, to cancer, and many other health effects. The heart is also an electromagnetic organ, with an electric pulse initiating a cascade of calcium ions that cause the cells in the heart to contract and produce a heartbeat. Exogenous electromagnetic signals can interfere with this regular, electrical pulse leading to heart disease and heart attack of the arrhythmic kind.

The activity of genes within the cell is 'controlled' by the presence or absence of the 'ensleeping' proteins, which are in turn controlled by environmental signals. Receptor "antennas" can read vibrational energy fields such as light, sound and radio frequencies. If an energy vibration in the environment resonates with a receptor's antenna, it will alter the protein's charge, causing the receptor to change shape, thus changing the message to the effector proteins which are in charge of cellular behaviour.

The flow of information between the external environment and the cell is incredibly complex and miscommunication can occur at any point in the information flow process. It is clear how interconnected these systems are, when we consider the variety of side effects possible as a result of taking a prescribed drug to treat a particular medical symptom.

Hundreds upon hundreds of scientific studies over the last 50 years have consistently revealed that "invisible forces" of the electromagnetic spectrum profoundly impact every facet of biological regulation. These energies include microwaves, radio frequencies, the visible light spectrum, extremely low frequencies, acoustic frequencies and even a newly recognised form of force known as scalar energy. Specific frequencies and patterns of electromagnetic radiation regulate DNA, RNA and protein syntheses, alter protein shape and function and control gene regulation, cell division, cell differentiation, morphogenesis (the process by which cells assemble into organs and tissues), hormone secretion, nerve growth and function. Each one of these cellular activities is a fundamental behaviour that contributes to the unfolding of life (Sivitz 2000, Jin [2000](#), Goodman & Blank [2002](#), Liboff [2004](#)).

Liboff added ([2017](#)) that *"it has been established that living things are sensitive to extremely low-frequency magnetic fields at vanishingly small intensities, on the order of tens of nT. We hypothesize, as a consequence of this sensitivity, that some fraction of an individual's central nervous system activity can be magnetically detected by nearby individuals. Even if we restrict the information content of such processes*

*to merely simple magnetic cues that are unconsciously received by individuals undergoing close-knit continuing exposure to these cues, it is likely that they will tend to associate these cues with the transmitting individual, no less than would occur if such signals were visual or auditory. Furthermore, following what happens when one experiences prolonged exposure to visual and like sensory inputs, it can be anticipated that such association occurring magnetically will eventually also enable the receiving individual to bond to the transmitting individual." He continues "it also provides a new approach to electromagnetic hypersensitivity, suggesting that it may simply result from sensory overload."*

According to Dr Dietrich Klinghardt, EMF and Lyme disease are connected. In an interview he said "Bugs (chronic infections) think they are being attacked and they step up their biotoxin production and virulence the moment we enter any electromagnetic (EM) field. Lyme disease leads to demyelination - that means the nerves lose some of their protection - the nerves become much more readily affected by EM radiation. There is a huge epidemic of chronic infections - including Lyme disease. Every patient I ever tested who had a diagnosis of electrosensitivity turned out to test positive for Lyme."

The revolution in telecommunications led to a massive change in the EMFs in our environment, as analogue signals gave way to digital ones; this is still continuing as the switchover to digital radio and TV is added to the existing digital signals from mobile phone (and other) technologies. As higher speeds were introduced in the 1980s, so began reports of cases of electrical hypersensitivity.

Physicists at UC Berkeley ([Jensen 2007](#)) have produced the world's smallest radio out of a single carbon nanotube that is 10,000 times thinner than a human hair. It serves as an antenna, tuner, amplifier and demodulator. The nanotube absorbs the radio transmission and physically vibrates in response, like a tuning fork or the tiny hairlike structures inside the human ear. The multi-walled cylinders were better at picking up AM and FM transmissions and the single walled nanotubes were best for receiving the frequencies used in cell phones. It is interesting that the mechanism is by physical vibration of the nanotube in response to RF fields. This may give more pointers as to the bio-detection capability of the body, even at a cellular level and also may well invoke a bio-response.

The best scientific text book, by far, at the moment is, without doubt, **Magnetobiology - Underlying Physical Problems** by Vladimir Binhi [2002]. In our opinion this requires the reader to have a minimum of university entrance requirements understanding of physics and / or mathematics, but it is a comprehensive over-view of this whole subject area.

Although some diseases are clearly hereditary, involving the simple significant existence of one changed gene, only 5% of cancer and cardiovascular patients can attribute their disease to heredity. The malignancies in a significant number of cancer patients are derived from environmentally-induced epigenetic alterations and not defective genes. Alasdair Philips is fairly sure that EMF exposures cause epigenetic changes on the genome and that these are at the root of many cases of ES - in some ways a misguided attempt by the body to adjust to the new environment. When the switches keep getting set/reset they habituate to 'on' (or 'off') and that is why ES often becomes a run-away situation and people become more and more sensitive. The switches change protein expression and the creation of neurotransmitter chemicals, hormones and enzymes.

It is not just external factors which can influence the expression of effector genes. The mind, acting via the nervous system, can override the body's reactions. This effect is sometimes described as a 'placebo' effect, which means that the brain is capable of making changes to the body's biological systems, without any externally obvious means. These changes can be brought under conscious control (e.g. by meditation, self-hypnosis, etc.). The placebo effect should be a major topic of study, training people to recognise the power of our internal resources. If medical

researchers could figure out how to engage the placebo effect, they would hand doctors an efficient, energy-based, side-effect-free tool to treat disease. In most clinical trials the placebos prove to be as effective as drug companies' engineered chemical cocktails (Moseley [2002](#), Greenberg 2003), even when the treatment involves surgical interventions (Horgan 1999). Up to 80% of the effect of antidepressants can be attributable to the placebo effect (Kirsch 2002). However, placebos do not earn pharmaceutical companies the same amount of income as prescription drugs.

The conscious mind is not only aware of cellular changes within the body, it can also generate emotions, which release signals that change the response of the nervous system. When it comes to sheer neurological processing abilities, the subconscious mind is millions of times more powerful than the conscious mind.

The mechanisms that support growth and protection cannot operate optimally at the same time. Humans unavoidably restrict their growth behaviours when they shift into a protective mode. Protection requires a closing down of the system to wall the organism off from the perceived threat. Growth processes both need and *produce* energy.

It is hardly surprising that the electromagnetic environment in which we live is responsible for reducing our body's ability to be optimally well, and restricts our supply of, and access to, energy.

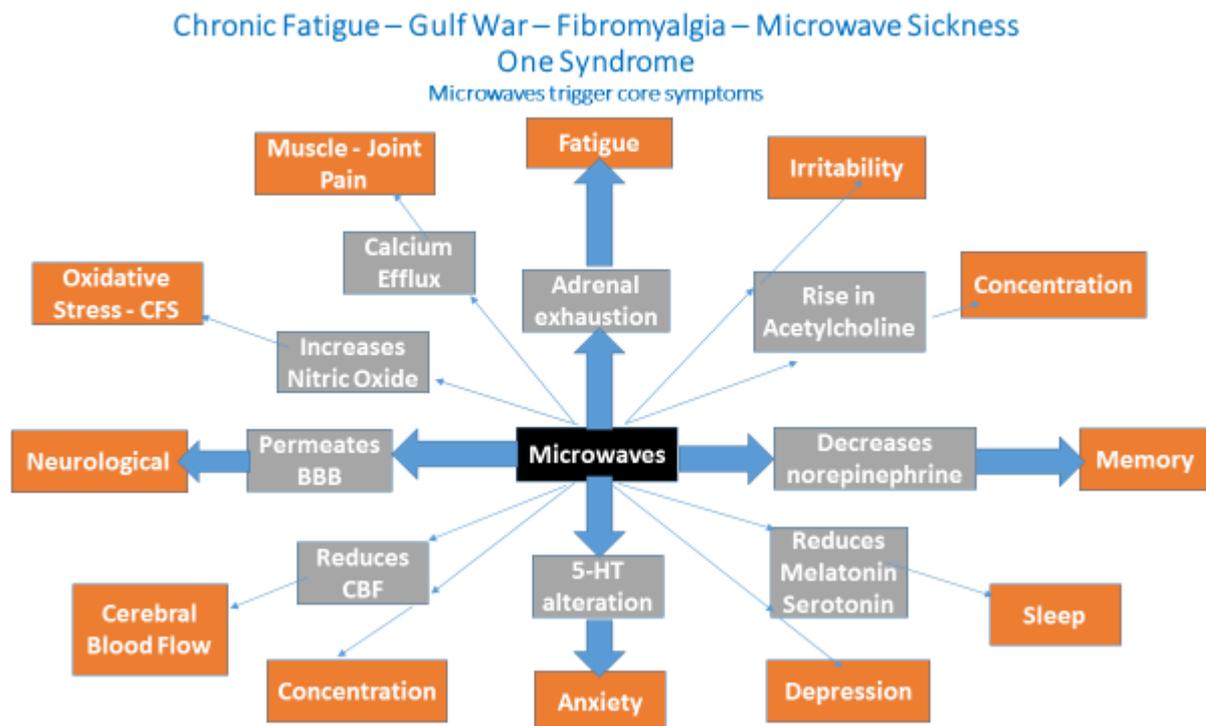
It is the nervous system's job to monitor environmental signals, interpret them, and organise appropriate behavioural responses. The body has 2 separate protection systems; the Hypothalamus-Pituitary-Adrenal (HPA) axis protects against '*external*' threats, and the immune system protects against '*internal*' threats. When the immune system is mobilised, it can consume much of the body's energy supply.

When the HPA mobilises the body, the action of the immune system is repressed. Activating the HPA axis also interferes with our ability to think clearly. The HPA system was not designed to be continuously activated resulting in chronically elevated stress hormones. Almost every major illness that people acquire has been linked to chronic stress (McEwen [1999](#), 2002, Segerstrom & Miller [2004](#), Kopp & Réthelyi [2004](#)).

When passing through the placenta, the hormones of a mother experiencing chronic stress will profoundly alter the distribution of blood flow in her foetus and change the character of her developing child's physiology (Arnsten [1998](#), Lentwyler 1998, Christensen 2000, Lesage [2004](#)). Wintour's research has found that prenatal exposure to cortisol eventually leads to high blood pressure (Dodic [2002](#)). An additional effect of excess cortisol is that it simultaneously switches the mother's and the foetus' system from a growth state to a protection posture.

As we grow, we develop programmes of behaviour that become automatic, which stop us having to think about every aspect of daily life. Our unthinking subconscious takes over and frees our conscious mind to meet new challenges or interests. These subconscious limitations not only influence our behaviour, they can also play a major role in determining our physiology and health.

As well as an assortment of physiological complaints, patients diagnosed with ES also report profound social and personal challenges, impairing their ability to function normally in society (Genuis & Lipp [2012](#)).



### Why do only some people become ES if all people are coping with increasing EMF stress?

Our 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.

Your body weight, body-mass index, bone density, and water and electrolyte levels can alter the conductivity and biological reactivity to EMFs. Heavy metals in your brain also act as micro-antennas, concentrating and increasing reception of EMF radiation. The issue of heavy metal toxicity in relation to electromagnetic toxicity may be one of the most significant. According to Dr Yoshiaki Omura's research, the more your system is contaminated with heavy metals from silver amalgam fillings, eating contaminated fish, living downstream from coal burning power plants and so forth, the more your body becomes a virtual antenna that actually concentrates radiation, making it far more destructive. Dr Theresa Dale says that if you have accumulated toxic metals in your brain, and since your brain is an antenna, you can actually receive more mobile phone radiation, which in turn can cause the microbes in your system to overreact and create more potent mycotoxins. This can create a never-ending vicious cycle between the microbes and metals in your body and your exposure to electromagnetic fields, which can lead to hypersensitivity.

Dr Andrew Goldsworthy suggested that *"symptoms can be accounted for by an electromagnetically-induced increase in the permeability of the cells of the nervous system that triggers their sensory cells to send false signals to the brain. These cells respond to normal stimulation by short circuiting the natural voltage that occurs across their membranes to give the so-called receptor potential. This triggers the release of neurotransmitters that make neighbouring nerve cells send impulses to the brain. Electromagnetically-*

*induced ion leakage also does this, and can result in false symptoms of heat, pressure, pins and needles, etc. depending on which cells are most affected. When the hair cells of the inner ear are affected, it results in tinnitus, dizziness and symptoms of motion sickness, including nausea”.*

*He continues “radiation releases calcium ions from cell membranes. These ions with their double positive charge, normally stabilise cell membranes by helping to bind together their negatively charged phospholipids. Without them, they can develop temporary pores and leak. This allows free calcium to enter the cell down a huge electrochemical gradient from the outside to raise the internal calcium concentration. This makes neurones more likely to release neurotransmitters and give action potentials that have no right to be there in neighbouring neurons. This manifests itself as a loss of concentration, confused thought and a reduced ability to perform complex tasks.”*

*He also says “Leakage of the contents of skin cells causes inflammation. Leakage of ions in the sensory cells scattered over our body surfaces triggers them to send spurious nerve impulses to the brain causing false sensations (paresthesias). Similar leakages in the sensory cells of the inner ear give false impulses leading to tinnitus, dizziness and symptoms of motion sickness. Leakages in the rods and cones of the eye can cause a partial loss of vision. Leakage in neurons can cause brain hyperactivity leading to sleep disturbances, loss of concentration, ADHD and autism. Leakage in the tight junction barriers that protect all of our body surfaces from the ingress of foreign materials increases the risk of developing allergies and multiple chemical sensitivities. Leakage through internal membranes of cells releases digestive enzymes from lysosomes that then damage DNA, causing a loss of fertility, genetic damage to offspring and an increased risk of developing cancer in later life.”*

Dr Goldsworthy's hypothesis about leaky cell membranes could explain the findings of the Eltiti study (2007), deeply flawed as it was, which demonstrated that the electrosensitive group were physiologically different to the controls in that they had significantly higher skin conductance measurement. It could be that skin conductivity may serve some role as a diagnostic tool for diagnosing EHS. The results of a study by Weitzen (2007) who used skin impedance in certain areas of the body as part of a process of diagnosing or screening for different types of cancer, with high success rates.

Redmayne & Johansson (2014) looked at the potential role of myelin integrity in electrohypersensitivity symptoms. Myelin integrity is vital to healthy nervous system development and functioning. Their paper considered the evidence for an association between myelin integrity and exposure to low-intensity radiofrequency electromagnetic fields (RF-EMFs). They discussed the following findings in the literature about RF-EMF-exposed cases: (1) significant morphological lesions in the myelin sheath of rats; (2) a greater risk of multiple sclerosis in a study subgroup; (3) effects in proteins related to myelin production; and (4) physical symptoms in individuals with the functional impairment electrohypersensitivity, many of which are the same as if myelin were affected by RF-EMF exposure. They concluded “*evidence from in vivo and in vitro and epidemiological studies suggests an association between RF-EMF exposure and either myelin deterioration or a direct impact on neuronal conduction, which may account for many electrohypersensitivity symptoms.*”

Professor Olle Johansson of the Karolinska Institute has investigated people suffering skin problems as a result of exposure to computer monitors and other EMF sources. In some of these people with ES he has clear photo-micrographs showing peripheral damage in the nerve endings which can be found within 0.01 to 0.02 mm of the skin surface (epidermis). They seem to become super-sensitive and react more strongly to electric fields and some chemicals. New electronic equipment, including computers, gives off significant levels of volatile organic fire-retardant chemicals that can mimic natural body messenger chemicals, and these are believed to be involved in the triggering of ES in some people.

In a study by Nordin (2014) the group of people with ES scored significantly higher than the controls on all Chemical Sensitivity and Noise Sensitivity Scales. The findings suggest a general sensitivity to environmental pollutants and an association between ES and odour and noise intolerance.

Professor Johansson (2001) and colleague Dr Gangi (2000) have found that the appearance of the peripheral nerve damage under the microscope is similar to the sort of early damage that occurs when a person gets sunburnt. There also appears to be a large increase in the number of mast cells and a change in distribution and appearance of cells in the skin of electrosensitive people. Some of the changes are similar to the effect of exposure to ionising radiation. When ordinary people were exposed to EMF radiation (from a TV) on their backs for 4 hours, they had a similar change in mast cells, which normalised after 24 hours. Mast cells play a large role in various types of well known allergic reactions. Physiological changes that are bedrock indicators of allergic response and inflammatory conditions that are stimulated by EMF exposures include: overreaction of the immune system; morphological alterations of immune cells; profound increases in mast cells in the upper skin layers; increased degranulation of mast cells and larger size of mast cells in ES individuals; presence of biological markers for inflammation that are sensitive to EMF exposure at non-thermal levels (Kitaoka 2016); changes in lymphocyte viability; decreased count of NK cells; decreased count of T-lymphocytes; negative effects on pregnancy (uteroplacental circulatory disturbances and placental dysfunction); suppressed or impaired immune function; and inflammatory responses that can result in cellular, tissue and organ damage if exposure occurs on a continuing basis over time (Belpomme 2015, Sage 2015). Mast cells are also found in the brain and heart, and this might account for some of the other symptoms commonly reported: headache, sensitivity to light, arrhythmias and other cardiac symptoms.

Kjell Hansson Mild, from the Swedish National Institute of Working Life, has had experimental results indicating that ES people show an imbalance in the autonomic nervous system (brain & heart reactions), and a tendency to increased arousal as a result of external physical factors.

Barrie Trower, a researcher into RF EMFs says *"There are a myriad of microwave devices in use today, each using waves of varying length. Microwaves are roughly 1 mm to 1 metre long. If the whole or part of your body is a multiple of the length of the wave, it can act as an aerial and absorb the microwave radiation. So, one transmitter may induce an unnatural current in your heart while another does so in your bone and another in your muscle, etc. As each person is physically different in size, density of bone/tissue, acidity, salt content, age, etc. two electrosensitive people in the same room could experience totally different symptoms from the same transmitting device."*

Resonance migraines which do not involve the headaches normally associated with migraines, and which are symptoms of ES, are believed to be caused by paroxysms of electrical energy in the brain.

The human immune system requires a fine balance between the two types of protector cells Th1 and Th2. Th1 cells inhibit hypersensitive reactions by reducing immunoglobulin E(IgE) levels. Th2 cells increase these levels, thus encouraging hypersensitive reactions as a side effect. Many atopic diseases are linked to a shift in the immune system profile towards Th2 dominance. Hemdan (2007) suggested that Th1/Th2 activity may be affected by some heavy metals, triggering autoimmunity in susceptible individuals. This may be another factor in the potential cause or trigger of EHS in an increasingly polluted world.

Belyaev (2005, 2009) in Sweden found that when exposed to 50 Hz magnetic fields or RF radiation, particularly UMTS microwave fields, lymphocyte responses were similar to the stress response induced by heat shock. He found different effects of mobile phone radiation on DNA repair systems between ES people and controls.

ES people can reach the biologically destructive point, where they are incapable of transmitting normal nerve impulses as they did before their use of and/or exposure to electronic products.

John McLaren-Howard has carried out some research on the blood of people who have ES. This can get round the reluctance of ES people to take part in studies where they can become very ill indeed as a result of their exposure. He believes that the best indicators of some electromagnetic sensitivity would be to assess the level of calcium accumulation inside the cell before and after exposure. There was a significant increase in calcium accumulation, as much as 100% more after exposure if they had also been exposed to allergenic chemicals. Without such exposure, there was no change. He suggests that electro sensitivity is merely exacerbating a pre-existing chemical sensitivity. This could help explain why there is such a variation in degrees of ES, due to variable chemical exposure. There is a clear link between electrical sensitivity and chemical sensitivity as can be seen in the following study. Pulsed electromagnetic fields (PEMF) treatment of 6 weeks showed a significant decrease in symptom severity in people with multiple chemical sensitivity (Tran [2017](#)).

## Research problems

We can only measure things our instruments are capable of measuring within their physical, chemical and biological limitations. It is possible that the measuring equipment cannot objectify the contents of individual perception, or that individual experiences can't be represented by measuring processes using methods of experimental research design in a laboratory. It is possible that the stimuli are only perceived at certain times and you are measuring during the wrong time period. It may also be dependent on the physiological and psychological well being of the person which is also likely to be time dependent. You might have to allow for a synergistic interaction between individual-specific substances that cause allergic reactions and this might be connected to inter-individual differing specific windows to the EMF.

To address some of these problems of inflexibility of choice of exposure and of study locations, Huss (2016) developed and tested novel portable exposure units that can generate different output levels of various extremely low frequency magnetic fields and radiofrequency electromagnetic fields at an individual's home or another environment of subjects' choosing. So far, results are inconclusive.

A study is currently being undertaken (October 2015) looking at fMRI and electrosensitivity. So far the comment is *"Out of the 8 electrosensitives in the study who have completed their functional MRIs, the results are all consistent with each other, showing neurological damage that is picked up by functional MRI but not regular MRI. These MRIs are then compared with the controls (non electrosensitives) whose functional MRIs look completely normal and are consistent with each other. There is a striking difference between the cases (electrosensitives) functional MRIs and the controls functional MRIs. This study could be a huge step in the direction of finally proving electrosensitivity in a regularly used, medical diagnostic tool - MRI. We have yet to see, but it is all looking extremely promising."*

Interestingly a study by McCarty ([2011](#)) found that ES symptoms were caused primarily by field transitions (off-on, on-off) rather than the presence of the field. There were statistically reliable somatic reactions in response to exposure to subliminal EMFs under conditions that reasonably excluded a causative role for psychological processes.

De Luca ([2014](#)) found metabolic pro-oxidant/proinflammatory alterations in EHS alterations in EHS with distinctively increased plasma coenzyme-Q10 oxidation ratio. The team also identified significantly altered distribution-versus-control of the CYP2C19\*1/\*2 SNP variants in EHS, and a 9.7-fold increased risk of developing EHS for the haplotype (null)GSTT1 + (null)GSTM1 variants.

Altogether, results on EHS strengthen our proposal to adopt this blood metabolic/genetic biomarkers' panel as suitable diagnostic tool for sensitivity-related illnesses.

In some laboratory studies the biological effects of EMFs and the weak electric currents they create in the body are:

1. Changes in functions of cells and tissue
2. Accelerated tumour growth
3. Decrease in the hormone melatonin
4. Changes in biorhythms
5. Alterations of the immune system
6. Changes in human brain activity and heart rate

People suffering from ES may respond far more strongly to stimuli than other people, following the sensitisation of parts of the brain from some as yet unidentified electro-bio-chemical signal. The Leitgeb & Schröttner study (2003) showed that ES people had a higher level of cortical arousal, as well as other differences in physiological baselines, than non-ES people. Landgrebe also found cognitive and neurobiological differences (2008) and central nervous system function (2007) between people who were ES and people who were not.

O Hänninen from the University of Kuopio in Finland, found people with ES had shifts in their heart rate and blood pressure as a result of EMF exposure, and suggested that recordings of circulatory parameters controlled by the autonomous nervous system could be used in the evaluation of subjects reporting ES. What has become clear, said the team led by Huss (Brand 2009) from Switzerland, is that ES people have highly complex problems. Only an interdisciplinary team is likely to be able to adequately diagnose environmental related health problems and provide suitable advice to concerned persons.

It has been estimated that up to 35% of the population may show indications of electro-stress. The problem with epidemiology is that it still looks for problems to show up in studies of the whole population. This methodology works well when most members of the population tended to react to the biological agent responsible for the disease, but when only a small percentage of the population are strongly affected, what should be strong evidence disappears into the "noise".

**Provocation studies** (e.g. Rubin 2005, 2006 (Appendix 2 for commentary), 2010, Nam 2009, Szemerszky 2010, Nieto-Hernandez 2010, and Eltiti 2007, Appendix 3) have also produced mixed results, possibly because:-

1. People who are electrically sensitive react too strongly to wish to continue with a multiple exposure study
2. People who are electrically sensitive react at different times after exposure, which makes it hard to determine what they are reacting to
3. The wrong metrics have been used as the condition is not yet well understood
4. People react to different parts of the electromagnetic spectrum so exposing them to one EMF source may not provoke any (never mind the same) symptom(s) in all the participants.

This makes provocation studies an inappropriate way to investigate electrical hypersensitivity.

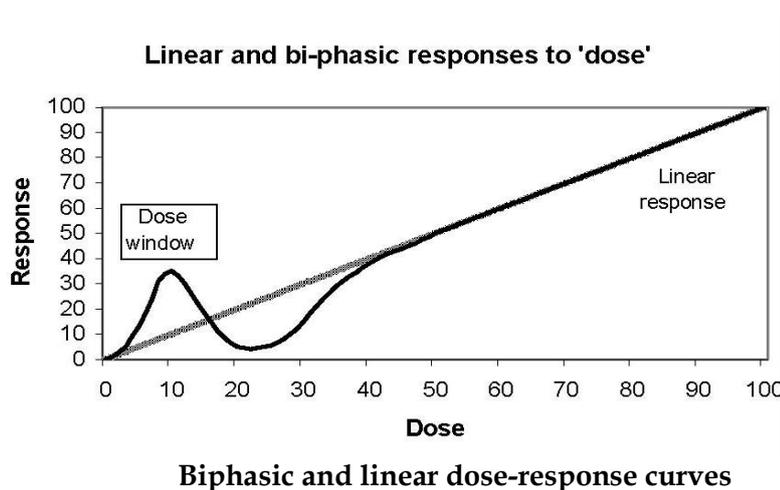
In July 2011, Dariusz Leszczynski commented, *"The so far published studies, and based on them e.g. WHO evaluation stating that there is no causal link between symptoms felt by the so-called 'electro-sensitive' people and the RF, indeed suggest that there is no causality link. However, this WHO evaluation is based on the published provocation studies, which, in my opinion, are methodologically inadequate to prove or disprove causality. Why? Because the symptoms that 'electro-sensitive' persons feel can be induced also by the ordinary stress. So, if person is put in an unusual environment of research laboratory*

and then asked to guess when the exposure is on or when it is off, such person undergoes 'experiment-associated stress' that can cause similar symptoms as these claimed to be caused by RF, e.g. headache, pain, etc. So, in my opinion, the so far executed provocation studies have very limited, if at all, ability to prove whether there can be any causality link between RF and symptoms experienced by some people."

He goes on to say "What we need are studies that would examine molecular level responses and show whether biochemical changes occurring in human body differ between 'non-sensitive' people and people claiming to be 'sensitive' to RF exposures. The classical provocation studies will not resolve this."

In February 2006, at a meeting of the Dutch working group on ES, Hugo Schooneveld, a neurobiologist, and himself a sufferer, showed how different radiation can have different effects on different people. He showed that there may be some delay before health effects are experienced. Indeed they can be perceived as positive at first and negative after a lengthy exposure. Sometimes low and high exposure do not have effects, but exposure in between do produce them (called a 'window' effect, see below). He also confirmed from his clinical experience that although EMFs may only cause small effects in biological systems, small effects on a cellular level can lead to large consequences on the organ level.

We propose that it is likely that adverse health effects caused by EMFs may well have a biphasic response curve causing a low level dosage window response. This may be deduced as likely from the substantial amount of published peer-reviewed research into the biological responses of animals and humans to very low doses of many pharmacological substances.



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.

We propose that it is also likely that ES occurs on an early biphasic sensitivity peak. This early biphasic response may become greater and greater as the individual's ES develops. Studies looking at high exposures which report negative findings may be confirming this biphasic effect (Kim [2011](#)).

It is an assumption, which is not always true, that cellular effects found in the laboratory are the same as cellular effects in bodies of living beings in the world at large. It is also assumed that no effects in the laboratory means that there are no effects in the population. Because of the type of responses reported by ES people, there is likely to be a nervous system involvement and possibly a hormonal / endocrinal system involvement. It is impossible to separate out the different systems of the complex human organism with respect to its everyday functioning in the world; all aspects are likely to be affected to a certain degree, but the research has to start somewhere!

A paper by Tuengler & von Klitzing ([2013](#)) presented a hypothesis on diagnosis and differentiation of ES. Simultaneous recordings of heart rate variability, microcirculation and electric skin potentials are used for ES classification, thus distinguishing it from other conditions.

### **What different countries have found, or are finding**

The NRPB commissioned a public health review of ES by Neil Irvine, Consultant in Public Health, Health Protection Agency, Northern Ireland. For our view of this research which reported in October 2005 see Appendix 1. We feel that they discovered ways this could be done in some of the research they looked at, but deliberately chose not to recommend further work to test these findings. The report concluded that it was impossible to construct even a symptom-based case definition of ES. This has major implications for the future study of EHS using a conventional epidemiological approach and in particular makes any findings population-specific.

The Federal Office of Public Health in Berne, **Switzerland**, suggest that observation and monitoring by medical practitioners, should be an important part of governmental fact finding.

EMF-attributed symptoms are being collected in **Germany** and **Australia**. ES indicators are being studied in **Germany** and **Japan**. One German study (Dahmen [2009](#)) found laboratory signs of thyroid dysfunction, liver dysfunction and chronic inflammatory processes in small but remarkable fractions of EHS sufferers (especially females) as potential sources of symptoms that merit further investigation in future studies. In the cases of thyroid-stimulating hormone (TSH), alanine transaminase (ALT) and aspartate transaminase (AST), there were significant differences between cases and controls.

EMF perception and biological responses are being studied in **Austria**, **Finland**, **Germany**, **Korea**, the **Netherlands**, **Sweden** and **Switzerland**. All ES symptoms are commonly reported in the general population. **Austria** is the only country with a written suggestion to guidelines on the diagnosis and treatment of EMF-related health problems (Hedendahl [2015](#)).

Sleep disturbance as a symptom of EMF sensitivity are being investigated in **Switzerland**, the **UK**, **Austria** and **Germany**.

In Toronto, Ontario, Women's College Hospital is the first Canadian hospital requiring its doctors to be trained in treating the effects of electromagnetic radiation. I would suspect there are many other countries which have NO hospitals requiring training in environmental pollutants.