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THE PHYSIOLOGICAL AND ENVIRONMENTAL EFFECTS OF NON-IONISING ELECTROMAGNETIC RADIATION

Final Study

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Abstract

This Study focuses upon an aspect of how living organisms and humans in particular can be adversely affected by highly coherent electromagnetic fields of technological origin, in a way that is not entertained or addressed by existing Safety Guidelines – namely, through the possibility of non-thermal, frequency-specific influences of an informational nature. Supporting evidence is presented, and attention drawn to a disturbing consistency between some of these influences and the nature of certain adverse health effects found amongst some exposed people. On the basis of a detailed analysis of the present situation, a number of recommendations are made to promote a higher degree of electromagnetic biocompatibility between these fields and the living human organism than currently obtains.

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Directorate General for Research-Directorate A

STOA - *Scientific and Technological Options Assessment*

Options Brief and Executive Summary

PE nr. 297.574 *March 2001*

THE PHYSIOLOGICAL AND ENVIRONMENTAL EFFECTS OF NON-IONISING ELECTROMAGNETIC RADIATION

OPTIONS BRIEF

1. Policy options for the European Parliament

- the non-emergency prolonged use of mobile phones by children – and particularly pre-adolescents – be strongly discouraged, on account of their increased vulnerability to any potential adverse health effects.

- the mobile phone industry refrain from promoting prolonged use of mobile phones by children by the use of advertising tactics exploiting peer pressure and other strategies to which the young are susceptible, such as the (now discontinued) use of DISNEY character fascias on the phones.

- the mobile phone industry make it clear to the consumer that the specific absorption rate (*SAR*) - which in some countries is shortly to be declared on the handset - refers *only* to the degree to which the microwave emissions from the antenna can heat biological tissue, and is in *no way* relevant to *non-thermal* effects that the emissions from a mobile phone may have on the user.

- The efficacy of devices such as shields and ear-pieces be indicated on the basis of *biological tests*, and not solely on the reduction in *SAR* value (as determined by the use of a 'phantom' head) that their use might achieve.
  b) It be made clear to the consumer that such devices afford no protection against the low frequency pulsed magnetic field from the battery of the phone.

- concerning personal protection devices claiming to boost the immunity of the user against any adverse impacts of exposure (including those from the battery magnetic field):
  a) The efficacy of such devices be established by biological testing.
  b) Such devices not be rejected (as has occurred in certain consumer surveys that have been published) solely on the grounds that their use does not reduce *SAR*, as measured using a 'phantom' head; for this is not what they are designed to do.
  Accordingly, the *SAR* is here a *fundamentally inappropriate* measure against which to assess their efficacy.

2. Policy options for the European Commission

- Future EU-sponsored research should incorporate the following recommendations:
  a) living systems under investigation be exposed to the emissions of an actual mobile phone, rather than a 'surrogate', since the emissions have a quite different biological impact, in consequence of certain pulse frequency differences.
  b) in assessing the significance to humans of results obtained using animals, particular attention be paid to differences in exposure conditions, such as whether exposure is size-resonant, whether it is to the near or far field of the antenna, and whether whole-body or more localised exposure occurs.
  c) systematic investigation be made into the influence of different kinds of pulsing (of real phones) on the human *EEG*, and ideally on the *MEG*, and of whether any observed changes in power spectra are correlated with changes in the level of deterministic chaos.

d) use be made of novel, non-invasive technologies, such as biophoton emission, to investigate the influence of mobile phone radiation on living systems.
e) in assessing the effects of mobile phone radiation more attention be paid to lessons that have been learnt from exposure to other kinds of related radio frequency fields, such as those from the Skrunda, military and police radars.
f) in the light of reports of cattle being quite seriously adversely affected at farms where there is a base-station, a veterinary monitoring service be established to collect and analyse such reports, and raise awareness amongst farmers of this potential hazard to their livestock.

- attempts be made – perhaps under the aegis of national regulatory bodies - to increase awareness of the electromagnetic nature of living organisms and their consequent hypersensitivity to coherent, ultraweak electromagnetic signals. [Until this is achieved, the need to extend thermally-based safety guidelines, by incorporating electromagnetic biocompatibility, is unlikely to be accepted.]

3. Technological options at the operational level

Whilst the question of precisely *how* adverse health effects can be provoked by non-thermal influences of the pulsed microwave radiation currently employed in *GSM* telecommunication, as well as those from *ELF* fields associated with other technologies, is far from resolved, the circumstantial evidence consistent with such influences suggests at least two ways in which biocompatibility with this technology could be enhanced by changes involving the fields alone:

- In the case of exposure to GSM radiation, reduce intensities to the level below which no adverse effects have been empirically found in exposed populations, bearing in mind that there are indications of non-thermal thresholds for biological effects of the order of a *microwatt/cm^2.* Power densities a few *tenths* of this value are common at distances of 150-200m from a typical 15m high Base-station mast and within the range of the more localised side-lobes in the immediate vicinity of a mast - *adverse effects being reported at both locations*. Incorporating a further safety factor of 10 indicates that, at locations where there is any long-term exposure, power densities should not exceed 10 nanoW/cm^2.
[To appeal to the (alleged) absence of health problems associated with the higher power density electromagnetic fields emitted by radio/TV transmitters in an attempt to justify the retention of the present level of emission from GSM Base-stations is untenable, on at least two accounts: (i) the nature of the emissions are quite different, with respect to carrier frequencies, modes of transmission (pulsed/analogue), and beam morphology, (ii) there are health problems connected with some such transmitters, contrary to what is often claimed!]

- Ensure that there are no *ELF* frequencies – either of amplitude modulation (including pulsing, as the extreme case) of *RF* fields, or of other electric /magnetic fields - in the range of human electrical brain-wave activity, or windows of calcium efflux.

[In the case of exposure to GSM radiation, this will be achieved, to a certain extent, with the advent of the Third Generation of mobile phones (UMTS) that utilise CDMA in place of TDMA. For although any sensitivity to the microwave carrier will remain, the pulsing used in CDMA is irregular; accordingly, CDMA radiation cannot enjoy the same 'oscillatory similitude' with the human brain-wave activity and electrochemical processes as does TDMA. In consequence, however, of the somewhat higher carrier frequency used, which is closer to where water strongly absorbs microwaves, thermal effects could here become more of a problem, particularly in view of the somewhat higher powers at which they operate! The introduction of TETRA, on the other hand, gives rise to an increased level of both thermal and non-thermal concern.]

EXECUTIVE SUMMARY

A major contemporary threat to the health of Society is man-made 'electrosmog'. This non-ionising electromagnetic pollution of technological origin is particularly insidious, in that it escapes detection by the senses – a circumstance which tends to promote a rather cavalier attitude regarding personal protection. Yet the nature of the pollution is such that there is literally 'nowhere to hide'. Furthermore, given the relatively short time for which humanity has been exposed to it, we have no evolutionary immunity either against any adverse effects it might directly have on our bodies or against possible interference with natural electromagnetic processes, upon which homeostasis appears to depend, for example, the Schumann resonance – a weak electromagnetic field that oscillates resonantly in the cavity between the earth's surface and the ionosphere at frequencies close to those of human brain rhythms, isolation from which has been found to damage human health.

What distinguishes technologically produced electromagnetic fields from most natural ones is their much higher degree of ***coherence***. This means that their frequencies are particularly well-defined, and therefore more easily discerned by living organisms, including humans. This greatly increases their biological potency, and 'opens the door' to the possibility of frequency-specific, *non-thermal* influences of various kinds, against which existing Safety Guidelines – such as those issued by the International Commission for Non-ionising Radiation Protection (*ICNIRP*) - afford no protection.

The Safety Guidelines are based solely on consideration of the ability of radio frequency (*RF*) and microwave radiation to heat tissue, and of extremely low frequency (*ELF*) magnetic fields to induce circulating electric currents in the interior of the body, both of which are known to be damaging to health, if excessive. Since the severity of these effects increases with the strength (intensity) of the fields in question, it is this that the Guidelines restrict, the frequency of the fields being taken into account *only* in so far as it affects (through 'size' resonance effects) the ability of the organism to absorb energy from the irradiating field and heat up accordingly.

The Guidelines thus do not protect against adverse health effects provoked *primarily* and *specifically* through influences that the *frequency* of the fields might have on the human body.

A necessary condition for such an influence is the existence in the organism of the biological counterpart of an electrically tuned circuit – *i.e.* an endogenous oscillatory electrical activity.

In this case the organism will respond - in a way akin to a radio - if the frequency of the external field (either of the carrier wave, or of lower frequency amplitude modulations/ pulsings) matches or is close to that of its tuned circuit.

This could result in either an undesirably high resonant amplification of, or damaging interference with, the associated endogenous biological activity.

These influences can be considered to arise from a transfer of *information* (in a generalised sense) from the field to a living organism, in that the organism is able, through this kind of 'oscillatory similitude', to recognise – and in turn respond to – a feature of the external field *other than* its intensity.

Equally important is that the external electromagnetic fields be sufficiently coherent to be discernible by the body against the level of its own incoherent thermal emission at physiological temperatures. Whilst this is usually the case, it should be noted that since the radiation is not perfectly coherent, the occurrence of non-thermal effects is still contingent upon a certain minimum intensity threshold, the magnitude of which is, however, well below that at which any discernible heating occurs.

A good example of such an 'informational', frequency-specific, non-thermal electromagnetic influence on the living organism is the ability of a light flashing at a certain rate to trigger seizures in people suffering from photosensitive epilepsy. This is primarily due, not to the brightness (intensity) of the light, but rather to the frequency of the flash – which, if close to the frequency of the electrical brain activity involved in epileptic seizures, can trigger their occurrence - *i.e*. the phenomenon is primarily a frequency-specific effect of information transfer from the light to the brain, the brain being able to 'recognise' the light by the rate at which it flashes.

Existing intensity-based Safety Guidelines (relating to the visible part of the electromagnetic spectrum) afford no protection against such a non-thermal effect, unless set so low that the light is not visible!

Some oscillatory endogenous electrical activities of the living human body are quite familiar - such as those of the heart and brain, which can be monitored by an electrocardiogram and electroencephalogram, respectively. Equally familiar is the circadian rhythm.

Others, - such as the coherent electrical excitations at the cellular level whose frequencies typically lie in the *microwave* region of the electromagnetic spectrum, and those pertaining to crucially important biochemical activities, involving, for example, the transport of calcium ions across cell membranes - are somewhat less well-known.

Until the frequency/information dimension of *non-visible* electromagnetic radiation (microwaves and other non-propagating electric and magnetic fields such as those from overhead power lines) - is recognised *in its own right*, these fields will constitute a potential threat to all living organisms.

Since electromagnetic fields are indispensable to technology that Society is reluctant to abandon, more comprehensive protection should be developed. As explained, we are currently vulnerable to adverse health effects that might be

provoked by non-thermal effects of the frequency dimension, which escapes regulation by the existing intensity-based Safety Guidelines.

Unlike intensity, the frequency aspect of the problem cannot be addressed without interfering with the frequency characteristics and informational content of the aggressing field (the integrity of which must, of course, be maintained in communication technologies, such as *GSM* telephony). We need therefore to consider strategies that do not target the field, but rather the person being irradiated, and devise ways to provide a higher degree of immunity than at present.

Such strategies are currently under development, and a number of related protection devices are already available commercially, although often their efficacy has not always been adequately demonstrated. (There is an obvious parallel here with the pharmacological strategy of attempting to protect against bacterial infection by taking vitamin *C*, for example, to fortify the immune system, rather than wearing a protective mask to simply reduce the intensity of the bacterial field to which the person is exposed.)

The competence of existing Safety Guidelines could be broadened by extending the familiar consideration of electromagnetic compatibility (*EMC*) between electromagnetic radiation and electronic instrumentation *to the living human organism*, as an electromagnetic instrument itself, *par excellence*. An ambitious programme of **electromagnetic biocompatibility** is an important task for the 21st century, and one that is shirked only at our peril.

There is currently much public concern over possible adverse health effects provoked by long or short term exposure to electrosmog. This concern focuses especially on overhead power lines and *GSM* telephony. Quite justifiably, the public remains sceptical of attempts at reassurance by government and industry, particularly given the unethical way in which they often operate symbiotically so as to promote vested interests, often under the brokerage of the regulatory bodies whose function it supposedly is to ensure that the safety of the public is *not* compromised by electromagnetic exposure!

Given recent experience with official duplicity over *BSE/CJD* – with the initial assurances of no risk and subsequent revelations of cover-ups - the public is now understandably wary of safety assurances from 'official' government scientific sources w.r.t. electromagnetic pollution. This scepticism is enhanced when views contrary to official perceived wisdom is, at worst silenced or, at best, studiously ignored.

Public scepticism is further exacerbated by reports of research supported financially by the Mobile Phone Industry and of its attempts to 'persuade' those whose findings might damage market development *to actually alter their results* to make them more 'market friendly'.

There is currently an attempt (under the aegis of the World Health Organisation) to globally 'harmonise' exposure standards, by persuading countries with more stringent limits – such as Russia and China - to relax them in favour of the higher levels tolerated in the West.

It can be no coincidence that in Russia, where the frequency-specific sensitivity of living organisms to ultra-low intensity microwave radiation was first discovered over 30 years ago, that the exposure guidelines (even if applied in theory, rather than in practice) are still 100 times more stringent that those of *ICNIRP*!

There is a regrettable tendency to attribute market–friendly research a greater significance, publicity and profile than non-market friendly research, which suggest the possibility of adverse health impacts. An example of this is provided by the recent publication of a USA epidemiological study, in which the statistically significant finding of an elevated risk amongst users of mobile phones of the incidence of a rare kind of tumour (epithelial neuroma) in the periphery of the brain – *precisely where there is maximum penetration of radiation from the mobile phone* (the laterality of which also correlated with phone usage) - was glossed over and completely escaped the attention of the media, who focused instead on the finding that there was no *overall* increase in the incidence of brain tumours amongst mobile phone users.

The mainstream scientific approach to assessing the harm of human exposure to electromagnetic fields is guided by an essentially *linear* perception, which might well be adequate to deal with thermal effects, but is inappropriate for realistic consideration of the non-thermal, frequency-specific vulnerability of the living organism to the rather coherent electromagnetic fields.

In contrast to thermal effects, non-thermal influence necessarily depends on the state of the organism when it is exposed.This of course varies not only between *different* individuals, but also for the *same* individual, depending on his/her condition at the time of exposure – *i.e.* such

influences are inherently *non*-linear in nature. As such, they often appear bizarre from a linear standpoint. In addition, difficulties in independently replicating in experiments tends to lead to their dismissal.

Attempts to address a problem that is inherently non-linear from a linear perspective only exacerbate things: outdated knowledge is worse than ignorance - at least the ignorant know what they do not know!

In the case of the mobile phone issue, not only has there been a reluctance on the part of official bodies to grasp this non-linear 'nettle', but a lamentable failure to pay attention to indications of the harm to humans and animals caused by exposure to pulsed microwave fields of sub-thermal intensity that have been long available from experience with microwave installations (not least military ones) similar to those used in *GSM* telephony.

It is not so much that, in the haste to make this new and valuable technology available, the necessary safety research has been bypassed or compromised, but rather - and more reprehensibly - that already available indications that the technology is potentially less than safe have been, and continue to be, *studiously ignored*, both by the industry and by national and international regulatory bodies.

A good example of this is afforded by the conduct of the UK National Radiological Protection Board, which was 'unable' to provide the Independent Expert Group on Mobile Phones (*IEGMP*) - for whom they were acting as the Secretariat - with certain highly relevant published papers, on the grounds that they could not 'find' them, despite having been provided with the full references by at least two individuals who gave evidence to the *IEGMP*, and curiously having had no difficulty in providing less significant papers from the *same issue* of the journal!

The concern of the public is thus not unfounded, and the irony of the present situation w.r.t mobile phones and base-stations is that current Safety Guidelines afford greater protection to electronic instrumentation than they do to human beings!

There is a lack of expert consensus on the significance and credibility of research into biological effects of GSM-type radiation and possible adverse health reactions in susceptible people (despite many consistent, anecdotal positive reports).

It is probably true to say that if the same lack of concensus and level of concern surrounded a new drug or foodstuff, it would never be licensed.

Of particular concern to the public – and generating the most outrage – is the involuntary subjection of certain groups of the population 24 hours/day, 7 days/week to the emissions of *GSM* base-stations, when they are insensitively sited near to homes, schools and hospitals. The environment of these people is permanently and unavoidably polluted.This is a totally unacceptable state of affairs, which raises serious ethical questions, and arguably contravenes the Nuremberg Code, in that it is these people who will eventually reveal the degree to which chronic exposure to such fields is noxious – information that *is* ***not*** *currently available*: in other words, they are effectively involuntary subjects in a mass experiment.

This study offers a perspective on the potential implications for human health of exposure to the pulsed microwave radiation currently used in *GSM* telephony, which differs somewhat from that currently espoused by mainstream science, but one that provides a much more holistic insight into the essential elements of the problem.

Of particular importance is the emphasis given to (*i*) the fact that electromagnetic fields are not alien to living organisms, but play a crucial role in controlling and maintaining their orderly functions – *i.e*. that a living organism is an electromagnetic instrument of great and exquisite sensitivity.
(*ii*) the subjectiveness of human vulnerability, which necessarily follows from the inherently non-linear nature of the problem, which is here recognised *ab initio,* and
(*iii*) the presence of *ELF* features both in the microwave pulses emitted by the antenna of a mobile phone *and* in the (much more penetrating) magnetic field associated with the surges of electric current from the battery of the handset, which are necessary for the generation of the microwave pulses.

Indeed, it is here suggested that it is precisely through the presence of these *ELF* features that the emissions of a *GSM* phone and other related communication technologies, such as *TETRA*, can influence brain function - notably, its electromagnetic activity (brain-waves), its electrochemistry (including that of the neuroendocrine system, particularly with respect to melatonin levels) and the permeability of the blood-brain barrier, as well as altering cellular

calcium ion concentrations. It is possible that this latter effect is only one particular facet of a more general disruptive influence that *ELF* fields can have on the integrity of essential ion-protein links (as suggested by recent Russian work) - an influence that could well be relevant also to consideration of bio-negative influences of exposure to *other* kinds of electromagnetic fields, such the low frequency magnetic fields associated with power lines and the mains appliances that they supply, which have been the subject of controversy for a much longer time.

The Study is structured as follows. Attention is first drawn to the irrationality of the current situation that effectively affords – through electromagnetic compatibility regulations (*EMC*) - electronic instrumentation a higher level of protection against *GSM* radiation, for example, than do existing Safety Guidelines governing human exposure, which protect only against adverse health effects attributable to excessive heating, and not against those that might be provoked in some people by the radiation's *non-thermal*, frequency-specific interference with endogenous electromagnetic activities essential for homeostasis.

To appreciate this more fully, the study explains why *GSM* signals are bio-active, and gives numerous examples of frequency specific, non-thermal biological influences that the kind of radiation currently used in *GSM* telephony can exert on living organisms, including humans.

Difficulties sometimes experienced in independent attempts to replicate these effects - which are frequently used to discredit positive results, and to dismiss them as artefacts of the particular experimental protocols used - are addressed, and possible reasons for discrepant results identified. The relevance to humans of findings obtained using animals, such as rats - which can be subject to exposure conditions that are quite different from those experienced during mobile phone use – is discussed and, in the case of human studies, the importance of exposing the subjects to the emissions of a real mobile phone, rather than a 'surrogate', as is often done, is stressed. Attention is then focused on the reality of adverse health impacts of both human and animal exposure to *GSM* and similar radiation, including that from military sources.

Although the occurrence of non-thermal influences *per se* does not, of course, necessarily entail adverse consequences for human health, growing indications of a consistency between some of the published non-thermal effects of *GSM* radiation and the nature of certain reported adverse health effects, is cause for concern - particularly the recent reports of an increased incidence in a rare kind of brain tumour (notwithstanding the relatively short exposure time in comparison with typical latency periods), which is consistent with the genotoxicity of the radiation.

Reasons why children must be considered potentially more at risk are identified, and arguably the most significant point - namely that *not everyone* is necessarily adversely affected - is addressed, as also are the implications of this on the validity of the familiar claim that there are no established adverse health effects of exposure to *GSM* radiation, provided its intensity conforms to the limits set by existing Safety Guidelines, which, it is argued, neglect the most discriminating feature of all – the fact that the object exposed is *alive.*

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Part B: ARGUMENTS and EVIDENCE

B-1. Introduction: Electromagnetic Compatibility and Electromagnetic Bio-incompatibility

The importance of ensuring compatibility between activated electronic instrumentation of various kinds and the pulsed microwave radiation currently used in *GSM* mobile telephony is well recognised and generally accepted. Prohibition of the use of cellular phones on aircraft and in hospitals, on the grounds that their emissions might adversely interfere with the operation of sensitive electronic equipment, is familiar, and their possible deleterious effect on personal medical devices, such as heart pacemakers, hearing aids, defibrillators and insulin pumps has been the subject of a number of published scientific studies in recent years. Given that it is inconceivable - at least in the case of aviation and hospital equipment - that the interference could arise from the heating effect of the radiation, some other, *non-thermal*, influence of the radiation must here (at least tacitly) be considered to be responsible. Unfortunately, however, the same considerations do not currently extend to the alive human organism, which is generally considered to be immune from adverse influences of *GSM* radiation, on account of its intensity[1] being far too low to cause any deleterious degree of body tissue heating, as quantified through the so-called specific absorption rate, or *SAR* - the rate at which the external electromagnetic field deposits energy in unit mass of the body, averaged over a certain period of time; for, contrary to case of electronic instrumentation, it is generally believed that for *humans* adverse effects can arise only from excessive heating. Indeed, this belief is reflected in the relative leniency of the Safety Guidelines[2] issued by the International Commission for Non-ionising Radiation Protection (*ICNIRP*), which permit humans to be exposed to electric fields that are *over ten times stronger* than the limit of 3V/m limit that is applicable to all electronic goods offered for sale in *EU* under current *EMC* legislation. on electromagnetic compatibility (*EMC*).

Despite the prevalence of this attitude - particularly amongst the various Regulatory Bodies, both national and international - it is not one that is universally held[3], and the debate over the potential noxiousness of *GSM* radiation continues at both professional and public levels. What is so disturbing is if the same level of concern and uncertainty obtained in the case of a new food or drug, they would almost certainly never be licensed.

A good example of the prevailing disregard for what might be termed 'electromagnetic biocompatibility' is the development of *TETRA* (**T**rans **E**uropean/or **T**errestrial **E**nhanced **T**runked **R**adio **A**ccess), which operates at somewhat higher powers than does *GSM*, and over a much wider range of microwave carrier frequencies. Most disturbing, however, is the fact that the basic frame repetition rate is here 17.6Hz. For this frequency (which lies in the range of beta brain-wave activity) is close both to that at which a flashing visible light can provoke seizures in people with photosensitive epilepsy[4], and to the modulation frequency at which there is a maximum in the expression of calcium ions from brain cells when they are irradiated with amplitude modulated, low intensity *RF* radiation over a wide range of carrier frequencies[5-7]; it should be remembered that these ions play a crucial role in inter-cellular communication, any interference with which could well undermine the integrity of the whole nervous system, although the extent to which this actually occurs is, at present uncertain, owing to a lack of the necessary research. Furthermore, in consequence of the lower frequency band assigned to the emergency services (380MHz - 400MHz), the penetration of the radiation is here much greater than it is with *GSM*, facilitating its deeper access into the brain directly through the skull.

B-2. Why *GSM* Signals are Bio-active

That the low intensity, pulsed microwave radiation currently used in *GSM* telephony can exert subtle, non-thermal influences on the alive human organism arises, in the first place, because microwaves are, after all, *waves*, and, as such, have properties other than solely intensity. In particular, *GSM* radiation has certain rather well defined frequencies, which facilitate its discernment by the living organism, and *via* which the organism can, in turn, be affected. This is so because the *alive* human organism itself supports a variety of oscillatory electrical biological activities, each characterised by a particular frequency, ***some of which happen to be close to those used in GSM!***

The particular frequencies utilised in *GSM* that must be anticipated to be particularly 'bio-active' are those of the microwave carrier (900/1800 MHz) and those associated with certain pulsings that characterise the signal employed in the Time Division Multiple Access (*TDMA*) strategy that is used in *GSM* - specifically, the *multi*-frame repetition rate of 8.34Hz, and the 2Hz periodicity associated with the discontinuous transmission (*DTX*) mode of the phone – an energy saving mode that becomes active when the user is listening but not speaking. For there is evidence[8] that adequately metabolising systems themselves support highly organised, oscillatory electrical activities at the cellular level, whose frequencies generally lie in the **microwave** band, in terms of which the dramatic effects of ultra-low intensity microwaves of specific frequencies on processes as fundamental as cell division and intercellular communication can be understood in a rather natural way[9]. It should be noted that this endogenous microwave activity is a quite general (non-equilibrium) prediction of modern, non-linear biophysics[10] for living systems, under appropriate metabolic conditions.

The two *ELF*s (at 8.34Hz and 2Hz), on the other hand, correspond to those found in the human *EEG* - specifically, in the ranges of the alpha and delta brain-waves, respectively.

In the case of a *GSM* mobile phone, these two *ELF*s are reinforced by those of the essentially unscreenable **magnetic** fields associated with the current surges from the battery of the phone that are necessary in order to endow the microwave emission with the pulse characteristics required for *TDMA*. Peak magnetic field strengths as high as 40μT have been measured near the back of one particular model of phone[11, 12], the noxiousness of which is indicated by recent experiments[13, 14] employing chick embryos, which reveal an *increased* degree of mortality when the phone is protected by a proprietary shielding device that reduces the microwave output. With the device in place, the increased (microwave) power output necessary to maintain contact with the base-station necessitates stronger surges of current, associated with which are correspondingly stronger (and evidently more noxious) *ELF* magnetic fields. These *ELF* **magnetic** fields could thus pose an even greater hazard to human health than do those associated with the microwave emission, a matter that warrants further experimental investigation. In this connection, mention should be made of recent theoretical advances[15] in understanding, at the quantum level, the disruptive influence that *ELF* fields (including pulsed ones) can have on the integrity of essential *ion-protein links*, resulting in an imbalance of intra and inter cellular ion concentrations; this can result in metabolism malfunction and high levels of stress that can be lethal to organisms in the early stages of development. It should be noted these ideas are also relevant to consideration of bio-negative influences of exposure to *other* kinds of electromagnetic fields, such the low frequency magnetic fields associated with power lines and the mains appliances that they supply, which have been the subject of controversy for a much longer time.

B-3. Indications of Non-thermal influences of Microwave Radiation, including GSM

3.1 *In vitro* and *in vivo* evidence

Much experimental evidence of non-thermal influences of microwave radiation on living systems has been published in the peer reviewed, scientific literature during the last 30 years – relating both to *in vitro* and *in vivo* studies - including some obtained more recently under exposure to radiation both from a real *GSM* phone; most often, however, an experimental 'surrogate' microwave generator is used, the emissions of which can differ in certain important ways, the importance of which is not generally recognised (*see* **Section B-3.3**). It should also be appreciated that the fields to which the investigative systems are exposed in some of the earlier work are even farther removed from *GSM*, both with respect carrier frequency, as well as CW/pulsed differences. A selection of some *in vitro* studies is given below in Table I.

Table I

Epileptic activity in rat brain slices in conjunction with certain drugs[16]
Resonant enhancement of cell division in the yeast, *Saccharomyces cerevisiae*[17],
Resonant effect on the genome conformation of *Escherichia coli* cells[18]
Synchronisation of cell division in the yeast *Saccharomyces carlsbergensis*[19] and in *E. coli*[20]
'Switch-on' of certain epigenetic processes, such as λ-phage[21, 22] and colicin synthesis[23]
Alteration in the activity of the enzyme orthinine decarboxylase (*ODC*)[24-26]
Reduced efficiency of lymphocyte cytoxicity[27, 28]
Increased permeability of the erythrocyte membrane[29, 30]
Effects on brain electrochemistry (calcium efflux)[5-7]
Increase of chromosome aberrations and micronuclei in human blood lymphocytes[31]
Synergistic effects with cancer promoting drugs such as phorbol ester[32]

In vivo evidence of non-thermal influences, mainly under exposure to actual GSM phone radiation, comes predominantly from animal studies, some of which are summarised in Table II:

Table II

Epileptiform activity in rats, in conjunction with certain drugs[33]
Depression of chicken immune systems (melatonin, corticosterone and IgG levels)[13, 14]
Increase in chick embryo mortality[13, 14]
Increased permeability of the blood-brain in rats[34, 35]
Effects on brain dopamine/ opiate electrochemistry [36]
Increases in *DNA* single and double strand breaks in rat brain[37, 38]
Promotion of lymphomas in transgenic mice[39]
Synergistic effects with certain psychoactive drugs[40]
Stressful effects in healthy and tumour bearing mice[41]
Neurogenetic effects and micronuclei formation in peritoneal macrophages in mice[41]

Human *in vivo* studies, under *GSM* or similar conditions, include:

> ***1***) Effects on the human *EEG*, specifically, a delayed increase in spectral power density particularly in the alpha band[42], which has been corroborated[43] in the awake *EEG* of adults exposed to *GSM* radiation. Influences on the asleep *EEG* have been reported, including a shortening of rapid eye movement (*REM*) sleep[44] (with possible adverse effects on learning) during which the power density in the alpha band again increases, and effects on non-*REM* sleep[45]. Exposure to mobile phone radiation also causes a significant decrease in the preparatory slow potentials in certain regions of the brain[46, 47], and affects memory tasks[48-50].
>
> ***2***) Observation of an increase in resting blood pressure during exposure[51].
>
> ***3***) Observation of an increase in the concentration of nitric oxide in exhaled air correlated with mobile phone use, indicative of an elevated level of stress and inflammation[52].
>
> ***4***) The established efficacy of Microwave Resonance Therapy[53, 54] – *i.e.* the possibility of restoring homeostasis in a wide variety of human pathological conditions by ultra-weak microwave irradiation at specific frequencies under carefully controlled clinical conditions - otherwise known as 'quantum medicine', in view of the fact that such low intensities are used that individual quanta are involved. The existence of such positive effects of microwave irradiation makes it difficult to argue that such radiation can not have the opposite effect – *i.e.* a bio-negative one – when applied indiscriminately, and at higher intensities – in much the same way that the therapeutically beneficial effect of pharmaceutical drugs does not preclude the possibility of allergic drug reactions or, indeed, drug abuse.

Although, apart from in the latter case, the power density of the radiation used in these experiments is typically that found at the head when using a mobile phone, and thus much higher than that found in publicly accessible areas in the vicinity of a base-station, the *information* content of the radiation emitted by the latter is the same; accordingly, these results are *not* irrelevant to the consideration of potential adverse health effects associated with chronic exposure to base-station radiation.

3.2 Difficulties in replication

It should be noted that difficulties sometimes experienced in attempts to independently replicate certain frequency-specific non-thermal effects are *actually to be expected.* For in consequence of the highly non-linear, non-equilibrium nature of living systems, even the slightest differences in the physiological state of the biosystems used, and in the conditions obtaining in a particular experiment can, in consequence of deterministic chaos, assume singular importance[55].

Quite apart from this problem, however, discrepant results can often be traced to certain differences in experimental protocols that only become apparent upon close scrutiny. Examples of this can be found in the attempt[56] to replicate the resonant influence of centimetre microwaves of sub-thermal intensity on cell division in the yeast *S. cerevisiae* found by Grundler *et al.*[17], and the attempt by Malyapa *et al.*[57] to replicate the increase in *DNA* breakage under low intensity microwave irradiation found by Lai and Singh[37, 38].

In the case of the yeast experiments, several features can be identified that could well account for the differing results, such as differences in the phase of the cell cycle at which exposure occurred, the use of synchronised cells in one experiment but not in the other, and differences in the imaging systems used (real-time *vs.* non-time lapse) to monitor cell division.

In the case of the *DNA* experiments, whilst both groups used microwave radiation of the same frequency, they irradiated different systems (live rats *vs.* a cell line), and used very different assays to assess the *DNA* damage; in addition, the replication attempt did not separate the (positively charged) bound protein from the (negatively charged) *DNA* strands, thus obtaining much less migration in the electrophoresis field, which was also applied for a much shorter time than in the original experiment; both these features militate against the formation of the 'comet' tails used to assess the degree of fragmentation.

3.3 Relevance of experiments to conditions realised in actual mobile phone usage

Quite apart from possible differences in the physiological states of the animals used in the original an replication experiments, it should not be overlooked that differences in irradiation conditions can also contribute to difficulties in achieving replication; in addition, they can also be a confounding factor in assessing the relevance of positive animal results to humans (as also, incidentally, can differences in the ratio of the duration of irradiation to the lifetime of the species in question.) Thus, for example, whereas, for humans, *whole-body* exposure is realised arise only in the case of a base-station, where 'far-field' conditions obtain, this is not necessarily so for animals, which, depending on their size, can be whole-body exposed to the *near*-field of a 900MHz phone antenna (or its experimental surrogate), the characteristics of which are quite different. In the case of humans, by contrast, use of a phone primarily results only in a rather *localised* exposure to the near-field of the antenna. A further factor to be remembered is that in many experiments, subjects are not exposed to the actual emission of an real *GSM* mobile phone, but rather to that of a 'surrogate' microwave generator whose the output can differ in certain crucial ways. For example, it may not even be pulsed, and even if it *does* so at the *GSM* frame repetition rate (217Hz), it most probably will **not** contain the (bioactive) *multi-frame* frequency of 8.34Hz, and certainly not the 2Hz that characterises the *DTX* mode.

B-4. Indications of Non-thermal Adverse Health Impacts of Exposure to GSM and similar microwave radiation

The popular belief that adverse health effects can be induced only by the heating effect of *GSM* radiation is a fallacy:

1. There is rather consistent empirical, anecdotal evidence from many countries that the health of some people *is* adversely affected in various ways when they are exposed to this kind of radiation, despite its intensity being ***well below*** existing safety limits based on consideration of the *SAR*. It should be stressed that the *anecdotal* nature of many of the reported health problems – such as headache, sleep disruption, impairment of short term memory, nose bleeds and, more seriously, an increase in the frequency of seizures in some children already suffering from epilepsy - does **not** constitute grounds for dismissing them out of hand, as is so often advocated. For given the paucity, to date, of systematic epidemiological studies pertaining to this relatively recently introduced

technology, such reports are an indispensable source of information – a point acknowledged in last year's Report[58] of the *UK* Commons' Select Committee, dealing with the question of mobile phones and health.

2. More disturbingly, not withstanding the absence of any *overall* increase in the incidence of brain tumours amongst users of mobile phones (mainly analogue ones, it should be emphasised), a statistically significant increase (by a factor of between 2 and 3) in the incidence of a rather rare kind of tumour (epithelial neuroma) in the periphery of the brain - *where the radiation has the greatest access* - the laterality of which correlates with mobile phone use, has been found[59] in an epidemiological study in the USA, as part of the *WTR* Programme[60].

3. There is documented evidence [61, 62] that long-term (involuntary) exposure to microwave radiation of intensities intermediate between that realised near an active phone and that found in the vicinity of a base-station (but at somewhat different carrier frequencies than used in *GSM*) *does* causes serious illness, such as leukaemia and lymphoma, in certain exposed people. This is the conclusion reached by a relatively recent reanalysis of the Lilienfeld report on the Moscow *US* Embassy irradiation during the 'cold' war, based on information that only became fully available following the Freedom of Information Act, which reveals that the original verdict of no serious health effects was, in fact, a sanitised version of Lilienfeld's findings, in which his statements of concern had been deliberately removed by the State Department.

4. A *US* Defence Intelligence Agency document[63] dated March 1976, reviewing Soviet work on biological effects of non-thermal exposure to microwave and radiofrequency radiation makes interesting, but disturbing, reading. For not only have many of the effects there reported now been found in the case of exposure to *GSM* telephony radiation, but the following extract (which, incidentally, was eventually also removed) reveals a less known 'dark side' of the issue that is consistent with the Moscow Embassy affair, and one that presaged – as it turned out - the subsequent deployment of this kind of radiation in psychotonics and other forms of non-lethal microwave weaponry:

> *'The potential for the development of a number of antipersonnel applications is suggested by the research published in the USSR, East Europe and the West. Sounds and possibly even words which appear to be originating intracranially can be induced by signal modulation at very low average power densities. Combinations of frequencies and other signal characteristics to produce other neurological effects may be feasible in several years. The possibility of inducing metabolic disorders also suggested. Animal experiments reported in the open literature have demonstrated the use of low level microwave signals to produce death by heart seizure or by neurological pathologies resulting from breaching of the blood-brain barrier'.*

5. An invaluable indicator of the potential noxiousness of the pulsed microwave fields emitted by base-stations is the increasing number of reports - some published, some as yet anecdotal - of adverse effects on the health and well-being of various animal species, specifically cattle, dogs, birds and bees. In the case of the affected cattle reported in one particular study[64], the cattle (which were found to line up, all facing away from the mast) displayed a variety of problems, including severely reduced

milk yields, emaciation, spontaneous abortions, and still births. Especially relevant are the following facts: (*i*) the condition of the cattle was found to improve dramatically when they were removed to pastures well away from the mast, only to deteriorate again once they were brought back, (*ii*) the adverse effects appeared only *after GSM* microwave antennae had been erected on a tower that had formerly been used to transmit only (analogue) TV and radio signals, associated with which there had, in this case, been *no* evident health problems. It should be noted that this is not an isolated occurrence, similar problems with cattle being reported from elsewhere[65]. In the case of domestic canine pets, there are a number of anecdotal reports of their immune systems being adversely affected, again in a *reversible* way. Finally, there are reports of declines in bird and bee populations following the commissioning of new base-station masts.

It should be noted that the occurrence of adverse effects in *animals* is particularly significant, in that it indicates that the effects are real, and not psychosomatical, as is often claimed, in the case of humans exposure, by those who maintain that base-station radiation is harmless. Furthermore, given that animals are often more highly electrosensitive than are humans, the serious nature of the health problems they have manifested over such a relatively short period of time could well portend a correspondingly serious noxiousness in the case of *long*-term exposure of humans, and constitute a valuable early-warning system, similar to the 'canary down the mine'!

6. It is of interest, and probably highly significant, to note that some of the *same* symptoms have been reported in epidemiological studies (involving animals and plant life, in addition to humans), connected, not with mobile phone base-stations, but with *other* kinds of installations operating at somewhat lower frequencies - specifically, a Short-wave radio transmitter[66], and a radar[67], the latter being at 154-162MHz, with a pulse repetition frequency of 24.4Hz - at locations where the intensity of the emitted radiation is *comparable* to that typically found at 150m from a base-station. Additional effects include:

i) Depressed nocturnal melatonin levels in cattle[66].

ii) Less developed memory and attention span (as well as decreased endurance of their neuromuscular apparatus) of children[68] living within a 20km radius of the radar, subject to a maximum exposure of 0.039μW/cm^2.

iii) A six-fold increase in chromosome damage in cows[69] exposed to a likely maximum intensity of 0.1μW/cm^2.

(The cited field intensities are estimated from information on the electric field intensity as a function of distance from the radar installation, given in Ref. **70**.)

In each case, the unexposed population to the rear of the beams constituted the control group.

7. At somewhat higher intensities, but still well below the exposure limits permitted by the *ICNIRP* Guidelines, is a 2-fold increase in the incidence of cancer amongst Polish military personnel, which has been revealed by a long term, on-going study[71].

With respect to the apparent absence to date of such serious, life-threatening adverse effects in the case of human exposure to *GSM* base-station radiation, it should be noted that this is no guarantee of

immunity against *long-term* (or chronic) exposure. For exposure to this kind of radiation is still in its 'early days' in comparison to the much longer (10-15 years) latency period of the kinds of cancers that might be initiated or promoted in certain people.

Partly responsible for the reluctance to accept the reality of the underlying non-thermal effects is not only their often counter-intuitive nature - as exemplified, for instance, by the fact that they often become more marked as the strength of the irradiating field *decreases* - but also the difficulties sometimes experienced in attempts to replicate them, as already mentioned in **Section 3.2**. On the other hand, the equal reluctance to accept that they can provoke adverse health reactions in some people can be attributed - at least in part - to a general lack of appreciation that electromagnetic fields are **not alien** to an alive organism, but actually play a rather fundamental and integral role in its organisation and control, from the cellular level upwards[72-74] - *i.e.* that an alive organism is *itself* an electromagnetic instrument of great and exquisite sensitivity, and, as such, is just as vulnerable to being deleteriously interfered with (non-thermally) by external electromagnetic fields as is an activated piece of electronic equipment, (although in the latter case the influence of a given field is always the *same*, unlike the situation with an alive organism.)

B-5. From Non-thermal Effects to Adverse Health Effects

The hypersensitivity of the alive human organism to ultraweak microwave radiation is reflected in the ways in which this kind of radiation has been found to affect a wide variety of brain functions, as already noted in **Section B-3.1** - such as electrical activity (*EEG*)[42-50], electrochemistry[5-7, 24-26, 36], and the permeability of the blood/brain barrier[34, 35] - and to degrade the immune system[13, 14, 27, 28]. Although these effects do not necessarily entail adverse health consequences, there is an undeniable *consistency*[75] between some of these non-thermal influences and the nature of many of the health problems reported, such as headache, sleep disruption, impairment of short term memory, and, more seriously, significant increases in the frequency of seizures in some epileptic children when exposed to base-station radiation, and of brain tumours amongst users of mobile phones; it must, however, be admitted that precisely *how* these influences actually provoke adverse health reactions is at present unclear. Thus, the reports of:

> ***a***) Headache are consistent with the fact that microwaves are known to non-thermally affect the dopamine–opiate system of the brain[36] and to increase the permeability of the blood-brain barrier[34-35], since both of these have been medically connected with headache[77-82].
>
> ***b***) Sleep disruption are consistent with the effect of *GSM* radiation on rapid eye movement (*REM)* sleep[44] and on melatonin levels[13, 14] - the latter being found also epidemiologically, in the case of *RF* exposure[66].
>
> ***c***) Memory impairment is consistent with the finding that microwave radiation targets the hippocampus[16].
>
> ***d***) Since there is no reason to suppose that the seizure inducing ability of a flashing *visible* light does not extend[83] to (invisible) ***microwave radiation*** (which can access the brain directly through the skull) flashing at a similarly low frequency, together with the fact that exposure to this kind of radiation is *known* to induce epileptic activity in certain animals[33],

reports[84] of *increased* seizure activity in some children that already suffer from epilepsy are perhaps not surprising.

e) The statistically significant increase in the incidence of amongst users of mobile phones in the incidence of epithelial neuroma is consistent both with the *genotoxicity* of low intensity microwave radiation, as indicated by the increased number[37-38] of *DNA* strand breaks[85], the formation of chromosome aberrations and micronuclei in human blood[31] (the latter being corroborated in the case of *GSM* radiation by the *WTR* Programme[60]), and with the *promotional* effect of *GSM* radiation in the case of transgenic mice that had been genetically engineered to have a predisposition to develop cancer[39].

B-6. The Increased Vulnerability of Pre-adolescent Children

Pre-adolescent children can be expected to be (potentially) more at risk than are adults - as recognised in the recently published Report[86] of the UK Independent Expert Group on Mobile Phones - for the following reasons:

i) Absorption of microwaves of the frequency used in mobile telephony is greatest[87] in an object about the size of a child's head – the so-called 'head resonance' – whilst, in consequence of the thinner skull of a child, the penetration of the radiation into the brain is greater than in an adult.

ii) The still developing nervous system and associated brain-wave activity in a child (and particularly one that is epileptic) are more vulnerable to aggression by the pulses of microwaves used in *GSM* than is the case with a mature adult. This is because the multi-frame repetition frequency of 8.34Hz and the 2Hz pulsing that characterises the signal from a phone equipped with discontinuous transmission (*DTX*), lie in the range of the *alpha* and *delta* brain wave activities, respectively. The fact that these *two* particular electrical activities are constantly 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 they must *both* be anticipated to be particularly vulnerable to interference from the *GSM* pulsing.

iii) The increased mitotic activity in the cells of developing children makes them more susceptible to genetic damage.

iv) A child's immune system, whose efficiency is, in any case, degraded by radiation of the kind used in mobile telephony, is generally less robust than is that of an adult, so that the child less able to 'cope' with any adverse health effect provoked by (chronic) exposure to such radiation.

B-7. But Not Everyone is Adversely Affected

Because both the occurrence of the initial provoking non-thermal effect *as well as* the severity of any associated adverse health effect depend on aliveness, they *necessarily depend on the physiological* ***state*** *of the organism when it is exposed to the radiation - i.e.* non-thermal effects are *non-linear* effects. Accordingly, it is quite possible that exposure to a low intensity field can entail a seemingly disproportionately *large* (non-linear) response (or none at all), and *vice versa* (consistent with which

is the familiar occurrence of 'windows' of response), quite unlike the situation with the predictable (linear) thermal effects.

Since the physiological state of different people cannot, however, be anticipated to be the same – depending as it does on factors such as the stability of an individual's brain rhythms against interference or entrainment by the radiation, their already prevailing level of stress, and the robustness of their immune system – it follows that *identical* exposure to exactly the *same* radiation can entail quite different (non-thermal) responses in different people (or even in the same person, depending on his/her condition at the time of exposure[88]), quite unlike the case of active electronic instruments. This is, of course, consistent both with the fact that not every exposed person is adversely affected (as is also the case with smoking*, for example,

***** In the case of smoking, it is often claimed that the odds ratio is here much higher than it is in the case of electromagnetic exposure; but this is *necessarily so*, because the former compares heavy smokers with non-smokers, of whom there is effectively no electromagnetic counterpart, everyone being unavoidably at least lightly exposed.

where not all smokers get lung cancer!) and with the difficulties encountered in some laboratory attempts to replicate non-thermal effects, particularly under *in vivo* conditions. For depending on a person's genetic predisposition, and the fact that stress is cumulative, it is quite possible that exposure to an electromagnetic field simply supplies the final contribution that raises a particular person's level of stress above some critical value, thereby 'triggering' the manifestation of some pathology that is already in a well advanced state, but which, in the absence of any exposure, would have remained latent. On the other hand, as already mentioned in **Section B-3.2**, difficulties sometimes experienced in attempts to independently replicate certain frequency-specific non-thermal effects are *actually to be expected,* in consequence of the highly non-linear, non-equilibrium nature of living systems, whereby even the slightest differences in the physiological state of the biosystems used and in conditions obtaining in a particular experiment can, in consequence of deterministic chaos, assume singular importance.

Accordingly, the oft-repeated statement that .....'*There are no established adverse health effects of exposure to GSM radiation (of sub-thermal intensity)*'..... is actually quite true, but, in view of the above, this is **necessarily so**, thus making the statement essentially vacuous. The more relevant consideration is whether there is an established **risk** to human health. It must be concluded that such a risk does indeed exist, but - in view of the above considerations- the actual number and identity of those at risk are necessarily unknown, *a priori*, although, for the reasons identified, children and highly stressed people - particularly those with already compromised immune systems (as well as those on certain prescribed psychoactive drugs) - must be considered more vulnerable.

For the Mobile Phone Industry, regulatory bodies and government to deny this risk is not only untenable, but also, more significantly, lays them open to the charge that they attempted to '*shield the public from uncertainty.*'[89]. There is nothing to be lost - and a lot to be gained - by frankly admitting the existence of this risk, albeit possibly only to a minority of the public, and, in accordance with the recommendations of the Stewart Report[86], taking the necessary steps to minimise it, such as those specified in **Part A**

B-8. The Inadequacy of Existing Safety Guidelines

Existing Safety Guidelines, based solely on consideration of the *SAR*, afford no protection against the ***frequency***-specific[90] effects that have been the subject of this Study, since they limit only the *intensity* of the microwave radiation sufficiently to ensure that tissue heating by absorption of energy from the microwaves is not in excess of what can be coped with by the body's thermoregulatory mechanism, so that temperature homeostasis is not compromised. Furthermore, it must be appreciated that the aliveness of the organism here enters only in so far as it dictates the magnitude of the temperature rise above which adverse health effects set in, the *heating itself* occurring *irrespective* of whether the organism is alive or dead.

In justifying the exclusion of any *non-thermal* input into the formulation of their Safety Guidelines, *ICNIRP* conclude[2]:

…..'*Overall, the literature on athermal effects of amplitude modulated electromagnetic fields is so complex, the validity of the reported effects so poorly established, and the relevance of the effects to human health is so uncertain, that it is impossible to use this body of information as a basis for setting limits on human exposure to these fields.*'

It is to be stressed that this is **not equivalent to denying the existence of non-thermal influences of this kind of radiation, or their potential to provoke adverse health reactions** - as is often maintained by the Mobile Phone Industry – but simply that in *ICNIRP*'s view (because for the reasons stated) such effects cannot be used as a basis for setting exposure limits. Let us consider each point in turn. As an example of the complexity of athermal (*i.e.* non-thermal) effects, the following statement appears in the paragraph preceding the one from which the above quotation is taken:

…..'*Interpretation of several observed biological effects (of this kind of radiation) is complicated by the apparent existence of 'windows' of response in both power and frequency domains. There are no accepted models that adequately explain this phenomenon, which challenges the traditional concept of a monotonic relationship between the field intensity and the severity of the resulting biological effects.*'

An absence of such a monotonic ('dose-response') relationship is, however, actually to be *expected*, since one is dealing with **living** organisms whose very aliveness means that they are far from thermal equilibrium, and hence well beyond the regime where such a monotonic relationship can be expected to hold. Being held far from thermal equilibrium, their response to an external electromagnetic field, for example, necessarily depends on the *state* of the organism at the time when it is exposed - *i.e.* one is dealing with what are known as **non-linear** systems, for which exposure to a weak microwave field does not necessarily entail a correspondingly weak response, or *vice versa*, and for which the 'window' phenomena referred to are actually to be expected[9, 10]! (In this connection, it should be remembered that the concept of a dose-response relationship is one inherited from toxicology, and as such, is in general, *inappropriate* in the present context. For electromagnetic fields are *not alien* to the alive organism, but play a fundamental and integral role in its organisation and control, as already noted.)

This dependence of non-thermal influences on the state of the alive organism must, in general, be expected to undermine the reproducibility of their detection, thus accounting for the reported effects being (in some cases) '*poorly established*'. Accordingly, such difficulties should, more positively, be considered as a biological fact of life – indeed as a 'hallmark' of aliveness! It should be noted that the 'poorly established' claim is not universally accepted, as evidenced both by the Vienna Resolution[3] of 1998, signed by 16 researchers of international standing, and by a recent analysis[91] of the *ICNIRP* document, which claims that it contains….'*a consistent pattern of bias, major mistakes and deliberate misrepresentations'*.

The least contentious part of the quotation is, of course, the question of the relevance of non-thermal effects (assuming their existence is accepted) to human health - it being, of course, essential to appreciate that the occurrence *per se* of non-thermal effects does not mean that they *necessarily* entail adverse health consequences, as already stressed.

In order that the radiation can exert *non*-thermal influences, it is essential that the organism be ***alive***, for only then are the various oscillatory endogenous electrical activities excited, *via* which the radiation can access the system: the Dead have no *ECG* or *EEG* with which an external electromagnetic field can interfere! Thus, just as a radio or another piece of electronic instrumentation has to be switched on (or energised) before it can respond to or be interfered with by an extraneous incoming signal, so the organism has itself to be energised (*i.e.* be alive) if it is to be non-thermally sensitive to radiation. *Existing Safety Guidelines thus neglect the most discriminating feature of all, namely, the* ***aliveness*** *of the irradiated organism*; they address only 'one side of the coin' - the thermal side - leaving the exposed person vulnerable to the possibility of adverse health effects provoked by the neglected *non-thermal* side. The same indictment, of course, applies to any protection device that acts simply to reduce - either by screening or by an employing an ear-piece, for example - the intensity of the microwave radiation emitted by a mobile phone into the head of the user; for the user is still left vulnerable to any adverse health effects that might be provoked by the neglected frequency dimension.

Clearly, non-thermal influences are connected more with the transfer of **information** from the irradiating field to the alive organism, through the latter's ability to 'recognise' certain **frequency** characteristics of the radiation[92], than with its ability to absorb energy from the field. In order, however, for the organism to be able to discern such weak radiation against the level of its own thermal *emission* at physiological temperatures, the radiation must have a certain minimum intensity. In the case of microwave radiation, this minimum intensity is, however, *far below* (of the order of 10^{-15} Watts/cm^2) even that at which *non*-thermal effects manifest themselves, in consequence of the radiation's rather well-defined carrier frequency (or relatively high degree of coherence). It should be noted that the magnitude of this minimum power density is close to those that characterise the human thresholds of *EEG* response[93], and also of sight and hearing. Given that the typical power densities in the main beam near ground level some hundreds of metres from a typical base-station, and also in the often neglected 'side-lobes', are many orders of magnitude *higher* than these threshold values, it is clear that the ability of the alive human organism to discern base-station radiation is *not* at all contingent on a sensitivity that is in any way superior to those that it already possesses (quite undisputedly) in the case of other exogenous fields of physiological relevance.

B-9. Some recommendations to enhance electromagnetic bio-compatibility

9.1. Policy options for the European Parliament

- That the non-emergency use of mobile phones by children – and particularly per-adolescents – be strongly discouraged, on account of their increased vulnerability to any potential adverse health effects.

- That the Mobile Phone Industry be required to refrain from promoting the use of mobile phones amongst children by the use of advertising tactics exploiting peer pressure and other strategies to which the young are particularly susceptible, such as the (now discontinued) use of DISNEY characters fascias on the phones.

- That the Mobile Phone Industry be required to make it clear to the consumer that the value of the specific absorption rate (*SAR*) - which in some countries is shortly to be declared on the handset - refers *only* to the degree to which the microwave emissions from the antenna can heat biological tissue, and is in *no way* relevant to *non-thermal* effects that the emissions from a mobile phone may have on the user.

- Concerning commercially available personal protection devices claiming to protect the user of a mobile phone against the microwave emissions from the antenna, it be required that:

  a) The efficacy of devices such as shields and ear-pieces be proven on the basis of *biological tests*, and not marketed solely on the reduction in *SAR* value (as determined by the use of a 'phantom' head) that their use might achieve.

  b) It be made clear to the consumer that such devices afford no protection against the low frequency pulsed magnetic field from the battery of the phone.

- Concerning commercially available personal protection devices claiming work by boosting the immunity of the user against any adverse impacts of exposure (including those from the battery magnetic field), it be required that:

  a) The efficacy of such devices be established by biological testing.

  b) Such devices not be rejected (as has occurred in certain consumer surveys that have been published) solely on the grounds that their use does not achieve any reduction in *SAR*, as measured using a 'phantom' head; for this is not what they are designed to do. Accordingly, the *SAR* is here a *fundamentally inappropriate* metric against which to assess their efficacy.

  [It should, however, be appreciated that in the case of *real human exposure* – as opposed to that involving a 'phantom' head – such devices could conceivably achieve a reduction in *SAR* if they somehow increase the efficiency of the body's thermoregulatory mechanism; in this way, anecdotal reports of a diminution in heating sensation when a phone is equipped with one particular such device might be rationalised.]

9.2 Policy options for the European Commission

- Future research sponsored by the *EC*, should incorporate the following recommendations:

  a) That the living systems under investigation be exposed to the emissions of an actual mobile

phone, as opposed to those of a 'surrogate', since the emissions from the former can be expected to have a quite different biological impact, in consequence of certain pulse frequency differences.

b) That in assessing the significance to humans of results obtained using animals, particular attention be given to differences in exposure conditions, such as whether exposure is size-resonant or non-resonant, whether it is to the near or far field of the antenna, and whether whole-body or of more localised exposure occurs.

c) That systematic investigation be made of the influence of different kinds of pulsing (of real phones) on the human *EEG*, and ideally on the *MEG*, and of whether any observed changes in power spectra are correlated with changes in the level of deterministic chaos.

d) That use be made of novel, non-invasive technologies, such as biophoton emission, to investigate the influence of mobile phone radiation on living systems.

e) That in assessing the noxiousness of mobile phone radiation more attention be paid to lessons that have been learnt from exposure to other kinds of related radio frequency fields, such as those from the Skrunda, military and police radars.

f) That, in the light of reports of cattle being quite seriously adversely affected at farms where there is a base-station, a veterinary monitoring service be established to collect and analyse such reports, and raise awareness amongst farmers of this potential hazard to their livestock.

- Attempts should be made – perhaps under the aegis of national regulatory bodies - to increase awareness of the fundamentally electromagnetic nature of the alive organism, and of its associated hypersensitivity to coherent, ultraweak electromagnetic signals of technological origin.

  [Until this is achieved, the necessity of extending existing thermally based safety guidelines, by incorporating therein the dimension of electromagnetic biocompatibility, is unlikely to be accepted, and the public will remain vulnerable to any adverse health effects provoked by non-thermal electromagnetic influences on the alive human organism.]

9.3 Technological options at the operational level

Whilst the question of precisely *how* adverse health effects can be provoked by non-thermal influences of the pulsed microwave radiation currently employed in *GSM* telecommunication, as well as those from *ELF* fields associated with other technologies, is far from resolved, the circumstantial evidence consistent with such influences suggests at least two ways in which biocompatibility with this technology could be enhanced by interventions involving the fields alone:

- In the case of exposure to GSM radiation, reduce intensities to the level below which no adverse effects have been empirically found in exposed populations, bearing in mind that there are indications of non-thermal thresholds for biological effects of the order of *microwatt/cm*^{2}. Power densities a few *tenths* of this value are common at distances of 150-200m from a typical 15m high Base-station mast and within the range of the more localised side-lobes in the immediate vicinity of a mast - *adverse effects being reported at* ***both*** *locations*. Incorporating a further safety factor of 10 indicates that, at locations where there is any long-term exposure, power densities should not exceed 10 **nano**W/cm^2.

  [To appeal to the (alleged) absence of health problems associated with the higher power density electromagnetic fields associated with radio/TV transmissions in an attempt to justify the retention of the present level of emission from *GSM* Base-stations is untenable on at least two accounts: (*i*) the nature of

the emissions are quite different, with respect to carrier frequencies, modes of transmission (pulsed/analogue), and beam morphology, (*ii*) there *are*[94-96] health problems connected with *some* such transmitters, contrary to what is often claimed!]

- Ensure that there is **no** *ELF* frequencies – either of amplitude modulations (including pulsing, as the extreme case) of *RF* fields, or of other electric /magnetic fields - in the range of human electrical brain-wave activity, or windows of calcium efflux.

  [In the case of exposure to GSM radiation, this will be achieved, to a certain extent, with the advent of the Third Generation of mobile phones (*UMTS*) that utilise *CDMA* in place of *TDMA*. For although any sensitivity to the microwave carrier will remain, the pulsing used in *CDMA* is *irregular*; accordingly, *CDMA* radiation cannot enjoy the same 'oscillatory similitude' with the human brain-wave activity and electrochemical processes as does *TDMA*. In consequence, however, of the somewhat higher carrier frequency used, which is closer to where water strongly absorbs microwaves, *thermal* effects could here become more of a problem, particularly in view of the somewhat higher powers at which they operate! The introduction of *TETRA*, similarly gives rise to an *increased* level of (non-thermal) concern, for the reasons already stated in **Section B-1**.]

B-10. Conclusions

Absorption of microwave radiation causes heating of biological tissue, which if excessive is deleterious to health; this is undisputed, and forms the basis of current Safety Guidelines, both national and international. In the case of exposure to the microwave radiation used in *GSM*, these Guidelines are generally not violated. Indeed, in the case of the emissions from base-stations, it has been repeatedly confirmed by field measurements that the emissions are *far* below - by many orders of magnitude - the limits set by the Guidelines. What *is* currently disputed, however, is whether, in the case of the alive human organism, this radiation can exert other, more subtle, kinds of non-thermal influences, which might also entail adverse health consequences. The root of the continuing public concern is that if this is, in fact, the case, then the existing guidelines afford an inadequate level of protection, in that they leave an exposed person vulnerable to these non-thermal hazards.

As has been explained, the heating ability of microwave radiation depends primarily on its intensity, and it is essentially only this that the Guidelines restrict. *Non-thermal* effects, on the other hand, depend primarily on the existence of an 'oscillatory similitude' between the frequencies of the radiation and those of certain endogenous biological electrical activities that the organism supports when alive, which effectively opens it to informational aspects of the radiation; it is this dimension of the problem that is not addressed by existing Safety Guidelines.

Whilst the existence of non-thermal influences is readily accepted in the case of active electronic instrumentation exposed to *GSM* radiation, the same does not currently prevail in the case of the alive human organism, which is generally considered immune to any effect other than heating, despite the fact that, in the case of mobile phone use, the brain (the most sensitive organ of the body) is, for the first time in its evolutionary history, being exposed at short range to a source of both pulsed microwaves (from near-field of the antenna) and more highly penetrating *ELF* magnetic fields (from the battery). This conviction continues to persist - particularly in Regulatory Circles - despite the fact that the possibility of non-thermal influences on living systems of the kind of radiation used in mobile telephony is a rather general prediction of modern, non-linear biophysics, and one that is

supported by 30 years of evidence, both of non-thermal effects *per se*, and of associated adverse health reactions, in particular – not only from exposure to GSM radiation, but also to that from other kinds of installations that emit microwave and *RF* radiation of an intensity at locations of human and animal exposure that is comparable to that realised several hundreds of metres from a base-station.

Two principal reasons for this state of affairs have been identified: 1) the negative outcome of some attempts to independently replicate certain non-thermal effects, even *in vitro*, the acceptance of which is not helped by their often counterintuitive nature (but only from a linear perspective), and 2) uncertainty as to whether such effects (assuming they *are* real) necessarily entail adverse health reactions. Both these problems have been addressed, and attention drawn (*i*) to the fact that difficulties in corroboration are actually to be expected as a hall-mark of the 'alive', and thus should, more positively, be accepted as a 'biological fact of life', and (*ii*) to the existence of a certain empirical consistency between the contentious non-thermal effects and the types of adverse health effects (mainly neurological) reported by some people when exposed to *GSM* radiation, as well as that (the indication of an increased incidence of brain cancer amongst mobile phone users) found epidemiological – a consistency that further enhances the credibility of the non–thermal effects, and one that will hopefully motivate further research (from the necessary non-linear standpoint, of course) towards establishing their causal connections with presenting pathologies.

In conclusion, and in accord with philosophy espoused by the World Health Organisation, it can hardly be disputed that to enjoy an acceptable quality of life requires more than simply an absence of terminal disease. In this respect, even adverse health effects *of a non-life threatening kind* that might be provoked by exposure to *GSM* radiation must be considered unacceptable, in that they undoubtedly have a debilitating effect that undoubtedly undermines the general well-being of those affected, and which in the case of certain pre-adolescent children could well undermine their scholastic and neurological development.

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It is to be stressed, however, that the heating itself *always* occurs, *irrespective* of the physiological condition of the person (even whether alive or dead!), quite unlike the situation with non-thermal effects. It is, of course, this fact that underlies the possibility of using 'phantom' heads to determine *SAR* values; it should, however, be realised that the reliability of the values so obtained is contingent on the extent to which the dielectric properties of the synthetic brain fluids used actually approximate to those in the **alive** human brain. On the basis of what little information is available, the differences could prove to be significant.

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