

How Exposure to GSM & TETRA Base-station Radiation can Adversely Affect Humans

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1. It is perfectly true that the levels of microwave radiation in publicly accessible locations near GSM and [TETRA](#) Base-stations comply, by many factors of 1000, with the current safety guidelines set by the International Commission for Non-Ionising Radiation Protection (ICNIRP) [1]. These limits are, however, purely thermally based - i.e. they simply limit the intensity of the radiation to ensure that the amount of tissue heating by absorption of microwave radiation is not in excess of what the body's thermoregulatory mechanism can cope with. If heating were the only effect of the radiation, existing guidelines would afford the public adequate protection against the emissions of Base-stations; unfortunately, however, this is not the case. For microwaves are simply one particular realisation of electromagnetic radiation (visible light being another, relative to which microwaves lie on the far side of the infrared) and, as such, have properties other than solely intensity. In particular, the pulsed microwave radiation used in the GSM and TETRA systems of telecommunication has a number of rather well-defined frequencies, which, in at least two quite distinct ways, entail the possibility of non-thermal effects.

2. Firstly, although microwave radiation is non-ionising i.e. has insufficient energy (energy being proportional to frequency) to break chemical bonds, thereby producing electrically charged ions it does have enough energy to be able to effect subtle conformational changes, whereby molecular 'architecture' can be sufficiently altered that certain biochemical processes are affected - even those that are apparently not contingent on aliveness, such as the increased leakage of calcium from brain tissue, which has been reported, in vitro, under exposure to radio frequency and microwave radiation that is (sinusoidally) amplitude modulated at certain low frequencies, in particular, 16Hz (See Para.5 below).

3. The second, more interesting, possibility is of an 'informational' non-thermal influence allied to the fact that the alive human organism as a whole itself supports (but only when alive) a variety of oscillatory electrical biological/ biochemical activities, each characterised by a specific frequency, some of which happen to be close to those found in the GSM/TETRA signals - a coincidence that makes these bioactivities potentially vulnerable to being affected in various ways [2]. Since these activities are involved in bio-communication and in the control and regulation of bioprocesses essential to well-being, it is reasonable to anticipate that it is the functionality of the alive organism that is impaired by exposure to radiation of sub-thermal intensity containing bioactive frequencies. Experience in the case of exposure to GSM radiation suggests that the interference is with bioprocesses that would otherwise afford a natural protection against adverse health effects. This contrasts strongly with the situation at thermal levels where actual material damage to DNA, cells and tissue can occur. It is to be stressed again, however, that unlike heating, non-thermal influences of an informational kind are possible only when the organism is alive: the Dead have no electrical brain activity, for example, with which an external electromagnetic field can interfere! The existence of endogenous biological oscillatory electrical activities thus makes the living organism an electromagnetic instrument of great and exquisite sensitivity that is able - by decoding (demodulating) its various frequency characteristics, including those of any (lower

frequency) amplitude modulations - to 'recognise' and discern the presence of external electromagnetic fields and radiation 'informationally', and so be affected in a purely non-thermal way.

4. The frequency of the radiation that is used to carry (by appropriate modulations) the voice information (messages) in both GSM and TETRA lies in the microwave band - a frequency range in which there is some evidence (particularly at higher frequencies [3]) that processes as fundamental as cell division can be interfered with in various ways - the somewhat lower carrier frequencies characterising the radiation used in TETRA facilitating its deeper penetration into tissue. On the other hand, the rates at which the microwaves are emitted in distinct groups of flashes (or pulses) happen to be close to the frequencies of some of the brain's own electrical and electrochemical rhythms; accordingly, these can be (resonantly) amplified (perhaps to a biologically unacceptably high level), interfered with (similar to the case of radio reception), and even entrained by the radiation i.e. forced to operate at frequencies that are 'unnatural', in that they differ from those that characterise the natural rhythms of the body, thereby possibly compromising homeostasis. In GSM, the basic 'flash rate' is 217Hz; these flashes are, however, emitted in groups of 25 (each group being defined by the absence of the 26th flash) at the rate of 8.34Hz a frequency lying in the range of the human alpha brain wave activity. In the case of TETRA, on the other hand, the nature of the Base-station pulsing is somewhat different, but is again described by low frequencies that are here close to 70Hz and 17Hz the latter characterising the much more accentuated pulsing of the emissions of vehicularly mounted transmitters.

5. 17Hz is very close to the frequency (16Hz) at which radio-frequency /microwave radiation of sub-thermal intensities that is amplitude modulated in various ways - in particular, continuously (sinusoidally) and discontinuously (pulsed) - is reported, mainly under in vitro conditions, to cause: (i) a significant increase in loss (efflux) of calcium from brain cells, which is, however, reproducible only under certain exposure conditions [4], and which occurs even in the case of dead brain tissue; since calcium triggers release of neurotransmitters, any disturbance in the delicate balance of this chemical could well upset the integrity of the nervous (and also the immune) system; (ii) increased levels [5] of Ornithine Decarboxylase (ODC), a (rate limiting) enzyme that plays an important role in DNA replication, and possibly also in cancer promotion (see Para.9); (iii) opposing (and thus possibly stress inducing) effects [6] on the principal inhibitory and excitatory neuro-mediating brain chemicals that underpin the activity of the central nervous system. In addition, it should further be noted that the TETRA frame repetition rate is also close to the frequency at which seizures can be provoked in people suffering from photosensitive epilepsy by exposure to a light, flashing at between 15-20 times per second (see Para.8).

6. More disturbing is that the low frequencies that characterise the GSM/TETRA pulsing are close to those at which it is known that human mood and behaviour can be influenced in a number of ways (ranging from depression/docility to rage), depending on the kind/ frequency of modulation used [7], it being actually possible to induce sounds, and even words, intercranially by appropriate modulations of the microwave signal [8].

7. What the Mobile Phone Industry and the various national governmental Regulatory Bodies (such as the NRPB in the UK) dispute is that the very weak, pulsed microwave radiation used in GSM and TETRA exerts any non-thermal biological influences that entail adverse health reactions. Their conviction that, provided the intensity of the radiation complies with the ICNIRP safety guidelines, human exposure to this kind of radiation is innocuous derives, however, firstly, from the erroneous belief that electromagnetic fields should be regarded as toxins to the body - rather than an integral feature of its alive state and, secondly, from an outdated 'linear' mindset that prejudices the conclusion that exposure to weak radiation (below guideline levels) can entail only correspondingly weak effects, and vice versa. The invalidity of the latter is clearly indicated by the existence of the 'informational' influences referred to above, which, being contingent on

our aliveness, are inherently non-linear effects i.e. they depend not only on the electromagnetic field to which a subject is exposed, but also on the state of the individual at the time of exposure: any attempt to understand such effects from a purely linear perspective is thus doomed, in that it is unable to address the most discriminating feature of all, namely, the 'aliveness' of the system under consideration.

8. 'Official' reviews of published research (such as the Stewart Report of the IEGMP [10], the Zmirou Report [11] commissioned by the French government, and the NRPB's report on TETRA [12]) fail to adequately address the issue of electromagnetic sensitivities that are contingent on aliveness, and are regrettably characterised by a consistent tendency to put the most negative possible 'spin' on any positive results (that are suggestive of, or consistent with, possible health problems) - demanding further corroboration before accepting them - or to reject them either on the grounds that, in their opinion, the experiments are flawed for one reason or another, or because of difficulties in identifying credible mechanisms for the (disputed) observed effects. Whilst such scepticism is, of course, healthy and essential to the progress of reliable science, care must, at the same time, be taken to ensure that valuable indicators of potential positive effects are not missed (or prematurely dismissed), and equally, that negative findings (consistent with the safety of the technology) are not automatically deemed exempt from similar scrutiny: at present, there is a definite bias towards regarding any positive results as 'false positives', whilst rarely considering the possibility of 'false negatives' a dangerous and totally unacceptable state of affairs that is geared to promote a quite unjustified and unrealistic sense of security.

9. The importance of ensuring non-thermal electromagnetic compatibility between mobile phone radiation and energised electronic equipment, such as that in aircraft and hospitals is, of course, generally accepted and respected. Ironically, however, the same does not yet obtain in the case of the alive human organism, despite (i) the fact that the latter is itself an electromagnetic instrument par excellence, which, as already mentioned, can detect electromagnetic fields that are millions of times weaker than those to which the public is exposed by GSM/TETRA Base-stations, (ii) the existence of a wide variety of non-thermal bio-effects induced by low intensity microwave radiation (both pulsed and non-pulsed) that have been revealed by many experiments, enjoying varying degrees of corroboration, which have been performed over the last 30 years on many different kinds of biosystems - ranging from cells in test-tubes to the entire living human organism most of which have been published in international, peer reviewed scientific journals [13].

10. Whilst the occurrence of non-thermal effects does not, of course, necessarily entail any adverse health consequences, there is, nevertheless, a disturbing consistency between some of these non-thermal bioeffects and the nature of some of the adverse health reactions reported both by certain users of mobile phones and by certain people (involuntarily) exposed long-term to the radiation from GSM Base-stations [2]. Of particular concern is the way in which this radiation (non-thermally) affects brain function specifically, its electrical activity (EEG), its electro-chemistry, and the blood/ brain barrier - and degrades the immune system. Thus, for example, the radiation is known to (i) disturb the delicate balance of chemicals in the brain in particular, the dopamine-opiate system - and (ii) to increase the permeability of the human blood brain barrier (thereby facilitating the passage of chemical toxins from the blood into brain fluid), both of which are medically considered to underlie headache, one of the most persistently reported adverse health effects. Similarly, the duration of REM sleep is shortened by exposure to radio-frequency radiation, whilst nocturnal secretion of melatonin is partly inhibited, both of which are consistent with reports of sleep disruption and concentration problems, and with anecdotal reports of an elevated incidence of certain cancers in some exposed people; for melatonin is an oncostatic hormone i.e. a hormone that protects against cancer, particularly in females. Furthermore, the possibility of deliberately provoking epileptic seizures in certain animals by exposing them to pulsed microwave radiation is consistent with reports of an increased incidence of seizures in some epileptic children when exposed to the emissions of GSM Base-stations. The latter finding is

not at all unreasonable, given the established ability of a visible light (such as that from a stroboscope) flashing at a rate somewhere between 15-20 times per second to provoke seizures in the 5% minority of people who suffer from photosensitive epilepsy. For visible light and microwaves are both simply different realisations of electromagnetic radiation, and the microwave radiation used in GSM and TETRA similarly 'flashes' (pulses) at rates that the brain is able to recognise; unlike visible light, however, pulsed microwaves are not reliant on the eye and optic nerve to access the brain, since they can penetrate the skull directly.

11. It has already been noted that although microwave radiation is non-ionising i.e. does not have enough energy to break chemical bonds, particularly in DNA it can, nevertheless, functionally interfere with the natural processes involved in DNA replication and repair by subtly altering molecular conformation (architecture), for example; this could well account, respectively, for the reports of certain effects observed in vitro, such as chromosome aberrations/ micronuclei formation and for the increased amount of DNA fragmentation found under irradiation. Similarly, the in vivo finding that exposure to pulsed GSM radiation (of an intensity comparable to that realised during mobile phone use) promotes the development of cancer in mice that have been genetically engineered to have a predisposition to cancer is consistent with other (in vitro) studies showing (i) increased levels [5] of an enzyme (ODC) that has been implicated in tumour promotion, and (ii) over-expression (in the short-term) of heat shock proteins (HSPs) in both human and animal cells [15] exposed to GSM radiation; for it has been hypothesised that over-expression of HSPs inhibits natural programmed cell death (apoptosis), thereby allowing cells that should have 'committed suicide' to continue to live; this hypothesis is currently being tested experimentally [16]. Under-expression (associated with chronic exposure), on the other hand, can adversely affect the natural repair of DNA breakage. Taken together, these various effects are, in turn, consistent with (a) the 2-3-fold increase in the incidence of a rare form of cancer in the periphery of the human brain, where the penetration of the (electric field component of the) radiation from the handset is greatest (the laterality of the tumours correlating with that of handset use), which has been found in an epidemiological study in the USA [17], and (b) with the increased incidence of cancer amongst users of mobile phones found in a recently published Swedish epidemiological study [18], although in both studies it should be noted that, in the majority of cases considered, exposure was not to (digital) GSM phones, but rather to the somewhat higher powered, older analogue ones, which, having been available for rather longer, permit the effects of exposure over a rather longer period to be studied.

12. It is important to appreciate that the contents of Paras.9-11, which pertain to exposure to the emissions of GSM handsets, are not irrelevant to the consideration of the effects of exposure to Base-station radiation, since the informational content of the latter is the same as that of the phone signals; indeed, the increasing number of disturbing reports of rather serious adverse health effects in animals (particularly cattle [19]) exposed to GSM Base-station radiation could well be valuable warning portents that should not be ignored; equally, the steadily increasing number of reports [20] of unexplained clusters of human cancers in the vicinity of certain GSM Base-stations warrants urgent investigation.

13. It is essential to appreciate, however, in the case of non-thermal influences contingent on aliveness, that it necessarily follows that not everyone will be equally susceptible, even when exposed to exactly the same radiation for exactly the same length of time - susceptibility depending not only on the radiation, but also on the genetic predisposition and physiological state of the individual when irradiated, such as the stability of a particular person's electrical brain activity and level of stress prior to exposure. Whilst this admittedly makes the occurrence of non-thermal effects more difficult to predict (and hence to regulate against) than is the case with thermal effects - and, of course, undermines the extent to which they can be considered to be 'established', in the sense required for them to be eligible for consideration in safety deliberations - it does not mean that they can be safely ignored, or that they cannot provoke adverse health

reactions in certain people, the severity of which will again vary from person to person, according to the robustness of their immune systems. More meaningful is to ask whether there is an established potential risk to human health from exposure to GSM/TETRA radiation: the answer is undoubtedly 'yes'. It is probably true to say that if a similar degree of risk and uncertainty as to subjective noxiousness obtained in the case of a new drug or foodstuff, it is unlikely that they would ever be licensed.

14. Quite apart from their weaker immune systems, pre-adolescent children are particularly vulnerable as recognised by the Stewart Report [10] - because of the increased rate at which their cells are dividing (which makes them more susceptible to genetic damage), and because their nervous system is still developing - the smaller size of their heads and their thinner skulls increasing the amount of radiation that they absorb, particularly at 900MHz. Especially vulnerable to interference by the pulsed microwave radiation used in GSM is their electrical brain-wave activity, which does not settle into a stable pattern until puberty. The use of mobile phones by pre-adolescent children is thus to be strongly discouraged, and the siting of Base-station masts in the vicinity of schools and nurseries (including those hidden in church towers and in illuminated signs, such as those at petrol stations, for example) must be strongly resisted: financial gain must not be allowed to be the overriding consideration.

15. In connection with Base-station exposure, it must be appreciated that it is impossible to cite a universally applicable 'safe distance'. The only meaningful approach, at present, is to require, in publicly accessible locations near a mast, that the intensity of the radiation should be below the level at which any adverse health effects have so far been reported; including an additional safety factor of 10, a maximum intensity limit of $10\text{nW}/\text{cm}^2$ ($= 10^{-4} \text{ W}/\text{m}^2$ - equivalent to $0.2\text{V}/\text{m}$) is, in this way, indicated. The precise distance from a mast at which this level is realised depends, however, on how powerful are the antennae, their height above ground-level, the orientations of the main beams and their 'side lobes' (subsidiary emissions that are much more localised in the immediate vicinity of a mast), and the local topography.

16. To cite the examples of radio and television transmissions (to which we have been exposed for a much longer time than is the case with GSM/TETRA) in an attempt to support the claim that exposure to the (much less intense) radiation used in mobile telephony is harmless is flawed on at least three accounts: (i) the occurrence, in any case, of certain health problems that correlate with exposure to the radiation from such installations [21], (ii) the fact that, unlike that used in GSM/TETRA, the radiation from TV and radio transmitters is not emitted in pulses, in particular, in patterns characterised by frequencies that the brain can recognise, and neither are the carrier frequencies in the (more biologically active) microwave band, and (iii) the beam morphologies are quite different. Furthermore, before taking reassurance from the asserted absence of health problems amongst continental users of TETRA, it should be remembered that it is often the much less biologically active TETRAPOL system (as opposed to TETRA) that is there used.

17. In conclusion, it can hardly be disputed that to enjoy an acceptable quality of life requires more than simply an absence of terminal disease. Adverse health effects in humans of the kinds already reported worldwide such as headaches, sleep disruption, impairment of short-term memory, etc. - whilst maybe not life-threatening in themselves, do nevertheless have a debilitating effect that undoubtedly affects general well-being, and which in the case of some children could well undermine their neurological and academic development, as is already evident from experience in the case of a number of infant/junior schools at which a GSM Base-station is located. It should be stressed, however, that, to date, the apparent absence on a global scale of more serious pathologies attributable to exposure to the emissions of GSM/TETRA Base-stations is no guarantee of immunity in the long-term; indeed, as mentioned earlier in Para.10, there is already an increasing number of reports [19] of unexplained clusters of cancers in the vicinity of certain GSM Base-stations, whose non-involvement remains to be established.

References:

1. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300GHz). *Health Physics* 74(4), 494-522 (1998).
2. G.J. Hyland. The physics and biology of mobile telephony. *The Lancet* 356, 1833-1836 (2000).
3. G.J. Hyland. Non-thermal bioeffects induced by low intensity irradiation of living systems. *Engineering Science and Education Journal* 7(6), 261-269 (1998).
4. See references in: J.H. Merritt. Interaction of calcium in biological systems with electromagnetic fields, in 'Radio Frequency Radiation Standards' (pp.197-206), edited by B.J. Klauenberg et al., NATO ASI Series, Plenum Press, New York, 1995 (ISBN: 0-306-44919-6). See also Ref. 14.
5. C.V. Byus et al. Increased Ornithine Decarboxylase (ODC) activity in cultured cells exposed to low energy microwave fields and phorbol ester tumour promoters. *Cancer Research* 48, 422-4226 (1988); L.M. Penafiel et al. Role of modulation on the effect of microwaves on ODC activity in L929 cells. *Bioelectromagnetics* 18, 132-141 (1997); R. Paulraj et al. Effect of amplitude modulated RF radiation on calcium efflux and ODC activity in chronically exposed rat brain. *Indian J. of Biochemistry & Biophysics* 36, 337-340 (1999).
6. M. M. Yurinskaya et al. Reactions of the receptor systems of the brain to the action of low-intensity microwaves. *Biophysics* 41(4), 869-875 (1996).
7. B.N. Rodionov. Energy-informational influences of low energy electromagnetic radiation on biological objects. *Vestnik novykh meditsinskikh tekhnologiy* VI(3-4), 24-26, 40-42 (1999). For similar effects using pulsed electromagnetic radiation with carrier frequencies in the short wave band, see - Puharich A. Proc. 6th World Congress of the International Ozone Association, Washington DC, 1983 contains references to Classified earlier work (1977) and to the confirmation in 1982 by the US Navy that ELF signals are indeed psychoactive, in that they can cause mental depression at 6.66Hz and can lead to manic and riotous behaviour at 11Hz
8. Defence Intelligence Agency. Biological effects of electromagnetic radiation (radiowaves and microwaves) Eurasian Communist Countries. DST-1810S-074-76, March 1976.
9. C.W. Smith C.W. & S. Best. 'Electromagnetic Man', J.M. Dent & Sons Ltd., London, 1989 (ISBN: 0-460-04698-5).
10. www.iegmp.org.uk/report/text.htm
11. www.web10975.vs.netbenefit.co.uk/zmirou/zmirousite.htm
12. www.nrp.org/publications/documents_of_nrp/abstracts/absd12-2.htm
13. G.J. Hyland. The physiological and environmental effects of non-ionising electromagnetic radiation, EU Parliament, Bruxelles, March 2001. See www.europarl.eu.int/stoa/publi/pdf/00-07-03_en.pdf For rebuttal of 'COST's criticism, see - www.cost281.org/activities.php
14. E. Postow & M.L. Swicord. Modulated fields and 'window' effects, in 'Handbook of Biological Effects of Electromagnetic Fields'(Chapter 12), edited by C. Polk and E. Postow, 2nd Edition, CRC Press, New York & London, 1995 (ISBN: 0-8493-0641-8).
15. P. French et al. Mobile phones, heats shock proteins and cancer. *Differentiation* 67, 93-97 (2001); D. Leszczynski et al. Non-thermal activation of the hsp27/p38MAPK stress pathway by mobile phone radiation in human endothelial cells: Molecular mechanism for cancer and blood-brain barrier related effects. *Differentiation* 70, 120-129 (2002).
16. See - New research projects. *Microwave News* XXII (1), 14 (2002).
17. J.E. Muscat et al. Handheld cellular telephone use and risk of brain cancer. *J. American Medical Association* 284, 3001-3007 (2000).
18. L. Hardell et al. Cellular and cordless phones and the risk for brain tumours. *European Journal of Cancer Prevention* 11(4), 377-386 (2002).
19. W. Löscher W. & G. Käs. Conspicuous behavioural abnormalities in a dairy herd near a TV and radio- transmitting antenna. *Practical Veterinary Surgeon* 79(5), 437-444 (1998); see also: A. Firstenberg, Special section on farms. *No Place to Hide* 2(4), 15-18 (2000).
20. See, for example: www.observer.co.uk/uk_news/story/0,6903,764389,00.html ; www.cfps.fsnet.co.uk/cluster.htm

21. J.R. Goldsmith. Epidemiologic evidence relevant to radar (microwave) effects. *Environmental Health Physics* 105, 1579-1587 (1997); Ö. Hallberg & O. Johansson. Melanoma incidence and FM broadcasting. *Archives of Environmental Health* 57(1), 32-39 (2002).

<http://www.energyfields.org/science/hyland1202.html>