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

G J Hyland

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Associate Fellow
Department of Physics
University of Warwick, UK

Executive Member
International Institute of Biophysics
Neuss-Holzheim, Germany

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* caused by absorption of microwave radiation is not in excess of what the body's thermoregulatory mechanism can cope with (*See*, however, Para.6). If heating were the *only* effect of the radiation, existing guidelines would probably afford the public adequate protection against the emissions of Base-stations; unfortunately, however, this is not the case. For microwaves are *waves* and, as such, have properties *other* than solely intensity.

2. In particular, the pulsed microwave radiation used in the GSM and TETRA[1] systems of telecommunication is '*coherent*', which means that it is characterised by a number of particularly well defined ***frequencies*** – a feature that can greatly enhance its impact on the biochemistry of the body, and facilitate its discernment (*see* Para.3) against the (very incoherent) heat radiation that is emitted by the body, depending on its physiological temperature. These frequencies range from the (very high) ones that define the radiation as *microwave*[2], through the (very much lower) ones that reflect the way in which (in order to increase the number of Handsets with which a given Base-station can simultaneously communicate) the radiation is transmitted in distinct short 'bursts' or pulses[3], to the even lower frequencies that characterise the way in which (for certain technical reasons) these bursts are organised into distinct groups, called 'frames' and 'multi-frames'[4].

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[1] In this Paper, attention will be confined to the version of TETRA manufactured by Motorola, which is that used in the UK 'Airwave' system, operated by *mmO2*.

[2] In this context, 'microwave' should be regarded as an invisible colour, lying on the far side of the infrared from visible light. In GSM/TETRA, microwave radiation is used to 'carry' the voice/data information by means of a certain kind of modulation (closely related to (FM) frequency modulation) involving changes in the *phase* of the carrier wave. The 'carrier frequencies' used by GSM are in the region of either 900MHz or 1800MHz (depending on the particular Operator [**2**]), whilst, in the case of TETRA, rather lower frequencies in the region of 400MHz (390-395MHz) are used in the UK [**3**].

[3] In GSM, the bursts are of (carrier frequency) microwave radiation, between which the transmitted power falls to zero, the burst repetition rate being 1.74kHz. In TETRA, on the other hand, where the carrier is transmitted *continuously*, the bursts are composed of electromagnetic oscillations (characterised by a spread of frequencies centred on about 11kHz – *see* Figure in Appendix C of [**3**]) - arising from the way in which the information encoding phase modulation is here implemented; the burst repetition rate is 70.4Hz, during which the power ranges between + and – 85% of the carrier value, as can clearly be seen from Figure 7 of the Technical Appendix to the NRPB Report [**3**].

[4] The basic group is called a *'frame'*, and contains 8 time-slots in GSM, and 4 in TETRA, each of which can accommodate a burst, into which voice information can be encoded; this allows a Base-station to simultaneously communicate with more than one Handset. In GSM, the frame repetition frequency is 217Hz, whilst in the case of TETRA it is 17.6Hz.

Even though the intensity of Base-station radiation is far too low to entail any heating, the amount of energy absorbed (which is proportional to intensity) can still be sufficient to effect subtle (conformational) changes in molecular architecture, particularly if the frequency of the radiation matches or is close to that of an organised (collective) electrical vibration of a molecule; this can lead to alterations to biochemistry (such as enzyme activity) of a kind that could be incompatible with health. In the case of an alive individual, on the other hand, the possibility of a **non-thermal** influence arises because a living system *itself* supports a variety of oscillatory electrical/ 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 interfered with in various (non-thermal) ways [**5**].

Thus, in both cases, the (non-thermal) influence arises essentially because the systems are able 'recognise' the incoming radiation through its well-defined (coherent) frequency characteristics. In the first case, this entails the possibility of a *selective* absorption of energy (by vibrations having the 'right' frequency), whilst in the second case it is more appropriate to interpret the non-thermal effect as an **informational** influence.

3. It cannot be stressed too strongly – particularly in connection with the second (aliveness contingent) case – that a non-thermal effect is not simply a thermal effect that is too weak to entail any measurable rise in temperature, but is instead a consequence of a fundamentally *quite different* kind of interaction between the living system and the electromagnetic field to which it is exposed, from that which causes heating. This is evident [**6**] from the fact these non-thermal effects (*i*) exhibit a very much sharper dependence on frequency than do thermal effects, (*ii*) cannot be replicated by conventional heating methods, and (*iii*) are often in a 'direction' *opposite* to that produced by heating; for example, irradiation of nematode worms with microwave radiation of sub-thermal intensity increases fertility, whilst heating decreases it [**7**]. Accordingly, at higher intensities, it is quite possible for non-thermal effects to be obliterated by thermal influences, which could explain the seemingly paradoxical finding that many non-thermal effects actually become more pronounced as the intensity is reduced. It should be noted, however, that despite their *much sharper* dependence on the *frequency* of the radiation than is typical of thermal effects (which are, instead, primarily dependent on *intensity*), the occurrence of non-thermal effects is still contingent on a minimum (threshold) intensity [**6**].

A fundamental intensity threshold is set by the requirement that the signal (which is not perfectly coherent) be discernible against the level of the (incoherent) thermal radiation emitted by a body appropriate to its physiological temperature. In the case of microwave radiation at 1GHz and a physiological temperature (of a *alive* human) of 37°C, this minimum intensity is only 10^{-16} W/cm^2 – a value, which, it should be noted, is close to the thresholds of human sight, hearing and EEG response [**8**, **9**]; accordingly, the ability of the alive body to discern (the generally much more intense) Base-station emissions is not at all reliant on a sensitivity that is in any way superior to those that it already possess (quite undisputedly) in respect of *other* physiologically significant fields.

On the other hand, threshold intensities associated with the onset of non-thermal effects in mono-cellular organisms, such as *E.coli*, are very much higher [**6**], but are still at least *1000 times lower* than that associated with the onset of thermal heating upon which existing safety guidelines are based. Other characteristics of non-thermal effects that distinguish them from thermal effects are that they often occur only within a certain range (or 'window') of intensities, and manifest themselves only after a certain duration of irradiation [**6**]. This multi-parameter feature could well account for difficulties experienced in some attempts to replicate certain non-thermal effects: having only the 'correct' frequency is not necessarily sufficient to ensure success (*See* also Footnote 7, however).

The GSM '*multi-frame*' associated with the BCCH(TCH) contains 51(26) frames, in which the 51st(26th) frame is a dummy (or idle) frame [**2**, **4**]; it is this feature that distinguishes one multi-frame from the next, resulting in associated multi-frame (repetition) frequencies of 4.25Hz (=217Hz/51) and 8.35Hz (=217Hz/26), respectively. An even lower frequency of 2Hz characterises the emission of a GSM Base-station when it operates in discontinuous transmission mode (DTX).

In the case of TETRA, a multi-frame contains 18 frames (each multi-frame being demarcated by the 18th frame, which is a Control frame [**3**]), the associated multi-frame repetition frequency being 0.98Hz.

4. As already noted, the frequency of the radiation that is used to carry (by appropriate modulations) the voice/ data 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 [**6**]) that processes as fundamental as cell division can be influenced - the somewhat lower carrier frequencies characterising the TETRA radiation facilitating its deeper penetration into tissue.

The GSM burst repetition rate of 1.74kHz is very close to the frequency (the so-called 'nuclear magnetic resonance frequency) at which the quantum mechanical spin of a proton precesses in the Earth's (static) magnetic field. Protons are the majority component of water (which is itself the dominant component of living systems), and irradiation of living systems by low intensity microwaves modulated at this NMR frequency has been found to influence and potentiate certain bioprocesses, such as causing a doubling in the rate of cell division, and an associated reduction in the size of the daughter cells [**10**]; a possible mechanism for such effects could be 'spin-orbit' coupling, *via* which the resonating spins affect the quantum mechanical orbitals upon which chemical bonding depends, and in turn, enzymatic activity. The GSM frame repetition rate of 217Hz, on the other hand, is close to that of coherent (synchronous) electrical oscillations that have been found in rat hippocampal slices, *in vivo* [**11**]; the hippocampus is involved in learning, memory, spatial awareness and epilepsy. Of particular significance, however, is that some of the much *lower* frequencies that characterise the *multi*-frame structures of the GSM signals happen to be close to those of some of the brain's own electrical and electrochemical rhythms, as recorded by the Electroencephalogram (EEG); accordingly, these rhythms can be (resonantly) amplified (perhaps to a biologically undesirably 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 (non-exposed) body, thereby possibly compromising homeostasis.

In the case of TETRA, the much lower burst repetition frequency (70.4Hz) lies in the range (40-120Hz) of electrical muscular activity, as recorded by Electromyography (EMG), whilst the 17.6Hz pattern that characterises the much *more accentuated* pulsing of the emissions of vehicularly mounted transmitters [**3**] and, to a somewhat lesser extent, *also* that of the Base-stations is very close to the frequency (16Hz) at which sub-thermal RF/microwave radiation that is amplitude modulated in various ways is reported, sometimes **even under** *in vitro* conditions, to cause: (*i*) a s*ignificant* increase in leakage (efflux) of calcium from brain cells; since calcium ions trigger the release of neurotransmitters, any disturbance in the delicate balance of this chemical could well undermine the integrity of the nervous (and also the immune) system; it should be noted, however, that this effect is reproducible only under certain exposure conditions [**12**], (*ii*) elevated levels [**13**] of Ornithine Decarbolylase (ODC), a (rate limiting) enzyme that plays an important role in DNA replication, and possibly also in cancer promotion (*see* Para.13), and (*iii*) opposing (and thus possibly stress inducing) effects [**14**] 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 (17Hz) is (*i*) 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.12), and (*ii*) in the range of frequencies (the so-called 'beta' brain-wave band) that characterise the electrical activity of the human brain during periods of concentrated mental activity, and also in REM (Rapid Eye Movement) sleep (*See* Para.12), during which important restorative processes in the body and information processing by the brain take place. Finally, the TETRA multi-frame frequency repetition frequency (0.98Hz) is close that of the human heart beat.

5. Particularly disturbing is that the low frequencies that characterise certain aspects of 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 [**15**], it being actually possible to induce sounds, and even words, intercranially by appropriate modulations of the microwave signal [**16**].

6. It is apparent from the foregoing that the existence of endogenous biological oscillatory electrical

activities makes the living organism an **electromagnetic instrument of great and exquisite sensitivity**[5] that is able to 'recognise' and discern the presence of external electromagnetic radiation '***informationally***', by decoding (demodulating[6]) its various frequency characteristics, including those of any (lower frequency) amplitude modulations, as already noted above. Since these activities are involved in bio-communication and in the control and regulation of bio-processes 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; one such possibility appears to be an **interference** with bioprocesses that would otherwise to afford *a natural protection **against** adverse health effects*, such as (*i*) the reduction in the amount of melatonin released from the pineal gland - melatonin being a hormone that protects against cancer, particularly in women (*See* Para.12), and (*ii*) interference with the thermoregulatory functioning of the hypothalamus – an effect that would be consistent with the sensation of *overheating* reported by some people resident near a Base-station, despite the very low (sub-thermal) level of radiation to which they are exposed; for other examples, see Para.13. 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, 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!

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 its intensity complies with the ICNIRP safety guidelines, the radiation is *not* harmful to humans derives, however, firstly, from the erroneous view that considers electromagnetic fields to be toxins to the body - rather than accepting them as an *integral* feature of its living 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 inherently unable to address the most discriminating feature of all, namely, the '***aliveness***' of the system under consideration.

8. Non-peer reviewed 'official' reviews of published research (such as the Stewart Report of the IEGMP [**2**], the Zmirou Report [**18**] commissioned by the French government, and the NRPB's TETRA Report [**3**]) fail to adequately address the existence of electromagnetic sensitivities that are *contingent on aliveness*, and are regrettably characterised by consistent tendencies to:

i) Conclude (invalidly) from a set of (seemingly) conflicting results (*See* Para.9 below, however) that there is really *no* effect.

ii) Put the most negative possible 'spin' on any positive results (that might be suggestive of, or consistent with, possible health problems), demanding further corroboration before accepting them.

iii) Reject positive effects on the grounds either that, in *their* opinion, the experiments are flawed for one reason or another, or because of difficulties in identifying what they consider to be credible underlying

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[5] This is dramatically illustrated by the efficacy of a number of modalities, such as those involving bio-feedback/resonance (including microwave resonance therapy) *via* acupuncture points.

[6] It is frequently claimed that there are no known mechanisms whereby such demodulation can occur at microwave frequencies. This conclusion is based, however, on consideration of the rectifying ability of non-linear elements in *individual* cell membranes, which is indeed limited to electromagnetic fields below about 10MHz [**17**]. A crucial characteristic of living systems, however, is a cooperative interaction between *many* cells, resulting in highly organised synchronous (coherent) collective vibrations over large regions, which, despite the presence of frictional damping, can be maintained provided an adequate supply of energy (such as from metabolism) is available [**6**]. These endogenous 'coherent excitations' are themselves in the nature of *non-linear* excitations whose frequencies can be in the microwave range; they thus afford quite novel possibilities whereby an incoming microwaves can be efficiently rectified, and any low frequency modulated structures (such as those characterising bursts, frames and multi-frames) thereby extracted.

mechanisms.

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 potential indicators of 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 a similar level of 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 concern does *not* yet extend to 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 found in publicly accessible places around 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[7], 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 [**9**].

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 bioeffects and the kinds of some of the adverse health reactions reported both by some users of mobile phones and by certain people (involuntarily) exposed long-term to the radiation from GSM Base-stations [**19**]. These include:

- Sleeping disorders/Chronic Fatigue Syndrome.
- Memory / concentration problems.
- Headaches.
- Anxiety.
- Seizures in people (particularly, pre-adolescent children) who already suffer from epilepsy.
- Nose bleeds, especially amongst young children attending schools where (or near to which) there is a GSM Base-station.
- Unexplained clusters of human cancers in the vicinity of certain GSM Base-stations [**20**], whose **non**-involvement remains to be established.
- Much reduced neutrophil counts, which **reverse** in the **absence** of exposure. (A *neurophil* is a kind of white blood cell, important to the immune system, which engulfs bacteria.)

*The last mentioned effect is particularly important in that it is an **objective quantifier** of an adverse effect of exposure to GSM radiation from a Base-station - in particular, on the immune system - and thus cannot (possibly unlike some of the other effects) be dismissed as psychosomatic.* Indeed, an extensive programme of blood testing is now underway in Germany, as part of the 'Human Ecological Social Economical (HESE) Project' [**21**].

A number of these symptoms have been the subject of recently published pilot epidemiological studies [**22**].

[7] Difficulties in replication can often be traced to some crucial difference in experimental protocol that effectively undermines the fidelity of the intended replication. Thus the reason why it has not been possible to replicate some experiments is precisely because they have not *actually* been replicated!

Of particular importance to establishing the *non*-psychosomatic nature of these symptoms are anecdotal reports of health problems that actually *predate* knowledge of the presence of a Base-station in the vicinity, the onset of which were *only retrospectively* found to coincide with the commissioning of the Base-station. Another important feature in this respect is that symptoms are often found to subside when the sufferers remove themselves from the vicinity of the mast, but *reappear* upon their return.

In addition to reports of health problems in humans, there are also reports of animals - particularly cattle [**23**] - being adversely affected, again in a *reversible* way, when exposed to GSM Base-station radiation. The value of such reports is that they show that, *in this case*, the adverse health effects are really a consequence of exposure to the radiation, and cannot be dismissed as psychosomatically provoked. Given the often-enhanced electromagnetic sensitivity of certain animals (including birds and other sensitive creatures, such as bees), such reports could well be valuable warning portents that should not be ignored.

11. The seriousness with which reports of ill-health (which can only be due to **non**-thermal influences of the radiation) are taken internationally is reflected in a number of recent developments:

a) The **Freiburger Appeal** [**24**]: This Appeal was published in October 2002 by the Interdisciplinary Society for Environmental Medicine (Germany), in response to the 'dramatic' rise in the number of reports of health problems (including cancer, cardiac disorders and neuro-degenerative diseases), which the 59 original Charter Signatories claim, after detailed investigations, are associated with the exposure of their patients to electromagnetic fields of various kinds - in particular those used in mobile telephony. The Appeal has so far been endorsed by over 1000 medical doctors throughout Germany.

b) The **Catania Resolution** [**25**]: This document was signed by 16 eminent scientists of international standing from 7 different countries, following a conference in Sicily in September 2002. The first and fourth clauses of the Resolution state, respectively: '*Epidemiological and in vivo and in vitro experimental evidence demonstrates the existence for electromagnetic field induced effects, some of which can be adverse to health'*, and: '*The weight of evidence calls for preventive strategies based on the Precautionary Principle. At times the Precautionary Principle may involve prudent avoidance and prudent use*'.

c) The **Salzburg Resolution** [**26**]: This document (signed by 19 scientists and public health doctors from 10 countries) was the outcome of the first international conference dedicated to public health issues connected with exposure to Base-station emissions, which was held in Salzburg in June 2000. To adequately protect against Base-station emissions, the Salzburg Resolution recommends that *outdoor* exposure should be **below 0.1ìW/cm^2** (= 10^{-3} W/m^2 = 1/1000W/m^2) - equivalent to an electric field of 0.6 volts per metre (V/m) - in publicly accessible areas surrounding such an installation. *It should be noted that this value is 4500(9000) times* ***lower*** *than the ICNIRP Guideline value for 900(1800)MHz radiation*.

d) A **Statement by a Body of Doctors in the UK** [**27**]: This Statement urges the removal of a Base-station currently under construction, prompted by fears of adverse health impacts on exposed children.

The exposure limit recommended by the **Salzburg Resolution** is effectively the (outdoor) electromagnetic field intensity *below* which no adverse health effect has yet been reported. The precise location from a mast at which this limit is exceeded depends, however, on how powerful the antennae are, their height above ground-level, the orientations of the main beams (defined by their horizontal and vertical angular widths), the location and concentration of 'side-lobes' (subsidiary emissions that are much more localised in the immediate vicinity of a mast[8]), the height above ground level of the location of concern (*e.g.* a second/third storey bedroom), and the local topography. Accordingly, it is impossible to cite a *universally* applicable

[8] Whilst the power in a side-lobe is certainly much less than in the main beam, the power *density* close to a mast can be comparable to that in the main beam, several hundreds of metres distant, because of the closer proximity of a side-lobe to the mast (power density at a distance *d* from the mast is given by $GP/4\delta d^2$, where *P* is the power (in watts) delivered by the antenna into a beam, and *G* is the 'gain' of the antenna, reflecting the degree of *directionality* of the emitted beam – *See* Para.18. Exposure to such side-lobes could well account for reports of health problems at locations that are *not* exposed to the main beam, such as occupied areas either immediately *beneath* an antenna (*e.g.* the floor immediately below the roof of a block of flats), or near the base of a mast.

'safe distance'. It should be especially noted that the existence of side-lobes **invalidates** the familiar claim that the safest place for a mast is actually on a school roof.

There is thus abundant evidence of genuine concern amongst reputable scientists and medical doctors that exposure to the emissions of Base-stations is **not** without risk to public health. Indeed, Prof. L Challis, Deputy Chairman of the IEGMP and Chairman of Mobile Telephone Health Research (MTHR), said in a recent interview [**28**] that …. *'The Government wants us to say that these masts are completely safe and aren't dangerous, but we can't say that.'*

12. Of particular concern is the way in which this radiation (non-thermally) affects *brain function* – specifically, its electrical activity, its electro-chemistry, and the blood/brain barrier (BBB) - and degrades the *immune system.* Thus, for example, the exposure to GSM (Handset) and similar radiation is known to:

(*i*) Alter the natural rhythms of the brain's electrical activity, as measured by the EEG [**29**].

(*ii*) Disturb the delicate balance of chemicals in the brain – in particular, the dopamine-opiate system [**30**].

(*iii*) Increase the permeability of the human BBB [**31**], thereby facilitating the passage of chemical toxins from
the blood into brain fluid.

It should be noted that (*ii*) and (*iii*) are medically considered [**32**] to underlie headache, one of the most persistently reported effects. Furthermore, the recent discovery [**33**] that associated with the increased permeability of the BBB are regions of 'dark neurones', indicating actual damage to brain cells, is cause for concern, particularly in the case of children, since ……'*it may, in the long run, result in reduced brain reserve capacity'* [**33**]; the possibility of premature aging must also be considered, with associated negative effects manifesting themselves already in middle age.

In addition, the duration of REM sleep is shortened by exposure to radio-frequency radiation [**34**], whilst nocturnal secretion of melatonin is reduced [**35**], both of which are consistent with reports of sleep disruption[9] and concentration problems. Reduction in melatonin levels is also consistent 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[10], particularly in females.

In connection with reports of an increased incidence of seizures in some epileptic children when exposed to the emissions of GSM Base-stations, it should be remembered that exposure to a light (such as that from a stroboscope) flashing at a rate somewhere between 15-20 times per second can provoke seizures in people who suffer from photosensitive epilepsy. Visible light and microwaves are, however, simply different realisations of electromagnetic radiation, and the microwave radiation used in GSM/TETRA similarly 'flashes' (pulses) at rates that the brain is able to recognise [**29**]; in particular, the TETRA flash rate (17.6Hz) falls within the 15-20Hz photo-epileptic range. It should be noted in this connection that, unlike visible light, pulsed microwaves are *not* reliant on the eye and optic nerve to access the brain, since they can penetrate the skull *directly*.

13. Although microwave radiation is non-ionising – *i.e.* does not have enough energy to break chemical bonds, in particular in DNA – it can, nevertheless, *functionally* interfere with the processes involved in DNA replication and those underlying the natural *repair* of the DNA breakage that occurs normally, even under *non*-exposed conditions, by subtly altering molecular conformation (architecture), for example. This could

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[9] Another possible contributory factor to sleeping problems is the phenomenon of so-called 'microwave hearing', whereby people (even those who are clinically totally deaf) can discern buzzing/clicking sounds in their heads when exposed to low energy, pulsed microwaves [**36**].

[10] In this connection, the ability [**37**] of melatonin to *block* the effect of exposure to low intensity microwaves on DNA fragmentation (*see* Para.13) is particularly significant.

well account, respectively, for the reports of certain effects observed *in vitro*, such as chromosome aberrations/micronuclei formation [**38**], and for the alteration in amount of DNA fragmentation caused by (non-thermal) irradiation [**39**], although it should be noted that exposure conditions do not always conform to those of GSM. It has recently been hypothesised [**40**] that the *over*-expression (in the short-term) of heat shock proteins (HSPs) in human [**41**] (and also animal) cells exposed to GSM radiation actually inhibits natural programmed cell death (apoptosis), thereby allowing cells that should have 'committed suicide' to *continue* to live; this hypothesis[11] is currently being tested experimentally [**43**]. On the other hand, it has been suggested that *under*-expression (associated with *chronic* exposure) can adversely interfere with the natural repair of DNA breakage [**44**]. Consistent with these possibilities are the following:

a) The *in vivo* finding that exposure to pulsed GSM radiation (of an intensity comparable to that realised during mobile phone use) promotes [**45**] the development of cancer in mice that have been genetically engineered to have a predisposition to cancer.

(*b*) The 2-3-fold increase in the incidence of a rare form of tumour (*Epithelial Neuroma*) in the *periphery* of the human brain - where the penetration of the *near*-field[12] of the handset's antenna is greatest (the laterality of the tumours correlating with that of handset use) - which was found in an epidemiological study in the USA [**48**].

(*c*) The increased incidence of cancer amongst users of mobile phones of various kinds found in recently published Swedish epidemiological studies [**49**, **50**], in particular [**50**], which showed an increased incidence of brain tumours not only amongst users of the older (somewhat higher powered) analogue phones (which, having been available for a longer time, permit the effects of exposure over a rather longer period to be studied[13]), but *also* amongst (more recent) users of digital GSM phones and cordless (digital) DECT phones.

14. It is important to appreciate that the contents of Paras.12 & 13, which pertain to exposure to the emissions of GSM *handsets*, are **not** necessarily irrelevant to the consideration of the effects of exposure to the very much weaker radiation from a Base-station, since, despite the fact that the public is here exposed to the *far*-field [14](as opposed to the near-field, as is the case during Handset use) the ***informational*** content of

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[11] Another *possible* contributory factor is the increased level [**42**] of an enzyme Orthinine Decarboxylase (*ODC*) that has been found to occur under exposure to certain kinds of microwave fields (which, however, *differ* somewhat from that used in *GSM* telephony); for *ODC* has been implicated in tumour *promotion*.

[12] In the *near*-field, the extent of which is governed by the wavelength of the emitted electromagnetic field and the length of the antenna, the electric and magnetic fields are effectively decoupled, and thus propagate *independently*. Since the (decoupled) magnetic field is very much less attenuated as it passes through biomatter, than is the electric field, it is possible for the external electromagnetic field to exert an influence at a much greater distance from the surface than it can in the (opposite) far-field case (*see* Footnote 14), where, being here *strongly coupled* to the electric field, the magnetic field is effectively subject to the *same* attenuation. This influence can be both direct (*e.g.* through the coupling of the deeply penetrating magnetic field to crystals of the magnetic mineral magnetite that exist in human brain tissue [**46**]) and indirect (through the effect of the *electric* field that is *induced* in consequence of the magnetic field's variation in time.) This electric field (together with the much more superficial one arising from the *direct* penetration of the external electric field) can entail both thermal *and* **non-thermal** effects; a novel possibility of the latter (which is *not* actually contingent on aliveness) would be a coupling of the *induced* electric field to the calcite crystals that have recently been discovered [**47**] in the pineal gland (lying *deep* in the centre of the human brain), *should* they prove to be piezoelectric, like those of a similar structure (*Otoconia*) that are found in the ear.

[13] It is sometimes argued that, even in the case of analogue phones, exposure is still in its 'early days', in comparison to the much longer latency periods that are generally considered to characterise the kinds of cancers that might be promoted or initiated in certain susceptible people; it should be appreciated, however, that existing latency estimates are not necessarily relevant here, since they are based on experience under **non**-exposed conditions.

[14] In the *far*-field, the electric and magnetic fields are tightly coupled, vibrating in-phase with each other (*i.e.* both attain their maximum/ minimum values at the same time) in planes that are at right angels to one another *and* to the direction in which the radiation propagates.

the Base-station signals (*i.e.* certain low frequency 'patterns' that the brain can 'recognise', and, in turn, respond to) is *very similar* to that of the signals emitted by a GSM Handset.

15. It is essential to appreciate, in the case of non-thermal influences contingent on aliveness, that it necessarily follows (similarly to the case of exposure to bacterial infection) that **not everyone will be equally susceptible**, *even when exposed to exactly the same radiation for exactly the same length of time*. For susceptibility depends not only on the radiation, but *also* on the genetic predisposition and neurological/ physiological state of the *individual* when irradiated, such as the stability of 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 *it does **not** mean that they can be safely ignored, or that they cannot provoke adverse health reactions in **certain** people*.

The severity of any such adverse health effects will, of course, again vary from person to person, according to the robustness of their immune systems. This, in turn, undermines the extent to which the underlying non-thermal effects can be considered to be 'established', in the sense required in order for them to be eligible for consideration in safety deliberations.

More meaningful is to ask whether there is an established *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; in the case of mobile telephony, however, the authorities appear to be content to presume its *non-thermal* innocuousness ('innocence') until it is proven to be otherwise ('guilty') - when, of course, it will be too late!

16. Quite apart from their weaker immune systems, pre-adolescent children are particularly vulnerable – as recognised by the Stewart Report [**2**] - because of the increased rate at which their cells are dividing (making 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[15]. 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**.

17. The familiar ploy of citing the purported innocuousness of radio and television transmissions (to which we have been exposed for a much longer time), in an attempt to support the claim that (the much shorted duration) 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 [**51**], (*ii*) the fact that, *unlike* that used in GSM, the radiation from TV and radio transmitters is **not** *pulsed*, in particular, in patterns characterised by frequencies that the brain can recognise, and (*iii*) the beam morphologies of the different kinds of installations are quite different, so that exposures to the different sources cannot be straightforwardly, or even meaningfully, compared. Furthermore, before taking reassurance from the asserted absence of health problems amongst users of TETRA in continental Europe, it should be remembered that there it is often the much *less* biologically

[15] This is so because the 8.34Hz multi-frame repetition frequency and the 2Hz pulsing that characterises the signal from Handsets *and* Base-stations that are equipped with the energy-saving discontinuous transmission (DTX) mode (which, in the case of a Handset, becomes active when the user is *listening*) lie in the range of the alpha and delta brain-wave activities, respectively. The fact that these two particular electrical activities are continuously changing in a child until the age of about 12 years, when the delta-waves disappear and the alpha rhythm is finally stabilised, means that a child's brain must be anticipated to be *doubly* vulnerable to interference from the pulsing of a GSM handset.

active *TETRAPOL* system (as opposed to TETRA) that is used.

18. Another familiar piece of misinformation that needs to be addressed is the assertion that the emissions of a Base-station are comparable[16] to that of only a 60W light bulb [**2**], and thus equally harmless. Quite apart from the fact that a 60W light bulb *can be* harmful to a person with photo-sensitive epilepsy, if it is flashed at an appropriate rate, the comparison is solely based on intensities, and neglects three important points:

(*i*) The fact that *more* than one carrier is always emitted. Thus, the figure of 60W must be multiplied by the number of carriers that are actually transmitted in any particular case; in order to minimise inter-carrier interference, however, this number is restricted typically to 4 at the most, whence the total output wattage can be a high as 240W.

(*ii*) The beams, however, are *not* emitted uniformly in all directions, but are instead concentrated in specific directions, the degree of directional focussing being quantified through the so-called 'gain' (G) of the antenna, typical values of which, in the case of GSM, range from about 40 to 60 [**2**]. (This applies even in the case of so-called 'omni-directional' antennae, which emit beams that are omni-directional *only* in the horizontal plane; in the vertical plane, the beam *is* directionally orientated by an amount that is determined by its vertical (angular) width – typically, about 10 degrees.) Accordingly, to calculate the power density (intensity) at a distance *d* from the mast using the familiar 'inverse square law', the power, *P*, delivered by the antenna must be multiplied by the gain, *G*, whence the intensity is given by the formula: $PG/4\delta d^2$; thus in the above example with $P = 60$W and $G = 30$, the effective directionally focussed power (per single carrier) – the so-called 'isotropic radiated power (EIRP), given by the product *PG* – is 1800W, which is further increased to 7.2kW if 4 carriers are transmitted – a value that is 120 times higher than the 60W cited! The maximum EIRP value permitted by law is 1500W *per carrier*, whilst the maximum number of carriers is 16 (at 1800MHz) and 10 (at 900MHz); in practice, however, the number of carriers is usually restricted to 4 at the most, for the reason mentioned above.

(*iii*) The comparison neglects the all important frequency dimension, in particular the difference in the frequency that characterises the visible light from the light bulb from that which defines the radiation to be (invisible) *microwave* radiation. For whilst the output from such a bulb is, during the day[17], completely negligible in comparison with visible light of natural origin – *i.e.* that from the Sun – this is not so in the case of the microwave radiation emitted by a Base-station antenna day *and* night, which, several hundred of metres away, is typically **10 billion (10^{13}) times higher** than the microwave radiation that is emitted by the Sun at the same frequency. Accordingly, the emissions of telecommunication Base-stations have caused an enormous (and relatively sudden) alteration in the natural environment (at this frequency) from that in which life on Earth has, over a very much longer time, evolved. The impact of this altered environment on biology is further enhanced by the high coherence of the Base-station radiation, as already noted in Para.2.

19. 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 or near which a GSM Base-station is located. It should be stressed, however, that, to date, the apparent absence on a

[16] This value is typical only of so-called 'macro' Base-stations, the powers characterising with 'micro' installations (such as those in 'lamp post-look-alike' masts), and the even smaller 'pico' installations (such as those found in shopping malls), being significantly lower. Regrettably, there are instances of deliberate misrepresentation by some operators, who, in an attempt to allay public concern at the planning stage, have classed proposed installations as a 'micro', when in fact the power per carrier is *higher* than is permitted for such (1.6W at 1800MHz [**52**]), and, in some cases, actually exceeds that of some macro Base-stations!

[17] At night, however, this is no longer true, and exposure to a 60W light is sufficient to cause a reduction in the level of melatonin released by the pineal gland (maximum around 3am), entailing potentially serious biological consequences.

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 [**20**] of unexplained clusters of cancers in the vicinity of certain GSM Base-stations, whose non-involvement remains to be established.

The reality of such a risk to public health is not yet officially recognised, however, and those who dare to depart from the 'official' line, by warning of potential dangers to human health posed by *non-thermal influences* of the radiation used in mobile telephony, are subject to immediate criticism and derision – particularly by those with a vested interest in maintaining the growth of mobile telephony.

For 'official' standard setting bodies (such as ICNIRP) to be so confident that their *purely thermal* guidelines afford a completely adequate degree of protection is effectively to deny that, when alive, our sensitivity and vulnerability to pulsed microwave radiation are no higher than when we are dead – an attitude that betrays a total lack of appreciation of the fundamental role that electromagnetic interactions play in the biocommunication and control, particularly in the regulation and protection of bioproceses essential to life[18].

Electromagnetic interactions are *not* alien to the alive body, and non-ionising electromagnetic fields below the thermal threshold should not be treated as though they were *toxins.* Unlike the heating effect of exposure to microwaves, which can, if excessive, cause actual material damage, *non-thermal* influences act in a **more subtle way**, *via* their potentiality to interfere with biological **functionality –** in particular, it would appear, with that of bioprocesses which are intended to afford (natural) protection *against* adverse health effects of various kinds.

The international scientific community is at present deeply divided even as to the reality of non-thermal effects of the kind of radiation utilised in GSM/TETRA telecommunications, let alone as to the implication of such effects for human health. Wider acceptance of the reality and significance of non-thermal effects and their potentiality to provoke adverse health reactions in some susceptible people is clearly contingent on the prior acceptance that a *living* body has special electromagnetic sensitivities precisely because of its *aliveness*. The incorporation of this into safety guidelines requires, however, a much more holistic, integrative approach[19] than that presently used, which effectively fails to recognise the most discriminating feature of all – namely, the aliveness of the people exposed.

20. Given the failure of Safety Guidelines to address the implications for human health of non-thermal influences of exposure to GSM/TETRA radiation, particularly those allied to *aliveness*, the only responsible strategy possible at present – which at least implicitly recognises the potential hazard posed by this crucially important, but disputed, dimension of the problem – is to have recourse to a Precautionary Approach. One possibility of implementing such an approach the case of exposure to GSM Base-stations would be to require compliance with the outdoor exposure limit of 10^{-3} W/m^2 prescribed by the Salzburg Resolution [26]; in the case of TETRA, on the other hand, there is, as yet, no corresponding (empirical) maximum 'safe' exposure limit that can be invoked.

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[18] This is borne out by the emission from living systems of ultra-weak light – so-called 'biophotons' [**53**] - the intensity and coherence of which provides an external indication of the internal electromagnetic condition of the system, particularly that which is allied to health.

[19] Modalities that suggests themselves in this connection are those that can access and monitor the human bio-energy field, such as Biophoton emission [*see* Footnote 18], Gas Discharge Visualisation (GDV) [**54**] (a modality based on the Kirlian effect), which has already been used [**55**] to investigate the effect of mobile phone Handsets emissions on the bio-energy field, and a related modality known as Polycontrast Interference Photography (PIP) [**56**].

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